The Park Service provided no evidence of even a single wildlife disturbance by a dog in San Mateo County from 2001 to 2010. Even though I see some wildlife flushing occur just like with any human activity (e.g., ranger patrols, hiking, bicycling, equestrian, etc.), there is no evidence that these inconsequential and rare disturbances have any more than insignificant impact on the wildlife populations in these parks particularly in comparison to other visitors without dogs. Rabbits, ground squirrels, and birds are the most common animals along the trail bed and they flush off the trail or beach when a person, horse, bicycle, or vehicle passes. There is no scientific evidence that provides more than speculative evidence that dogs on-leash or off-leash have any significant impact on these wildlife above that of a hiker without a dog. In almost 50 years of living on a farm and regularly visiting parks, I've never seen a dog catch wildlife but I'm sure it happens on extremely rare occasions. Even if a dog once in a while catches a bird somewhere in the GGNRA, that is inconsequential in comparison to other activities that the Park Service sanctions such as fishing and hunting and inconsequential in comparison to the 80,000 acres and natural attrition and wildlife interactions.

Any disturbances are further minimized in the coastal scrub/chaparral areas by the denseness of the vegetation and the poison oak, which encourages owners to keep their dogs on the trail bed. All DEIS impact statements and justifications should be modified to indicate negligible impacts on from dog recreation on wildlife unless studies in the GGNRA provide evidence that adverse effects are more than speculative and negligible for these recreation areas.

Row Labels	Moderate Impact	Minor Impact
Milagra Ridge	1	
Wildlife - Coastal scrub and chaparral	1	
Mori Point	1	2
Wildlife - Coastal communities		1
Wildlife - Coastal scrub and chaparral	1	
Wildlife - Wetlands and open water		1
Pedro Point Headlands	1	
Wildlife - Coastal scrub and chaparral	1	
Sweeney Ridge	1	
Wildlife - Coastal scrub and chaparral	1	
Grand Total	**4**	**2**

San Francisco Garter Snake
(Thamnophis sirtalis tetrataenia)

5-Year Review:
Summary and Evaluation

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

September 2006

5-YEAR REVIEW
San Francisco Garter Snake (*Thamnophis sirtalis tetrataenia*)

TABLE OF CONTENTS

5-YEAR REVIEW
San Francisco garter snake
(*Thamnophis sirtalis tetrataenia*)

1. GENERAL INFORMATION

1.1. Reviewers

Lucy Triffleman, Sacramento Fish and Wildlife Office (916) 414-6600

Diane Elam and Mary Grim, California/Nevada Operations (916) 414-6464

1.2. Methodology used to complete the review:

This review was completed by Sacramento Fish and Wildlife Office (SFWO) staff using information from species survey and monitoring reports, the 1985 Recovery Plan for the San Francisco garter snake, peer-reviewed journal articles and papers, and documents generated as part of section 7 consultations. Spatial analysis assistance was provided by staff in the Geographic Information Systems (GIS) branch of the SFWO. Survey information, peer reviewed publications and personal communications with experts were the primary sources of information used to update the species status and threats section of this review.

1.3. Background:

1.3.1. FR Notice citation announcing initiation of this review:

The FR notice initiating this review was published on July 7, 2005 (70 FR 39327). This notice opened a 60-day request for information period, which closed on September 6, 2005. A second FR notice was published on November 3, 2005 (70 FR 66842), which extended the request for information period for an additional 60 days until January 3, 2006.

1.3.2. Listing history

<u>Original Listing</u>
FR notice: 32 FR 4001
Date listed: March 11, 1967 under the Endangered Species Preservation Act of 1966
Entity listed: Subspecies
Classification: Endangered

1.3.3. Associated rulemakings

Not Applicable

1.3.4. Review History

July, 1995:	Recovery Outline prepared
September, 1985:	Publication of *San Francisco Garter Snake Recovery Plan*
March, 1967:	Listing of species under the Endangered Species Preservation Act (1966).

1.3.5. Species' Recovery Priority Number at start of 5-year review

The recovery priority number for the San Francisco garter snake (SFGS) prior to initiating the review is 3C. Three is the highest rating for a federally-listed sub-species and is indicative of the high potential for recovery of the species. This potential is based on how well biological and ecological limiting factors and threats to the species' existence are understood and how much management is needed. The letter "C" after this number indicates the conflict of the species with construction or other development projects or other forms of economic activity (48 FR 3098).

1.3.6. Recovery Plan or Outline

Name of plan: *San Francisco Garter Snake Recovery Plan*
Date issued: September 11, 1985
Dates of previous revisions: An updated recovery outline for the SFGS was issued in July 1995. In 2005, the U.S. Fish and Wildlife Service (Service) initiated efforts to produce a new recovery plan. However, due to staffing limitations and changing workload priorities, the completion of this document is currently on hold.

2. REVIEW ANALYSIS

2.1. Application of the 1996 Distinct Population Segment (DPS) policy

2.1.1. Is the species under review a vertebrate?

__X__ Yes
_____ No

2.1.2. Is the species under review listed as a DPS?

____ Yes
__X__ No

2.1.3. Is there relevant new information for this species regarding the application of the DPS policy?

____ Yes

_X__ No

2.2. Recovery Criteria

2.2.1. Does the species have a final, approved recovery plan containing objective, measurable criteria?

_X_ Yes
____ No

2.2.2. Adequacy of recovery criteria.

2.2.2.1. Do the recovery criteria reflect the best available and most up-to date information on the biology of the species and its habitat?

____ Yes
_X__ No

Recovery criteria listed in the 1985 recovery plan are outdated and reflect the lack of information available at the time the plan was prepared. In the past two decades, significant changes have been made regarding our understanding of the ecology, biology and habitat requirements of the species. Significant new information has been developed since the original recovery criteria were determined and, as a result, has made some of the previously listed criteria obsolete.

2.2.2.2. Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)?

____ Yes
__X_ No

2.2.3. List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information (for threats-related recovery criteria, please note which of the 5 listing factors are addressed by that criterion. If any of the 5-listing factors are not relevant to this species, please note that here):

Due to the listing of the SFGS in 1967 under the Endangered Species Preservation Act, the species was not subject to the same listing processes currently undertaken under the Endangered Species Act of 1973, as amended (Act). When the Act was signed into law, the SFGS was grandfathered in as an endangered species. Therefore, no five factor analysis was conducted. In 1985, the Service issued a recovery plan for the SFGS, which included the best scientific and commercial data available at the time.

The recovery criteria in the recovery plan focused on the protection of six "significant" populations and the creation of four populations at undefined sites. The six significant populations included the West of Bayshore property (San Francisco International Airport), San Francisco State Fish and Game Refuge property (San Francisco Public Utilities Commission), Laguna Salada/Mori Point property (City of San Francisco/National Park Service), Pescadero Marsh and Ano Nuevo State Reserve properties (California State Parks) and Cascade Ranch property (private land owner) (fig. 1 and 2). If 200 or more individuals could be maintained at a 1:1 sex ratio at each of the six existing locations for five consecutive years, the species could be considered for downlisting to threatened. If these abundance and sex ratios could be maintained at each of the ten locations for 15 consecutive years, the species would be eligible for delisting. The recovery plan proposed that conservation agreements be signed with each of the land owners controlling the lands containing the six significant populations identified in the plan. However, no agreements have been completed to date and the additional four populations proposed in the recovery plan have not been identified. Additionally, although the precise population ratios of SFGS are unknown, studies of the eastern garter snake (*Thamnophis sirtalis sirtalis*) and the red-sided garter snake (*Thamnophis sirtalis infernalis*) indicate that those sub-species do not exhibit 1:1 sex ratios, with males outnumbering females in the wild (R. Shine *et al.* 2001). If the sex ratios of the SFGS are similar to the eastern and red-sided garter snakes, then a sex ratio of 1:1 may not be the appropriate criterion.

In response to the issues described above, an updated recovery outline was prepared by the Service in July, 1995. In 2004, the SFWO established a SFGS working group which is comprised of Service employees familiar with current issues facing the species. The group's purpose is to design and implement specific conservation actions that could be performed prior to, and concurrent with, updating the recovery plan. The group is preparing an interim recovery implementation document consistent with the 1995 recovery outline to assist in guiding recovery actions until a revised recovery plan can be developed.

2.3. Updated Information and Current Species Status

2.3.1. Biology and Habitat

Historic and Current Distribution

The historic range of the SFGS extended from just north of the San Francisco-San Mateo County line near Merced Lake south along the base of the Santa Cruz Mountains to Waddell Creek (U.S. Fish and Wildlife Service 1985) (fig. 1 and 2). Within this area, SFGS populations may have principally occupied the Buri Buri Ridge along the San Andres Rift and south in an arc from the San Gregorio-Pescadero highlands west to Tunitas Creek. From here, SFGS populations extended along the west coastline of the Peninsula to Ano Nuevo State Reserve (ANSR), which is the southernmost location of the species' historic range. An intergrade zone comprised of SFGS-red sided garter snake hybrids stretched from Palo Alto north to the Pulgas region near Upper Crystal Springs Reservoir (Barry 1994).

A population at San Bruno Mountain may have once represented the extreme northeastern portion of SFGS' range, though it may now be extirpated (Barry 1994). However, the San Bruno Mountain population may have been the result of the translocation of individuals from other locations to San Bruno Mountain by amateur herpetologists in order to protect them from development occurring elsewhere on the Peninsula (Barry 1994). Barry (1994) suggested similar methods were employed farther south as well, resulting in the current populations at Half Moon Bay. He did not discuss when, and for how long, these activities were performed. Regardless of its origin, the SFGS is extant in Half Moon Bay (McGinnis 1988). Additionally, the historic range of the species may have extended as far south as Stanford in northern Santa Clara County, based on hybrids between SFGS and other garter snake species collected from this location (Barry 1975). In addition to these historic records, the Service believes that additional coastal property on the west side of the Santa Cruz Mountains may be inhabited by SFGS. However, because much of this property is privately owned, surveys are not available. Recent surveys reveal that there has likely been very little decrease in the overall historic range of the SFGS; however, SFGS have been extirpated from individual locales within that range (California Natural Diversity Data Base, 2006).

Population trends and habitat availability

Overall, little data exists regarding population trends, demographic features and demographic trends for the San Francisco garter snake. Through trapping and monitoring, the Service has been working with its partners over the past three years to develop improved estimates of the current population trend. However, this process is ongoing and has not yet been completed due to limited funding and the time needed to conduct population studies.

Sufficient data does exist to discern a population trend for the West of Bayshore population. This population is located near San Francisco International Airport (SFO) and was thought at one time to be one of the largest SFGS populations (U.S. Fish and Wildlife Service 1985, Natureserve *in litt.* 2006). Wharton (1989) trapped 695 individuals at the site between 1983 through 1985. By the mid-1990s, Larsen reported trapping 179 individuals from the same location. The results from these two studies can not be easily compared due to differences in collection techniques and sampling design resulting in Larsen's surveys being more efficient. When all factors are taken into consideration, the difference in the number of snakes captured indicates a decline in the population. Although Larsen suggested that the reduction in SFGS numbers observed in the early 1990s may have been the result of drought conditions, she noted that low population counts continued into wetter years (Larsen 1994). Further, trapping surveys conducted prior to construction of the Bay Area Regional Transport (BART) station in 1997 resulted in the capture of only 25 individuals (S. Larsen, U.S. Fish and Wildlife Service, pers. comm.). Although these surveys were performed within a limited area on the West of Bayshore site, the results of these efforts were less than would have been anticipated based upon previous observations and trapping efforts for the SFGS there (S. Larsen, pers. comm.).

In the absence of reliable data regarding trends in the number of individuals in a population, population trends are often inferred from changes in habitat quality and quantity. The degradation of suitable habitat at the West Bayshore site suggests that this SFGS population is declining. Loss of habitat quality may be primarily related to increased quantities of vegetation and silt in the canal system that have reduced the open water component necessary to support a viable population of the snake's primary prey base (S. Larsen, pers. comm.). Although in prior years the canals had been cleared as needed in order to maintain sufficient flows within the channels, these activities were greatly reduced starting in the mid-1980s (S. Larsen, pers. comm.). Negative impacts to the species may have been further heightened by encroaching development, illegal collecting, and limited law enforcement in the area (Larsen 1994). Recently, in order to increase the number of snakes at the site, the Service and SFO agreed to partner to improve SFGS habitat at the West of Bayshore property.

As with the West of Bayshore property, the SFGS population at Laguna Salada is thought to have decreased, although at Laguna Salada, the perceived decline is likely primarily due to two occurrences of salt water inundation of the snake's habitat during the 1980s. Since that time, the protective levee that separates the lagoon from the levee was reinforced and there have not been additional salinization events (Steiner and Hafernik 1992). Because of the frequent water quality degradation at the site observed prior to the repair, Barry (1994) speculated that this area may not have been historically occupied by the species. SFGS distribution in the area may also have been reduced by off-highway vehicle (OHV) activity and illegal trash dumping during the 1980s at the neighboring Mori Point property which is located in the greater Laguna Salada area (Steiner and Hafernik 1992, D. Fong, pers. comm.). In recent years however, these adverse activities have been greatly reduced due to actions taken by the National Park Service, which owns and manages the area around Mori Point (D. Fong, National Park Service, pers. comm.). Additionally, the Service and the National Park Service recently partnered to construct two ponds at Mori Point for the benefit of the snake (S. Larsen, pers. comm.; H. McQuillen, pers. comm.). These ponds were constructed in order to provide additional breeding habitat for amphibian species. National Park Service volunteers recorded SFGS using these areas for foraging for California red-legged frogs (*Rana aurora draytonii*), which were at both ponds in February of 2006 (S. Gardner *in litt.* 2006). This rapid utilization of the area demonstrates the potential benefits of even small scale pond creation.

Recovery of the SFGS in the Laguna Salada region beyond Mori Point continues to face challenges. The filling of several ponds and the intensive disking practices that were implemented in 1990 along Calera Creek were problematic for the species. The Calera Creek channel lies approximately one kilometer south of Sharp Park, and had previously been noted by researchers to have a high number of confirmed SFGS occurrences (McGinnis 1990; S. McGinnis, pers. comm.) (fig 1). Since the filling of these ponds, however, biologists have not observed the species along Calera Creek while conducting informal walk-through surveys (S. McGinnis, pers. comm.; K. Swaim, pers. comm.). Barry (*in litt.* 2006a) observed movement of the SFGS along the ridgeline separating the Calera Creek corridor and Mori Point in 1978 and 1990, which implies that there is movement between these two sites. However, current trapping efforts have not produced any SFGS between Mori Point and Calera Creek, indicating that the species has yet to expand beyond the immediate Mori Point vicinity to reinhabit this outlying location (K. Swaim, pers. comm.). A further complication is a proposal for residential and road development along Calera Creek which may threaten restored SFGS habitat within this watershed (S. Larsen, pers. comm.; H. McQuillen, pers. comm.).

Several factors adversely affect the SFGS population at the San Francisco State Fish and Game Refuge surrounding Crystal Springs and San Andreas Reservoirs. Although this property is designated as a California Department of Fish and Game (CDFG) refuge, the San Francisco Public Utilities Commission (SFPUC) has ownership and management responsibility for the area (J. Stoltz, pers. comm.). Though designated public land, human access to the area has been restricted in order to protect the reservoirs, which provide drinking water for the City of San Francisco (J. Naras, pers. comm.). The infrequency of human use has allowed for the persistence of quality SFGS habitat and high SFGS densities, demonstrated by the large number of individuals that have been observed on the property (Barry 1996). Although currently protected from most human activity, the area is not specifically managed for the species (J. Stoltz, pers. comm.). Additionally, public trail systems maintained by San Mateo County exist along certain water bodies within the property, and more are currently being proposed. The current and future establishment of this trail system allows for increased human presence on SFPUC property, and may result in activities that disturb, injure, or kill the SFGS. For example, a SFGS individual was run over by a bicycle on a road adjacent to the SFPUC property (A.M. McGraw *in litt.* 2005). Although the Service and SFPUC have discussed developing a habitat conservation plan, this process has yet to be initiated (S. Larsen, pers. comm., J. Naras, pers. comm.).

The population of SFGS at Pescadero Marsh is another significant SFGS population that is most likely experiencing a decline. According to Larsen (pers. comm.), SFGS in this area match the phenotype of the holotype (the single specimen that was chosen as a representative type by the author when establishing the taxonomic group) more closely than any other population on the Peninsula. At this property, saline inundation of the marsh has contributed to the decline of quality fresh water habitat (J. Kerbavaz, pers. comm.). With the implementation of several recovery actions aimed at improving fresh water conditions in portions of Pescadero Marsh during 1990s, some California State Parks staff believe that habitat conditions for SFGS and their primary prey base have greatly improved in recent years (J. Kerbavaz, pers. comm.). The SFGS can now be found in the eastern portions of the marsh, as well as in several artificial ponds adjacent to originally inhabited areas (McGinnis 2002). However, much of the marsh remains brackish (J. Smith, pers. comm.), with salinities unsuitable for the various frog species that comprise the SFGS' diet (C. Atkinson, pers. comm.; P. Keel, pers. comm.). Further suitable habitat for these anuran (taxonomic group of amphibians containing frogs and toads) populations continues to decline in the area (J. Smith, pers. comm.). Due to this perpetuation of high salinity levels in portions of the marsh, the effectiveness of current restoration work does not appear to have reduced the quantity of sea water entering the fresh water system.

In addition to restoration work being performed in wetland areas at Pescadero Marsh, upland conservation management is being implemented on the neighboring property that may be benefiting this population. In 2005, staff from Pescadero Marsh and Peninsula Open Space Trust (POST) conducted a prescribed burn on the Cloverdale Ranch, with funds provided in part by the Service. Data is currently being collected to determine the impacts of the burn on the species and its habitat, though additional research is necessary to properly assess the results (A. Willy, pers. comm.). More data is expected from further trapping surveys as well as the continuation of prescribed fires on the POST property planned for later this year.

Ano Nuevo State Reserve (ANSR), another population location identified in the recovery plan, has had documented sightings of SFGS since 1978 when Barry observed several SFGS individuals around the ANSR headquarters' pond (Barry 1978). In 1987, McGinnis performed a trapping survey which resulted in the capture of 13 SFGS in the vicinity of this same pond (McGinnis *et al.* 1987). Keel *et. al.* (1991) performed further trapping studies over a larger area of ANSR between May and August, 1988. During the course of this study, 57 SFGS were captured, leading the authors to believe that ANSR may contain one of the largest known SFGS populations. Although prey abundance was low within the headquarters pond, the authors believe that these high SFGS densities at ANSR may be attributed to the high number of wetlands and suitable upland foraging habitats available for the SFGS prey base.

In order to further encourage SFGS presence at ANSR, California State Parks, in conjunction with the Service, performed two prescribed burns on 45 acres in SFGS habitat in 2004 and 2005 (Halbert 2005). Results from trapping surveys conducted before and after the 2004 fire show that the number of snakes increased on the site from seven SFGS (Willy *in. litt.* 2004) to 53 individuals (Swaim Biological Consulting 2006). This high number of captures comprised of a mix of sexes and age classes indicates that ANSR currently supports a good breeding population of SFGS (Swaim Biological Consulting 2006). However, in addition to the reintroduction of burn disturbance, the apparent population increase may also be due to differences in the trapping efficiency between the two surveys; understanding the true impact of these prescribed burns on SFGS in the area will require additional monitoring (P. Halbert, pers. comm.).

