Mediterranean Coast Network
Vital Signs Monitoring Plan

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Executive Summary

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> *.... all conservation of wilderness is self-defeating, for to cherish we must see and fondle, and when enough have seen and fondled, there is no wilderness left to cherish.*
>
> Aldo Leopold,
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Mediterranean Coast Network

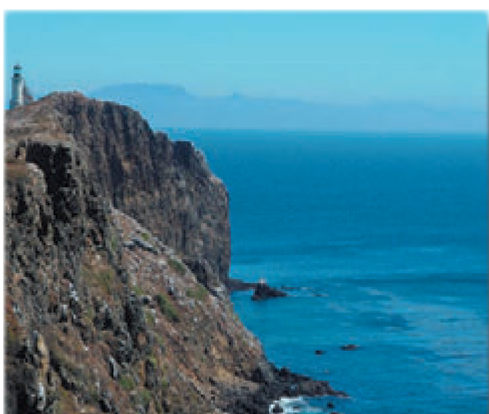
The parks of the Mediterranean Coast Network are linked by their Mediterranean-type climate characterized by cool wet winters and hot dry summers. Mediterranean-type climates are distributed worldwide among five distinct geographical zones along continental coastlines between 30º and 40º latitude. Mediterranean ecosystems cover only about 3.0% of the earth's land area, but are identified as hotspots for biodiversity and host a disproportionately large share of plant species. Additionally, the moderate Mediterranean climate has historically attracted a disproportionate share of human inhabitants with all the attendant impacts on native ecosystems. Balancing the preservation of native resources with the needs of thriving human populations in Mediterranean-type ecosystems presents a significant challenge.

Parks of the Mediterranean Coast Network

- Cabrillo National Monument
- Channel Islands National Park
- Santa Monica Mountains National Recreation Area

The parks of the Mediterranean Coast Network include some of the most significant examples of terrestrial Mediterranean-type ecosystems and coastal marine environments anywhere in the world. At the same time, the parks are embedded in the highly developed and rapidly expanding southern California metropolitan area. Consequently, each park experiences numerous ecological threats, including introduction of non-native invasive species, declining fresh and marine water quality, fragmentation of habitat, altered fire regimes, *etc*. Amid these challenges, park managers must strive to understand and protect natural resources in order to leave them unimpaired for future generations.

To accomplish this mission, it is imperative to identify ecological threats and stressors, including those originating from outside park boundaries,



understand the condition of extant resources, determine the pathways of impacts from stressors, and evaluate the effects of stressors on natural resources. As a result, long-term monitoring is necessary to provide data on resource status and trends, identify potential mechanisms of resource change, and suggest research activities or management actions required to help clarify understanding and mitigate resource impacts.

Monitoring: a New Approach

In 1999, the National Park Service began the Natural Resource Challenge, a multiyear program created by Congress to improve management and protection of natural resources in the National Park System. This program brought substantial new funding to accelerate biotic inventories and expand ecological monitoring throughout the National Park Service. Through the Natural Resource Challenge, a new approach to ecosystem monitoring in national parks has developed, embracing the concept of vital signs of ecosystem health to guide the development of long-term monitoring efforts in parks and networks of parks. The hallmark of the renewed monitoring approach is a clearly specified procedure for identifying, selecting and ultimately monitoring ecosystem vital signs, which are defined by the National Park Service Inventory and Monitoring Program 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".

Service-wide goals of the monitoring program guide development of individual network monitoring programs.

Under this definition, vital signs may include a wide variety of ecosystem elements and processes, including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources.

Resource managers must know and understand the status and trends of resources, natural processes, and threats to resource integrity within network parks.

Beginning in 2000, networks of parks began identifying and prioritizing their ecosystem vital signs, and ultimately selecting subsets for long-term monitoring within a framework of goals articulated by the National Park Service Inventory and Monitoring Program:

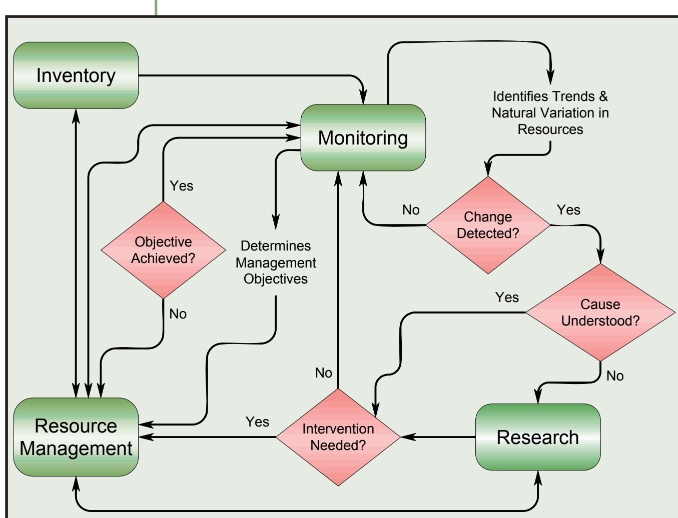
- Determine status and trends in selected indicators of the condition of park ecosystems to allow managers to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources.
- Provide early warning of abnormal conditions of selected resources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

Based on this new approach, the Mediterranean Coast Network has embarked on a comprehensive effort to identify, prioritize, select, develop protocols for and monitor vital signs of ecosystem condition at network parks. This renewed effort and support complements the prototype monitoring already established at Channel Islands National Park and, as appropriate, will augment inventory and monitoring efforts underway at Cabrillo National Monument and Santa Monica Mountains National Recreation Area.

The Process

Identifying monitoring goals, objectives and then vital signs of ecosystem health in the Mediterranean Coast Network began with a series of discussions with park resource managers, and a review of park general and resource management plans. Following this, a series of workshops and discussion groups were organized to bring together subject matter experts from the National Park Service, state and federal agencies, local universities, and the private sector to identify ecosystems drivers and stressors, and to review current management activities that would help determine the course of monitoring planning within the Mediterranean Coast Network.

Information from these workshops, along with information obtained from published literature, park resource managers, and academic subject matter experts was incorporated into a series of conceptual models that highlighted ecosystem



The Adaptive Management Process

Vitals Signs Monitored by the Mediterranean Coast Network			
Category	**Vital Sign**		**Vital Sign Measure**
Air and Climate	Air Quality	•	Atmospheric ozone concentration
	Visibility	•	Visibility
	Weather and Climate	•	Temperature, precipitation, & wind speed.
Water	Stream Flow	+	Flow & discharge.
	Marine Hydrology, Waves & Currents	•	Wave height & current speed & direction.
	Water chemistry	+	Core parameters (pH, DO, specific conductance, & temperature).
	Nutrients	+	Nitrate, ammonia, & total phosphate.
	Toxic Pollution	+	Metals, pesticide, & hydrocarbons.
	Microorganisms	+	Most probable number.
Biological Integrity	Non-native Plant Species Introduction & Spread	+	Detect introduction & spread of non-native invasive plants.
	Non-native Crayfish & Fishes	+	Distribution & abundance
	Kelp Forests	•	Species composition, distribution & abundance
	Sand Beach Infauna	•	Species composition, distribution & abundance
	White Abalone	•	Distribution & abundance
	Intertidal communities	•	Species composition, distribution & abundance
	Shrubland vegetation	+	Species composition, distribution & abundance
	Grassland Vegetation	•	Species composition, distribution & abundance
	Woodlands	+	Species composition, distribution & abundance
	Riparian Plant Communities	+	Species composition, distribution & abundance
	Marine Fishes	•	Species composition, distribution & abundance
	Amphibians and Reptiles	+	Species composition, proportion of area occupied, & malformations.
	Raptors, Marine Birds, Shore Birds, Breeding Birds	•	Species composition, distribution & abundance
	Small Mammals, Carnivores, Pinnipeds, Humpback & Blue Whales	•	Species composition, distribution & abundance
	T&E species and communities	•	Distribution & abundance
Human use	Fisheries Harvest	•	Landings by species
	Visitor usage	•	Number & pattern of visitor use.
Ecosystem Pattern and Processes	Fire	•	Occurrence, scope, & intensity.
	Land cover and use: Habitat Fragmentation	+	Changes in land use patterns & habitat type conversion.

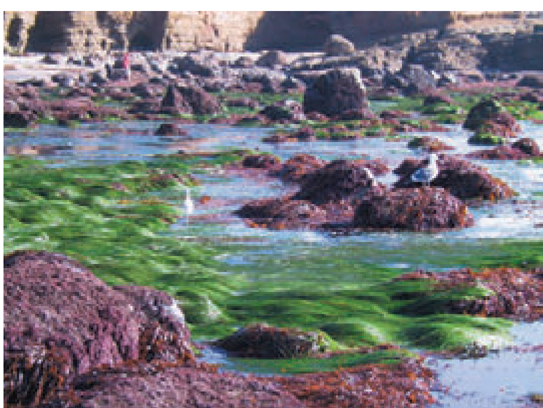
+ Network Vital Sign; • Park or other agency monitoring

Other than stream flow, all water quality vital signs will be monitored in both marine and fresh waters.

functional relationships. The models provided a framework for understanding potential indicators of ecosystem condition by illustrating the ecosystem drivers, stressors, and ecological effects of the drivers and stressors within the southern California Mediterranean-type Ecosystem.

The conceptual models were used to identify a long list of candidate vital signs. Again, the network pulled in outside expertise, as subject matter experts from outside the National Park Service worked together with park and network staff, through an internet-based exercise, to evaluate and rank the candidate vital signs according to ecological relevance, feasibility for monitoring, and utility and relevance to management of network parks. Ultimately, a short list was selected based on the results of this ranking exercise. Although water quality issues were not among the very highest ranked, priority water quality vital signs were added to the final list as the network receives independent funding for water quality related monitoring.

This process resulted in 17 vital signs grouped into eight monitoring programs for which monitoring protocols will be written and new monitoring implemented (see table). With the addition of the vital signs currently monitored by Channel Islands National Park prototype program, this will form the core of the Mediterranean Coast Network vital signs monitoring program.



Implementation

Over the next five years, the network anticipates developing detailed monitoring protocols and implementing monitoring for the eight selected program. Protocols will adhere to national standards in content and format, documenting step-by-step guidance for collecting, analyzing, and reporting information for each vital sign to

be monitored. Protocols will also contain specific instructions for data management to ensure the quality, interpretability, security, longevity and availability of all collected data.

Although a general budget and staffing plan has been developed and is presented within this monitoring plan, full implementation of even this core program will require creative partnerships of network staff stationed at parks, park-supported staff, cooperative partners, and interns and volunteers. In some cases agencies or organizations other than the National Park Service are already monitoring vital elements of park and network ecosystems (for example air and climate). The network will seek to work with these outside organizations and others and develop new partnerships where common needs exist. In addition, the network monitoring program will work to acquire and interpret data collected by outside sources where these data complement or add analytical power to data and information collected through the network's program.

Integration with Management

Ultimately, all data collected and interpreted is of little value unless delivered to park managers or other interested and engaged parties. As part of the National Park Service effort to improve park management through greater reliance on scientific knowledge, the vital signs monitoring program will develop, organize, and transform natural resource data into useful information through analysis, synthesis, modeling, and reporting. Detailed guidance on reporting requirements and procedures has been developed to ensure the timely delivery of monitoring data to the appropriate audience. More critically, information will be provided in a variety of forms and formats. For example, all reports will contain executive summaries to assist managers in synthesizing and using information. The network will present annual “science days” to inform park staff and management of monitoring results and implications. The network will also explore connections with the California Mediterranean Research Learning Center for involving and informing both the public and the scientific field.

Vital signs monitoring is an integral part of the adaptive management process, providing critical information about trends in natural resource conditions. The information and stories presented to park managers and stakeholders will allow the evaluation of management effectiveness, better planning to meet desired conditions, and identification of crucial information gaps and research needs to address resource threats. The Mediterranean Coast Network VItal Signs Monitoring Plan outlines the comprehensive approach taken by network parks to develop this essential program. When implemented, the vital signs monitoring program will provide the data and information needed for better resource stewardship, ecosystem understanding, and scientific management of natural resources in network parks.

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Chapter 1: Introduction and Background

…. all conservation of wilderness is self-defeating, for to cherish we must see and fondle, and when enough have seen and fondled, there is no wilderness left to cherish.

Aldo Leopold, Wisconsin, Marshland Elegy

The Mediterranean Coast Network, comprising Cabrillo National Monument (NM), Channel Islands National Park (NP), and Santa Monica Mountains National Recreation Area (NRA), is one of 32 networks of national park units included in the Servicewide Inventory & Monitoring (I&M) program. The parks of the Mediterranean Coast Network protect a diverse array of natural resources characteristic of Mediterranean and temperate marine ecosystems.

1.1 Mediterranean-type Ecosystems

Mediterranean-type ecosystems are distributed worldwide among five distinct geographical zones: the Mediterranean Basin, the Cape region of South Africa, Central Chile, South and Southwestern Australia, and California located along continental coastlines between 30º and 40º latitude. Hot dry summers and cool rainy winters characterize the climate in these areas. Mediterranean ecosystems cover only approximately 3.0% of the world's land area. Ten percent of the world's Mediterranean-type ecosystem occurs in California and northern Baja California. Vegetation communities in Mediterranean-type ecosystems are moisture and elevation dependent, and vary along a continuum from desert and semi-desert shrubs through savannas and grasslands, sclerophyllous woodlands, to coniferous and deciduous forests (Rundel, 1998a).