In addition to increased management on currently owned property, ANSR may also receive land suitable for habitat restoration for the California red-legged frog (*Rana aurora draytonii*) and the SFGS. Presently, the California Department of Parks and Recreation is in active discussions with the land owner regarding the conveyance of the property. If this land acquisition is completed, it will increase the availability of protected habitat for the species and will allow for increased opportunities to further experiment with land management techniques that encourage garter snake survivorship (A. Willy, pers. comm.; V. Roth, pers. comm.).

Little is known regarding the distribution of the significant population at Cascade Ranch, the only population on private property discussed in the recovery plan. The area was severely overgrazed through the late 1980s. In 1989, the Service completed a formal section 7 consultation to allow the construction of a resort lodge, general store, cabins, and a camping area on the adjacent property while supporting recovery actions for SFGS on-site (Biosearch Associates 2003). Recovery actions for the project, as described in the Service's biological opinion (U.S. Fish and Wildlife Service 1996a), included the establishment of a 200-foot easement around the Whitehouse Road Pond, as well as hydroseeding and other habitat improvement practices. The camping resort was completed in 1999 and a final compliance report was submitted in 2001. A CDFG Memorandum of Understanding with the property owner required five years of biological monitoring of the area around the resort starting in 2001 to observe compliance to recovery actions, to monitor habitat quality, to remove introduced predatory centrarchid fish if the California red-legged frogs did not successfully breed, and to fence the easement for the exclusion of feral pigs (*Sus scofra*) (Biosearch Associates 2003). The final monitoring report from Biosearch Associates (2005) indicates that the pond, easement, and enhancements are providing suitable habitat for the SFGS, including a prey base of CRLF. Incidental sightings of SFGS occurred in 2005 and the population of introduced predatory fish was apparently extirpated from the pond. It is noted in the report that the easement was sold into private ownership in 2003 without a finalized easement contract. However, this issue is currently being resolved by USFWS and a private consultant (Biosearch Associates 2005). Finally, although Cascade Ranch was identified in 1994 as high-quality SFGS habitat in close proximity to breeding ponds at ANSR, SFGS may be unable to move between these locations due to the establishment of Highway 1 and the adjacent agricultural areas (Freel and Giorni 1994).

Habitat destruction continues to occur due to a number of small projects throughout the range of the species. High density urban development continues to expand in the northern portion of the Peninsula, limiting suitable habitat in this area. Additionally, the prevalent agricultural practice of managing small farm plots throughout San Mateo County has resulted in continuous disking and planting cycles, increasing habitat fragmentation in rural regions of the species' range (J. Howard, pers. comm.). The consequence of these combined land use patterns is the reduction of SFGS numbers through direct mortality and indirect impacts resulting from limitations on movement to new and more suitable habitats (Barry 1994).

Relevant new information regarding the biology and ecology of the San Francisco garter snake

When the recovery plan was published, little was known regarding the extent to which SFGS utilized upland habitat (U.S. Fish and Wildlife Service 1985). It is now known that essential habitat for a breeding SFGS population includes open grassy uplands and shallow marshlands with adequate emergent vegetation, and the presence of both Pacific tree frog (*Pseudacris regilla*) and California red-legged frog breeding populations (McGinnis 1987). Uplands may be essential to the snake's survival (S. Barry *in litt.* 2006b). Flora composition in the upland habitat sites includes, but is not limited to, coyote bush (*Bachari pillularis*), wild oat (*Avena fatua*), wild barley (*Hordeum* spp.), and various brome species (*Bromus* spp.) (Larsen 1994). Barry (1994) observed that SFGS may prefer a grassland/shrub matrix with brush densities ranging from 1 average sized bush/30 square meters to 1 large bush/ 20 square meters. By maintaining these ratios, there is sufficient cover from predators, while allowing for exposed surfaces to facilitate thermoregulation (Barry 1994).

One way to encourage the brush to grassland ratios preferred by the SFGS may be to introduce managed livestock grazing into a system. Through the use of domestic herbivores, the disturbance pattern associated with grazing species would be allowed to develop and persist, thus limiting the dense brush canopy associated with advanced ecological successional stages. By implementing managed grazing, grass production would increase, and the grassland system would remain in the early successional state. Barry (*in litt.* 2006b) discussed how large areas of land disturbed solely by properly managed livestock appeared to positively correlate with large SFGS populations. However, overgrazing can be highly detrimental to SFGS. Barry (1994) speculated that allowing vegetative cover to fall below a mean understory (i.e., height of bunch grasses or depth of litter) of 20 centimeters (cm) can result in the loss of habitat suitability for breeding populations.

The SFGS also may depend on ground burrowing rodents for survival. Larsen (1994) found that rodent burrows in upland areas provide hibernacula for SFGS during the winter months. These burrows also may provide cover for SFGS throughout the rest of the year (H. McQuillen, pers. comm.). Additionally, there is some evidence that gophers are important in maintaining the dynamic open grasslands required by SFGS. In a recent study conducted in Monterey County, gopher burrowing activities that moved nitrogen-poor subsoils to the surface were shown to stimulate early successional conditions within a grassland system and may be able to substitute in this role for larger grazing species (Stromberg and Griffin 1996). The presence of burrowing mammals can therefore be beneficial for the SFGS.

In addition to upland areas, the SFGS requires fresh water marsh habitat with a diversity of habitat components. Generally, individuals have been observed in habitat that contains a variety of emergent vegetation such as cattails (*Typha* spp.), spike rush (*Eleocharis* spp.), and water plantain (*Alisma* spp.) (Larsen 1994). Barry (1994) has observed that, in areas where marsh vegetation does not exist, the SFGS inhabit aquatic habitats surrounded by willows (*Salix* spp.) and various members of *Rubus* spp., indicating that these species may act as substitutes for traditional wetland plants. However, these substitute species' ability to function in this capacity is contingent on there being minimal clearance between the overhanging vegetation and the ground (Barry 1994). An open water component to the wetland also is important to the SFGS. This may be due to the anuran prey base that requires sufficient quantities of open water be present throughout the spring and summer in order prevent the desiccation of egg masses or loss of tadpoles. Premature water reductions may result from uptake and storage by cattails, and sedimentation levels may rise due to the presence of dense vegetative stands that trap soil from upland flows (S. Larsen, pers. comm.). However, the requirement for open water habitat should not be confused with deep water habitat. The need for shallow water near the shore line is especially important from May to July, in order to ensure the successful hatching and metamorphosis of SFGS prey items (S. McGinnis, pers. comm.). Shallow water is also directly important to the SFGS since the species, which is adapted to more terrestrial habitats, has been shown to be unable to effectively capture prey in water deeper than 5 cm (Larsen 1994). Further, shallow water allows for greater exposure of rocks, alga mats and floating vegetation along pond edges, all of which have been observed serving as basking sites for SFGS (Freel and Giorni 1994). These components may provide similar benefits to Pacific tree frogs and California red-legged frogs, allowing for greater accessibility of SFGS to these prey species.

Research conducted since the issuance of the recovery plan indicates that the SFGS prefer habitat consisting of densely vegetated ponds near open hillsides (California Department of Fish and Game 2005). The SFGS may prefer slopes with southern or western facing exposures, which receive increased levels of solar radiation, due to the enhanced ability for thermoregulation at these sites (McGinnis 1991). For much of the winter, SFGS retreat to hibernacula (shelters where they spend their dormant time during the winter). However, unlike other snake species found in the central regions of the United States, SFGS have been observed emerging from hibernacula to bask at various times throughout the winter. This indicates that SFGS may not enter into true hibernation (S. Larsen, pers. comm.). Larsen (1994) hypothesized that this behavioral difference between garter snake species could be attributed to the relatively temperate climate of the San Francisco Bay area. When SFGS do retreat to upland habitat refugia, the upland areas often chosen include rodent burrows and thick mats of grass near ponds (Larsen 1994). Mature SFGS were recaptured near the same burrows in several studies conducted at various locations, indicating that SFGS possess relatively small home ranges (Larsen, 1994, McGinnis *et al.* 1987).

Mating activities are conducted during both the spring and fall, but principally during the first few warm days of March (Fox 1955 in Freel and Giorni 1994). The augmented frequency in spring mating is thought to be due to the increased likelihood of encountering a mate as individuals emerge from hibernacula and concentrate near aquatic hunting grounds (Larsen 1994). Peak activity for the species occurs between March and July (Freel and Giorni 1994). These observed movements may correspond with the predicted behavior associated with mating and foraging activities. For the remainder of the year, Larsen observed that most individuals at the West of Bayshore property remained within a relatively small area (Larsen 1994).

During the spring and early summer, feeding occurs near or within ephemeral ponds inhabited by Pacific tree frogs (*Pseudacris regilla*), the primary food source for SFGS during this time (Freel and Giorni 1994). Although juvenile SFGS may initially capture and consume Pacific tree frog metamorphs (tadpoles that have recently gained adult frog features) in upland habitat, they have principally been observed moving back to aquatic sites to feed on the young-of-year frogs once these wetter areas begin to dry up and the tree frogs begin to disperse (S. Barry *in litt.* 2006c; S. Larsen, pers. comm.). Mature individuals prey on Pacific tree frogs as well, although they also eat California red-legged frogs during the late summer months (S. Larsen, pers. comm.). Tadpole California red-legged frogs develop throughout the spring and summer allowing for their full metamorphosis in July and August. The late emergence of California red-legged frogs allows for a necessary second cycle of feeding by adult SFGS after the Pacific tree frogs have retreated from the drying wetlands to upland aestivation areas (McGinnis 2002). In late summer and early fall, post-metamorphic California red-legged frog populations disperse from wetlands as well, moving into nearby rodent burrows in upland areas (Freel and Giorni 1994) or to new aquatic habitats in neighboring streams or permanent ponds (H. McQuillen, pers. comm.). This distribution of food resources may explain the high level of SFGS movement activity later in the summer months (Larsen 1994).

SFGS appear to remain in close proximity to suitable aquatic habitat. Radio tracking studies of SFGS at Ano Nuevo State Reserve and Pearson Ranch indicate that most individuals remain within one to two hundred meters of pond foraging habitats and wintering upland sites (McGinnis 2002). Larsen (1994) reported similar findings at the West of Bayshore site though she did record a travel distance of 671 meters for one female and 632 meters for one male. Although SFGS do not appear to move distances greater than a kilometer, as has been observed for many other garter snake species, their anuran food base frequently moves up and down riparian corridors, traveling over two kilometers from pond habitat (McGinnis 2002). SFGS may follow or disperse to new areas in pursuit of their prey. This dispersal in pursuit of prey is one reason that the snake may be adversely affected by creek channelization, excessive vegetation removal, and other flood control measures implemented in riparian areas. Additionally, this may also allow for the interference and elimination of dispersal of SFGS and their prey to new areas as a result of new urban infrastructure (McGinnis 2002).

The presence of habitat conditions that encourage viable breeding populations of Pacific tree frogs and California red-legged frogs is crucial to the survival of the SFGS. Laboratory feeding experiments performed with natal SFGS from the West of Bayshore site indicate that Pacific tree frogs elicit the highest response rate over numerous tested items common in the diet of other garter snake species (Larsen 1994). Barry (1994) found that individuals under 500 mm snout-to-vent length (SVL) require Pacific tree frogs in various stages of metamorphosis, while individuals over 500 mm SVL can subsist on tadpoles and adults of Pacific tree frogs, California red-legged frogs, and bullfrogs. Captive SFGS also have demonstrated a high response to earthworms (Lumbricidae). However, although readily eaten by some SFGS individuals, others starved rather than consume the worm (Larsen 1994). Additionally, Larsen (pers. comm.) notes that the earthworm is not a readily available species for SFGS in the wild, further reducing the suitability of this animal to function as an adequate food source. SFGS may be able to consume certain fish species if it is able to capture them in shallow areas. However, because of SFGS' terrestrial adaptations, it may be difficult for the snake to effectively hunt under water (Larsen 1994). Additionally, breeding populations of SFGS are unknown in locations where the amphibian prey is absent (Barry 1978 in Freel and Giorni 1994).

Some amphibian populations fluctuate between drought and flood years (Blaustein *et al.* 2001, Skelly *et al.* 1999) and some anuran species may play a key role in determining SFGS predator-prey cycles. Larsen (1994) observed that newly metamorphosed frog numbers decreased during drought years at the West of Bayshore site, and noted a subsequent decrease in juvenile SFGS survival. This indicates that the dependence of SFGS on anuran species may be so strong that the snake may be unable to switch to more available food (Larsen 1994; Barry 1994).

Although California red-legged frog and Pacfic tree frog are known to be key components in the diet of SFGS, Barry (*in litt.* 2006c) states that bullfrogs may also serve as appropriate SFGS prey. Bullfrogs (*Rana catesbeiana*) are habitat generalists and can survive in areas that have been degraded by humans or other disturbance. Therefore, Barry (*in litt.* 2006c) believes that bullfrogs may facilitate the recolonization or persistence of SFGS in areas that are not inhabited by red-legged frogs and Pacific tree frogs, which require the more specialized habitat components previously addressed. Research however has shown that, although mature SFGS may prey on bullfrogs in a captive setting, they often immediately regurgitate the amphibian (Larsen 1994). The SFGS, therefore, may not be able to properly digest bullfrogs, which would preclude its suitability as a prey item for SFGS in the wild (Larsen 1994).

Genetics

Although a number of SFGS population surveys have been conducted during the past fifteen years, neither the genetic structure of snakes at specific sites nor the genetic dynamics of the animal have been using molecular markers. Current knowledge of the historic distribution and gene flow of SFGS populations is based on a single study that involved 12 years of field work covering the greater San Francisco Bay area (Barry 1994). The result of these morphological surveys was the identification of a northern SFGS-red sided garter snake (*Thamnophis sirtalis infernalis*) intergrade zone in Marin County and discussion of the southern SFGS-RSGS intergrade zone at the Santa Clara-San Mateo County boundary. In all, Barry (1994) identified six intergrade populations in southern San Mateo and northern Santa Clara Counties, mainly within the area of the San Andreas rift and the bordering foothills from Palo Alto to the Pulgas Water Temple (fig. 2). The author also noted that, although both populations were comprised of the same two subspecies, coloration between the northern and the southern intergrade zones differed greatly in their overall expression (Barry 1994).

The one phylogenetic study completed to date that specifically examined a SFGS from San Mateo County consisted of a single SFGS sample taken from the West of Bayshore population in order to compare SFGS mitochondrial DNA (mtDNA) with other subspecies of *T. sirtalis* (Janzen *et al.* 2002). The investigation included 19 western populations of garter snake species, including 32 samples representing five of the 12 presently recognized subspecies. The authors found that there may be very little genetic difference between the various garter snake subspecies across North America. They also implied that a subspecies designation for many garter snake species based on morphology alone is not supported genetically. Further, they suggested that the SFGS sample taken from the West of Bayshore property was more closely related to individuals found in El

Dorado County, California, than those from nearby Santa Cruz and Sonoma counties (Janzen *et al.* 2002, Janzen *in litt.* 2006). In light of these results, additional studies on the Peninsula are currently being pursued to address genetic makeup and clearly define the SFGS at the molecular level (Lim 2004; Barry 2004).

Trapping studies done in 1997 prior to the construction of the BART station at the West Bayshore site found that many of the individuals captured there did not possess the phenotype of the "type" specimen (S. Larsen, pers. comm.). The color pattern of the SFGS is a wide green-yellow dorsal stripe edged with black and bordered on each side by a distinct, wide, red stripe with a green-blue underbelly and red to orange head (Stebbins 1985). It has been suggested by some experts that absence of this distinctive coloration at the West of Bayshore site may indicate a loss of genetic purity due to outbreeding with other garter snake species (A. Willy, pers. comm.). However, other experts believe that this alternate color pattern may simply be a broader expression of the species' natural phenotype (S. McGinnis, pers. comm.). Until the early 1950s, the 190 acre West of Bayshore property had been a large salt marsh. Starting in the late 1940s, the property was diked and formed into fresh water canals in order to drain storm water from adjacent urban development (Barry 1994). These artificial waterways and the associated wetlands formed by overflow and storm events, have allowed a SFGS population to persist in an otherwise unsuitable location. Because of the historical condition of the site, some experts question the origin of this SFGS population, citing the presence of the saline conditions that previously existed at the West of Bayshore property as evidence that the area would have excluded pre-development SFGS occupation (Barry 1994). This, in conjunction with the "muddied" coloration of many of the remaining individuals, may indicate a hybridized or imported source of SFGS at the West of Bayshore location (Barry 1994; A. Willy, pers. comm.). Other experts believe that SFGS may have entered the site from fresh water habitat elsewhere in the surrounding area, and that the observed differences in coloration can be attributed to a broader genetic expression within the species (S. Larsen, pers. comm.). As a result of these varying opinions, there is currently discussion among experts regarding the genetic makeup and origin of SFGS at this location and what the full range of phenotype for the species may be (S. Barry *in litt.* 2006d; A. Willy, pers. comm., S. Larsen, pers. comm.).

Other potential genetic concerns with the SFGS include problems of inbreeding within small populations, which reduces the reproductive viability within a region and potentially throughout the entire range of the species. Additionally, decreases in the size of the various populations may result in the Allee effect, wherein low numbers of individuals reduce the likelihood of encountering a mate, and limit mating frequency (Barryman *in litt.* 1997). However, the extent of these genetic problems on the SFGS remains unknown.

Taxonomy

In 1995, the taxonomic validity of the SFGS as a distinct subspecies, *Thamnophus sirtalis tetrataenia*, was questioned. After a reexamination of the colored illustrations and the preserved holotype specimen of the red-sided garter snake (RSGS), *Thamnophus sirtalis infernalis*, Boundy and Rossman (1995) indicated that this specimen, which may have been collected from the San Francisco Peninsula in 1827, had a similar color pattern to that of the SFGS (Boundy and Rossman 1995). This holotype specimen had been collected 40 years prior to the description of SFGS and therefore *T.s. tetrataenia* would become synonomous with RSGS, due to the taxonomic designation which would take precedence under the International Code of Zoological Nomenclature (Boundy and Rossman 1995; Barry *in litt.* 2006e). However, this change was not adopted because of a subsequent petition to the International Commission on Zoological Nomenclature (ICZN) by Barry and Jennings (1998). They requested that the ICZN retain *T. s. tetrataenia* as a valid taxon. Barry and Jennings (1998) stated the subspecies *tetrataenia* should be retained as a valid name to avoid confusion regarding SFGS and RSGS, to avoid extensive editing in previous literature, and ultimately, the need to avoid further complicating the ongoing efforts to protect and conserve SFGS populations (Barry and Jennings 1998). The ICZN approved Barry and Jenning's (1998) petition, and *T.s. tetrataenia* remains the valid taxonomic nomenclature for the SFGS (ICZN 2000).

2.3.2. Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms)

2.3.2.1. Present or threatened destruction, modification or curtailment of its habitat or range:

When the recovery plan was published, alteration and isolation of habitats resulting from urbanization was identified as the primary threat to the survival of SFGS in the wild (U.S. Fish and Wildlife Service 1985). Habitat loss and the degradation of remaining habitat continue to be the primary threats to the recovery of the SFGS. The degradation of SFGS habitat is primarily due to fragmentation by the expansion of infrastructure supporting increasing residential and commercial developments, including new roads, improved utilities matrices, and recreational facilities. Secondarily, habitat is degraded by management practices conflicting with the needs of the SFGS including the allowance of seral succession, the increased use of perch ponds (shallow artificial water impondments often used in San Mateo for irrigation) with decreasing use of stock ponds, the dredging of waterways, and recreational use (OHV). Finally, the fluctuations in water levels at reservoirs, flood control and channelization, and saline inundation events can result in further habitat degradation.

Since the recovery plan was published, urban areas have continued to expand throughout San Mateo County. As of 2005, the human population on the San Francisco Peninsula had experienced a 16% increase since the end of the World War II, growing by over half a million people during that time (fig. 1 and 2) (US Census Bureau *in litt.* 2006). As cities throughout San Mateo County expand, high density urban development has replaced the large ranches that historically dominated the region (Barry *in litt.* 2006d). Urbanization, combined with an increase in intensive agriculture operations

(San Mateo County Department of Agriculture 2004) has contributed to the rapid loss and fragmentation of SFGS habitat.

Numerous projects associated with urbanization are currently undergoing consultation with the Service in areas of known SFGS occupation, potentially threatening the survival of wild populations. In the vicinity of Half Moon Bay, the construction of a bike path along Pilarcitos Creek and two associated parks are currently undergoing section 7 consultation (U.S, Fish and Wildlife Service 2006). Pilarcitos Quarry is in negotiations with the Service to expand operations into SFGS habitat within the Pilarcitos watershed. In the City of Pacifica, several projects are currently being proposed in known SFGS habitat, including the establishment of a housing development in the upland area between Mori Point and Calera Creek, and the Caltrans proposed Calera Parkway Project. In the northern part of the species' range, Dennison Reservoir is being examined for continuous dredging activities due to the increased levels of siltation. Wireless facilities have been proposed on SFPUC property and in 2005, Pacific Gas and Electric (PG&E) completed the Jefferson-Martin transmission line project, which involved the replacement and rerouting of 27 miles of transmission line from Canada Rd on the San Andreas Ridge down to the west bayshore city of Brisbane (U.S. Fish and Wildlife Service 2005). A total of 0.38 acre of wetlands which provided suitable foraging and dispersal habitat for SFGS and California red-legged frogs, were affected due to substation expansion. An additional 7.55 acres of suitable upland dispersal and aestivation habitat were temporarily affected by project-related activities (U.S. Fish and Wildlife Service 2005). Mitigation for these effects that is now being established requires the maintenance and monitoring of wetlands upstream of San Andreas Lake on CPUC property (U.S. Fish and Wildlife Service 2005). In addition to the previously discussed BART station, the West of Bayshore population has also been exposed to temporary impacts due to dredging activities along the Cupid's Row canal. These proposals and projects indicate the continuing high demand for property and the continuing threat of destruction of the SFGS habitat in much of its range.

Urbanization in San Mateo County has required the development of large-scale infrastructure systems. At the West of Bayshore property, a SFGS population was recently bisected by the expansion of a SFO Bay Area Regional Transportation (BART) station requiring the realignment of the creek and cupid's row canal (U.S. Fish and Wildlife Service 1996b, California Department of Fish and Game 2005). During construction, six SFGS individuals were lost, all due to human activity (California Department of Fish and Game 2005). Although the completed structure likely has relatively benign impacts on the species due to its elevated design, the long term effects on the animal is not known. Mitigation for the disruption to SFGS habitat and the incidental take of SFGS resulting from the BART expansion project included the purchase of Steele Ranch, which is suitable SFGS habitat adjacent to Cascade Ranch, and restoration activities on the West of Bayshore Property (U.S. Fish and Wildlife Service 1996b). However, restoration activities at West of Bayshore or at Steele Ranch were never fully completed (McGinnis pers. comm.).

Increased growth in the human population has also put greater pressure on land managers to provide recreational opportunities. Most recreational activities like hiking and jogging are not a threat to the SFGS. However, off-road vehicles (OHVs) and bicycle activity at the West of Bayshore site have killed snakes and degraded the habitat (Larsen 1994). OHVs have been used at Mori Point as well, which has led to the erosion and degradation of upland habitat for the species (D. Fong, pers. comm.). Unfortunately, efforts to limit OHV trespass on protected public and private land is difficult without adequate enforcement and regulation.

The increased presence of golf courses in rural areas has resulted in intensive chemical use in areas near lakes and streams that may not otherwise be associated with urban development. There is, for example, a golf course at Sharp Park in the Laguna Salada area, which is inhabited by a SFGS population (McGinnis 1986). Although no environmental toxicology studies have been conducted at the Sharp Park course, the introduction of high concentrations of chemical compounds often associated with golf courses may contribute to the degradation of valuable aquatic habitat and movement corridors, negatively impacting the SFGS and its primary prey base (Sparling *et al.* 2000, A. Willy, pers. comm.). For example, the accidental over-application of phosphorous into golf course ponds in Solano County resulted in the fatality of numerous California red-legged frogs and their larvae (U.S. Fish and Wildlife Service 2002a). A similar event within the range of SFGS could adversely affect the snake. In addition, a SFGS was killed last year by a lawn mower at a golf course, which further demonstrated the potential negative impacts that these areas may have on the species (S. Gardner *in litt.* 2005).

Although the number of stock ponds continues to decline, demand for perch (i.e., irrigation) ponds remains high throughout the rural areas of San Mateo County (J. Howard *in litt.* 2006). However, unlike ponds in range or pasture land, irrigation ponds are often of little benefit to SFGS. This is primarily due to the rapid summer drawdown resulting in the temporary nature of these water bodies (McGinnis 1984). Much of the water from these ponds is needed for the irrigation of row and nursery crops that comprise the majority of agricultural acreage in San Mateo County, so the ponds may not provide a reliable aquatic habitat during times of high utilization by SFGS and various amphibian species (McGinnis 1984, McGinnis 1987, San Mateo County Department of Agriculture 2004). Without the presence of shallow water habitat throughout the spring and summer months, the Pacific tree frog and California red-legged frog populations that SFGS depend on for their survival can rapidly decline (Larsen 1994). This, in turn, may result in the dispersion of the local SFGS population, exposing individuals to increased predation. Additionally, residents in the agricultural areas of San Mateo County have observed that young bullfrogs that often inhabit perch ponds disperse en masse once the ponds are fully drained. This dispersal may result in bullfrog establishment in areas formerly dominated by native species, thus potentially resulting in subsequent declines of California ranids (P. Keel, pers. comm.). This reduction of the SFGS native ranid prey base would potentially lead to decreases in the SFGS populations.

Perch ponds used for irrigation can further negatively impact the SFGS because they are often filled using water pumped from nearby creeks and waterways utilized by wildlife for daily and seasonal migrations (P. Keel, pers. comm.). If the drawdown of these creeks and waterways results in unreliable minimal water levels, then both the SFGS and its amphibian prey could be extirpated (McGinnis 1984). Pumps and wells that enable the use of ground water for irrigation ponds are often favored by most farmers due to their desire to halt the often expensive and controversial practice of pumping water from these channels during spring-time runoff (J. Howard *in litt.* 2006). However, these farmers are concerned that by establishing permanent water bodies that have the potential to become habitat for SFGS and other species, they will face increased regulation and oversight by State and Federal entities (J. Howard *in litt.* 2006). These concerns are not warranted because federal programs like the Safe Harbor agreements and the Wetland Reserve Program allow land owners to build and operate irrigation ponds with little intervention, thus preserving natural creeks and waterways from excessive pumping and drawdown (Environmental Defense 1999, U.S. Fish and Wildlife Service 1999).

In addition to decreasing the suitability of wetland habitat, agricultural practices contribute to the loss of suitable upland areas. Field plowing is an example of one agricultural practice that is commonly used in the flower and vegetable crops of San Mateo County (San Mateo County Department of Agriculture 2004)) and that may negatively affect the SFGS. Although there is no study specifically examining the relationship between SFGS and row crops, in one study from Ohio, the plains garter snake (*Thamnophis radix*), which occupies similar habitat to the SFGS, was found in fields that had experienced fire and moderate grazing pressure, but not in areas that had been plowed (Conant *et al.* 1945). Similar results were encountered in agricultural areas near the Middle Fork State Fish and Wildlife Area in Illinois. At this location, researchers studying various garter snake species observed low numbers of various garter snake species in suitable habitat (Keller and Heske 2000). The authors speculated that the low number of individuals encountered could most likely be attributed to the prevalence of plowing activities in the region surrounding the wildlife area (Keller and Heske 2000). Larger, heavier equipment used for tillage, planting, application of agrochemicals, and harvesting contributes to increased soil compaction and decreased soil tilth (suitability), further contributing to erosion (A. Allen *in litt.* 1995). The use of plows and pesticide applicators across the 34,684 acres of highly managed outdoor crop production (San Mateo County Department of Agriculture 2004) may also result in direct mortality from vehicular strikes of SFGS that may be searching for new water sources, moving from hibernacula, or looking for mates.

SFGS habitat is impacted at the Crystal Springs and San Andreas Reservoirs, even though measures, such as boundary fencing and security patrols, are in place to discourage human activity. These water bodies were constructed in the last century over the natural sag ponds that had previously existed in the area. The rapidly fluctuating water levels common to most reservoir systems have resulted in large areas lacking the appropriate habitat components for the snake and its anuran prey species (Freel and Giorni 1994). Drops in water level of only 2-3 vertical meters below springtime capacities have been shown to reduce habitat suitability and expose the snake and its prey to such high vulnerability to predation that a site can potentially become uninhabitable (Barry 1996). Frogs preyed upon by the snake may decline in numbers when the reservoirs experience drawdown because Pacific tree frog and California red-legged frog egg masses attached to emergent vegetation may become stranded and dry out. Additionally, bullfrogs may be able to more effectively exploit large artificial water bodies such as reservoirs due to their preference for the deeper and more permanent waters and as the presence of non-native fishes that may facilitate bullfrog breeding (Adams *et al.* 2003). Although the role of bullfrogs in SFGS ecology is still uncertain, bullfrogs are known to be highly voracious predators that feed on other amphibians, including the SFGS' prey species (U.S. Fish and Wildlife Service 2002b). The increased population of bullfrogs in reservoirs and ponds is therefore a concern for sustaining viable populations of California red-legged frogs, Pacific tree frogs, and neonatal SFGS throughout the Peninsula.

Degradation of riparian vegetation and stream channelization continues to threaten the SFGS (U.S. Fish and Wildlife Service 1985). Specifically, channelization and flood water control activities occurring in some of the Peninsula's riparian areas have reduced habitat for frogs and the SFGS (U.S. Fish and Wildlife Service 1985). Stream alterations can impact SFGS and migrating frogs through the elimination of stream complexity and further reduce connectivity between occupied sites (California Department of Fish and Game 2005). Additionally, the lack of adequate water in these riparian areas can limit their ability to function as movement areas for the SFGS.

Increased levels of salinity in fresh water corridors threatens some of the significant SFGS populations identified in the recovery plan. Pacific tree frogs and their larvae are unable to survive at salinity concentrations of 7.0 ppt or greater (Larsen 1994). This level was exceeded at the West of Bayshore property in the Cupid's Row canal during the early 1990s (Larsen 1994). Wharton (1989) reported a similar problem with salinity during his investigations of SFGS at the West of Bayshore location in the early 1980s. A broken floodgate between the canal system and the San Francisco Bay was identified as the cause of the salinity on the site at that time, leading to the repair of the gate shortly thereafter. McGinnis (2002) hypothesized that the return of high salinity levels in the early 1990s was a result of the same malfunctioning gate. However, it is unknown if the gate has been inspected or maintained by the owners of the property since its initial repair or what the salinity levels currently are at the site (S. O'Brien, LSA Associates, pers. comm.). Although there has not been a complete vegetation die-off, the emergence of pickleweed (*Salicornia* spp.) and other saline-tolerant plants along Cupid's Row canal at the West of Bayshore site indicates degradation in fresh water quality (S. O'Brien, pers. comm.).

Increased salinity levels also have affected the habitat at Pescadero Marsh where high wave action has inundated the site with sea water (J. Smith, pers. comm.). Mori Point has experienced similar events with Pacific Ocean surges breaching the sea wall two times during the 1980s, leading to declines in the population size of SFGS. Ultimately, the combined impacts of high levels of urban and agricultural development, lack of appropriate land management, and increased salinity levels continue to make habitat degradation the greatest threat to the SFGS throughout its range at this time.

2.3.2.2. Overutilization for commercial, recreational, scientific, or educational purposes:

The amount of illegal collection of the SFGS and its effect on the species is not clear. Several factors are believed to have contributed to a decline of these illegal activities at the West of Bayshore site in recent years. However, employees with the California State Parks continue to believe that unauthorized take remains a threat to the species (P. Keel pers. comm., J Kerbavaz pers. comm.).

The SFGS has been illegally collected by amateur herpetologists due to its rarity and beautiful coloration (U.S. Fish and Wildlife Service 1985), and some amount of illegal collection likely still occurs. Illegal collecting was a primary threat to the species at the West of Bayshore site during the 1970's and 1980's. Since that time however, illegal collection at the West of Bayshore property reportedly has subsided, possibly due to speculation regarding the genetic purity of individuals there (S. Barry *in litt.* 2006d).

Illegal take of SFGS is thought to have occurred at Pescadero Marsh in the late 1990's and may be continuing to this day (J. Kerbavaz, pers. comm.). California State Park employees believe that illegal collecting may also still be occuring at ANSR (J. Kerbavaz, pers. comm., P. Keel, pers. comm.).

Despite the desire of the State Parks Department to comply with and enforce the Act, staffing restrictions and the multiple use mandate of the public areas prevent the allocation of additional resources to SFGS take enforcement (P. Keel, pers. comm.). Additionally, the CDFG game warden position for San Mateo County is currently vacant, due to California State budget shortfalls. Because of these factors, it is unclear what the impact of unauthorized take is having on wild SFGS populations and what can be done to reduce this impact.

2.3.2.3. Disease or predation:

The primary threat to the SFGS within this category is the chytrid fungus epidemic which poses a threat to most of the SFGS natural prey base. The proliferation of chytrid fungus (*Batrachochytrium dendrobatidis*), a potentially deadly parasite, may drastically impact the snake's amphibian prey. Outbreaks of chytrid fungus are increasing in size and severity throughout the world, perhaps due to recent climatic changes that have resulted from abnormal weather patterns (Pounds *et al.* 2006). Ideal conditions for a lethal Chytrid fungus pandemic exist where daily temperature extremes are minimized and humidity levels increase. These weather conditions are similar to the patterns predicted with global warming in many areas (Pounds *et al.* 2006). Thus, frogs in areas that traditionally have seen high daily temperature fluctuations may now be more likely impacted by chytrid fungus than during prior years (P. Johnson *in litt.* 2006). Because of the rapid pace in which Chytrid fungus can spread, a lethal outbreak on the Peninsula could be capable of extirpating entire cohorts of amphibians. In the absence of an adequate food source, such an event could lead to catastrophic declines in all garter snake populations range-wide (Jennings *et al.* 1992, AmphibiaWeb *in litt.* 2006). Other types of parasitic infections are recognized as a threat, but are not considered to present a high level of risk to the survival of the species.

Secondary to chytrid fungus is predation on the species by bullfrogs and native avian species. Mortality studies of the red-sided garter snake in central Canada found the American crow (*Corvus brachyrhynchos*) to be a significant predator. Crows showed a selective preference for individuals within a size cohort (Shine *et al.* 2001). Although crows are rarely sighted at the SFGS sites, this study suggests that avian predators, in general, may be a concern (H. McQuillen, pers. com.; S. Barry *in litt.* 2006f).

Local field surveys and observations have indicated a number of other probable avian SFGS predators including red-tailed hawks (*Buteo jamaicensis*), red-shouldered hawks (*Buteo lineatus*), great egrets (*Ardea alba*), snowy egrets (*Egretta thula*), and black crowned night herons (*Nycticorax nycticorax*) (Larsen, 1994). Freel and Giorni (1994) further discussed red-tailed hawks (*Buteo jamaicensus*), northern harriers (*Circus cyaneus*), great blue herons (*Ardea herodias*), long tailed weasels (*Mustela* *frenata*) and large-mouthed bass (*Micropterus salmoides*) as potential SFGS predators. However, in all cases, the extent that these predators influence SFGS populations is not known. Introduced high densities of mosquito fish (*Gambusia affinis*) have been observed attacking California red-legged frog tadpoles. The stress produced from these attacks was shown to slow development of the tadpoles, limiting the viability of individuals (Lawler *et al.* 1999; U.S. Fish and Wildlife Service 2002b). With a reduction in the population of California red-legged frogs at a location with mosquito fish, SFGS could experience a similar decline in numbers.

There have been several reports of bullfrog predation on young SFGS; however, the extent of predation by these exotic ranids remains unclear. Barry (*in litt.* 2005) stated that, although bullfrogs may consume a limited number of SFGS juveniles, he has not observed bullfrogs preying upon SFGS and this is most likely a discountable threat. Rather, bullfrogs may serve as a secondary food source for SFGS and are therefore beneficial to the snake (Barry *in litt.* 2005). However, during a 1997 bullfrog eradication effort, staff at ANSR found a SFGS juvenile in the stomach of a dissected bullfrog (P. Keel, pers. comm.). This discovery demonstrates that some level of predation on SFGS by bullfrogs occurs in wild populations. Additionally, bullfrogs have been shown to be significant predators of the California red-legged frog and Pacific tree frog which comprise the primary prey base for SFGS (Lawler *et al.* 1999, U.S. Fish and Wildlife Service 2002b). Bullfrogs also may compete with California red-legged frogs for food and adequate habitat sites (Lawler et al. 1999; U.S. Fish and Wildlife Service 2002b; K. Leyse, pers. comm.; S. McGinnis pers. comm.; P. Keel pers. comm.). There is however, some discussion as to the extent of this competition. Barry (pers. comm.) believes that the difference in dietary preferences of bullfrogs and California red-legged frogs precludes competition between these two species. Additionally, several experts believe that the cooler climatic conditions that persist on the San Francisco Peninsula throughout the majority of the year may limit the ability of bullfrogs to reproduce and thus out-compete native species that have evolved within the region (Barry 1994; P. Keel, pers. comm.).

Parasites may have been responsible for several mortalities of juvenile SFGS captured at the West of Bayshore location. Parasitic species encountered include a tapeworm, several flagellate protists and eight different occurrences of nematode worms (Larsen 1994). Mosquito fish throughout the Northern San Francisco Bay area may serve as hosts for parasitic tapeworms and thorny headed worms. These parasites could possibly be transmitted to animals that prey on mosquito fish, which include various ranid species and potentially SFGS (M. Kolipinski *in litt.* 2006).

2.3.2.4. Inadequacy of existing regulatory mechanisms:

State Protections

The SFGS was listed as endangered species and as a fully protected species by the State of California in 1971. This is the highest level of protection for an animal by the State of California. The special status species classification prohibits any take that results in the death of a SFGS or the permitting thereof, regardless of Federal or local laws (California Fish and Game Code section 5050). The one exemption from this prohibition is in instances when the action resulting in take will be entirely beneficial for the species or for research purposes.

Federal protections

NEPA - The National Environmental Policy Act (NEPA) and section 404 of the Clean Water Act are Federal laws that provide some protection for the SFGS. For activities undertaken, authorized, or funded by federal agencies, NEPA requires the project be analyzed for potential impacts to the human environment prior to implementation (42 U.S.C. 4371 et seq.). Instances where that analysis reveals significant environmental effects, the federal agency must propose mitigations that could offset those effects (40 CFR 1502.16). These mitigations are usually developed in coordination with the Service during Section 7 consultation and should provide some protection for listed species. However, NEPA does not require that adverse impacts be fully mitigated, and so some impacts could still occur. Additionally, NEPA is only required for projects with a federal nexus, and therefore, actions taken by private landowners are not required to comply with this law.