Mediterranean-type ecosystems host a disproportionately large share of plant species worldwide in both the number of species and the number of rare or locally endemic species (Cowling & McDonald, 1998). All five Mediterranean-type regions support similar communities of broadleaf evergreen shrubs and dwarf trees known in North America as chaparral. Scrub oaks (*Quercus dumosa*), chamise (*Adenostoma fasciculatum*), and California lilac (*Ceanothus spp.*) dominate California chaparral. Chaparral grades to coastal sage scrub at arid inland margins and along drier coastal areas. Vegetation in each of the Mediterranean systems also shows similar adaptations to fire and to low nutrient levels in the soils. Typically, natural fire is a very significant factor in structuring Mediterranean-type ecosystems, and many of the plant species native to southern California require the heat and scarring action of fire to induce germination (Smith, 1980).

The moderate Mediterranean climate has historically attracted a disproportionate share of human inhabitants with all the attendant impacts on native ecosystems (Rundel *et al.*, 1998a). Balancing the preservation of native resources with the needs of thriving human populations in Mediterranean-type ecosystems presents a significant challenge.

1.2 Parks of the Mediterranean Coast Network

The three parks of the Mediterranean Coast Network make a significant and unique contribution to the Southern California experience. As islands of natural open space within one of the most densely populated regions in the United States, these three parks provide refuges for wildlife and native vegetation, and opportunities for scientific research, natural history education, equestrian sports, mountain biking, hiking, picnicking, and camping. Opportunities for ocean fishing, scuba diving, snorkeling, ocean kayaking, and tide pool exploration are also available. All of these possibilities are within just a few miles of the major urban centers of Southern California (Figure 1.1).

1.2.1 Cabrillo National Monument

Cabrillo NM is located within the city limits of San Diego, California, on the southern end of Point Loma Peninsula (Figure 1.2). The peninsula

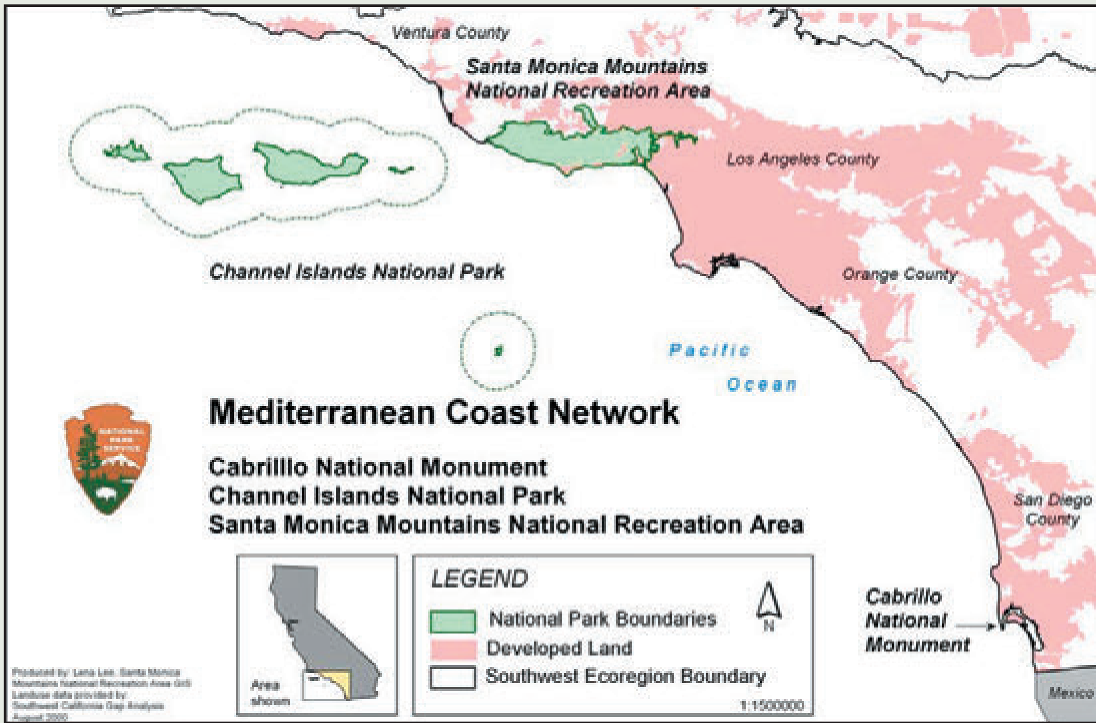

Figure 1.1 Mediterranean Coast Network of National Parks.

which rises to a height of approximately 128 meters above sea level forms the western lip of the mouth of San Diego Bay. The Point Loma Peninsula has been home to several units of US military for much of the past 100+ years.

In 1913 President Woodrow Wilson proclaimed nearly 2,045 square meters of land on Point Loma as a National Monument for the placement of an heroic statue of the Spanish Explorer Juan Rodriguez Cabrillo, the first European to set foot in what is now California (Presidential Proclamation No. 1255, October 14, 1913). Subsequent presidential proclamations (Calvin Coolidge, No. 1773, May 12, 1926; Dwight Eisenhower, No. 3273, February 2, 1959; & Gerald Ford, No. 4319, October 1, 1974) and actions by Congress have increased the size of Cabrillo NM to its present 66 hectares.

The protected open space on Point Loma occurs on the coastal fringe of the sixth largest city in the nation and, isolated from other natural land by the ocean and surrounding development, forms an effective island of rare habitats. Many of these habitats have been recognized as globally endangered or extremely endangered by the California Natural Diversity Database, 1992[1] and include such communities as maritime succulent scrub, coastal sage scrub, and maritime chaparral. Cabrillo NM has been fire free for much of the past 100 years. This lack of fire has resulted in the establishment of a rare example of “old growth” chaparral scrub on the peninsula. The integrity of much of the coastal sage scrub community on Point Loma is considered to be very high.

With over 1,000,000 visitors annually, Cabrillo NM is one of the most intensively visited small parks in the national park system. The bluff at Cabrillo NM provides panoramic vistas of the Pacific Ocean with great opportunities for observing the annual southward migrations of gray whales. Cabrillo’s tide pools attract thousands of visitors, from school age to senior citizens and aesthetes to academics. Over 1000 species of organisms, including more than 80 sensitive species, reside in the marine and terrestrial environments of Point Loma. Unfortunately, San Diego Bay, bounding the peninsula on the east, has been listed as the second most polluted bay in the nation.

Several federal agencies[2] hold ownership or stewardship over the lands on Point Loma. In 1994, these agencies, including the National Park Service (Cabrillo NM), developed a joint natural

Figure 1.2 Cabrillo National Monument (outlined in red) and the Point Loma Ecological Reserve (shaded green) on the Point Loma Peninsula.

resources management plan and entered into a memorandum of understanding establishing the 256 ha Point Loma Ecological Reserve (PLER) to "set aside sensitive biological communities in amounts and configurations that would be viable in the long term on Point Loma" (Anonymous, 1995).

1.2.2 Channel Islands National Park

Channel Islands National Park consists of nearly 101,000 hectares half of which are submerged lands. The park's significance with respect to natural resources lies largely in the remarkably diverse marine environment resulting from confluence of major ocean currents and upwelling of nutrient-rich waters and, on the islands, the numerous species, subspecies, or varieties of unique flora and fauna which have evolved as part of the island ecosystem. Over 2,000 species of plants and animals can be found within the park. One hundred and forty-five of these are unique to the islands and found nowhere else in the world. The Channel Islands are characterized by windswept landscapes, rugged coastlines, and unspoiled beaches. Wave-cut marine terraces, formed as changing sea levels and rising islands caused shorelines to recede, are a conspicuous landscape feature.

On April 26, 1938 Franklin D. Roosevelt (Proclamation No. 2281) established the Channel Islands National Monument consisting of Anacapa and Santa Barbara Islands to protect "Fossils of Pleistocene elephants and ancient trees," and to preserve "noteworthy examples of ancient volcanism, deposition, and active sea erosion." In 1949, President Harry S. Truman proclaimed the boundaries of Channel Islands National Monument to include the area within one nautical mile of the shoreline of Anacapa and Santa Barbara Islands (Proclamation No. 2825).

In 1976, Channel Islands National Monument assumed management of San Miguel Island from the US Navy. In 1980, Congress created Channel Islands National Park as it exists today (6 United States Code 1 [§ 410ff.]) and stated that the "Channel Islands National Park … shall include San Miguel and Prince Islands, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara Islands, including the rocks, islets, submerged lands, and waters within one nautical mile of each island." That same year the Secretary of Commerce designated a 325,000 ha portion of the Santa Barbara Channel as the Channel Islands National Marine Sanctuary, to include the waters surrounding the islands of Channel Islands National Park from mean high tide to six nautical miles offshore. The sanctuary's primary goal is the protection of the natural and cultural resources contained within its boundaries.[3] Finally in April of 2003, the state of California designated 10 areas of the Channel Islands National Marine Sanctuary as Marine Protected Areas (MPA) where the taking of living, geologic, and cultural resources is prohibited (Figure 1.3).

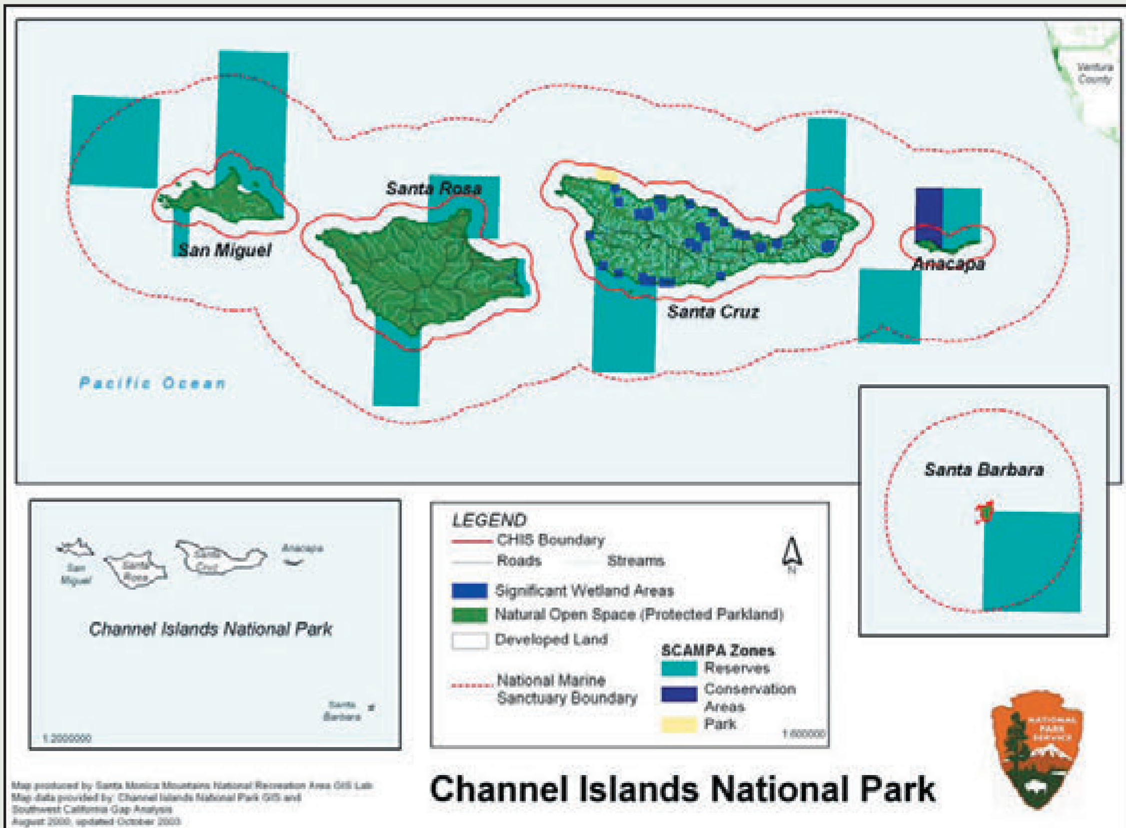

Figure 1.3 Channel Islands National Park, the boundary of the Channel Islands National Marine Sanctuary, and the boundaries of marine protected areas associated with Channel Islands National Park[4].

Habitat types on the islands include coastal dune, coastal bluff, grasslands, coastal sage scrub, chaparral, island oak woodlands, mixed hardwood woodlands, conifer stands, riparian areas and wetland communities. Coastal beach and associated dune habitats occur in the windiest sandy locations on all the northern Channel Islands and appear to be relatively undisturbed compared to their counterparts on the mainland. The coastal bluff, chaparral, coastal sage scrub, and mixed woodland communities of the Channel Islands support a very high number of rare plants. The islands' flora also includes several relict species such as the endemic island ironwoods (*Lyonothamnus floribundus*), and the Torrey pine (*Pinus torreyana*). There is a high degree of endemism among the island flora with many species occurring on only one of the Islands.

Island vertebrate populations have also evolved into distinct subspecies as a result of insularization. The deer mouse and island fox are recognized as distinct subspecies on each of the islands on which they occur. The island fox (*Urocycon littoralis*) illustrates a typical case of island evolution wherein a species that occurs only on the Channel Islands is thought to have evolved from the mainland gray fox (*Urocycon cineroargenteus*). Although birds are generally more mobile, the Channel Islands are also home to some distinct avian forms such as the Santa Cruz Island jay (*Aphelocoma insularis*) and a distinct subspecies of non-migratory song sparrow on San Miguel Island.

Due to a low frequency of ignition sources and a climate regime moderated by maritime influences, fire is uncommon in the Channel Islands. Although similar plant communities on the mainland experience regular fire, historically fire on the islands has been much less frequent than on the mainland. Several island taxa have relaxed fire adapted traits as compared to their mainland counterparts (Walter & Taha, 1999; Wells, 2000; Carroll *et al.*, 1993; Anderson, 1998 & 2002). Fire return intervals on the Channel

Islands are significantly longer than estimates of modern fire return intervals in mainland shrubland communities.

The marine waters of Channel Islands NP contain a remarkably diverse array of ecological assemblages. More than a third of all kelp forests in southern California occur within the park. Vast sand plains between the reefs host a variety of clams and other burrowing organisms. Many commercially important fish inhabit deeper waters of the park. Invertebrates, such as corals, sponges, and feather stars, cover deep reefs below the reach of sunlight.

At least 26 kinds of whales and porpoises and five species of seals and sea lions can be found in the park. Many of these species are endangered and several species of marine birds and mammals which once commonly bred along the southern California coast now breed only on the Channel Islands. San Miguel Island is the only place in the world where four different species of pinnipeds regularly breed and the only area where five species are regularly found. At least 15 species of seabirds or shorebirds are known to nest in the park.[4] These Channel Islands colonies of pinnipeds and birds are significant contributors to global populations of many of these species.

1.2.3 Santa Monica Mountains National Recreation Area

The Santa Monica Mountains National Recreation Area is the largest urban park in the United States, and represents one of the largest and most significant areas of protected Mediterranean-type ecosystem in the world.

The park was established in 1978 in recognition of the value of the geological, biological, archeological, historical, sociological, recreational, and scenic resources of the Santa Monica Mountains and adjacent seashore, and the vulnerability of these resources to impacts from their proximity to a large urban and suburban population. Congress also "found that there are … public health benefits provided by the Santa Monica Mountains and adjacent coastline area, (and that) there is a national interest in protecting and preserving these benefits for the residents of and visitors to the area." In creating Santa Monica Mountains NRA, Congress charged the Secretary of the Interior to "manage the recreation area in a manner which will preserve and enhance its scenic, natural, and historical setting and its public health value as an air shed for the Southern California metropolitan area while providing for the recreational and educational needs of the visiting public" (16 United States Code 1 [§ 460kk]) (Figure 1.4).

The park exists today as a mosaic of different land ownerships and land uses extending over 62,000 ha. Of that amount, 31,500 ha (≈ 50%) are currently in protected status through public ownership (state and federal). The remaining 30,500 ha are in private ownership. Of the protected lands 9,400 ha are owned by the National Park Service. Unlike most national parks, Santa Monica Mountains NRA is still expanding as remaining open space around the park and within the boundaries of the park becomes available and is purchased for protection as public parkland.

The Santa Monica Mountains are the southernmost mountain chain in the east-west trending, or transverse ranges of southern California. While there are no natural freshwater ponds or lakes, intermittent streams and springs are abundant in the mountains.

Vegetation community types occurring in the Santa Monica Mountains include coastal salt marsh, coastal strand, coastal sage scrub, chaparral, coast live oak woodland, riparian woodland, valley oak savanna, and valley grassland (Holland, 1986). A wide variety of localized plant communities can be found associated with the streams of the Santa Monica Mountains. These include native riparian vegetation and remnant populations of big leaf maples, cottonwoods, and alder. From Mugu Lagoon to the Santa Monica Pier, the Santa Monica Mountains National Recreation Area boundary includes 66 kilometers of Pacific coastline down to the mean high tide line. A variety of upland habitats including coastal bluffs, sand dunes, rocky and sandy beaches stretch along this part of the coast. Several perennial and intermittent streams that drain into the ocean and several lagoons are included within the park boundary along this coastal area.

More than 450 vertebrate species occur in the park, including 50 mammals, 384 birds, and 36 reptiles and amphibians. Mule deer are the largest herbivore in the mountains, and the mountains still support mountain lions, bobcats, gray foxes, badgers, and long-tailed weasels. Omnivorous predators in the mountains include coyotes, ring-tails, raccoons, and spotted and striped skunks.

Figure 1.4 Santa Monica Mountains National Recreation Area

Harbor seals breed in Mugu lagoon. Of the total number of birds that are found within the park, approximately one-third breed there including thirteen species of raptors. Twenty-five species of reptiles inhabit the Santa Monica Mountains. A variety of native and introduced fishes occur in the waters of the Santa Monica Mountains. Of significance are two spawning populations of steelhead trout and one spawning population of the Pacific lamprey. Arroyo chub occur in the slow moving waters of Malibu Creek and a variety of introduced fish, such as largemouth bass, bluegill and goldfish occur in freshwater streams up and downstream of man made lakes and ponds. Additionally the park protects a large number of sensitive species. Twenty-three plant and animal species of the Santa Monica Mountains are federally listed as threatened or endangered. Two additional species are state-listed. Another forty-nine species are candidates for or have been proposed for listing by the U.S. Fish and Wildlife Service.

1.3 Significant Management & Scientific Issues in Network Parks

As with other Mediterranean climate regions, southern California is favorable to human habitation, agriculture, and recreational activities. While these human influences have dramatically affected the health of ecological systems and individual species within the region, the high degree of continuing urbanization along the coastline of southern California has resulted in the loss of many significant natural areas (Mac, *et al.* 1998). Several common plant communities of the southern California Mediterranean-type ecosystem are identified as being very sensitive to environmental perturbation (Lock-Dawson, 2000).

Within the context of natural open space preservation, all areas of native vegetation are important to resource managers and efforts are underway to protect them from invasion of non-native plant species, impacts from undue visitor use, habitat type conversion, fragmentation, and encroachments from development. In addition, development continues to reduce and fragment the remaining natural habitat throughout southern California posing significant problems for many species dependent upon large contiguous areas of habitat. For this reason habitat type conversion, habitat connectivity, and barriers to animal movements have become major issues for park managers as they respond to development and urban growth within and adjacent to network parks—particularly in the Santa Monica Mountains. Natural resources on the Channel Islands have been buffered somewhat by the physical difficulty of human access, however historic ranching and hunting activities have had significant impacts on island resources.

These factors, largely related to human activities, combine to make preservation of natural resources in southern California more difficult than in many other comparable natural areas.

1.3.1 Native Vegetation

In spite of its small size, Cabrillo has taken on significant importance in protecting an ecosystem in a transition zone where coastal sage scrub, common along the California coast as far north as San Luis Obispo County, mixes with succulent coastal species more common to the Baja California peninsula. In addition, Cabrillo NM also protects one of the last remnants of chaparral dominated by the wart-stemmed *Ceanothus*, a California sensitive species with its distribution centered in southern San Diego County. These issues coupled with high human use, elimination of open space through development, and the invasion of non-native plants have made the protection of existing native vegetation and the restoration of degraded habitats a significant priority for Cabrillo NM. Past land use practices in the Channel Islands have significantly impacted native vegetation. In Channel Islands NP management of native vegetation focuses on the restoration and protection of the flora of the islands and especially those that are rare or unique to the islands. Of the three parks, the vegetation of the Santa Monica Mountains is most representative of the southern California Mediterranean-type ecosystem. Resource managers at Santa Monica Mountains NRA are actively managing vegetation resources to maintain native plant diversity at current levels, restore valley oak savanna and native grasslands, restore coastal sage scrub in damaged areas, and to restore damaged riparian areas.

1.3.2 Native Fauna

Point Loma's complete insularization by development has isolated several relict populations of meso-carnivores, reptiles, amphibians, and raptors. A small pack of gray foxes are resident on the very tip of Point Loma and are kept isolated by urbanization and cosmopolitan coyotes that roam between available open space, the adjacent military reservation, and local residential neighborhoods. Point Loma also provides a significant stopover point for many species of migratory birds and while there is a single nesting pair of Peregrine Falcons resident on the point, many other species of raptors are frequently observed within the park and reserve.

Resource managers within the Santa Monica Mountains are concerned over maintaining the distribution and abundance of reptiles and amphibians and small mammals at current levels. Maintaining the diversity and abundance of migratory and resident nesting bird species, especially raptors, at current levels is also important. Continued loss of natural open space from development has managers concerned over the decline of bobcat breeding habitat as has as increases in mortality from disease and anti-coagulant poisoning in bobcats, coyotes, and mountain lions.

In Channel Islands NP, monitoring revealed a precipitous drop in island fox (*Urocycon littoralis*) populations over the past few years and this endemic species has subsequently been federally listed as endangered and is under active management on the islands. The channel islands were once home to breeding bald eagles (*Haliaeetus leucocephalus*) and peregrine falcons (*Falco peregrinus*). Both species all but disappeared from the islands during the early part of this century, due to harassment, shooting, egg stealing, and the insidious effects of organochlorine pesticides on reproduction. Thanks to aggressive introduction efforts, the peregrine is making a comeback on the northern channel islands. The park is currently attempting to remove golden eagles (*Aquila chrysaetos*), historically not present on the islands, in order to re-introduce bald eagles and reduce predation on the island fox.

1.3.3 Landscape Pattern

Loss of connectivity between major habitat areas and decreases in the number of usable wildlife connections between patches of native habitat are of major concern in the Santa Monica Mountains. Factors that impact connectivity and isolation of habitat are mostly related to continuing development and conversion of native open space to non-native habitat types. Management strategies include the development of actions to mitigate the impact of loss of connectivity and increased fragmentation on native wildlife. The Channel Islands and remaining open space on Point Loma (Cabrillo NM & the PLER) are relatively immune to this stress. Habitat management strategies and ownership within the Channel Islands protects these islands from this source of impact. While the Point Loma Peninsula may be subject to expansion or construction of facilities related to military activities, additional fragmentation of the native habitat is not likely to increase. There is however the potential for a reduction in the patch size of some currently protected habitats on the peninsula.

1.3.4 Fire

Fire is a rare event on Point Loma. For nearly a century fire has been actively excluded. Only two fires have been documented on the peninsula in the 20th century (Zedler *et al.*, 1995). There is some concern by managers that the chaparral of the peninsula may be reaching a senescent condition, and that the mix of species is not representative of the dynamics of fire influenced chaparral that should exist there. This apparent dilemma is difficult to mitigate because fire will always be actively suppressed and prescribed fire, to restore natural vegetation cycling, is not presently an option available to managers.

Fire in the Channel Islands is also a very rare event. The maritime climate results in increased fuel moisture and cooler air temperatures than generally seen in nearby mainland areas. Fire starts from human activity or natural thunder storms are very rare in the islands. Fire is not the natural recurring process on the channel islands as it is on the mainland. Still, fire is one tool resource managers hope to use in restoring native vegetation displaced by non-native invasive plants.

In the Santa Monica Mountains fire is a natural and integral component contributing to the health and integrity of ecosystems dominated by chaparral, coastal sage scrub, savannah, and oak woodlands vegetation habitats. As a consequence of accidentally and deliberately started fires, the fire return interval in the much of the mountains, is greatly reduced from past conditions. This has resulted in type conversion of much native habitat to habitats dominated by non-native annual plant species. These areas are unlikely to ever return to more natural habitat without a significant restoration effort. Additionally, to protect life and private property in the mountains, fire is actively suppressed. This dichotomy of impact, from too much fire to too little fire, presents managers with a significant challenge in managing vegetation in the Santa Monica Mountains. Of specific interest to park managers is the possibility of employing prescribed fire to control the distribution of non-native invasive plants.

1.3.5 Marine

Cabrillo NM protects and manages one of the last relatively undisturbed marine intertidal areas in the San Diego area. Quality of the surrounding marine waters and the ecological integrity of the marine intertidal community have been concerns of local natural resource managers for many years and a long-term monitoring of intertidal resources began in 1990 with experience and methodology exported from Channel Islands National Park (Becker, 2003, Appendix B). The goals of this program are:

1. To collect long-term, baseline information on the “ecological health” of the rocky intertidal area, and to determine normal limits of variation.
2. To determine differences between three zones of controlled access, which experience very different amounts of visitation, and to determine the effects of the closure of Zone III to the public.
3. To be comparable and compatible with existing data and similar programs in southern California (*e.g.*, Channel Islands National Park and the Multi-Agency Rocky Intertidal Network [MARINE]).
4. To detect large changes in community structure reasonably quickly.
5. To provide baseline data in case of an acute disturbance (*e.g.*, oil spill or sewage spill), and to serve as an opportunity for public education and outreach.

The waters surrounding the Channel Islands contain a rich and diverse ecosystem which is the focus of long-term monitoring. Park waters support valuable commercial fisheries and significant impacts have resulted from exploitative harvest over the past century. Management authority over these resources resides with the state of California. Park managers have established long-term monitoring of the intertidal and subtidal communities in these waters to assist the state in developing strategies to ensure the perpetuation of these resources. Information gleaned to date has contributed to the establishment of 12 marine protected areas (MPA) in the islands where recreational and commercial take of marine species is prohibited. Continued monitoring will hopefully provide data to justify these MPAs and ensure their continued existence.

1.3.6 Non-native Invasive Species

Point Loma has been occupied by the U.S. military for much of its modern history. Relict coastal gun emplacements and bunkers from World War II are part of the landscape of Point Loma and Cabrillo NM. These patches of disturbance, their supporting infrastructure and access roads have facilitated significant invasions of non-native vegetation to the area. Efforts to restore these areas to native habitat are ongoing and play an important role in resource management activities for Cabrillo NM.