Section 404 - Pursuant to section 404 of the Clean Water Act (33 U.S.C. 1344) and section 10 of the Rivers and Harbors.
Under section 404 of the Clean Water Act, the U.S. Army Corps of Engineers (Corps) regulates the discharge of fill material into waters of the United States, which include navigable and isolated waters, headwaters, and adjacent wetlands (33 U.S.C. 1344). In general, the term "wetland" refers to areas meeting the Corps criteria of having hydric soils, hydrology (either sufficient flooding or water on the soil surface), and hydrophytic vegetation (plants specifically adapted for growing in wetlands). Pursuant to 33 CFR 323.4, the Corps has exempted various farming, forestry, and maintenance activities from the regulatory requirements of section 404. Many of the irrigation and drainage canals, as well as wetlands in agricultural areas are generally not subject to section 404 regulations. However, jurisdiction over agricultural fields is determined on a case-by-case basis and is dependent upon whether wetlands existed on the site prior to the establishment of farmed lots. Upland habitats adjacent to wetlands that provide basking sites and mammal burrows

which serve as SFGS hibernacula areas and birthing dens are not protected under section 404 of the Clean Water Act.

Endangered Species Act - The Act is the primary Federal law providing protection for the SFGS. Since its listing, the Service has analyzed the potential effects of many projects under section 7(a)(2) of the Act, which requires Federal agencies to consult with the Service prior to authorizing, funding, or carrying out activities that may affect listed species. A jeopardy determination is made for a project that is reasonably expected, either directly or indirectly, to appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild or reducing its reproduction, numbers or distribution (50 CFR § 402.02). The non-jeopardy opinion may include reasonable and prudent measures that minimize the amount or extent of incidental take of the SFGS from a project. Incidental take refers to taking that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by a Federal agency or applicant (50 CFR § 402.02). While projects that are likely to result in adverse effects often include minimization measures, the Service is limited to requesting minor modifications in the project description. In instances where some incidental take is unavoidable, the Service requires that additional measures be performed by the project proponents to compensate for negative impacts. Compensation measures for these effects generally are included in biological opinions; however, due to the number of projects that have been permitted since the listing of the species in 1967, examination of the completion and success of the proposed compensation will require significantly more resources and time than are currently available for this review. Therefore, the overall effect to the SFGS from the issuance of individual biological opinions is not yet known. However, in the process of preparing this five year review, we described the current baseline for the species, thus evaluating the current status of the species across its entire range based upon the best available data.

Incidental take permits, pursuant to Section 10(a)(1)(B) of the Endangered Species Act, may be issued for projects without a Federal nexus. This section provides protection for the SFGS through approval of a habitat conservation plan that details measures to minimize and mitigate the potential impacts of the project to the maximum extent practicable.

Required or recommended minimization and avoidance measures for section 7 and 10 consultations typically include the following: (1) limiting activities to the winter months when SFGS's activity is low, (2) surveying for SFGS prior to disturbance or construction, and (3) establishing wildlife exclusion fencing prior to and during construction activities. Most of these conservation measures have not been completely examined for effectiveness and therefore, may not fully minimize the effects of the proposed project. In an effort to gain more information regarding the success of these measures, the Service requires biological monitoring during and after completion of permitted projects. However, due to staffing issues and budgetary constraints, enforcement of this requirement is difficult.

The Service generally only authorizes harm and harassment of SFGS due to its designation as a Special Status Species under State law. Special Status or Fully Protected Species "...may not be taken or possessed at any time and no provision of [California Department of Fish and Game] code or any other law shall be construed to authorize the issuance of permits or licenses to take any fully protected" species. Take is defined by the CDFG as "hunt, pursue, catch, capture, or kill listed species," or attempt to engage in these activities. Take is permitted by State entities only during recovery efforts, when projects are being performed solely for the enhancement of the species and its habitat, or during the course of research. To allow for consistency between State and Federal entities, the Service recommends applicants contact the CDFG for projects that may affect the SFGS.

2.3.2.5. Other natural or manmade factors affecting its continued existence:

One of the greatest threats to the SFGS is the reduction of habitat quality resulting from the elimination of disturbance events throughout the Peninsula. Primarily, this is based on changes in management that encourage seral ecosystems. Other factors affecting the continued existence of SFGS include the increased presence of invasive species which can compete for resources with SFGS or hunt individual SFGS directly. Finally, lower level threats include reservoir topology and hydrology, vehicular strikes, hybridization with the RSGS, and interspecific competition with congeners (other *Thamnophis* species and subspecies). However, due to a continuing lack of accurate population estimates, the overall impacts of these events on the species remain unknown.

The persistence of seral ecosystems in protected regions of the Peninsula threatens the SFGS (H. McQuillen, pers. comm.; S. Larsen, pers. comm.). Dynamic grass-dominated uplands provide for, and are potentially maintained by, burrowing rodents (Stromberg and Griffin 1996) which create tunnel systems used by SFGS for hibernacula during the winter months (Larsen 1994, McGinnis *et. al.* 1987). The loss in recent years of ecological disturbance throughout the majority of San Mateo County has made it possible for brush species to dominate former grasslands, potentially precluding burrowing animals. Fire suppression has allowed for the domination of these woody species across the coastal landscape, limiting the extent of grasslands which were likely important movement corridors for populations of SFGS in their migrations between aquatic habitats (D. Hankins, *in litt.* 2006). Additionally, the loss of traditional grazing practices on public lands has allowed for the accumulation of dense brush-dominated canopies across the remaining grasslands which may decrease habitat suitability for the

SFGS. Reintroducing domestic grazing to grasslands could improve and restore habitat conditions for the SFGS.

The perpetuation of seral conditions also has negatively impacted suitable aquatic habitat. Cattails and other emergent aquatic vegetation species may increase siltation rates in fresh water marshes due to the high water demands of these species, as well as their ability to trap overland run-off (S. Larsen, pers. comm.). The augmented production level of cattails contributes to the loss of the open water component in aquatic systems. Open water, combined with emergent vegetation, creates a matrix of habitat elements thought to be necessary for Pacific tree frog and California red-legged frog populations, which are crucial for SFGS reproduction and survival (McGinnis *et al.* 1987). Potential declines in the primary prey base due to excessive siltation further reduces the limited remaining SFGS aquatic habitat, already threatened by salinization events (J. Smith, pers. comm.) and the presence of bullfrogs (H. McQuillen, pers. comm.). To help resolve this issue and ensure the persistence of suitable wetland areas, California Department of Parks and Recreation, the National Park Service and the Service are currently engaged in developing and performing management prescriptions to encourage the development of early succession grasslands and marshlands. These efforts have resulted in two burns at Ano Nuevo State Preserve and vegetation management at Mori Point. However, additional data is needed to measure the success of these activities.

SFGS populations are vulnerable to the growing presence of exotic species on the Peninsula. In addition to the potential threat from bullfrogs previously discussed, exotic centrarchid fish, like large mouth bass (*Micropterus salmoides*) and sunfish (*Lepomis sp.*), are known to consume the tadpoles of California red-legged frogs and Pacific tree frogs (S. McGinnis, pers. comm.). Additionally, the introduction of both bullfrogs and non-native fish into the same aquatic system may have a synergistic impact, described as the "Invasion Meltdown Hypothesis" (Simberloff and Van Holle 1999). According to this hypothesis, certain species act as keystone invaders, facilitating the arrival of other non-native species. Researchers demonstrated this idea by showing that non-native bluegills (*Lepomis macrochirus*) enhanced bullfrog survival by consuming dragonfly nymphs that would normally prey on bullfrog larvae. The fish avoided bullfrogs because they are unpalatable to a variety of fishes (Kruse and Francis 1977 in Adams *et al.* 2003). The result of this relationship was that ponds inhabited by non-native fish had the highest concentrations of bullfrogs (Adams *et al.* 2003). The presence of bullfrogs at a location may result in decreases in Pacific tree frogs and California red-legged tree frogs, which could negatively affect the SFGS.

Steep banks and earthen dams associated with artificial water impoundment reduce the suitability of an area for SFGS. High grade slopes formed to assist with the hydrologic flows of reservoirs may reduce basking opportunities because of the absence of level areas in close proximity of dense vegetation, precluding suitable areas for thermoregulation for SFGS and its primary prey species (Barry 1996). Additionally, reservoirs are often absent of adequate vegetation, exposing both the snake and its prey to additional predators (Barry 1994).

Roads and highways may adversely affect dispersal and movement of the SFGS. Reptiles often utilize roads for thermoregulation. The SFGS has been observed basking on dirt roadways in the vicinity of SFO, and vehicle strikes of SFGS have been recorded on SFPUC and Ano Nuevo properties (Larsen, pers. comm.). Barry (*in litt.* 2006b) indicates however that the reclusive nature of SFGS may preclude it from utilizing these areas as frequently as other snake species. However, in addition to direct mortality of the SFGS, highways may adversely affect dispersal and movement of its amphibian prey species (McGinnis 2002). Roads with a vehicle frequency above 30 cars/hour between 2200 hours and 0400 hours may serve as effective dispersal barriers, due to the nocturnal habits of many amphibians and the associated fatalities from vehicular strikes (Fahrig *et al.* 1995, Mazerolle 2004). Roads in close proximity to wetlands, especially heavy use roads such as Highway 1 running alongside the Pescadero Marsh and Calara Creek, may also lead to an overall reduction of water quality as a result of chemical run-off during storm events. Amphibians with moist, highly permeable skin are especially sensitive and vulnerable to pollutants (Sparling *et al.* 2000). Degraded water quality may result in low recruitment of Pacific tree frogs and California red-legged frogs, and, therefore, potentially limit the survivorship of SFGS.

Observations of SFGS at the West of Bayshore property have shown that individuals at this site display a much broader range in color-pattern than other populations on the Peninsula (Wharton 1989, Barry 1994, Larsen 1994, McGinnis *in litt.* 2005). This diversity in gene expression is currently thought to be attributed to one of two factors. The first is that SFGS at this location are not related to other peninsular SFGS (i.e., not monophyletic). Rather, the airport population may be the result of hybridization with other garter snake species that have immigrated or been released at the Millbrae site (Barry 1994). However, Larsen notes that she was unable to locate other sub-species of garter snakes on the site, making some experts question what species SFGS could be hybridizing with at that site (S. Larsen, pers. comm.). An alternative view is that SFGS do not fall into the single phenotype traits described by Stebbins (1985) because they are the result of a range of environmental variables (McGinnis *in litt.* 2005).

Barry (1994, 1996) believed that hybridization destroying "pure" SFGS populations was not a threat because SFGS and RSGS populations near the La Honda Upland have remained distinct for many years despite the proximity of these areas and the absence of geographical barriers. Barry (1994) discussed that hybridization was not seen at these locations despite the vagile nature of

RSGS. Examination of morphological traits by researchers throughout the SFGS' range has produced few instances of color deviation to the extent seen at the West of Bayshore property, indicating that hybridization may not be an imminent threat to the species. However, it remains to be seen what the effects of hybridization are on the subspecies overall when examined at the molecular level.

Interspecific competition between the SFGS and other *Thamnophis* species does not appear to be a significant threat to the SFGS due to the different dietary preferences of the species (McGinnis 1988, S. Barry *in litt.*. 2006b). The Santa Cruz garter snake (*T. atratus atratus*, SCGS) overlaps in range with the SFGS and has some similar feeding habits; however it is rarely found within the same sites as the SFGS. This is most likely due to the SCGS' more fish dependent diet and its ability to utilize areas not inhabited by the listed snake (Barry *in litt.* 2006c). The coast garter snake (*T. elegans terrestris*, CGS) also has overlapping range with the SFGS, but the two species most likely do not compete for food since the CGS diet is primarily comprised of terrestrial prey such as rodents and slugs (S. Larsen, pers. comm.).

2.4. Synthesis

When the recovery plan for the SFGS was written in 1985, the primary threats to the survival and recovery of the SFGS were the alteration and isolation of habitats resulting from urbanization. This remains a primary threat to SFGS recovery. The continuous expansion of cities and associated infrastructure in San Mateo County reduces the quantity and quality of habitat by filling wetlands and fragmenting upland habitat. New infrastructure developments include roads, utility routings and maintenance activities, and recreational facilities. Mitigation for the negative impacts on the SFGS and its habitat from these development and maintenance projects has resulted in acquisition and protection of suitable habitat, and the enhancement of existing degraded habitat. Recovery efforts have also been implemented in recent years in order to restore previously degraded areas. These include the reduction and enforcement of OHV usage at Mori Point as well as the creation of several ponds at this same location. Additionally, the Service is promoting partnerships with entities such as SFO to develop a plan to minimize the impacts of the airport at the site while simultaneously improving habitat at the West of Bayshore location. The Service is also working through section 7 and section 10 consultations to encourage the minimization of urbanization projects in Half Moon Bay and throughout the Peninsula. However, urbanization continues to expand faster than the positive impacts of these actions can take effect. Additionally, human growth expansion into historically rural and isolated locations may result in fatalities from a number of activities including mowing activities, vehicles strikes, and habitat fragmentation making minimization efforts difficult throughout many areas of San Mateo County.

Current management practices on private ranch and agricultural lands and some public lands do not always support the recovery of the SFGS. For example, the loss of or reduction in grazing in many areas has facilitated an increase in brush canopy and a reduction in stock ponds. Seral succession and the overgrowth of brush species in upland areas preclude burrowing mammals that provide the dens necessary for a breeding SFGS population. The practice of suppressing ecological disturbances on public and semi-public property has further contributed to the decline of the SFGS by allowing seral succession species to dominate prior grassland habitat necessary for the SFGS. The Service is attempting to solve this issue by reintroducing natural successional processes into some of these areas through the implementation of prescribed burn programs on property owned by POST and ANSR. Additionally, the Service is examining appropriate grazing regimes that will improve upland habitat for the SFGS on both public and private land. However, the success of these plans is still uncertain and full implementation of these practices has yet to be developed or completed.

The recovery of the SFGS is also indirectly threatened by the possible loss of the snake's necessary anuran prey as a result of decreases in the quantity of stock ponds, sea water inundation and predation and competition with introduced invasive species. The Service is attempting to minimize some of these impacts by encouraging partnerships with local communities. By working through the Partners program and supporting outreach efforts, the Service hopes to encourage the maintenance of high quality aquatic resources and prevent further introductions of non-native species. These efforts will require the support of the local private sector and the cooperation of local communities to be effective.

Finally, chytrid fungus, parasites, and illegal collection may negatively affect the species, although the degree to which these threats impact the snake remains unknown. Despite the Service's efforts to minimize the impacts of habitat loss, predation, illegal collection, and urbanization, the combined presence of these continued threats indicate that this species is in danger of extinction throughout all or a significant portion of its range. This qualifies the species as an endangered species under the Act, (ESA §3(6)), thus justifying its current position on the endangered species list.

3. RESULTS

3.1. Recommended Classification

____ Downlist to Threatened

____ Uplist to Endangered

____ Delist (Indicate reasons for delisting per 50 CFR 424.11):

____ Extinction

____ Recovery

____ Original data for classification in error

__X__ No change is needed

After reviewing the best available scientific data, the Service has concluded that the SFGS should remain classified as endangered. Numerous activities continue to threaten the survival of the snake and its prey base throughout the range of species. The primary threat to SFGS from habitat alteration and degradation by urbanization remains unchanged in the 21 years since the recovery plan was published. Threats since the recovery plan was published such as the continued loss of grazing lands, improper management of suitable habitat and a reduction in the primary SFGS prey base combine to endanger the SFGS with extinction. This qualifies the species as an endangered species under the Act, (ESA §3(6)), thus justifying its current position on the endangered species list.

3.2. New Recovery Priority Number: 3C

The Service has determined that the current recovery priority number should remain unchanged. The current recovery number, "3", indicates that a subspecies has a high degree of threat as well as a high recovery potential. The letter "C" after this number indicates that there may be conflict associated with the species and its affect on construction, development and other economic activities.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

Development of an updated recovery plan and an expanded San Francisco garter snake working group:

An updated recovery plan should be prepared. Knowledge of SFGS life history and habitats has increased since the recovery plan was issued in 1985. Outdated habitat requirements and life history information described in the recovery plan could possibly result in mismanagement of habitat, which could reduce SFGS numbers. An updated recovery plan would provide guidance regarding the species' needs (including the possible description of new core recovery areas) based upon our improved understanding of the species. These efforts would serve to increase attention toward the SFGS and help to guide future recovery actions.

The current SFGS workgroup should be expanded. The recovery plan listed the formation of memoranda of understanding (MOU) with various public and private landowners as primary actions to be undertaken to improve habitat for SFGS. None of these agreements were ever completed. This has resulted in several uncoordinated SFGS management efforts between the various landowners in San Mateo County, further hindering recovery. To resolve this issue, a workgroup should be established to coordinate and facilitate the implementation of the recovery actions recommended through an updated recovery plan. This group should include Federal entities such as the Service, the U.S. Army Corps of Engineers, and the Natural Resources Conservation Service. Representatives from the CDFG and California State Parks, as well as staff from San Mateo County, the American Zoo and Aquarium Association, and concerned landowners and other interested parties also should be considered for inclusion in the workgroup. By conducting organized discussions with relevant parties, coordination in conservation efforts will be increased.

Encourage conservation among private landowners:

Conservation by private landowners should to be encouraged. In addition to including public entities in conservation and recovery efforts, participation by private land owners from both agricultural and urban settings is needed to recover the SFGS. This is especially important in locations in which substantial quantities of suitable habitat persist. In order to accomplish this, ongoing efforts to conduct outreach meetings to educate the public as to the needs of the species should be fully supported by the Service and its partners. Service staff is working toward this goal through discussions of Safe Harbor agreements and the Partners for Fish and Wildlife (PFW) program, and further augmentation and support by the various public entities entrusted with the protection of endangered species such as the National Park Service and the CDFG would be beneficial.

Continue ongoing habitat restoration and enhancement for wild populations:

Concerted recovery actions need to continue for wild SFGS populations. Currently, recovery actions are being implemented on several public properties in San Mateo County. In 2004, the Service assisted the National Park Service in constructing two shallow ponds on their property at Mori Point. Current projects are underway to remove levees and culverts at Pescadero Marsh which will restore areas that continue to have high salinity concentrations. These and other recovery actions should be continued and expanded. Additionally, the establishment of several new ponds there will begin the process of replacing fresh water habitat that was destroyed during numerous salinization events. Continuation of the current prescribed burning regime at Cloverdale Ranch will improve upland habitat conditions for the SFGS population at Pescadero Marsh. Prescribed burns throughout this area will result in the removal of dead vegetation and assist in the reestablishment or maintenance of grassland and early seral stage habitats. The prescribed burning program at Ano Nuevo State Reserve should be continued as well, in order to assist in canopy reduction and facilitate the natural recruitment of burrowing mammals. This will improve upland habitat conditions for the SFGS and facilitate successful reproduction of the species.