The introduction of non-native invasive species, both plant and animal, to the Channel Islands during periods of past human habitation has resulted in significant changes in the natural ecosystems and ecosystem processes on the islands. One of the major management practices within Channel Islands NP has been the removal of non-native species and the reintroduction of extirpated species in an effort to shift the islands ecosystems toward a naturally functioning and self-regulating condition. Past non-native species eradication programs have included the removal of rabbits from Santa Barbara Island, burros from San Miguel Island, sheep from Santa Cruz Island, pigs from Santa Rosa Island, and non-native rats from Anacapa Island. Eradication of feral pigs from Santa Cruz Island began in 2005. Elk, deer, and horses on Santa Rosa Island are being managed under a special use permit and will likely be removed by the end of 2011. Reintroduction of extirpated species is also underway. Bald eagles and peregrine falcons have been reintroduced to Santa Cruz Island, and the northern island tree mallow was recently reintroduced to the park.

Species of both plants and animals not native to the Santa Monica Mountains cause concern for the welfare of native species. Crayfish and non-native finfish introduced to mountain streams prey upon native fishes and the eggs, larvae and adults of native amphibians. Non-native invasive plant species pose significant concerns in fire scared areas, areas disturbed by development, and along riparian corridors. Additionally, decorative plants used for landscaping in developed areas also pose threats to native vegetation. Holding the line on the diversity, distribution and abundance of non-native species within the mountains is a major goal of park managers.

1.3.7 Urbanization & Development

In most national parks and reserves, land within the legislated boundaries is completely or nearly completely owned by the federal government and threats from internal development are nearly nonexistent. While 90% of Santa Monica Mountains NRA contains relatively undisturbed natural habitat, almost half of this area is privately owned. The greatest threats to natural resources within the park are impacts associated with transforming natural open space to a built environment including the direct loss of native habitat to housing, commercial uses, or agriculture, loss of habitat connectivity and reduction in patch size (*i.e.*, reduced foraging and protective cover), increased interactions among humans and wildlife (*i.e.*, road kill), increased frequency of fire, increased introduction of pollutants to water and air, ever encroaching urban-wildland interface, changes in surface hydrology with the importation of water for domestic uses, *etc*. Specific management concerns in the Santa Monica Mountains include understanding and mitigating the effects of urbanization and development on natural communities.

While it is very unlikely that any significant areas of open space on Point Loma will be developed, past development has fragmented the landscape and interrupted habitat connectivity. On a macro scale the impacts of this are quite obvious with the loss of several reptile and amphibians species and the isolation of some meso-carnivore species. The impacts of this fragmentation on smaller animal species and native vegetation is not understood but is of concern. Conversely, the islands of Channel Islands NP are completely protected from significant development by current legislation and policy. What landscape fragmentation and loss of connectivity that has occurred in Channel Islands NP is relatively limited and is the result of historic ranching activities which is, to a great extent, being mitigated by changing land use practices that are allowing disturbed areas to return to a more natural condition.

1.4 Mediterranean Coast Network Water Quality

Monitoring of water quality in network parks as part of the vital signs monitoring program is mandated by specific appropriations through the NPS Water Resources Division to I&M networks. The Mediterranean Coast Network receives approximately $75,000 each year to implement a water quality monitoring program within the parks of this network.

Park units of the Mediterranean Coast Network may be included in or are influenced by at least five USGS defined watersheds (Hydrologic Unit Code – HUC): Calleguas (HUC 18070103), San Diego (HUC 18070304), Santa Barbara Channel Islands (HUC 18060014), San Pedro Channel Islands (HUC 18070107) and Santa Monica Bay (HUC 18070104). Over 120 streams from these watersheds are listed as 303d impaired water bodies (see requirements of section 303 of the Clean Water Act [CWA]) by the State of California, No surface waters within these watersheds meet the criteria of the CWA to be identified as Outstanding Natural Resource Waters. The California 1998 305(b) (section 303, CWA) report indicates that 19% or less of all water bodies in the Santa Monica Mountains meet all designated uses (again a designation originating with the requirements of the Clean Water Act), there are insufficient data to categorize the water bodies of Channel Islands NP, and despite San Diego Bay's polluted status, 80% or more of the water bodies in the San Diego basin meet all designated uses. Each of the three parks of the network includes or is adjacent to significant marine waters. While no marine waters lie within the boundaries of the Santa Monica Mountains NRA, there are several significant coastal lagoons. Channel Islands NP lies within the Channel Islands Marine Sanctuary and nearly half of park lands are submerged. Coastal resources are a significant component of management priorities at Cabrillo National Monument. Of the 116 hectares of lands owned and administered by the NPS, 52 hectares are marine intertidal. Additionally, 2.25 km of coastline are managed by the NPS. The NPS also manages coastal resources 275 meters out from the shoreline at mean lower low water on the western side of Point Loma.

A survey of all water monitoring activities occurring within network parks and marine waters monitoring within one mile of the coasts of network parks was completed in 2004 (Appendix D). The focus was on identifying all agencies or organizations conducting water quality monitoring of value to network parks and to gather information about the parameters being monitored, the frequency of monitoring activities, sample collection and analysis methods, and data analysis and data storage procedures.

1.4.1 Cabrillo National Monument

Cabrillo NM is situated on the southern tip of Point Loma. To the east the park overlooks the mouth of San Diego Bay and the City of San Diego, and to the west it has an unobstructed view of the Pacific Ocean. San Diego Bay waters effectively wash the eastern flank of the park with each tidal cycle. Degraded benthic communities, sediment toxicity, dissolved copper, and coliform and enterococci bacterial contamination have resulted in 303d listing for the San Diego Bay Shoreline Point Loma Hydrological Area at the U.S. Navy Submarine Base, the Shelter Island Yacht Basin, at Kellogg Street, and at the Shelter Island Shoreline Park. All these locations are within a few kilometers of the Cabrillo National Monument eastern shoreline and the intertidal resources around Point Loma on the western side of the peninsula.

On the western side of Point Loma is the City of San Diego E.W. Blom Metropolitan Waste Water Treatment Plant. This is the primary waste water treatment facility for the City of San Diego and surrounding communities. Waste water is brought from a nearly 1200 km^2 area to this 16 hectare site which processes 720×10^6 L of waste water per day and deposits some 11,000 metric tons of suspended solids per year into the waters off Point Loma. National Pollutant Discharge Elimination System permitting for the Blom Waste Water Treatment Plant requires regular and extensive monitoring of offshore marine waters. These monitoring results are public information and readily available for review.

While there are several drainage channels within the management area for Cabrillo NM these contain flowing water for only a few hours after significant rainfall events. The geomorphology of Point Loma does not support any truly intermittent or perennial streams. There is an historic record of a pond on Point Loma but it was filled in many years ago. Because of its proximity to the Pacific Ocean, precipitation in the form of fog drip is quite common and a significant amount of ground water is present as indicated by several freshwater seeps along the heavily eroded coastline of Point Loma.

1.4.2 Channel Islands National Park

Surface water resources in Channel Islands NP include the Pacific Ocean, Santa Barbara Channel, Santa Cruz Channel, Anacapa Passage, San Miguel Passage, and numerous bays and coves. There are several perennial creeks on Santa Rosa and Santa Cruz Islands. San Miguel Island has a few streams that flow most of the year. These are spring fed and have standing water along much of their lengths throughout the year. There are also many low-flowing perennial springs throughout the park (Kate Faulkner, personal communication). Very little if any marine water quality data exist for the park. From 1983 through 1994 some 2,000 observations for 14 separate parameters were collected from 15 freshwater monitoring stations located within the park's boundaries. Eleven stations were located on Santa Rosa Island and four stations on Santa Cruz Island. Eight of these stations were monitored only once or if monitored several times it was done in a single calendar year. Seven stations on Santa Rosa Island were sampled in more than one year.

State Water Quality Protection Areas (SWQPA) have been established by the California Water Resources Control Board in the waters surrounding San Miguel, Santa Rosa, and Santa Cruz Islands. SWQPAs are areas where alteration of natural water quality would jeopardize biological communities. Because water quality is threatened by new or expanding land uses, these same areas have also been designated as Critical Coastal Areas (CCA) by the State of California.

Since 1993, Channel Islands NP has been monitoring water quality at a number of locations within the Lobo, Water, and Quemada drainages on Santa Rosa Island. Water quality in these drainages reflects the lack of a functioning riparian community and other impacts from past cattle grazing. Cattle were removed from Santa Rosa Island in 1998 and substantial improvement in water quality and riparian vegetation has been observed.

1.4.3 Santa Monica Mountains

The aquatic resources of the Santa Monica Mountains are very diverse and support a variety of sensitive plant and animal communities. Dozens of north-south canyons parallel each other throughout the mountains. Each of these has an intermittent or perennial stream, with an associated riparian corridor, and there are numerous east-west trending drainages coming down the slopes of these canyons. Across the Santa Monica Mountains Zone (a region that extends beyond the recreation area boundary to include all watersheds that are within or partly within the recreation area) there are a total of 828 stream segments, including 179 major streams with 49 coastal outlets.

The largest watershed within the recreation area is the 270 km^2 Malibu Creek watershed which incorporates several major drainage basins (Medea Creek, Triunfo Creek, Cold Creek, and Malibu Creek; and Sleeper, Las Virgenes, and Potrero Valleys). Conversely, the smallest stream courses in the Santa Monica Mountains are in isolated drainages which comprise 17% of all streams in the Santa Monica Mountains.

Runoff originating from developed areas (*e.g.*, roads, parking lots, and residential and commercial development) has placed significant pressures on existing fresh water resources This runoff has actually increased the flow and duration of flow in many mountain streamd. The now perrenial availability of water in formerly intermittent streams has in turn facilitated the persistence of a variety of introduced aquatic fauna, some of which inpact sensitive native communities (Riley et al., 2005; cf. Kats & Ferrer, 2003). Aditionally, runoff from developed areas contains elevated levels of nutrients (such as phosphorous and nitrogen), pathogens, toxicants (*e.g.*, heavy metals), and litter and trash. It is critical to identify and monitor the consequences of these impacts on the condition and quality of water resources in the Santa Monica Mountains. Within the Santa Monica Mountains from Pt. Mugu to Santa Monica Canyon there are nine streams, four lakes, and one lagoon listed as impaired on the state's 303d list (Table 1.1).

Numerous ongoing water quality monitoring efforts are being conducted in the mountains. Often they are independent projects with very little interagency coordination. For example, in the Malibu Creek watershed alone (Review of Monitoring and Response Protocol for the Malibu Creek Watershed, 1994) there are 42 surface water and sediment monitoring groups and over 70 ground water monitoring wells. Some samples are analyzed for a complete suite of chemical constituents ranging from conventional pollutants to organic chemicals, pesticides, bacteria and viruses while others have a more limited scope of analysis. The network is examining opportunities to partner with or to at lest coordinate efforts with other agencies and stakeholders monitoring water quality within the Santa Monica Mountains.

A State of California initiative that promises to be of great value to the Santa Monica Mountains is the Surface-Water Ambient Monitoring Program (SWAMP). SWAMP is a statewide monitoring effort designed to assess the conditions of surface waters throughout the state of California. The program is administered by State (California)

Table 1.1 303d listed water bodies in the Santa Monica Mountains National Recreation Area that are included in the Santa Monica Bay Watershed and their reason for listing.

Water Body Name	Impairment:
Lake Lindero	Selenium, Algae, Chloride, Eutrophication, Odor, Specific Conductance, Trash
Lake Sherwood	Mercury, Algae, Ammonia, Eutrophication, Organic Enrichment/Low Dissolved Oxygen
Westlake Lake	Chlordane, Algae, Ammonia, Eutrophication, Organic Enrichment/ Low Dissolved Oxygen, Copper, Lead
Malibu Lake	Chlordane, Algae, PCBs, Eutrophication, Organic Enrichment/Low Dissolved Oxygen, Copper
Malibu Lagoon	Benthic Impacts, Enteric Viruses, High Coliform, Eutrophication, Shellfish Harvesting Advisory, Swimming Restriction
Malibu Creek	Fish Barriers, Algae, High Coliform, Scum/Foam, Trash
Las Virgenes Creek	Selenium, Algae, High Coliform, Organic Enrichment/Low Dissolved Oxygen
Lindero Creek Reach No. 1	Selenium, Algae, High Coliform, Scum/Foam, Trash
Lindero Creek Reach No. 2	Selenium, Algae, High Coliform, Scum/Foam, Trash
Medea Creek Reach No. 1 (Lake to Confluence with Lindero Creek)	Selenium, Algae, High Coliform, Trash
Medea Creek Reach No.1 (Above Confluence with Lindero Creek)	Selenium, Algae, High Coliform, Trash
Palo Comado Creek	High Coliform
Santa Monica Canyon	Lead, High Coliform
Stokes Creek	High Coliform
Topanga Canyon Creek	Lead
Triunfo Canyon Creek Reach No. 1	Lead, Mercury
Triunfo Canyon Creek Reach No. 2	Lead, Mercury

Water Resources Control Board. Responsibility for implementation of monitoring activities resides with the nine Regional Water Quality Control Boards (RWQCB) that have jurisdiction over their specific geographical areas of the state. Monitoring is conducted in SWAMP through the Department of Fish and Game and U.S. Geological Survey master contracts and local RWQCB monitoring contracts.

SWAMP also hopes to capture monitoring information collected under other State and Regional Board Programs such as the State's TMDL (Total Maximum Daily Load), Nonpoint Source, and Watershed Project Support programs. SWAMP does not conduct effluent or discharge monitoring which is covered under National Pollutant Discharge Elimination System permits and Waste Discharge Requirements.

The SWAMP program will monitor some 33 streams within the Santa Monica Mountains once in the next two years. If funding continues, the SWAMP program will repeat this monitoring every two years. A significant opportunity exists for the network to partner with the SWAMP program in either adding sampling locations or to conduct repeated monitoring in selected streams in the off-year for a particular stream. Target contaminates identified for testing under the SWAMP program include: Trace Organic Chemistry, Trace Metal Chemistry, Conventional Water Chemistry, Bacteriology and Pathology, Biological Assessment, Toxicity Testing, and Fresh Water Origin.