Complete captive holding facilities for use in head starting programs, the restoration of world-wide zoo populations, and as temporary lodging during habitat maintenance:

Holding facilities for SFGS should be completed to protect individuals during restoration and enhancement activities. Historically, various facilities for captive holding have been utilized to protect the species during these events. However, these sites are no longer available. With the implementation of recent recovery actions, it is vital that new areas, which have already been identified and are under construction at the San Francisco zoo, are completed in order to provide a safe disease-free environment for the species. Temporary holding facilities should simulate natural wild conditions for SFGS that have been trapped out of areas prior to the initiation of burns or wetland enhancement activities. Completion of these facilities will benefit the recovery of the SFGS by:

- Protecting individuals during recovery actions, such as prescribed burns, to ensure a population will be present upon the completion of these actions.
- Promoting the continuing efforts to begin a head start program for neonatal SFGS. Young SFGS are likely to be the most vulnerable life stage of the species due to the high rates of predation and starvation associated with young snakes. By fully implementing efforts to temporarily hold the young of trapped gravid females, the Service and its partners could reduce the impact of predators on unstable SFGS populations. Keeping juvenile SFGS in temporary captivity will also help ensure that young-of-year individuals would have easy access to necessary prey items, limiting starvation within this demographic. Additionally, maintaining only half of some broods in captivity will provide valuable insight on the survivorship of wild SFGS populations.
- Promoting restoration of Zoo populations in the United States and Canada to viable levels. Ten SFGS individuals were recently purchased by the San Francisco Zoo and have been divided between this location and the San Diego Zoo. As snakes at these facilities reproduce, their offspring should be placed on loan to other facilities throughout North America to educate the public and raise awareness of the species. Additionally, a captive breeding population comprised of the offspring of wild-born SFGS should be implemented. The source of these broods could be the product of half of the young SFGS retained for the head start program proposed above. By maintaining this wild lineage in captivity, researchers would have access to a stable population for conducting investigations and wild SFGS lineages would be preserved in case of a catastrophic extinction event (H. McQuillen, U.S. Fish and Wildlife Service, *in litt.* 2006). In an attempt to achieve this goal, the Service and the American Zoo and Aquarium Association (AZA) are supporting the development of propagation technology. However, absent additional funds, it is unknown whether this project will be able to continue.

Increase research of population trends, demography, and phylogenetics:

Further scientific research on the species should be performed. Despite various monitoring plans that have been performed in recent years, there remains a large gap in substantive scientific data concerning the SFGS. The absence of accurate population size estimates, population trends, and demographic structure continues to hinder adaptive management efforts while the level of hybridization occurring within the species and the genetic relatedness of populations remains speculative among experts. Additional information is required to achieve effective and relevant management goals that promote genetic diversity and reduce the further loss of individuals. Research will require increased permitting and may require the need to temporarily reduce take restrictions on the snake for federally- and State- approved research projects.

Increase law enforcement at vulnerable locations:

Several State and Federal laws currently protect the SFGS and its habitat. Despite these protections illegal collection may be continuing in California state parks and other easily accessed areas. To minimize these unauthorized collections, the Service should encourage additional law enforcement at sensitive sites.

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U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW
of
San Francisco garter snake (*Thamnophis sirtalis tetrataenia*)

Current Classification ___Endangered___

Recommendation resulting from the 5-Year Review

____ **Downlist to Threatened**

____ **Uplist to Endangered**

____ **Delist**

_X_ **No change is needed**

Review Conducted By: Lucy Triffleman, David Kelly and Joni Mitchel (GIS support)

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Acting

Approve David T. Hanlon Date 9/18/06

REGIONAL OFFICE APPROVAL:

Lead Regional Director, Fish and Wildlife Service

Approve Steve Thompson Date 9/26/2006

Figure 1. Northern Range of the San Francisco Garter Snake (*Thamnophis Sirtalis Tetrataenia*)

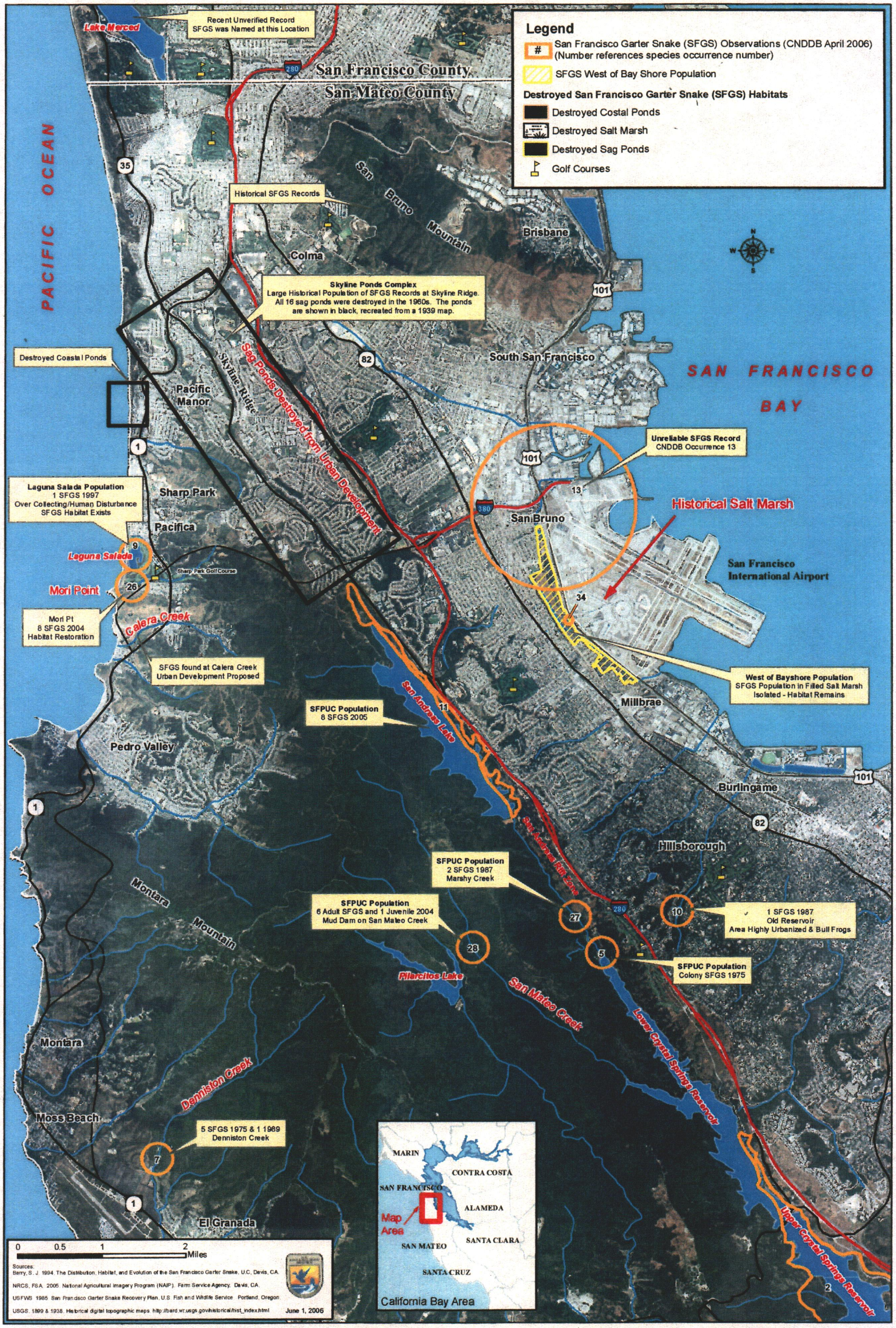
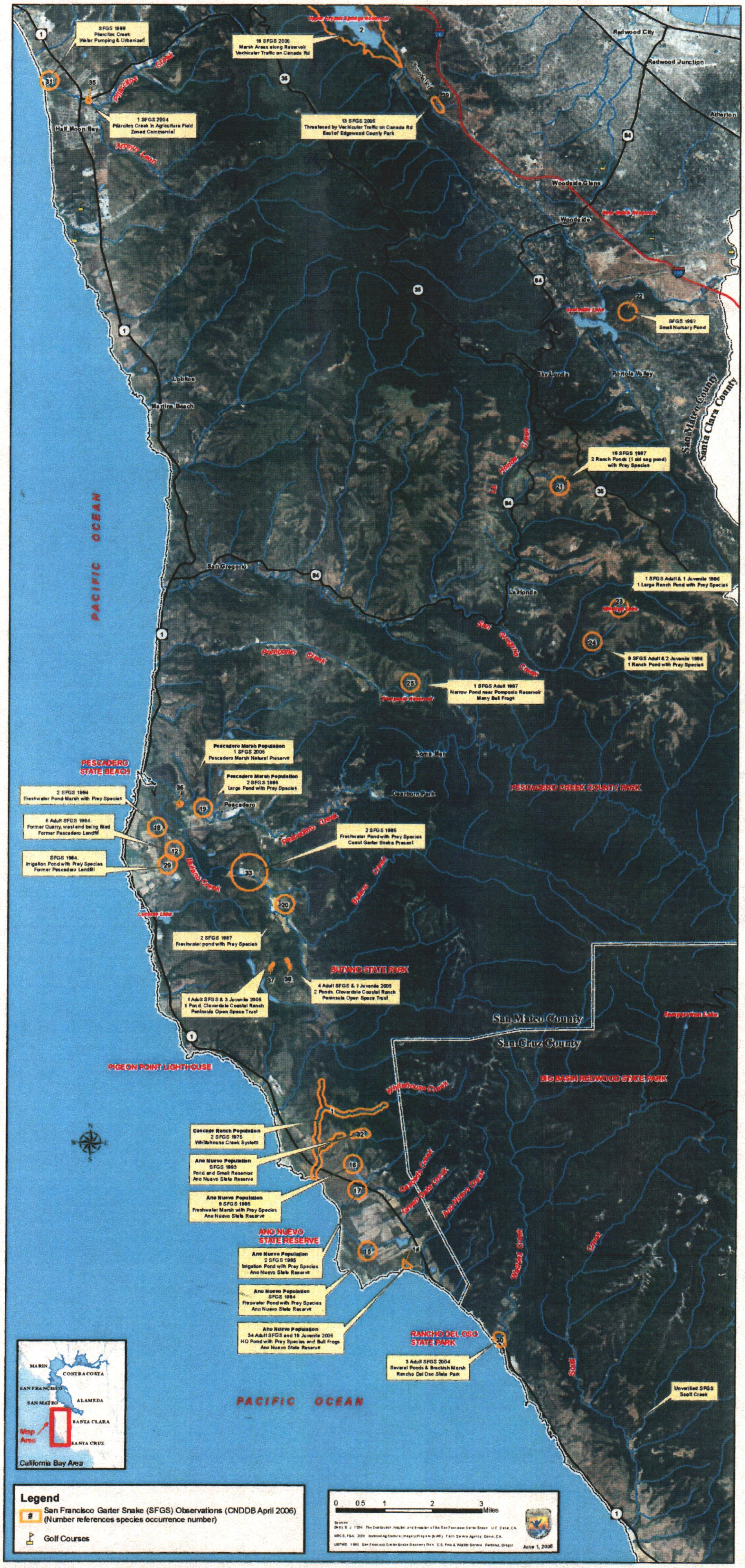


Figure 2. Southern Range of the San Francisco Garter Snake (*Thamnophis Sirtalis Tetrataenia*)



National Park Service
U.S. Department of the Interior

Chickasaw National Recreation Area

Hunting

NPS/CHICKASAW NATIONAL RECREATION AREA

On the hunt.

Hunting is a permitted use under the enabling legislation for Chickasaw National Recreation Area (P.L. 94-235, §3). The legislation also provides for the designation of zones and periods when no hunting is permitted for reasons of public safety, administration, wildlife management, or public use and enjoyment.

A variety of game including quail, turkey, squirrel, rabbit, dove, ducks, geese, and deer may be found here. However, due to the small size of the area and heavy hunting pressure, success is limited. **Trapping is prohibited**. All deer and turkey taken within the Chickasaw National Recreation Area must be checked-in at the nearest certified Oklahoma Game Check Station.

Antlerless Deer Hunt

In an effort to improve the deer herd and provide a quality hunting experience, the park will institute specific regulations. An additional 515 acres have been opened to archery and shotshell hunting. In addition, the deer harvest will be Antlerless only. Over a ten year period, deer surveys have indicated an over abundance of females (does), compared to a very low number of bucks. Of these bucks, very few are over three years old. These “Park Specific” regulation changes should help to control the doe population, and eventually provide for a chance at a quality buck.

2010 Hunting dates and specifications for Chickasaw National Recreation Area

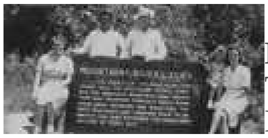
- ***Deer Archery, Youth Deer Gun, Deer Muzzleloader, Dove, Rail, Gallinule, Crow, Waterfowl, Turkey Fall Archery, Pursuit with Hounds, Predator/Furbearer Calling:*** Same as statewide season dates.
- ***Deer Gun:*** Open the first nine (9) days only. ***November 20th through 28th, 2010***
- ***Quail, Snipe, Woodcock, Rabbit, Squirrel:*** Same as statewide season dates, except closed during the first nine (9) days of deer gun season.
- ***Turkey Fall Gun:*** Same as statewide season dates. One (1) tom limit.
- ***Turkey Spring, Youth Turkey Spring:*** Same as statewide season dates. One (1) tom limit combined.

Most state hunting regulations are applicable in Chickasaw National Recreation Area with the following exceptions or items of special emphasis:

- The use of artificial light to view wildlife is prohibited.
- Baiting of wildlife is prohibited.
- Feral hogs may be taken year round in compliance with state regulations.
- All tree stands must be portable.
- Damage to trees such as cutting limbs and using nails or screws is prohibited.
- Tree stands unattended for more than 36 hours will be considered abandoned property and subject to removal by the National Park Service.
- The deer harvest is anterless only.
- Hunters must have a valid Oklahoma hunting license.

The “Oklahoma Hunting Regulations” provides state hunting information and special regulations for Chickasaw National Recreation Area. It is available from the Oklahoma Department of Wildlife Conservation, State Game Rangers, Park Rangers, and license sales outlets.

Hunting Map and Regulations



Did You Know?
Throughout the 1930s, an Easter sunrise pageant was conducted in the Bromide area of Platt National Park [the present-day Platt Historic District in the Chickasaw National Recreation Area]. Initially attracting thousands of visitors, this practice ended during the Second World War. **more...**

Last Updated: May 28, 2011 at 16:32 MST

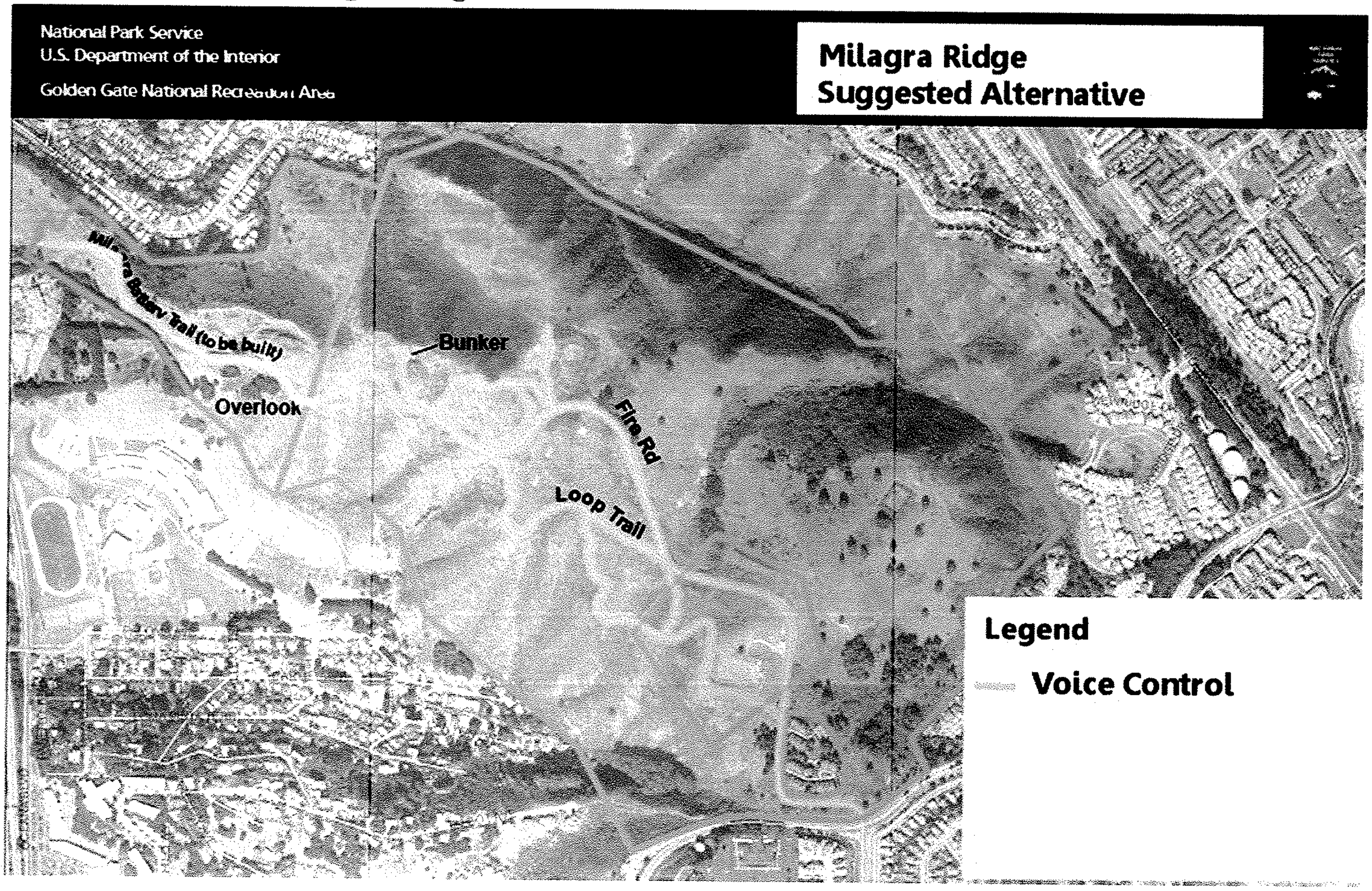
Milagra Ridge Analysis and Suggestions

Overall Assessment

All adverse impacts shown for Milagra Ridge for the "No Action" alternative need to be changed to no impact or negligible. There is no reasonable justification for reducing dog activity on Milagra Ridge that is supported by scientific evidence or even reasonable correlations.

I oppose all of the DEIS "action alternatives" as they represent "conservation hoarding" by marginalize the recreational mandate for the GGNRA and the recreational needs of an urban population and future generations. I support adding voice-control trails and adding other solutions to improve dog recreation at Milagra.