1.5 Mediterranean Coast Network Air Quality

The quality of the air in the parks of the Mediterranean Coast Network is affected by human caused air pollution from the Los Angeles basin and the San Diego metropolitan area. This condition is ameliorated somewhat by the prevailing westerly winds that continually push and concentrate polluted air to the east away from network parks. Still the risk of foliar damage to vegetation from ozone in the parks of the Mediterranean Coast Network is quite high. Nutrient accumulation from atmospheric deposition seems to be of minor consequence to the parks of the Mediterranean Coast Network.

Several air quality monitoring agencies have jurisdiction over air quality issues in the parks of the Mediterranean Coast Network. These include the California Air Resource Board, the South Coast Air Quality Management District, the Ventura County Air Pollution Control District, and the County of San Diego Air Pollution Control District. With the exception of two ozone monitoring stations, one on Santa Rosa Island and one on Santa Cruz Island, and a visibility monitoring station in Cabrillo NM, air quality monitoring stations in the region are all located outside of park boundaries.

While visibility data are being collected on a regular basis in Cabrillo NM no analysis of these data are being done at the present time. Specific air quality issues and risk of air quality caused degradation of the resources at Point Loma are currently under evaluation by the Air Resources Division of the National Park Service. At least one air-pollution sensitive lichen, *Evernia prunastri* (California Spanish moss or Oakmoss lichen), has disappeared from Cabrillo NM since the 1960s. *E. prunastri* is known to be sensitive to sulphur dioxide, fluoride, and Ozone/PAN (peroxyacetyl nitrate) (Bratt, 1994).

1.6 Need for Monitoring

The parks of the Mediterranean Coast Network include some of the most significant examples of terrestrial Mediterranean-type ecosystems and coastal marine environments anywhere in the world. At the same time, the parks are embedded in the highly developed and rapidly expanding southern California metropolitan area. Consequently, each park experiences numerous ecological threats, including introduction of non-native invasive species, declining fresh and marine water quality, fragmentation of habitat, altered fire regimes, and many others. Amid these challenges, park managers must strive to understand and protect natural resources in order to leave them unimpaired for future generations to appreciate and enjoy (Organic Act of 1916, 16 United States Code 1 § 1). To accomplish this mission, it is imperative to identify ecological threats and stressors, including those originating from outside park boundaries, understand the condition of extant resources, determine the pathways of impacts from stressors, and evaluate the effects of stressors on natural resources. As a result, long-term monitoring is necessary to provide data on resource status and trends, identify potential mechanisms of resource change, and suggest research activities or management actions required to help clarify understanding and mitigate resource impacts (Fig. 1.5). For all of these reasons, the network parks have embarked on a comprehensive long-term monitoring program to measure the status and trends of selected ecosystem components.

The relationship between effective resource monitoring, scientific research, and park management activities was formally recognized by Congress in the National Parks Omnibus Management Act of 1998. In this act the Secretary of the Interior is charged with developing 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." This information when coupled with research on resource impacts, provides powerful data to support science-based management of national parks. In addition, the importance of monitoring resource condition and trends by federal agencies has been a Congressional priority for some time. Federal laws such as the Endangered Species Act, Clean Water Act, Marine Mammal Protection Act, National Environmental Policy Act, and others[5] all point to the need to understand resource conditions and trends to support effective management decision making.

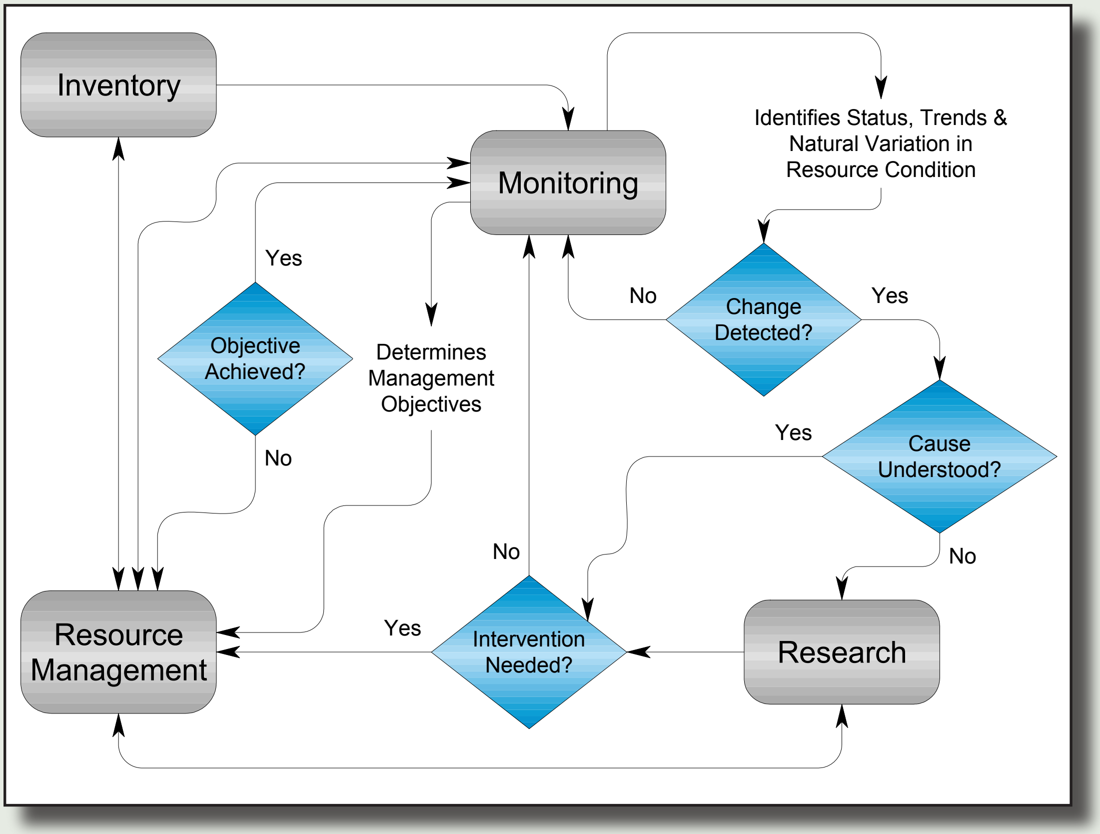

Figure 1.5 Relationships among monitoring, resource inventories, research, and natural resource management in national parks (after Jenkins *et al.*, 2002).

Consistent with these managerial and legislative requirements, the National Park Service Inventory and Monitoring Program has developed a comprehensive set of guidelines for parks and park networks to use for developing and implementing effective long-term resource monitoring activities. In particular, the Inventory and Monitoring Program strives to, "Chart a course and provide leadership and information needed by the National Park Service to preserve and protect the natural resources placed under its trust…." (NPS Director's Order 75). Specific to monitoring, the national program has developed a set of goals to guide development of park and network monitoring programs:

1. Determine 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.

Using this guidance the Mediterranean Coast Network vital signs monitoring program has been developed to help understand, interpret and respond to changes in condition of the resources within and surrounding network parks.

1.7 Park Specific Monitoring Goals & Objectives

While this document focuses on the development of a network monitoring program, the individual parks of the Mediterranean Coast Network have long recognized the critical need to monitor resources within their respective units. In some cases, monitoring needs have been specific to particular resource issues or concerns, while in other instances, park-specific monitoring goals are broader, identifying the general importance of monitoring resource status and trends. For example, the Resource Management Plan for Cabrillo NM (1998) identifies the proposed expansion of the Blom Wastewater Treatment Plant, a close neighbor on the western shore of Point Loma, as the most significant outside threat to park resources and as such proposes to establish a long term monitoring program for marine water quality in the park. Additional primary resource management concerns that would benefit from long term monitoring include the condition of the coastal sage scrub vegetation that dominates the park landscape and the status of tide pool communities in the park. Other monitoring-related resource concerns identified in the 1998 plan for Cabrillo include:

1. Monitoring air quality for impacts on viewshed deterioration,
2. Eliminating, where possible, non-native vegetation from the park (particularly ice plant in sensitive coastal sage scrub vegetation),
3. Monitoring soil erosion and developing mitigation plans to conserve soil resources,
4. Developing interagency plans for the management of sensitive ecological resources within the Point Loma Ecological Reserve, and
5. Monitoring visitor use patterns and their impacts on natural resources within the park.

The Channel Islands NP Resource Management Plan (1999) is based on a long-range resource management perspective but includes specific tactical plans for short-term projects to meet long-range needs. The plan “Identifies and describes specific inventory, monitoring, research, restoration, and mitigation actions … needed to perpetuate natural processes and resources … in Channel Islands National Park.” A general goal of resource management and the monitoring program is to restore the terrestrial ecosystem to a condition reminiscent of the period before European settlement of the islands (National Park Service, 1999). Specific monitoring goals from the plan include:

1. Knowing and understanding the status and trends of resources, natural processes, and threats to resource integrity,
2. Restoring impaired resources and processes,
3. Protecting resources from harm, and
4. Partnering with agencies, organizations, and individuals to better achieve the park mission.

The Santa Monica Mountains National Recreation Area Resource Management Plan (1999) also identifies the need for long-term monitoring, specifically stating that the “first goal of the park’s resource stewardship program (is) to obtain knowledge and understanding of (the) natural … resources.” The plan states further that “It is critical for park managers to evaluate trends in resource conditions over time,” and that the way to meet this objective is to “identify vital signs of ecosystem condition and monitor them to detect potentially important changes over time.” Specific monitoring goals identified in the Santa Monica Mountains plan include:

1. Determining the status and trends of ecosystem health,
2. Establishing empirically normal ranges of variation of ecosystem resources,
3. Providing early diagnosis of abnormal conditions that require intervention, and
4. Identifying potential agents of abnormal change to guide research and prescribe treatments.

1.8 Previously Established Monitoring Efforts in the Mediterranean Coast Network

Consistent with the resource values and recognized ecosystem threats, and the acknowledged need to monitor resource condition and trends for better management decision making, parks in the Mediterranean Coast Network have already begun establishing inventory and monitoring programs in their respective units, subject to the availability of staff, funds and partnership opportunities. The most significant effort has been in Channel Islands NP, which was identified in the early 1980s as one of several Prototype Monitoring Parks across the National Park System. Much smaller inventory and monitoring efforts were also pursued at Cabrillo NM and Santa Monica Mountains NRA.

As a National Park System “prototype monitoring park,” Channel Islands NP was provided specific funds to develop and implement a comprehensive ecosystem monitoring program. Prototype monitoring programs were established at several national parks as part of a conscious effort by the NPS to establish monitoring as a foundation for science-based stewardship in national parks (Gary E. Davis, personal communication, see Appendix A). This process began with the identification of ten biome-related groupings of national parks from which "prototype" monitoring programs would be established. Channel Islands NP was selected to develop monitoring protocols for west-coast marine and southern California terrestrial ecosystems.

Development of the Channel Islands NP prototype monitoring program instituted the concept of "vital signs" monitoring (Davis, 2005). The notion of ecosystem vital signs was derived from the medical model where established characteristics of functioning physiological processes in human patients can be easily measured to provide an indication of the overall health of the patient (Davis, 2005). A population dynamics monitoring approach was selected for identifying Channel Islands NP vital signs over monitoring that might emphasize energy flux, biodiversity, or nutrient budgets (Davis *et al.*, 1994), and vital signs were selected from among the five categories of species inhabiting the park:

1. Common species that dominate community structure,
2. Species with legal status, *e.g.*, designated endangered species,
3. Park or island endemic species,
4. Non-native species, and
5. Heroic, charismatic species with current human constituencies (Davis, 2005).

Identifying threats to park resources such as fishing, grazing, and habitat fragmentation; air and water pollution; invasions by non-native species; and loss of soil and vegetation shaped the monitoring program at Channel Islands NP. Even before selection as an NPS prototype-monitoring park, Channel Islands NP had a relatively well-developed marine monitoring program in place. Park monitoring has directly led to many management actions including creation of harvest limits and fisheries closures for abalone and other marine species and non-native species eradication efforts. Data derived from kelp forest monitoring have been instrumental in guiding coastal use regulations for the State of California and in providing a reliable data baseline for use in identifying changes in similar habitats associated with unprotected areas. The recent precipitous decline in the island fox population that was documented through their monitoring program led Channel Islands NP resource managers to quickly implement a multifaceted program to prevent extinction of this species.

While monitoring of biological resources at Channel Islands has centered on population dynamics of living resources, collecting air quality and climate data has been an integral part of the monitoring program. As critical drivers of vegetation community dynamics, data from monitoring climate and air quality play a significant role in interpreting monitoring data from other park resources.

The experiences and expertise from Channel Islands NP helped catalyze monitoring efforts at Cabrillo NM. For example, technical assistance was provided by Channel Islands NP to develop an intertidal monitoring program. Consequently, since 1990 the condition of tide pools adjacent to Cabrillo NM have been monitored, with much of the work performed by volunteers. Significant declines in several indicator species led the park to restrict public access to ⅓ of the beach area of the tide pools. As a direct result of the information gained through the tide pool monitoring program, the public has supported this otherwise controversial decision.

In the 1994, USGS scientists working at Channel Islands NP began a program to inventory and monitor the plant communities at Cabrillo NM and on the Point Loma peninsula. Initially, this program was established to develop a plant species list (including herbarium vouchers) for the park. In conjunction with the development of the plant species list, a long-term vegetation monitoring program was implemented to track changes in vegetation community diversity. This monitoring program generally parallels the protocols developed at Channel Islands NP, focusing specifically on habitat types at Cabrillo NM, including coastal sage succulent scrub, southern maritime chaparral (C*eanothus verrucosus*), lemonade berry (*Rhus integrifolia*), cactus, and disturbed areas. Depending upon winter rainfall, sampling is conducted once every three to five years.

Systematic long-term monitoring of reptiles and amphibians has been conducted for up to ten years on Point Loma (Atkinson *et al.,* 2003). Historically (through the 1930s), 19 species of reptiles and amphibians occurred on the peninsula. Six of these are now considered sensitive at the state or federal level. In 1995, herpetofauna inventories were initiated on Point Loma by Robert Fisher of the USGS and Ted Case of the University of California at San Diego utilizing 17 arrays of pitfall traps and drift fences. Data collection from 1995 through 1999 established baseline data for converting this inventory program to long term monitoring in 2000 (Fisher & Case, 2000).

The nature of land ownership within the Santa Monica Mountains NRA has demanded a unique and aggressive natural resource science and resource management program. Fragmentation of habitats, habitat type conversion, and the introduction of non-native invasive species through expanding residential development have long been recognized as major threats to park resources. Species at particular risk include sensitive plant communities, rare, threatened, and endangered plant and animal species, and species especially vulnerable to urban encroachment and habitat fragmentation effects, including certain reptiles and amphibians, and mammalian carnivores. In the last decade, Santa Monica Mountains NRA science and resource management programs have focused on gathering baseline information on park natural resources, developing long-term monitoring strategies for critical at-risk resources, and building relationships with local academic researchers and agency resource managers to further science and resource management objectives. More recently, with grant funds and funding from the NPS, Santa Monica Mountains NRA has been able to implement some high-priority monitoring efforts consistent with national inventory and monitoring goals. The multi-agency management of the Santa Monica Mountains has also provided numerous opportunities for partnerships and cooperation in resources studies and ecosystem monitoring. For example, monitoring of natural resources being done by stakeholders in the Santa Monica Mountains includes surface water quality by local and state water regulatory agencies, stream water quality in the Malibu Creek watershed by Heal the Bay, and a cooperative effort to assess aquatic herpetofauna in streams by the NPS, Pepperdine University and the Resource Conservation District of the Santa Monica Mountains.

1.9 Renewing the Commitment: Vital Signs Monitoring in the Mediterranean Coast Network

In 1999, the NPS began the Natural Resource Challenge, a multiyear program created by Congress to improve management and protection of natural resources in the national park system. As part of the Natural Resource Challenge, substantial new funding became available to accelerate biotic inventories and to develop a new approach to ecosystem monitoring in national parks. The new approach embraced the concept of ecosystem vital signs to guide the development of long-term monitoring efforts in parks and networks of parks. The addition of funds provided the opportunity for implementation of vital signs or ecosystem monitoring efforts to expand servicewide, building from the existing and far more intensive efforts already established in selected prototype monitoring parks. Based on the new approach, the Mediterranean Coast Network has embarked on a comprehensive effort to identify, prioritize, select, develop protocols for and monitor vital signs of ecosystem condition at network parks. This renewed effort and support complements the prototype monitoring already established at Channel Islands NP and, as appropriate, will augment inventory and monitoring efforts underway at Cabrillo NM and Santa Monica Mountains NRA. The hallmark of the renewed monitoring approach is a clearly specified process for identifying, selecting and ultimately monitoring particular vital signs.

As defined by the NPS Inventory and Monitoring Program, vital signs are "… 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"[6]. Under this definition, vital signs may include a wide variety of ecosystem elements and processes, including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources. Vital signs may also be selected from any level of organization, from genetic to landscape features.

Beginning in 2000, networks of parks began identifying and prioritizing their ecosystem vital signs, and ultimately selecting subsets for long-term monitoring. For the Mediterranean Coast Network, efforts have been focused on designing a program to identify and monitor, on a long-term basis, network vital signs not already addressed through the existing prototype program at

Channel Islands NP and the related park-based monitoring at Cabrillo NM. The network began with a series of discussions with park resource managers, and a review of park general and resource management plans. Following this, a series of workshops and discussion groups were organized to bring together subject matter experts from the National Park Service, state and federal agencies with stewardship over natural resources, and other interested stakeholders to identify significant ecosystems drivers and stressors, and to review current management activities that could help determine the course of monitoring at network parks. Conceptual models of ecosystem function were developed, and key vital signs were identified with reference to the conceptual models. After top priority vital signs were selected, more detailed monitoring objectives, sampling plans, data management, analysis, and reporting procedures, and program administration details were considered. The details of all of these activities and the resulting vital signs monitoring plan for the Mediterranean Coast Network are fully described in the remaining chapters of this report.

End Notes:

[1] http://www.dfg.ca.gov/whdab/html/cnddb.html
[2] US Coast Guard, NPS, US Fish & WIldlife Service, Dept. of Veterans Affairs, & the Point Loma Naval Cmplex
[3] http://www.cinms.nos.noaa.gov/marineres/map.htm
[4] http://www.nps.gov/chis
[5] http://science.nature.nps.gov/im/monitor/LawsPolicy.htm
[6] http://science.nature.nps.gov/im/monitor/glossary.htm

Chapter 2: Conceptual Ecological Models

Identifying vital signs of ecosystems' health or condition must be related to a well-understood and generally accepted conceptual understanding of the system to which (they are) applied

National Research Council, 2000; Jackson *et al.*, 2000; Cairns *et al.*, 1993

An ecosystem conceptual model is a visual or narrative summary that identifies the important components of an ecosystem and describes the interactions among those components. Development of a conceptual model helps in understanding how the diverse elements of a monitoring program might interact, and promotes integration and communication about the ecosystem to be monitored among scientists and resource managers from different disciplines.[1] Well designed conceptual models formalize current understanding of system processes and dynamics, identify linkages between or among ecosystem processes across disciplinary boundaries, and identify the bounds and scope of the system of interest. Conceptual models are a critical tool in the development of a monitoring program.

2.1 Channel Islands Prototype Monitoring Conceptual Model

Planning for the Channel Islands prototype monitoring program began in the early 1980s. Factors such as the islands ecological setting, biological resources (populations and communities), environmental forces (climate and ocean currents), land forms (islands and ocean basins), management issues, and the park's legal purpose were evaluated to determine the function, and thereby the structure, of the prototype monitoring program at Channel Islands NP (Davis, 2005).

Major issues that focused this monitoring program and that were considered driving mechanisms of the Channel Islands ecosystems included:

- Unsustainable fishing, destructive grazing, and disturbance by visitors;
- Habitat fragmentation, including loss of nearby mainland habitat and island erosion;
- Air and water pollution, and loss of fog-drip precipitation; and
- Invasive non-native species, such as the seaweeds *Undaria pinnatifida*, *Sargassum muticum*, and *Caulerpa taxifolia*, and feral pigs, sheep, and rabbits.

A park-wide conceptual model was developed to capture these influences and included descriptions of the park's biological features, environmental setting, and its environs and the identification of specific issues or elements that contribute to the integrity of the island ecosystems (Table 2.1).

A channel islands ecosystem cartoon was prepared for displaying ecosystems elements and processes visually (Figure 2.1). This process has been promoted by the Center for Environmental Science at the University of Maryland. While every element of the narrative conceptual model for the Channel Islands (Table 2.1) is not depicted in the cartoon, sufficient numbers of elements are presented to provide a feeling for the dynamic processes interacting in the islands that have the potential to significantly alter the natural integrity of island ecosystems. This model provided the conceptual framework for identifying and prioritizing the ecosystem attributes to be monitored for the Channel Islands NP prototype monitoring program.

2.2 Ecosystem Conceptual Models

The Mediterranean Coast Network began development of a general model of ecosystem functional relationships for the southern California Mediterranean-type ecosystem by synthesizing information obtained from published literature, workshop discussion groups, park resource managers, and academic subject matter experts. This information was compiled into a summary of ecosystem drivers and stressors and the potential

Table 2.1 Summary of major elements of the Channel Islands NP conceptual ecological system model used to design the monitoring program that began in 1980 (Davis, 2005).

Mediterranean-type ecological system
Warm, dry summers (10-35 ºC, trace precipitation)
Cool moist winters (0-20 ºC, 30-40 cm precipitation)
Spring and summer coastal fog
Fall and winter continental winds—Santa Anas
Two biogeographic provinces
Warm-temperate Californian
Cool-temperate Oregonian
Transition Zone
Islands
Large (20,000-22,000 ha)
Medium (5,000 ha)
Small (260-300 ha)
Perennial streams
Diverse shoreline—sea cliffs, beaches, sand dunes, and sea caves
Ocean
Persistent oceanic upwelling and strong south-flowing California Current nearby
Confluence of warm (14-22 ºC) and cool (10-16 ºC) inshore ocean currents
El Niño-La Niña and decadal climatic oscillations
Biological features
Island plant communities—pine forests, oak woodland, coastal scrub, grassland
Island plant populations—endangered, threatened, and endemic species
Island animals—mammals, herpetofauna, birds, and invertebrates
Lagoon and estuarine communities
Sand beach community
Rocky intertidal communities
Kelp forests—algae, invertebrates, and fishes
Human influences
Regional pollution, *e.g.*, DDT, PCBs, ozone
Grazing
Fishing
Offshore petroleum extraction
Invasive non-native species
Park visitors

effects of those stressors on natural elements of this ecosystem (Table 2.2).

In this context, ecosystem drivers are forces or conditions either intrinsic or extrinsic to an ecosystem that have large scale influences on the processes or components of an ecosystem. These can include, for example, land-use changes, consumptive extraction of resources, climate, fire, earthquakes, *etc.* Five primary categories of drivers were identified for the Mediterranean Coast Network park ecosystems: parent materials, climate, fire, anthropogenic drivers, and biological processes. Ecosystem stressors—significant activities, actions, events, or processes that can alter the organizational properties or integrity of ecosystems—within Mediterranean-type ecosystems were identified for the five categories of drivers. Ecological effects are the measurable components of the ecosystem that are most responsive to the effects of drivers and stressors and that could be quantified and monitored over time.

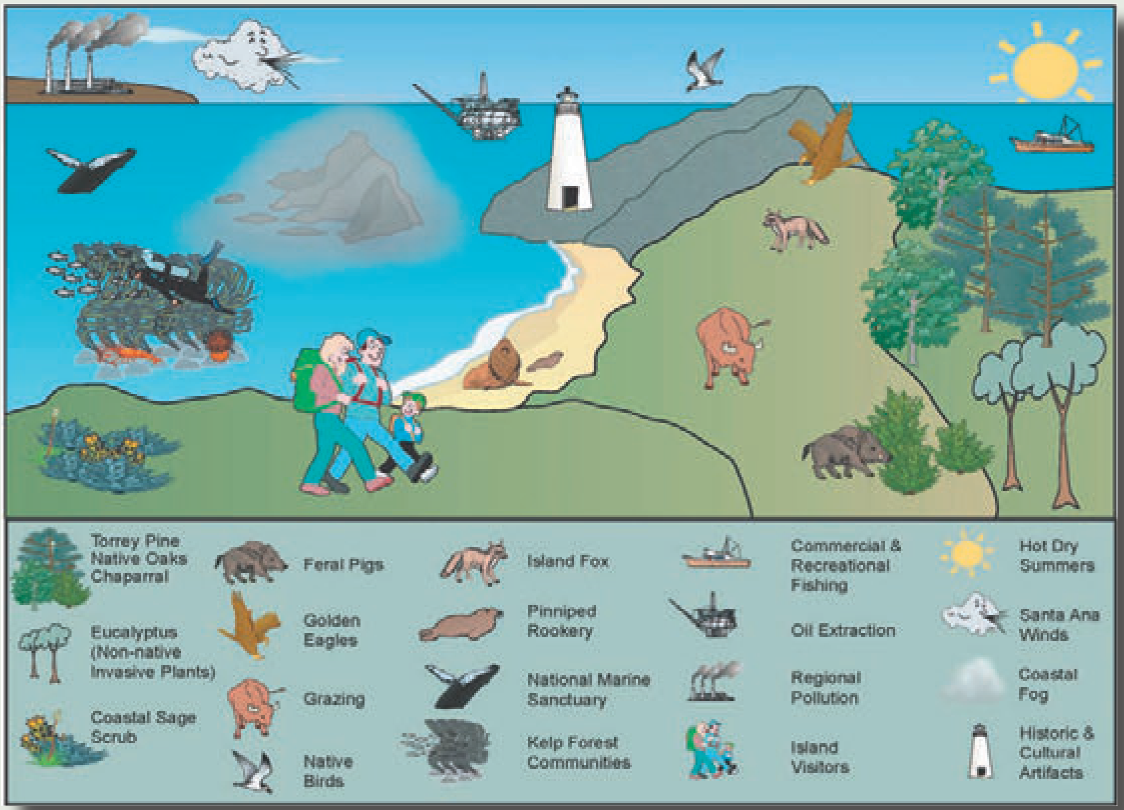

Figure 2.1 Cartoon representation of significant drivers, stressors, and ecosystem components of Channel Islands NP.

The model focused on the resources and perspectives of the Santa Monica Mountains for several reasons. First (except for water quality), no new monitoring would be proposed for the Channel Islands. Secondly, of the three parks in the network Santa Monica Mountains NRA most generally represents the diverse array of drivers, stressors, and ecological effects characteristic of the Mediterranean-type ecosystem of southern California. And third, of the two parks where new monitoring is to be implemented (Cabrillo NM and Santa Monica Mountains NRA), Santa Monica Mountains NRA is approximately 200 times larger than Cabrillo NM.