Map of Suggested Milagra Ridge Alternative



Recommended Changes to the "No Action" Current Dog Management Plan

Allow voice control trail access

Suggested Balanced Options

Voice-Control Allowed:

All trails, due to the nature of the trail system there is no reasonable method to create separate areas

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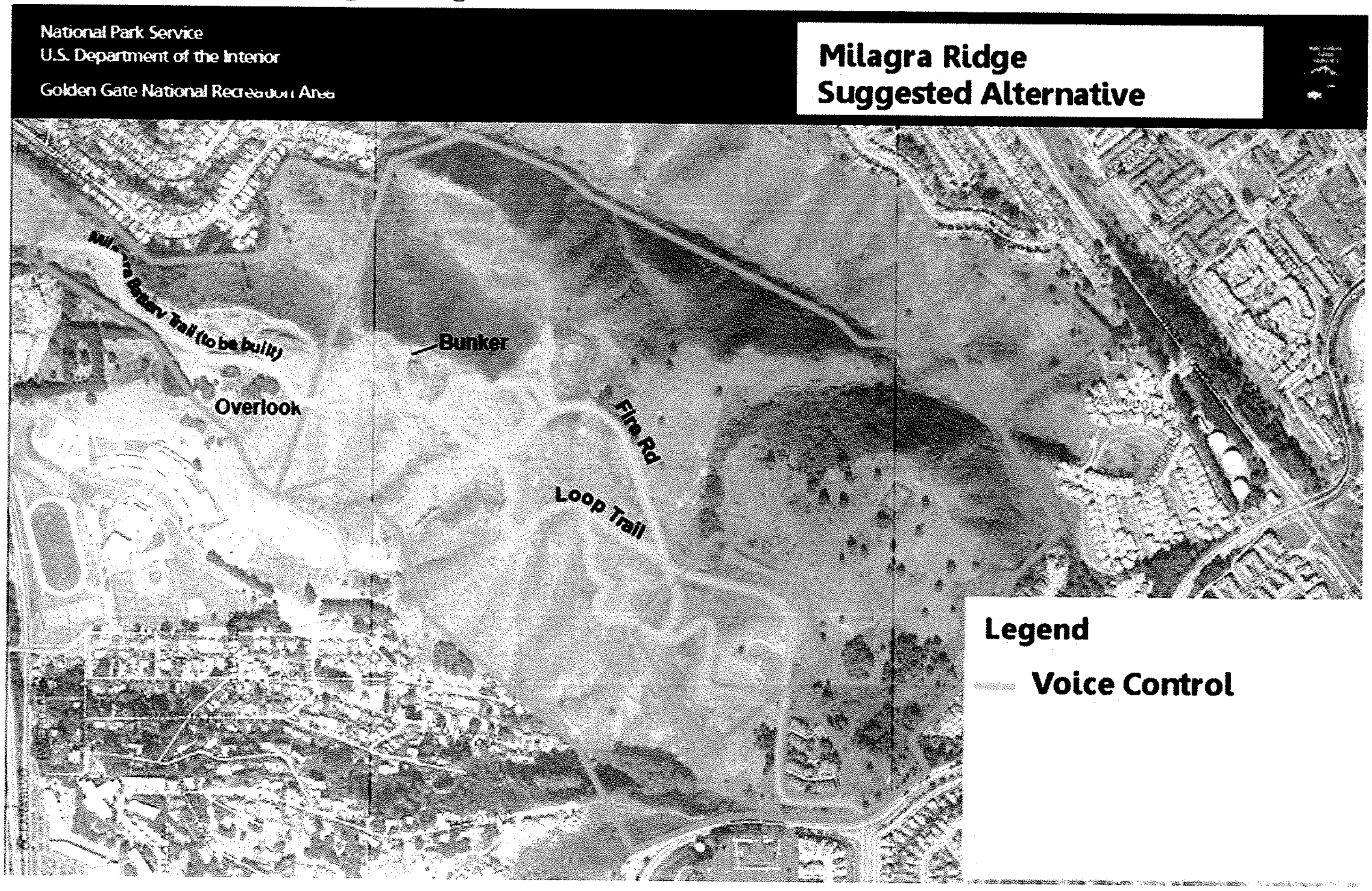

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Monitoring the Condition of Natural Resources in US National Parks

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Abstract The National Park Service has developed a long-term ecological monitoring program for 32 ecoregional networks containing more than 270 parks with significant natural resources. The monitoring program assists park managers in developing a broad-based understanding of the status and trends of park resources as a basis for making decisions and working with other agencies and the public for the long-term protection of park ecosystems. We found that the basic steps involved in planning and designing a long-term ecological monitoring program were the same for a range of ecological systems including coral reefs, deserts, arctic tundra, prairie grasslands, caves, and tropical rainforests. These steps involve (1) clearly defining goals and objectives, (2) compiling and summarizing existing information, (3) developing conceptual models, (4) prioritizing and selecting indicators, (5) developing an overall sampling design, (6) developing monitoring protocols, and (7) establishing data management, analysis, and reporting procedures. The broad-based, scientifically sound information obtained through this systems-based monitoring program will have multiple applications for management decision-making, research, education, and promoting public understanding of park resources. When combined with an effective education program, monitoring results can contribute not only to park issues, but also to larger quality-of-life issues that affect surrounding communities and can contribute significantly to the environmental health of the nation.

Keywords Ecological monitoring • Environmental monitoring • Monitoring design • Indicator • National park • Protected areas • Protocol • Sampling design • Vital signs

Introduction

Knowing the condition of natural resources in national parks, which protect many of the nation's most pristine and intact ecosystems, is fundamental to the National Park Service's (NPS) mission to manage park resources "unimpaired for the enjoyment of future generations." Park managers are confronted with increasingly complex and challenging issues that require a broad-based understanding of the status and trends of park resources as a basis for making decisions and working with other agencies and the public for the long-term protection of park ecosystems. Understanding the dynamic nature of park ecosystems and the consequences of human activities is essential for management decision-making aimed to maintain, enhance, or restore the ecological integrity of park ecosystems and to avoid, minimize, or mitigate ecological threats to these systems (Roman and Barrett 1999; Vaughan et al. 2001; Busch and Trexler 2003).

The overall purpose of natural resource monitoring in parks is to develop scientifically sound information on the current status and long term trends in the composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems. Use of monitoring information will increase confidence in manager's decisions and improve their ability to manage park resources, and will allow managers to confront and mitigate threats to the park and operate more effectively in legal and political arenas. National parks also play an important role as natural laboratories and locations for developing ecological baselines against which data from more disturbed areas can be compared. When combined with an effective education program, monitoring results can contribute not only to park issues, but also to larger quality-of-life issues that affect surrounding communities and can contribute significantly to the environmental health of the nation (Soukup 2007).

The National Park Service has initiated a long-term ecological monitoring program, known as "Vital Signs Monitoring", to provide the minimum infrastructure to allow more than 270 national park system units to identify and implement long-term monitoring of their highest-priority measurements of resource condition. The NPS has used the term "vital signs monitoring" since the early 1980s (Davis 1989, 2005) to refer to a relatively small set of information-rich attributes that are used to track the overall condition or "health" of park natural resources and to provide early warning of situations that require intervention. We define vital signs as a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values. The broad-based, scientifically sound information obtained through this systems-based monitoring program will have multiple applications for management decision-making, research, education, and promoting public understanding of park resources. In this paper, we describe the goals and implementation strategy for the vital signs monitoring program, and summarize the planning and design steps that were successfully used to develop long-term ecological monitoring programs for more than 270 parks organized into 32 ecoregional networks.

Policy and Management Context

The 1916 National Park Service Organic Act is the core of park service authority and the definitive statement of the purposes of the parks and of the National Park Service mission. The act establishes the purpose of national parks: "…. To conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." NPS Management Policies (NPS 2006) state that "*The Service will also strive to ensure that park resources and values are passed on to future generations in a condition that is as good as, or better than, the conditions that exist today*", and that *"Decision makers and planners will use the best available scientific and technical information and scholarly analysis to identify appropriate management actions for protection and use of park resources"*. In the National Parks Omnibus Management Act of 1998, Congress specifically directed the NPS to "undertake a program of inventory and monitoring of National Park System resources to establish baseline information and to provide information on the long-term trends in the condition of National Park System resources".

Program Goals and Implementation Strategy

The common programmatic goals of Vital Signs Monitoring for the 32 networks are as follows:

1. Determine the status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
2. Provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management.
3. Provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments.
4. Provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment.
5. Provide a means of measuring progress towards performance goals.

Three factors were key in the development of the vision, goals, and implementation strategy of the NPS vital signs monitoring program: (1) An analysis of the targeted audiences and primary uses of the monitoring results; (2) Recognition of the need to leverage the limited resources available to the program through partnerships with parks, other NPS programs, and other agencies; and (3) Recognition that the "information rich" attributes that best characterized park ecosystems differed greatly across the wide range of ecological systems represented in the national park system.

The primary audience and users of the monitoring results are managers, planners, natural resource specialists, interpreters, and scientists at the local, park level (Figure 1). In partnership with other NPS programs and park interpreters, monitoring results are also provided to the general public, "because it is the broader public that will decide the fate of the resources" (National Park System Advisory Board 2001), and to Congress and the Office of Management and Budget for accountability and performance management purposes.

The level of funding provided for long-term monitoring would allow each park to monitor only a few vital signs, which in most cases was inadequate to track the condition of air, water, geological, and biological resources managed by the park. There was an obvious need to leverage the program's limited resources through partnerships with others, and to maximize the use and relevance of the data for key target audiences. Most of the larger parks were already monitoring a few high-priority resources using funding from other sources, and other NPS programs and other agencies had monitoring components that provided relevant data for tracking resource condition (Figure 1). Partnerships with other NPS programs and with federal and state agencies and adjacent landowners are critical to effectively understand and manage the many resources and threats that extend beyond park boundaries. Parks are part of larger ecological systems and must be managed in that context.

A top-down, "one size fits all" approach to monitoring design would not be effective or supported in the NPS because of the tremendous variability among parks in ecological context and in park sizes and management capabilities. The National Park System, by design, includes a huge diversity of ecological systems including coral reefs, deserts, arctic tundra, prairie grasslands, caves, and tropical rainforests. We evaluated and rejected the strategy of selecting a set of core indicators that every park would measure in a similar way because the "information rich" attributes that best characterized park ecosystems differed greatly among ecological systems, very few measures were common across parks, and because partnership opportunities (and the appropriate ecological indicators and sampling methodologies associated with them) available to parks differed throughout the national park system. We instead adopted a strategy that allowed each park, working with partners and subject-matter experts, to prioritize and select their vital signs based on their most critical data needs and local partnership opportunities, with coordination and sharing of protocols and data sets facilitated by the national office.

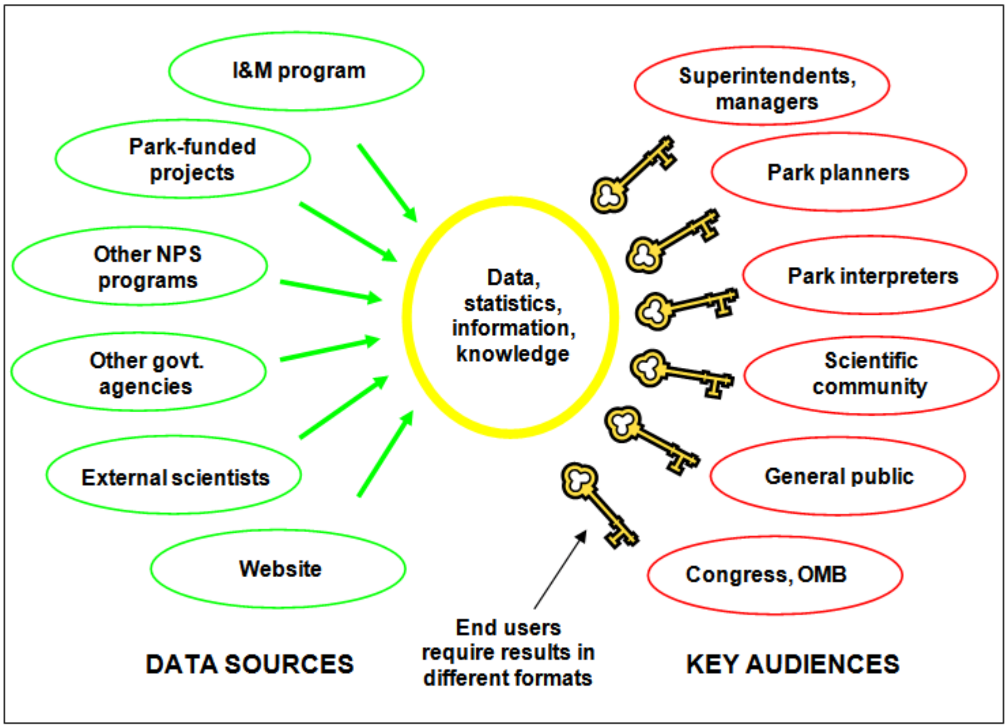

Figure 1. Scientific data for monitoring the condition of park natural resources are obtained from a number of sources, and are managed, analyzed, and distributed to key targeted audiences in various formats to maximize utility and availability of results. The I&M Program has made a large investment in information management to ensure that relevant monitoring data are managed, analyzed, and reported to key audiences.

To facilitate collaboration, information sharing, and economies of scale in inventory and monitoring (I & M), the NPS organized the more than 270 parks with significant natural resources into 32 I & M networks linked by geography and shared natural resource characteristics (Figure 2). We initially used Bailey's ecoregions (Bailey 1998) and estimates of the workload needed to manage the natural resources of each park to assign parks to each network. Parks in each network share core funding and a professional staff that are augmented by funding and staffing from park base accounts and other sources to plan, design, and implement an integrated long-term monitoring program.

Figure 2. More than 270 park units with significant natural resources have been organized into 32 ecoregional networks that share core funding and a professional staff to conduct long-term monitoring of park ecosystems.

Steps in Monitoring Design

The complex task of developing a network monitoring program requires a front-end investment in planning and design to ensure that monitoring will meet the most critical information needs of each park and produce scientifically credible data that are accessible to managers and researchers in a timely manner. The investment in planning and design also ensures that monitoring will build upon existing information and understanding of park ecosystems and make maximum use of leveraging and partnerships with other programs, agencies, and academia. We found that the following basic steps for designing a long-term ecological monitoring program worked effectively across all 32 networks. Detailed guidance, examples, monitoring plans, and sampling protocols are available on the internet (NPS 2007).

Clearly Define Goals and Objectives

One of the most critical steps in designing a complex interdisciplinary monitoring program is to clearly define the goals and objectives of the program and get agreement on them from key stakeholders. In our evaluation of "lessons learned" by other monitoring programs, we found that differences in opinion regarding the purpose of the monitoring as the program was being developed often led to significant problems later during the design and implementation phases. The 32 networks of parks all shared the same five goals of vital signs monitoring, as listed above in Section 3. The development of monitoring objectives, which provide additional focus about the purpose or desired outcome of the monitoring effort, was an iterative process that sometimes required several years to refine. Early in the design process, monitoring objectives were stated in more general terms, such as "Determine trends in the incidence of disease and infestation in selected plant communities and populations", whereas the final monitoring plan and protocols provided monitoring objectives that met the test of being realistic, specific, and measurable (e.g., "Estimate trends in the proportion, severity, and survivorship of limber pine trees infected with white pine blister rust at Craters of the Moon National Monument"; Garrett et al. 2007).

Compile and Summarize Existing Information

Another important early step in the process of developing a monitoring strategy is the task of identifying, summarizing, and evaluating existing information and understanding of park ecosystems. The I&M networks discovered and summarized existing information through a series of literature reviews, scoping workshops, and interviews and surveys with park managers and subject-matter experts. The results from these "data mining" and scoping efforts were summarized in databases and reports that were used as the basis for conceptual modeling and subsequent monitoring design work; these databases and reports are expected to have multiple future applications by park managers, planners, educators, the scientific community, and others.

Develop Conceptual Models

The development of conceptual models, which are visual or narrative summaries that describe the important components of the ecosystem and the interactions among them, are a key step in understanding how the diverse components of a monitoring program interact and in promoting integration and communication among scientists and managers from different disciplines. We found that the learning that accompanied the design, construction, and revision of the models contributed to a shared understanding of system dynamics and an appreciation of the diversity of information needed to identify an appropriate suite of ecological measurements, and the process of developing conceptual models was often more important than the model itself.

Early in the planning and design process, I&M networks developed simple models that were highly aggregated representations of ecological systems, primarily as a framework for organizing, summarizing, and communicating the large amount of information obtained from literature reviews, scoping sessions, and interviews with park managers, staff, and subject-matter experts (e.g., Figure 3). Many networks based their highest-level model on a very general ecosystem (Chapin et al. 1996), modified to include broad-scale stressors more specific to the park or ecosystems of interest (e.g., Miller 2005). Once potential indicators were identified, models became more detailed and often more mechanistic, to clearly articulate relationships between measurements and the ecological attributes they represent. The proper interpretation of indicators will be greatly facilitated by scientifically sound and defensible linkages between the indicator and the ecological function or critical resource it is intended to represent (Kurtz et al. 2001). These key linkages should be explicit in conceptual models and their articulation is essential to justifying and interpreting ecological measurements.

Conceptual models can take the form of any combination of narratives, tables, matrices of factors, box-and-arrow diagrams, and conceptual diagrams using graphical symbols, and all of these forms were used in this program. All of the networks developed a set of conceptual models that consisted of diagrams with accompanying narratives that described the model, justified functional relationships in figures, and cited sources of information and data on which the models were based. Three fundamentally different model structures, with many modifications, used by the I&M networks and other agencies are control models, stressor models (e.g., Ogden et al. 2005), and state and transition models (Westoby 1989, Bestelmeyer 2003). Figure 4 illustrates the models used by one network to meet different needs as the network matured (NPS 2008).

All conceptual models should be viewed as representing our current understanding of a systems' dynamics, and a model is just one articulation of a set of hypotheses. As data are acquired and our understanding is improved, conceptual models need to evolve to match increased knowledge (Cloern 2001).

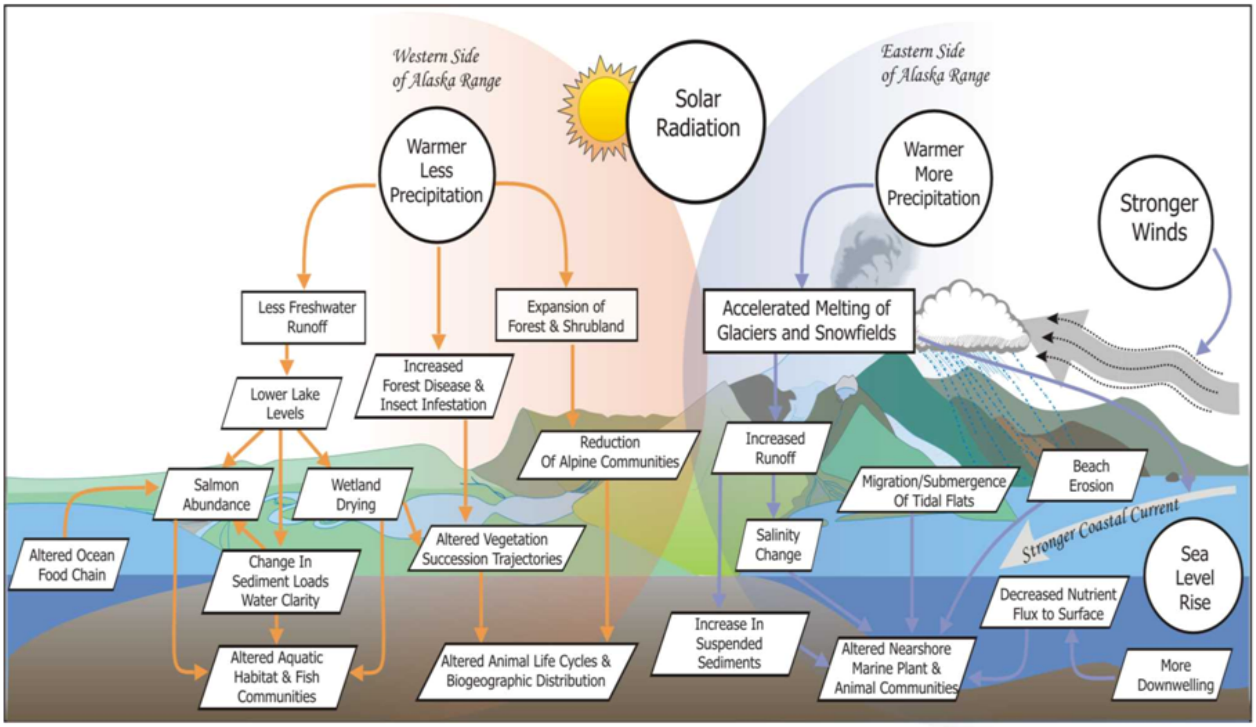

Figure 3. Example of a conceptual model summarizing expected changes from a warming climate on park ecosystems, habitats, plants, and animals in the Southwest Alaska network of parks. Warming is likely to alter the hydrologic cycle and influence processes that have created and maintained park ecosystems. Some anticipated changes include sea-level rise, greater storm intensity and frequency, altered patterns of seasonal runoff, rapid glacial retreat, and shorter duration of lake ice cover (Bennett et al. 2006).