This first model, which is simply lists of major influences (drivers and stressors) and effects, was then translated into a generalized block and arrow graphic model to better illustrate connections, relationships, and interactions among the elements of the southern California Mediterranean-type ecosystem identified in Table 2.2 (Figure 2.2).

The interrelationships of the physical components of the ecosystem, including geomorphology, hydrology, climate, and air, are included in the model, as are some wildlife elements of concern. The effects of urbanization are extremely important, affecting all components of the system in one way or another. Non-native invasive plants are highlighted and are a significant influence on native vegetation communities and wildlife. Fire, while standing basically alone in the model, is probably the single major factor determining the structure of vegetation communities in the Santa Monica Mountains (Moreno & Oechel, 1994; *cf.* Trabaud, 1994).

From this general model, detailed sub-models were produced to capture and communicate, on a finer scale, expert knowledge related to ecosystem elements that would be directly related to the vital sign selection process. A selection of these detailed models can be seen in Figures 2.3 & 2.4 below. To capture the significant components of the marine intertidal that were important in developing a list of candidate vital signs for Cabrillo NM, a marine sub-model was developed for the Point Loma peninsula (see Figure 2.5). The complete array of sub-models are included in Appendices H, I, & J.

In the block and arrow models, major components of are grouped by color: anthropogenic drivers and stressors are gray; water, air and climate are generally dark blue; geological resources and associated processes are brown; vegetation resources and associated ecosystem processes are in various shades of green; fire is in red; vertebrates and invertebrates are in light blue, and non-native invasive plants are in a mixture of orange/red. Where possible these color relationships are carried throughout all the various sub-models. Where there is an interaction of model elements, blocks are a mixture of the colors indicating the interaction of factors.

Table 2.2 Summary of ecosystem drivers, stressors, and general ecological effects aggregated within structural or functional elements of Mediterranean-type ecosystems as proposed for the National Park Service units of the Mediterranean Coast Network (Cabrillo National Monument, Santa Monica Mountains National Recreation Area, and Channel Islands National Park.) Ecological effects may be processes or unique constituents of process or elements listed below. The process of identifying vital signs isolated specific measurable elements to address the driver – stressor – effects process.

Ecosystem Drivers	Ecosystem Stressors (Agents of Change)	General Ecological Effects (Response, Things Affected)
Parent Materials (Geology)		
• Geology • Soils • Topography • Geological Change • Hydrology	♦ Erosion ♦ Land Form Changes ♦ Urban Development ♦ Seismic Events ♦ Extreme Storms (Precipitation)	▪ Sediment & Nutrient Transport ▪ Toxic Materials Transport & Accumulation ▪ Water Budget ▪ Water Quality ▪ Mass Wasting ▪ Geologic Stability ▪ Altered Soils Structure ▪ Vegetation Community
Climate (Weather)		
• Precipitation • El Niño • Climate Change (Temperature) • Fog • Ocean Currents	♦ Flood ♦ Drought ♦ Winds ♦ Solar Radiation ♦ Erosion ♦ Temperature Change ♦ Global Climate Change	▪ Mass Wasting ▪ Altered Soils Structure ▪ Vegetation Habitat Type ▪ Non-native invasive Propagule Transport ▪ Fire Susceptibility
Fire		
• Fire Return Interval • Fire Seasonality • Fire Intensity	♦ Decreased Intensity* ♦ Increased Intensity* ♦ Altered Fire Return Interval ♦ Altered Timing of Fire Starts ♦ Fire Suppression ♦ Prescribed Burning	▪ Community Structure ▪ Colonization & Dispersal of Non-native invasives ▪ Native Community or Population Genetics ▪ Water Budget ▪ Water Quality ▪ Seed Bank Structure ▪ Vegetation Community Type

Table continued on next page

Table 2.2 continued

Ecosystem Drivers	Ecosystem Stressors (Agents of Change)	General Ecological Effects (Response, Things Affected)
Other Impacts†		
• Land Use Conversion • Urbanization • Direct Human Contact	♦ Recreational Use ♦ Consumptive Use ♦ Light Pollution ♦ Water Pollution ♦ Air Pollution ♦ Hazard Fuel Reduction ♦ Increased Fire Frequency ♦ Introduction of Horticultural & non-Horticultural Non-native invasives ♦ Habitat Loss ♦ Habitat Fragmentation ♦ Pesticide & Fertilizer Use ♦ Urban Irrigation ♦ Habitat Disturbance ♦ Grazing by Introduced Species ♦ Roadway Mortality ♦ Noise/Disturbance from Aircraft ♦ Noise Pollution ♦ Domestic Animals ♦ Wild Animal Control ♦ Resource Harvesting	▪ Native Community Structure ▪ Colonization & Dispersal of Non-native invasives ▪ Native Community & Population Genetics ▪ Water Budget ▪ Toxic Materials Accumulation ▪ Species or Community Specific Habitat Structure & Composition ▪ Vegetation Community Type ▪ Migration & Dispersal ▪ Water Quality ▪ Air Quality ▪ Visibility ▪ Wildlife Survival & Reproductive Success ▪ Species Loss ▪ Disease ▪ Wildlife Behavioral Changes ▪ Resource (Food) Availability ▪ Altered Hydrology
Biological Processes		
• Succession (Community Dynamics) • Evolution • Species Range Dynamics	♦ Dispersal ♦ Invasion ♦ Hybridization ♦ Natural Selection ♦ Extirpation ♦ Drift ♦ Disease ♦ Native Richness & Diversity ♦ Non-native invasive Richness & Diversity ♦ Competition ♦ Predation ♦ Dispersal ♦ Herbivory	▪ Habitat Type Conversion ▪ Genetic Change ▪ Community Structure ▪ Predator/Prey Dynamics ▪ Population Dynamics

*Beyond the range of normal variation.

†These impacts may act directly on natural resources or may act in concert with other natural drivers.

2.3 Ecosystems Drivers

2.3.1 Geology (Parent Materials)

Geologic factors can strongly affect the distribution and abundance of vegetation types within the Mediterranean ecosystem of southern California (Figure 2.3). Soil volume, depth to bedrock, bedrock fracturing, slope, aspect, soil structure, and erosivity are just a few of the geologic or parent materials features that can determine vegetation community structure. These features when interacting with climate (rainfall), ground water, springs, seeps, and water storage capacity are significant determinants of plant community

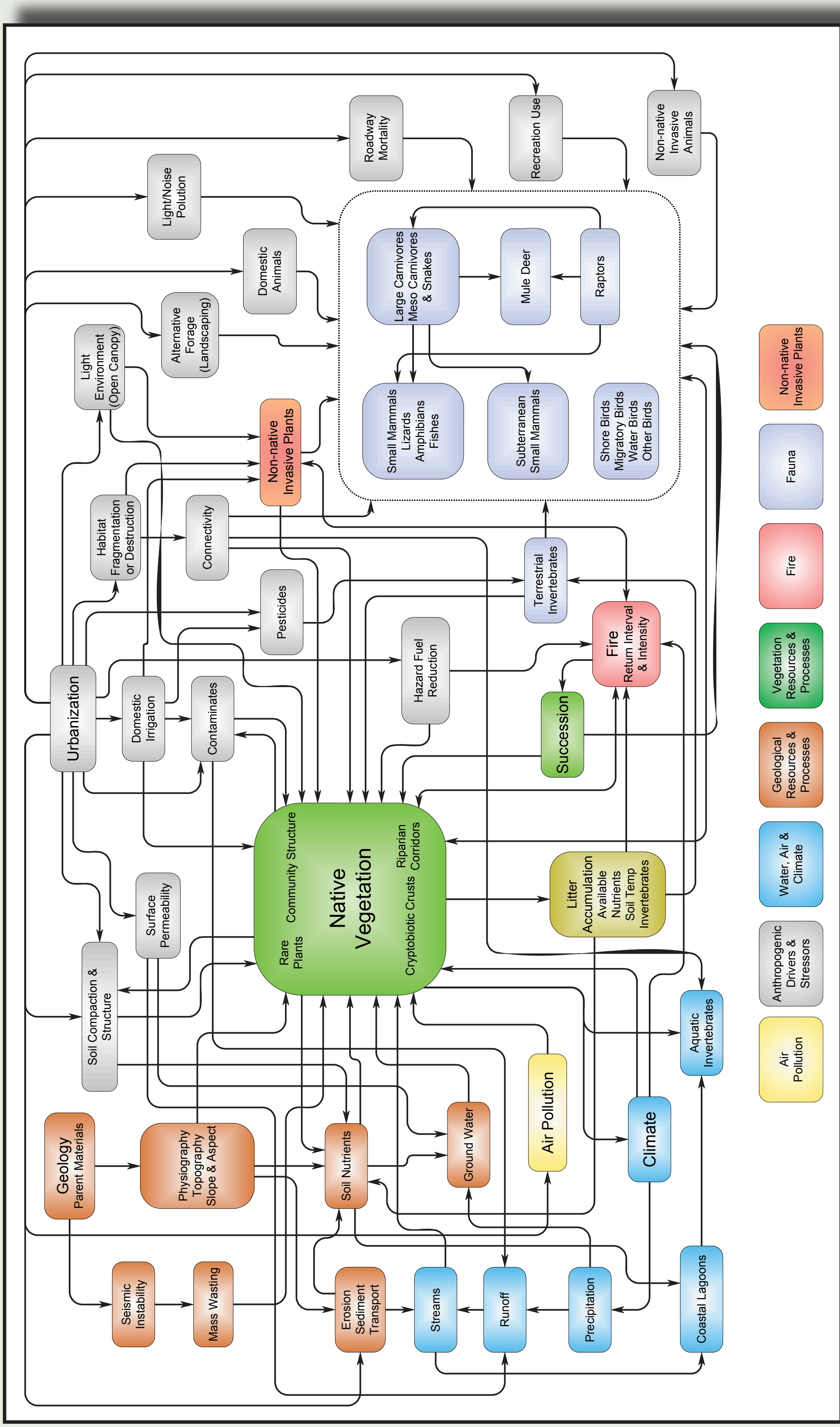

Figure 2.2 Block and arrow model of ecosystem drivers and stressors on elements of the southern California Mediterranean-type ecosystem.

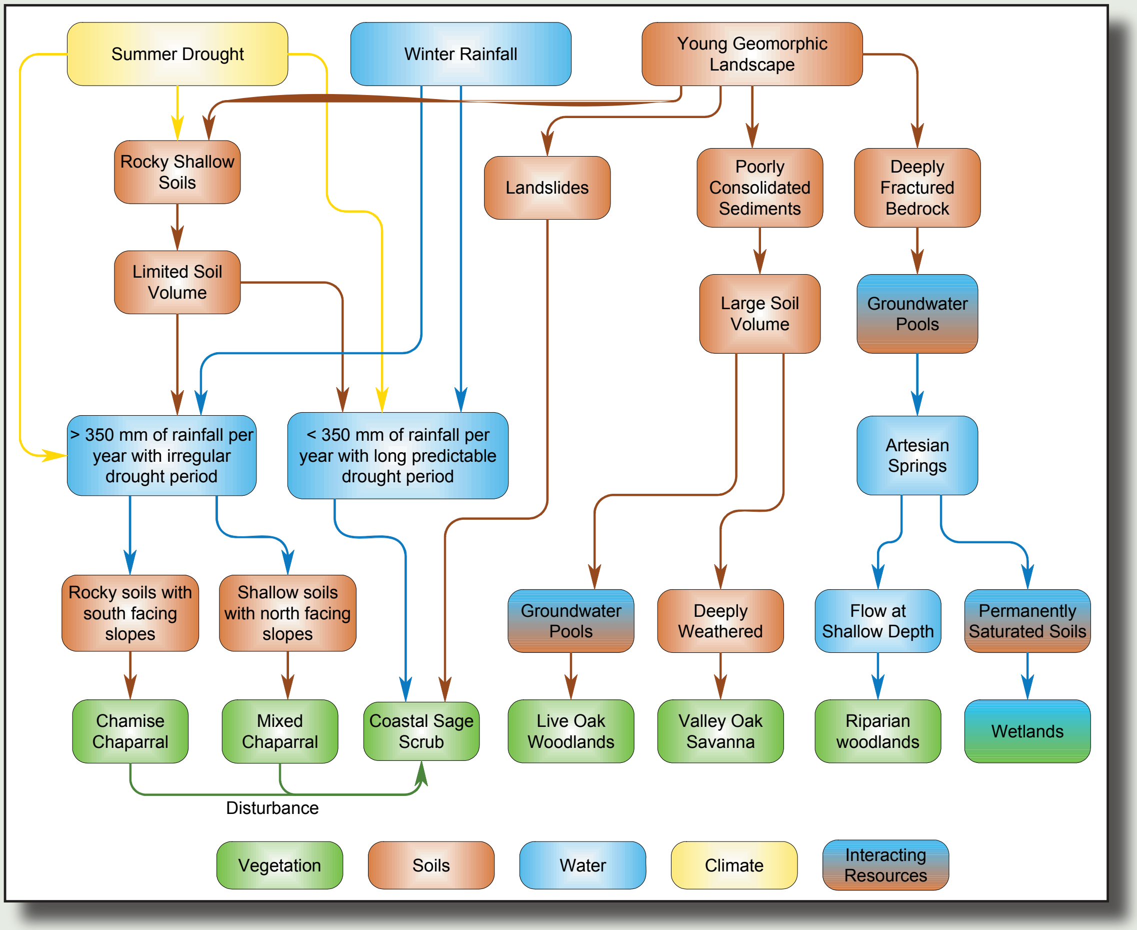

Figure 2.3 Geology-Climate sub-model presenting the dynamic influences of rainfall, soil moisture, and geomorphology on the establishment and maintenance of vegetation communities within the Mediterranean Coast Network.

establishment and maintenance (Figure 2.3) (Phillip W. Rundel, personal communication).