Prioritize and Select Indicators

The task of selecting a relatively small set of long-term measurements for each national park that "represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values" is very challenging, particularly when taking into account the need to maximize the use and relevance of the data and to leverage core funding and staffing through partnerships. Most park networks followed the basic approach summarized in Figure 5 to identify and prioritize potential vital signs (NPS 2007). The scoping process identified park issues, monitoring questions, and data needs that included (1) focal resources (including ecological processes) important to each park, (2) agents of change or stressors that are known or suspected to cause changes in the focal resources over time; and (3) key properties and processes of ecosystem health (e.g., weather, soil nutrients). Conceptual models were then developed to help organize and communicate the information compiled during scoping, and to identify where cause-effect was known between some of the stressors and response variables. The scoping and conceptual modeling efforts resulted in a long list of potential vital signs, which were then prioritized using a set of criteria and a scoring system agreed upon by the parks (Table 1). We found that the process of defining vital signs and the relationships among them was critical for building shared understanding and support for the indicators that were ultimately selected (Dennison et al. 2007). The final step in the process incorporated other criteria such as efficient use of personnel, cost and logistical feasibility, partnership opportunities with other programs, and a large dose of common sense to select the initial set of vital signs for the network's monitoring program. We obtained best results when prioritization and selection of vital signs were treated as two separate steps in the process.

We developed an Ecological Monitoring Framework (Table 2) as an organizational tool for promoting a systems-based monitoring program and for promoting communication, collaboration, and coordination with other networks, programs, and agencies involved in ecological monitoring. The framework is based on earlier work by Woodley (1993) for national parks in Canada, the European Habitat Classification System (EEA 2003), and work by Noss (1990), Grossman et al. (1998), Harwell et al. (1999), and EPA (2002). The framework has subsequently been modified and adopted by numerous agencies as part of the Natural Resource Monitoring Partnership (NRMP 2007).

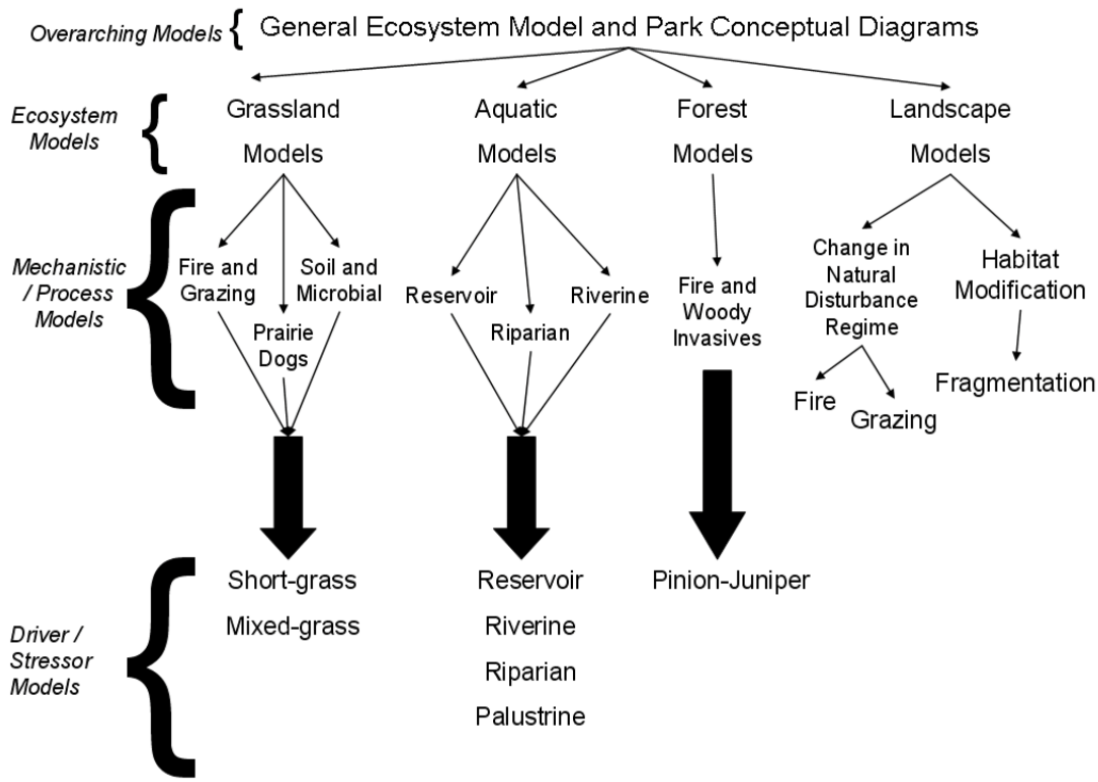

Figure 4. Conceptual models and model types used by the Southern Plains I&M Network (NPS 2008).

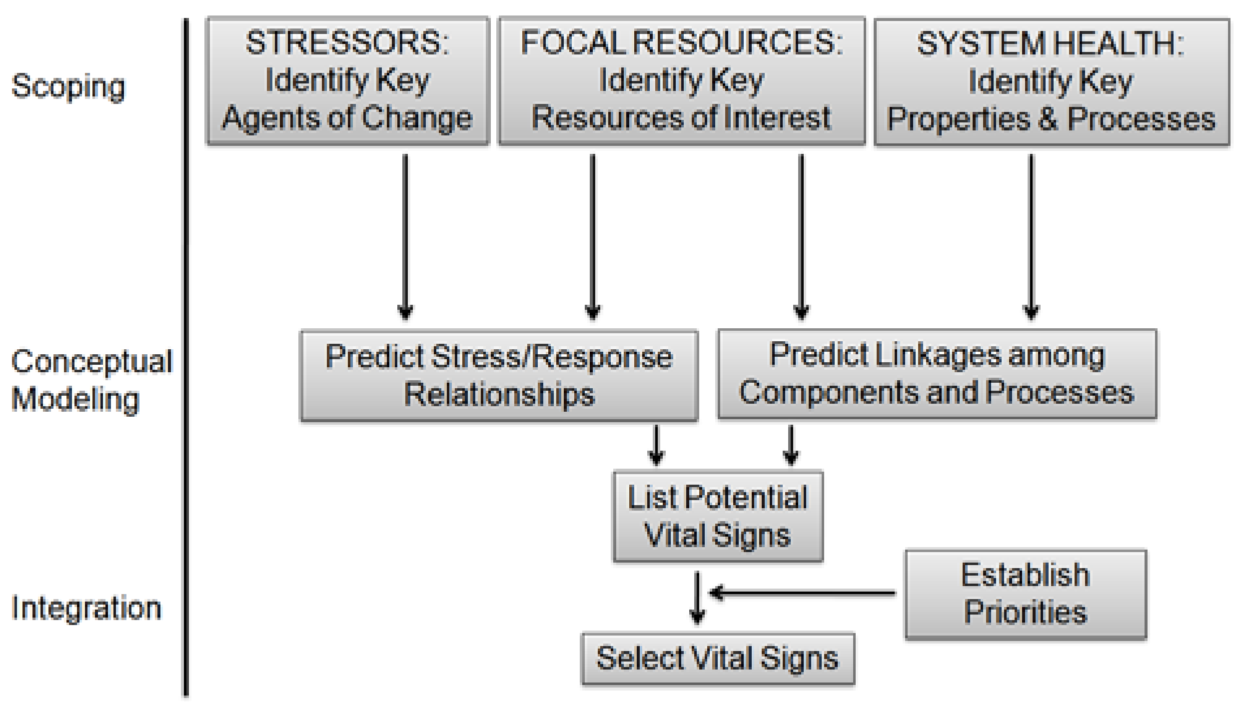

Figure 5. Basic approach to identifying and selecting vital signs for integrated monitoring of park resources (source: Kurt Jenkins, USGS Olympic Field Station).

Table 1. Criteria used to calculate priority ranks for the list of potential vital signs for monitoring resource condition.

Criterion 1: Management Significance (Weight - 40 %) - A useful ecological indicator must produce results that are clearly understood and accepted by park managers, other policy makers, research scientists, and the general public, all of whom are able to recognize the implications of the indicator's results for protecting and managing the park's natural resources. Ultimately, an indicator is useful only if it can provide information to support a management decision (including decisions by other agencies and organizations that benefit park resources) or to quantify the success of past decisions.

- There is an obvious, direct application of the data to a key management decision, or for evaluating the effectiveness of past management decisions.
- The measurements will produce results that are clearly understood and accepted by park managers, other policy makers, research scientists, and the general public, all of whom should be able to recognize the implications of the results for protecting and managing the park's natural resources.
- Monitoring results are likely to provide early warning of resource impairment, and will save park resources and money if a problem is discovered early.
- In cases where data will be used primarily to influence external decisions, the decisions will affect key resources in the park, and there is a great potential for the park to influence the external decisions.
- Data are of high interest to the public.
- For species-level monitoring, involves species that are harvested, endemic, alien, species of special interest, or are threatened or endangered.
- There is an obvious, direct application of the data to performance goals.
- Contributes to increased understanding that ultimately leads to better management.

Criterion 2: Ecological Significance (Weight - 40 %)

- There is a strong, defensible linkage between the indicator and the ecological function or critical resource it is intended to represent.
- The resource being represented by the indicator has high ecological importance based on the conceptual model of the system and the supporting ecological literature.
- The indicator characterizes the state of unmeasured structural and compositional resources and system processes.
- The indicator provides early warning of undesirable changes to important resources. It can signify an impending change in the ecological system.
- The indicator reflects the functional status of one or more key ecosystem processes or the status of ecosystem properties that are clearly related to these ecosystem processes. [Note: replace the term ecosystem with landscape or population, as appropriate.]
- The indicator reflects the capacity of key ecosystem processes to resist or recover from change induced by exposure to natural disturbances and/or anthropogenic stressors.

Criterion 3: Legal/Policy Mandate (Weight: 20 %) - This criterion provides additional weight to a potential vital sign if a park is directed to monitor specific resources because of some binding legal or Congressional mandate, such as specific legislation and executive orders, or park enabling legislation.

Table 2. The Ecological Monitoring Framework is a systems-based, heirarchical, organizational tool for promoting communication, collaboration, and coordination among parks, networks, programs, and agencies involved in ecological monitoring.

Level 1 Category	Level 2 Category	Level 3 Category
Air and Climate	Air Quality	Ozone
		Wet and Dry Deposition
		Visibility and Particulate Matter
		Air Contaminants
	Weather and Climate	Weather and Climate
Geology and Soils	Geomorphology	Windblown Features and Processes
		Glacial Features and Processes
		Hillslope Features and Processes
		Coastal/Oceanographic Features and Processes
		Marine Features and Processes
		Stream/River Channel Characteristics
		Lake Features and Processes
	Subsurface Geologic Processes	Geothermal Features and Processes

Level 1 Category	Level 2 Category	Level 3 Category
		Cave/Karst Features and Processes
		Volcanic Features and Processes
		Seismic Activity
	Soil Quality	Soil Function and Dynamics
	Paleontology	Paleontology
Water	Hydrology	Groundwater Dynamics
		Surface Water Dynamics
		Marine Hydrology
	Water Quality	Water Chemistry
		Nutrient Dynamics
		Toxics
		Microorganisms
		Aquatic Macroinvertebrates and Algae
Biological Integrity	Invasive Species	Invasive/Exotic Plants
		Invasive/Exotic Animals
	Infestations and Disease	Insect Pests
		Plant Diseases
		Animal Diseases
	Focal Species or Communities	Marine Communities
		Intertidal Communities
		Estuarine Communities
		Wetland Communities
		Riparian Communities
Biological Integrity		Freshwater Communities
		Sparsely Vegetated Communities
		Cave Communities
		Desert Communities
		Grassland/Herbaceous Communities
		Shrubland Communities
		Forest/Woodland Communities
		Marine Invertebrates
		Freshwater Invertebrates
		Terrestrial Invertebrates
		Fishes
		Amphibians and Reptiles
		Birds
		Mammals
		Vegetation Complex (use sparingly)
		Terrestrial Complex (use sparingly)
	At-risk Biota	T&E Species and Communities
Human Use	Point Source Human Effects	Point Source Human Effects
	Non-point Source Human Effects	Non-point Source Human Effects
	Consumptive Use	Consumptive Use
	Visitor and Recreation Use	Visitor Use
	Cultural Landscapes	Cultural Landscapes
Landscapes (Ecosystem Pattern and Processes)	Fire and Fuel Dynamics	Fire and Fuel Dynamics
	Landscape Dynamics	Land Cover and Use
	Extreme Disturbance Events	Extreme Disturbance Events
	Soundscape	Soundscape
	Viewscape	Viewscape/Dark Night Sky
	Nutrient Dynamics	Nutrient Dynamics
	Energy Flow	Primary Production

A successful group decision-making process used by many of the I&M networks to prioritize vital signs involved the use of a database in a workshop setting with park managers and subject-matter experts to review and evaluate existing information and produce numerical rankings for a list of potential vital signs. Prior to holding a large, interdisciplinary workshop, a list of potential vital signs was developed based on a series of meetings, workshops, brainstorming sessions, questionnaires, literature reviews, and other information-gathering exercises to identify key monitoring questions and data needs. The list of potential vital signs was entered into a relational database that for each vital sign includes a justification statement about its importance, a draft set of monitoring questions and objectives, and other relevant information. Potential vital signs were first ranked by park managers and staff using criteria (Table 1) that are applied consistently across all parks and disciplines. The 3 criteria used by the majority of networks were Management Significance, Ecological Significance, and Legal Mandate. During the interdisciplinary workshop, subject-matter experts and managers working in teams were asked to review and improve the information in the database, and to consistently apply the criteria to rank the potential vital signs. Working with the highest-ranking vital signs, teams were then asked to develop specific measurable objectives and to identify existing protocols and partnership opportunities for each vital sign. Workshop results were documented in a report that was reviewed by all interested stakeholders, and was then used to guide park superintendents and/or technical committee members in the final step of selecting the initial set of vital signs to monitor.

Develop an Overall Sampling Design

All networks were required to develop an overall sampling design with the goals of (1) making unbiased and defensible inferences from sample observations to the intended target populations, and (2) encouraging the co-location of sampling sites and events among vital signs to improve efficiency and depth of ecological understanding. Monitoring protocols developed by each network provided more detailed descriptions of sampling design such as the size and location of sampling sites, how sites were selected, and the frequency of sampling for each vital sign.

Networks were guided by four basic principles in developing their overall sampling design:

- Wherever possible, some sort of probability design should always be used. Probability designs, where each unit in the target population has a known, non-zero probability of being included in the sample, and a random component is included in the selection of sampling sites, allow for unbiased inference from sampled sites to unsampled elements of the resource of interest (Hansen et al. 1983, McDonald 2003). Probability designs provide more reliable and defensible parameter estimates than model-based designs or convenience or judgment samples (Olsen et al. 1999, Schreuder et al. 2004), and they make it possible to provide measures of the precision of population estimates (Stevens and Olsen 2003). The most common spatially-balanced probability design is the Generalized Random Tessellation Stratified Design (GRTS; Stevens and Olsen 2003, 2004), which has been used by almost all of the park networks for a wide range of vital signs in both aquatic and terrestrial systems.
- Judgment samples that use "representative" sites selected by experts should not be used because they may produce biased, unreliable information (Olsen et al. 1999) and can often be easily discredited by critics.
- Stratification of the park using vegetation maps or other biological data or models is not recommended because stratum boundaries will change over time. A vegetation map is a model based on remote sensing and field data, and map boundaries will change as classification models are modified or as additional ground-truthing data becomes available. Using these units to define strata will limit (and greatly complicate) long-term uses of the data by restricting future park managers' abilities to include new information into the sampling framework. It is legitimate, and better, to delineate areas of special interest such as riparian or alpine areas based on physical characteristics such as terrain, and use these to judiciously define either strata or areas to sample with higher probability.
- Permanent plots that are revisited over time are recommended for monitoring, because the objective is to detect changes over time. Revisiting the same plots removes plot to plot differences from the change estimates, increasing the precision.

Develop Monitoring Protocols

A monitoring protocol is a detailed study plan that describes how data are to be collected, managed, analyzed, and reported, and is a key component of quality assurance for natural resource monitoring programs (Oakley et al. 2003). To be able to demonstrate that any changes in measurements are actually occurring in nature, and are not simply a result of measurements being taken by different people or in slightly different ways, long-term monitoring protocols require a large up-front investment in planning and design and must be fully documented, peer reviewed, and tested so that different people can take measurements in exactly the same way. Protocols should not rely on the latest instrumentation or technology that may change in a few years, such that measurements cannot be repeated.

Protocol development is an expensive, time-consuming process involving a research component. To promote consistency and data comparability and to reduce costs, existing protocols developed by other programs and agencies should be adopted or modified whenever monitoring objectives are similar. Monitoring protocols developed by our program are available on the internet in the NPS Protocol Database (NPS 2007). We also partner with the Association of Fish and Wildlife Agencies and numerous other federal and State agencies and private organizations to share protocols and monitoring project information through the Natural Resource Monitoring Partnership (NRMP 2007).

Establish Data Management, Analysis, and Reporting Procedures

Data and information are the primary products of ecological monitoring. As part of the Service's efforts to improve park management through greater reliance on scientific knowledge, a primary purpose of the monitoring program is to acquire, organize, and make available natural resource data and to contribute to the Service's institutional knowledge by facilitating the transformation of data into information and knowledge through analysis, synthesis, and modeling. A well-designed and well-documented data management system is particularly important for the success of long-term programs where the lifespan of a data set will extend across the careers of many scientists, and numerous changes in technology are to be expected.

Each network has developed a detailed plan for managing, analyzing, and reporting monitoring results (NPS 2007). Based on our evaluation of other long-term monitoring programs, all networks are expected to invest at least a third of their available resources in data management, analysis, and reporting to ensure that data are adequately entered into databases, quality-checked, analyzed, reported, archived, and made available to others for management decision-making, research, and education. All networks produce routine data summary reports, resource briefs, and occasional trend analysis and synthesis reports that are distributed in several formats to key audiences. Websites developed and maintained by each network are a key outlet for delivering monitoring results to park managers, planners, interpreters, the scientific community, and the general public.

Application of Monitoring Results to Natural Resource Stewardship

Natural resource monitoring provides site-specific information for understanding and identifying meaningful change in natural systems characterized by complexity, variability, and surprises. Monitoring results help managers determine whether observed changes are within natural levels of variability or may be indicators of unwanted human influences. The improved understanding of the status and trend in resource condition and "how park systems work" will be used by park managers to adjust management practices that sustain or improve the health of park resources, such as reallocating funding and staffing to achieve desired outcomes, initiating or modifying restoration activities, or working with State or federal partners to achieve desired outcomes. The I&M program has infused NPS with an increased scientific capacity to evaluate and interpret monitoring data. Staff dedicated to environmental monitoring have been added to parks and, as a result, on-the-ground management actions and stewardship planning activities are better informed.

In addition to providing information for management decision-making, monitoring results will be used for various park planning efforts (e.g., comparing estimates of current condition for key resources with desired conditions as part of developing management strategies), and for informing policy makers and the general public about the status and trend in key resources. The detailed, complex scientific data and information depicted as the lower levels of the information pyramid in Figure 6 must be aggregated and translated through data synthesis, modeling, and resource assessments to produce information products that effectively communicate monitoring results to policy makers and the general public. The networks are working with science communication specialists and interpreters to develop more effective summary reports and graphics for presenting monitoring results.

Summary and Future Challenges

The National Park Service has completed the first steps in developing a long-term ecological monitoring program to provide information on the status and trends of selected park resources as a basis for making decisions and working with other agencies and the public for the long-term protection of park ecosystems. We found that the basic steps involved in planning and designing a long-term ecological monitoring program were the same for a diverse range of ecological systems. The process of building the program seemed to be as important as the final result in terms of building a shared understanding between scientists and managers of what the priorities are for obtaining status and trend information, and why. Key benefits of our approach are that (1) the program is park-based, with a clear link between management needs and the monitoring information being provided; (2) it builds on and leverages current monitoring investments by NPS and other partners; and (3) it provides the basic information needed by a variety of other stewardship programs in the National Park Service. These benefits are key to the relevance and long-term sustainability of the monitoring program.

Key challenges for the many scientists, data managers, park staff, and collaborators involved with this long-term program are the need to develop integrated information products through data synthesis and modeling from the data sets and reports produced for individual vital signs, and the need to aggregate and translate the large amount of complex, scientific data to decision makers, policy makers, and the general public. With the limited staff and funding we have available, we must balance the need for collecting and analyzing new data with the need to better utilize and integrate existing data so that we can provide park managers, educators, and others with useful information products.

It is becoming increasingly accepted that parks must be managed as parts of larger ecological systems, and that scientific information must form the foundation for natural resource stewardship efforts to meet the NPS mission. The day-to-day tasks involved in managing a park's natural resources have become much more technically and politically complex. The National Park Service Advisory Board (2001) stated that "A sophisticated knowledge of resources and their condition is essential. The Service

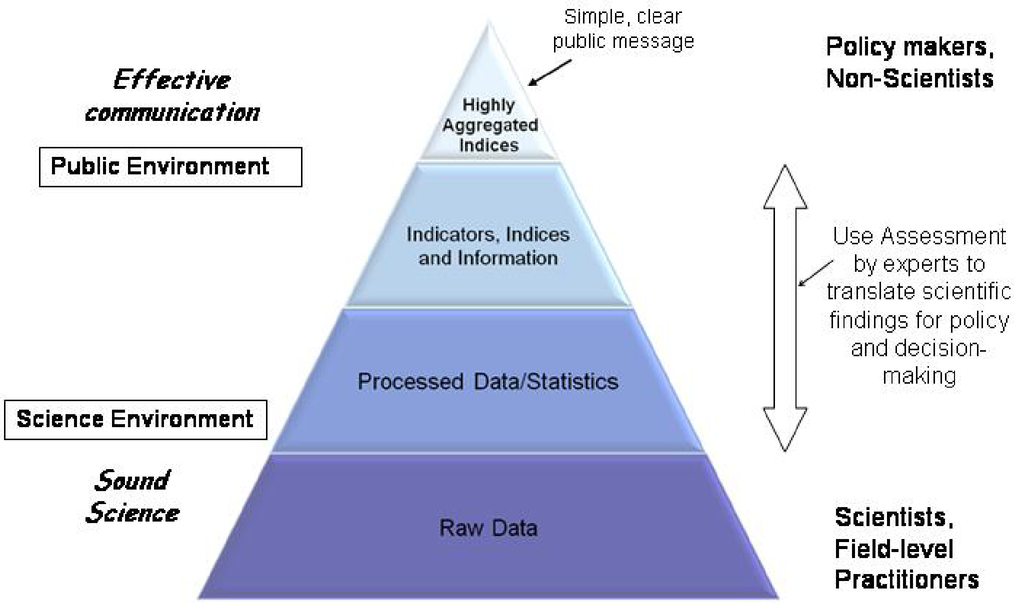

Figure 6. The information pyramid. The amount of detail and scale of analysis of scientific data will differ depending on the intended audience for the various reports and presentations. National-level reporting to policy makers and the general public will involve assessments by experts and presentations of data using highly aggregated indices and simple graphical messages. Results must be supported by a large amount of detailed, complex scientific data that is available at the park and network level.

must gain this knowledge through extensive collaboration with other agencies and academia, and its findings must be communicated to the public, for it is the broader public that will decide the fate of these resources." As the National Park Service approaches its 100th anniversary, the establishment of this long-term monitoring program is an important step towards developing the sophisticated knowledge of resources and their condition that is needed to preserve parks unimpaired for the enjoyment, education, and inspiration of this and future generations.

Acknowledgements More than a thousand individuals have been actively involved in recent years in the development of the NPS vital signs program, including superintendents and resource staff from most of the parks, scientists and data managers with the 32 I&M networks, and subject-matter experts from federal and state agencies and more than 150 universities. We particularly want to thank Gary Davis, Gary Williams, Abby Miller, and Mike Soukup for their vision and support in developing this program. The U. S. Geological Survey provided expertise and funding for monitoring planning and design work, and we particularly thank Paul Geissler for his many contributions to this effort.

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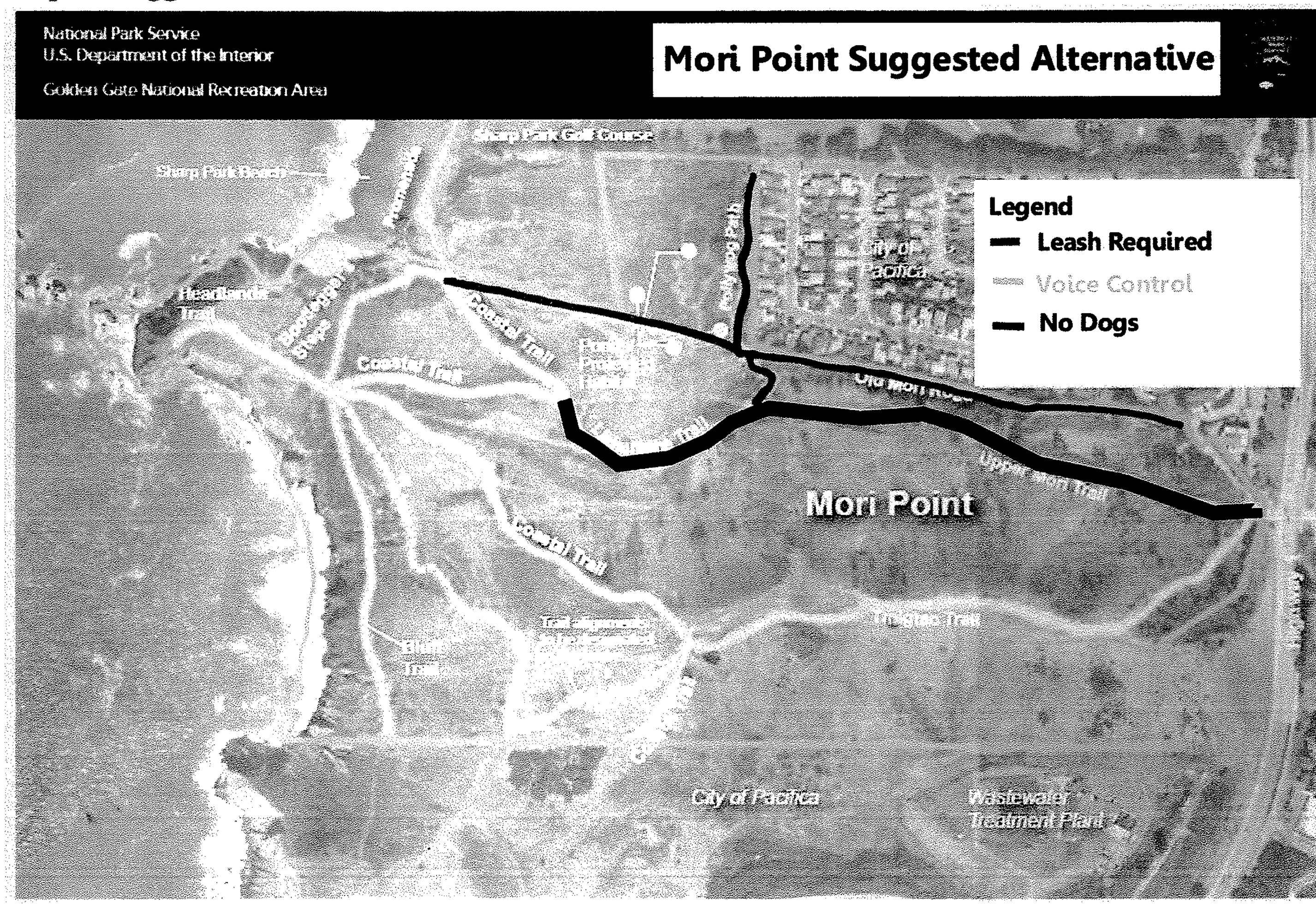
Mori Point Analysis and Suggestions

Overall Assessment

All adverse impacts shown for Mori Point for the "No Action" alternative need to be changed to no impact or negligible. There is no reasonable justification for reducing dog activity on Mori Point since there is no scientific evidence or even reasonable correlations that dogs are more than negligibly impacting the park and particularly not the protected California Red-Legged Frog or the San Francisco Garter Snake.

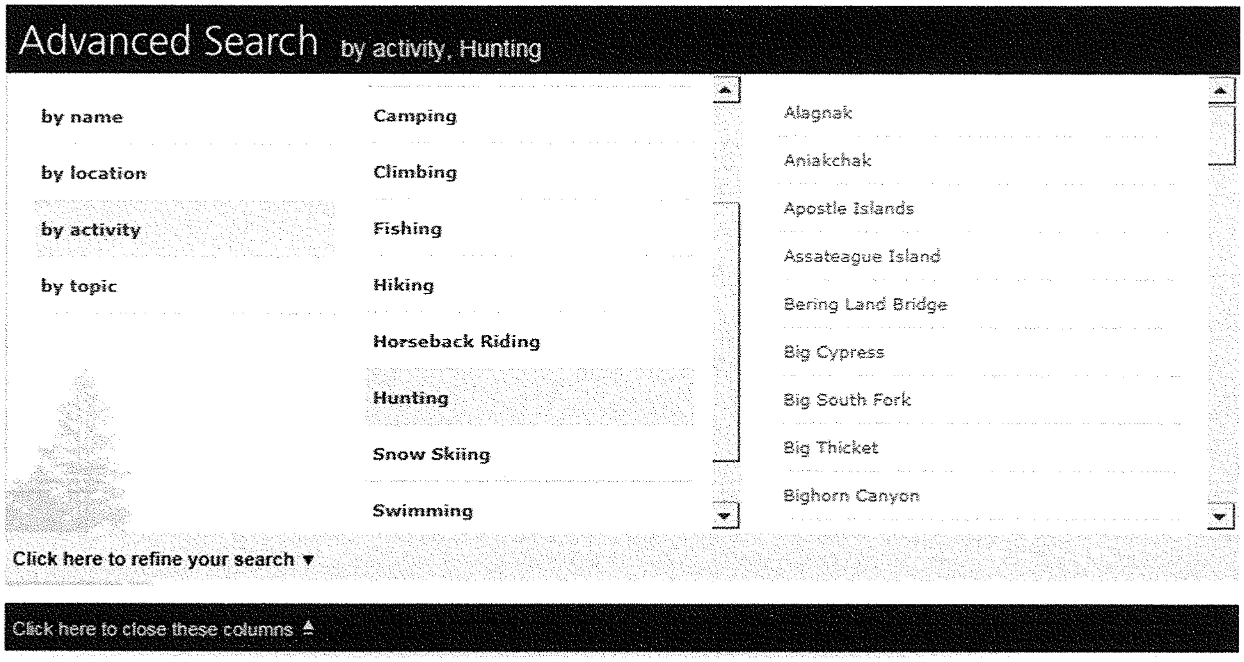
I oppose all of the DEIS "action alternatives" as they represent "hoarding" by marginalizing the recreational mandate for the GGNRA and the recreational needs of an urban population and future generations. I support adding voice-control trails, one no dog trail, and adding other more inclusive solutions to improve dog recreation at Mori Point as defined below. Note that Sharp Park to the north and the Rock Quarry to the south are both heavy dog use areas, with many dogs off-leash. Access for dogs from the Pacifica residences must be maintained from the northeast as well. This is not a location that anyone with a significant fear of dogs would frequent.

Map of Suggested Mori Point Alternative



>60 National Park Service Ran Parks Allow Hunting

http://www.nps.gov/findapark/index.htm



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Vital Signs Monitoring
Discovering and protecting America's natural heritage

Background Documents

Download "Monitoring the Condition of Natural Resources in US National Parks"

Download Vital Signs Monitoring Brochure

Program Administration & Organizational Framework

Justification for Integrated Natural Resource Monitoring
Legislation and Policy
Definition of Key Terms
  Glossary of Terms as used by NPS I&M Division
National Framework for I & M
  National and Regional Oversight
  Natural Resource Program Center & MTAG
  Basic Resource Inventories
  Prototype Monitoring Programs
  Vital Signs Monitoring Networks
Monitoring Planning & Design: The 3-Phase Approach
  Monitoring Plan Outline
  Monitoring Plan Checklist Memo
  Ecological Monitoring Framework
  Schedule - Network Due Dates for Phase 1, 2, 3
  Peer Review and Approval Process

Other Links & Documents

List of Coordinators, Data Managers and Ecologists
Meeting Notes and Presentations
Literature Cited and Extended Bibliography
Download Documents for Designing a Monitoring Program
Websites You Should Know About

Monitoring Intranet (requires NPS computer)

Memos establishing policy & guidance
AARWP guidance & budget software
Best Examples of Draft Monitoring Plans by Chapter

Guidance for Designing an Integrated Monitoring Program

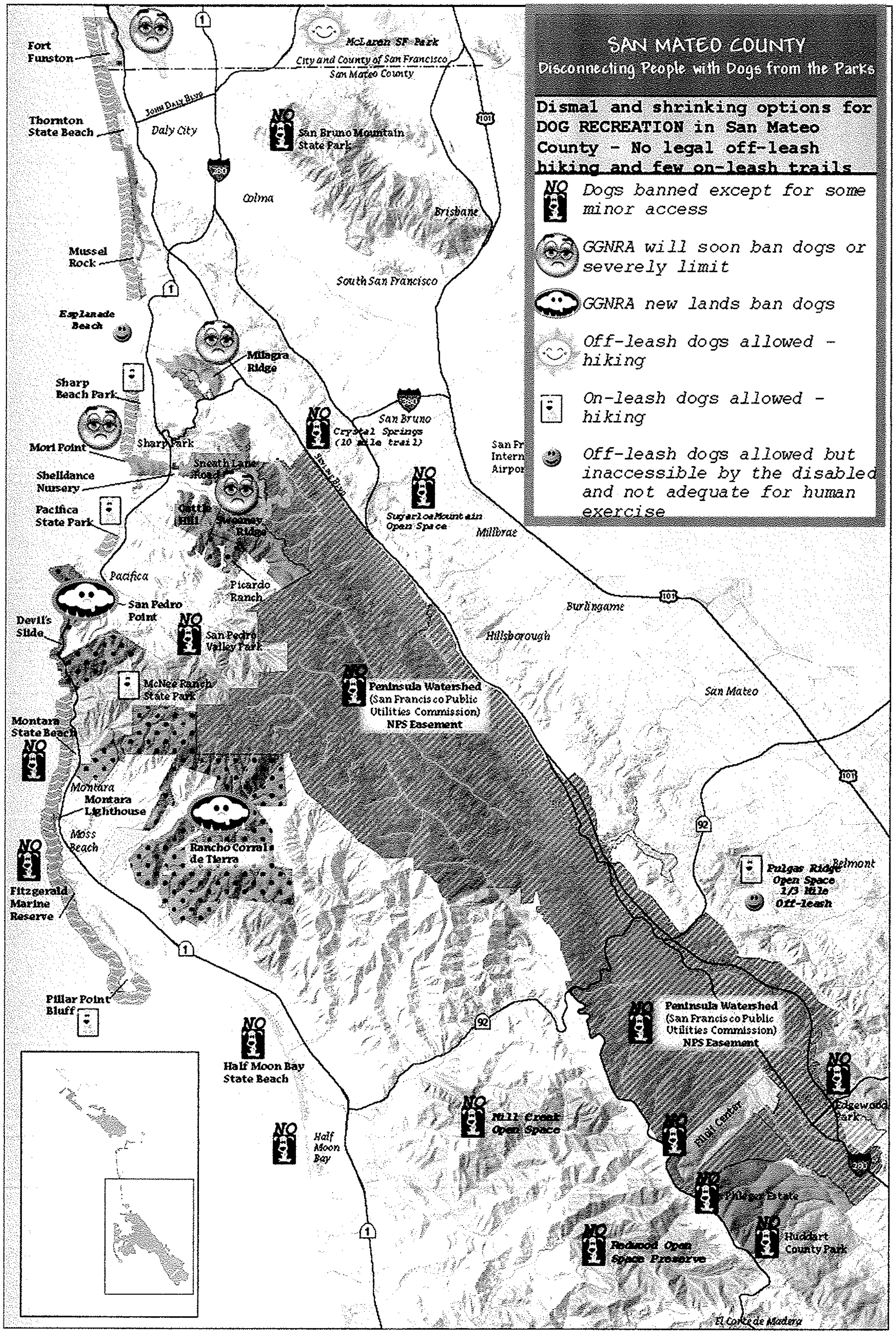
Introduction
Integration: Ecological, Spatial, Temporal & Programmatic
Establishing Monitoring Goals & Objectives
  Examples of Specific, Measurable Monitoring Objectives
Developing Conceptual Models of Ecosystem Components
Prioritizing & Selecting Vital Signs - What Should be Monitored?
Sampling Design Considerations - Where & When to Sample
Monitoring Protocols
  Required Content/Format of Protocols
  Protocol Development Process
  Guidance for Protocol Development Summaries
  Protocol Database
  Protocol Examples from Other Programs & Agencies
  Download Example Protocol for Land Bird Monitoring
Data Management and Analysis
Reporting the Results of Monitoring
  Recommended Style for Literature Cited in Monitoring Plans
Technical Guidance on Specific Topics
  Air Resources
  Geologic Resources
  Water Resources
    WRD Guidance for Designing and Conducting Water Quality Monitoring
    Invasive Species
    Land Birds
  Fire & Fuels Dynamics
    Other fire links
  Landscape Dynamics and Remote Sensing

Network Monitoring Plans

Monitoring Plans for 32 networks
Guidelines for publishing Monitoring Plans

TOP OF PAGE

San Mateo County is Unfriendly to People with Dogs – particularly those that enjoy voice control hiking and play



Map of Suggested Sweeney Ridge/Cattle Hill Alternative