The Santa Monica Mountains are the southern-most mountain chain in the east-west trending Transverse Ranges of southern California. Numerous faults, folds, down warps, and a complex geologic structure characterize this area. The mountains are a complex assemblage of marine and non-marine deposition. The western end of the mountains is igneous in origin shifting to a largely sedimentary base in the east. Due to a combination of steep unstable slopes and poorly cemented sedimentary bedrock, the Santa Monica Mountains are prone to landslides. The shrink-swell behavior and erosivity of soils throughout the mountains are important concerns. Soil erosion typically results from concentrated runoff on unprotected slopes or along unlined streambeds. Debris flows occur with some regularity where sufficient sediment mixes with water flow to form a thick slurry of water, soil, and rock.

The geology of the California channel islands is similar to that of the Santa Monica Mountains. The northern channel islands occur along the seaward extension of the mainland transverse mountains that have been separated from the mainland since the late- to mid-Pleistocene by the Santa Barbara Channel. The islands represent emergent portions of a complex system of submarine canyons and ridges. During the time of probable minimum sea levels about 17-18,000 years ago, the four present-day northern channel islands were all part of one large landmass, referred to as "Santarosae" (National Park Service, 1999). The Channel Islands exhibit extensive marine terracing formed as changing sea levels and rising islands caused shorelines to recede. The larger islands are topographically diverse with sea caves, rugged shorelines, sandy beaches, mountain peaks, and valleys. Eolian landforms with active dunes are also present in the islands. Santa Barbara Island, the southernmost of the islands comprising the park, was formed by underwater volcanic activity

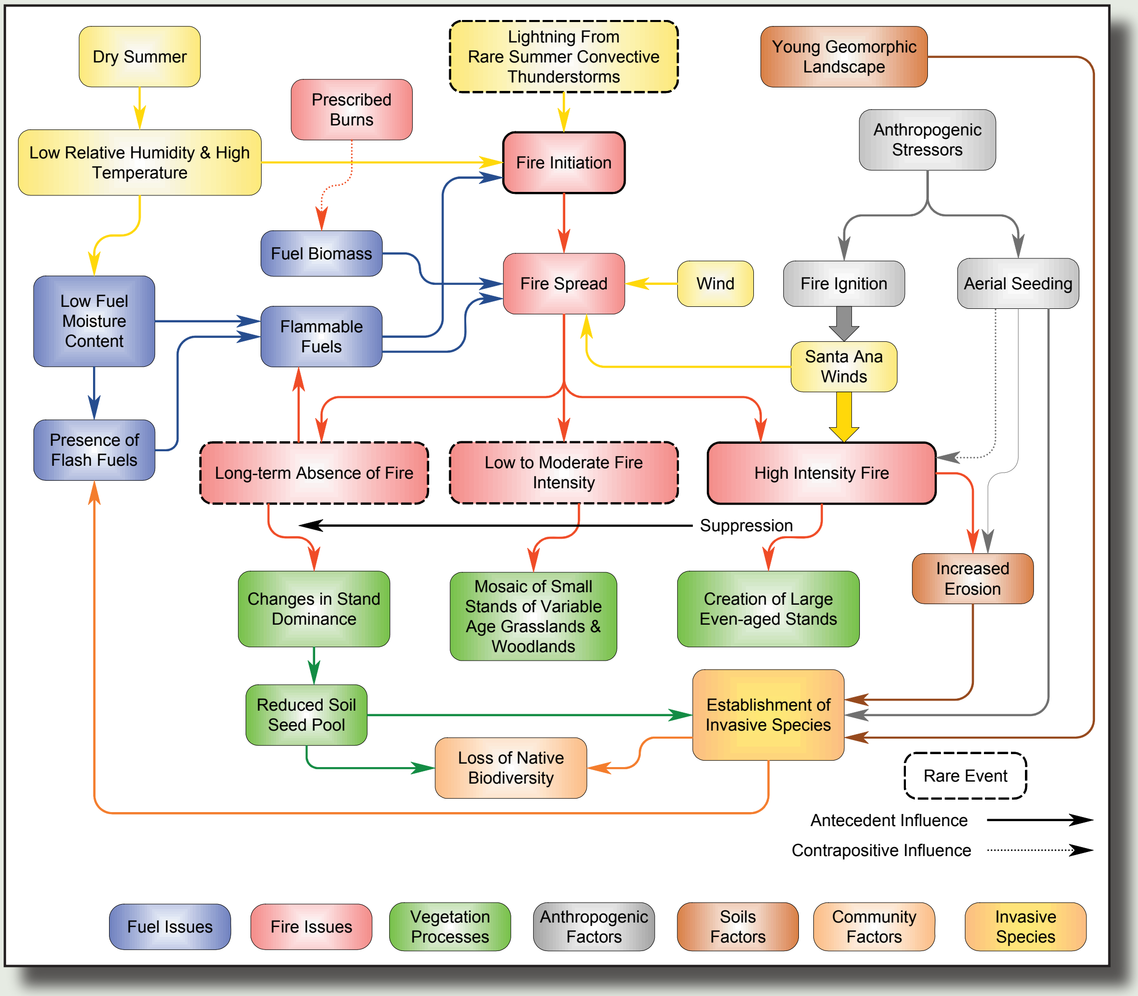

Figure 2.4 Fire sub-model for the role of fire in the Mediterranean Coast Network.
Antecedent influences precipitate, facilitate, or set the stage for components or process of this model. Contrapositive influences ameliorate or limit the effect of model components.

and emerges from the ocean as a giant twin-peaked mesa with steep cliffs.

Cabrillo NM lies within the coastal plain region of San Diego County which is underlain by a layer cake sequence of marine and non-marine sedimentary rock. Over geologic time, the relationship of land and sea has fluctuated drastically. Faulting related to the local La Naçion and Rose Canyon fault zones has broken up this layer cake sedimentary sequence into a number of distinct fault blocks in the southwestern part of the county. Significant exposures of late Cretaceous-aged marine sedimentary rocks occur in the sea cliffs along the west side of the Point Loma Peninsula.[2]

2.3.2 Climate

The Mediterranean-type climate of southern California is typified by hot, dry summers and cool, rainy winters. Summer fog (coastal haze) is an important climatic element, particularly in the Channel Islands, at Point Loma (Cabrillo NM), and along the south-facing coastal slopes of the Santa Monica Mountains. Accumulation of moisture on vegetation results in fog drip precipitation which is a significant source of moisture during otherwise dry periods (Gary E. Davis, personal communication).

Cabrillo NM lies within a transition zone between temperate northern climate and a more southerly subtropical climate. The confluence of these climate types, when associated with oceanic influences, results in a unique mixing of coastal sage scrub vegetation and southern succulent vegetation and lichens.

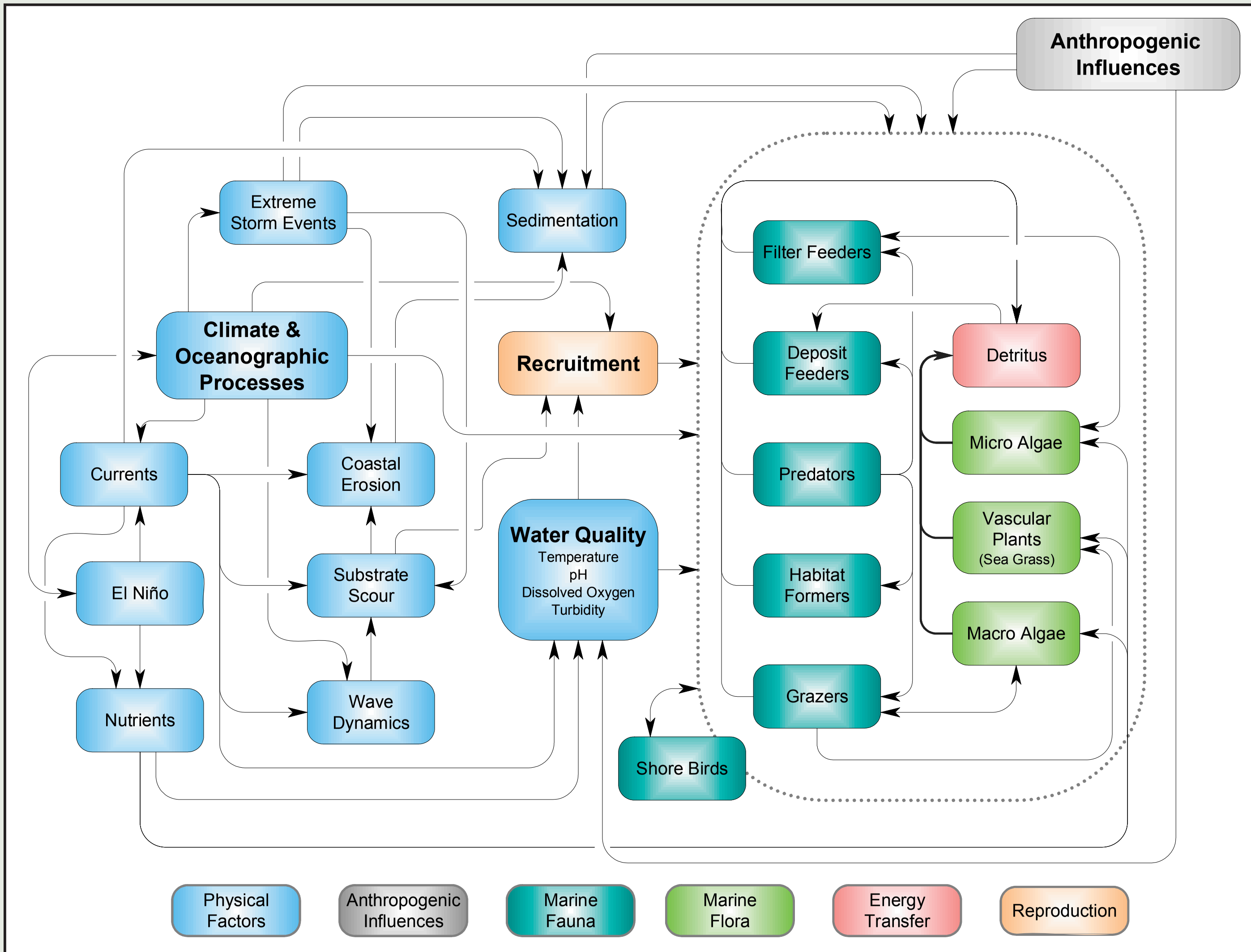

Figure 2.5 Marine sub-model displaying the primary factors contributing to the structure and integrity of the marine intertidal ecosystem in the Mediterranean Coast Network.

The Mediterranean climate of the northern channel islands is moderated somewhat by the confluence of two oceanic biogeographic provinces, the northern, cooler Oregonian and the southern, warmer Californian. These water masses significantly influence the marine communities and the local climates surrounding the four northern islands of Channel Islands NP. Santa Cruz and nearly half of Santa Rosa Islands are within a mixing zone of the waters of these provinces. Local climates and marine communities show considerable transitions between the flora and fauna typical of these provinces.

One of the most significant factors to affect climate throughout the Mediterranean Coast Network is El Niño, a climatic anomaly resulting from the periodic (2 to 10 year cycle) development of warm surface waters in the Pacific Ocean along the coast of equatorial South America. The formation of El Niño is linked with the cycling of a Pacific Ocean circulation pattern known as the El Niño Southern Oscillation or ENSO. In a normal year, low atmospheric pressure develops over northern Australia and Indonesia, with high pressure over the Pacific. Consequently, winds over the Pacific move from east to west. The easterly flow of the trade winds carries warm surface waters westward bringing rainstorms to Indonesia and northern Australia. Along the coast of Peru and Ecuador, cold deep water wells up to the surface to replace the warm water that is pulled to the west (Henson & Trenberth, 2001).

In an El Niño year air pressure falls over large areas of the central Pacific and along the coast of South America. This change in pressure pattern causes the normal easterly winds to be reduced and sometimes reversed, allowing warm equatorial water to flow or slop back eastward across the Pacific accumulating along the coastlines of Peru and Ecuador. El Niño effects in the Mediterranean Coast Network include wetter than normal winters with the possibility of significant flooding and localized warming of marine surface waters resulting in northward migration of subtropical species and the temporary loss of temperate marine algae (kelp) beds (Engle, 1997; Edwards, 2004). La Niña, periods of anomalous cold surface water temperature, generally cycle opposite of El Niño events resulting in winters that are colder and dryer than normal. (Henson & Trenberth, 2001; *cf.* National Academy of Sciences, 2000).[3]

2.3.3 Fire

In southern California, large fires are most common in the fall when dry northeasterly winds known as Santa Anas fan fires ignited in summer dried vegetation. Fire containment can be complicated by these high winds. Fire is a fundamental natural process contributing to ecosystem function, structure, and integrity in most Mediterranean-type ecosystems (Figure 2.4 & Rundel 1998a). While natural, lightning-caused fires are rare in coastal and low elevation Mediterranean climate areas of California (Keeley, 1982 & 2002), fire has nonetheless, been a significant factor in the evolution and adaptation of chaparral and coastal sage scrub communities. Changes in natural fire pattern, from shortened fire return interval, increased fire intensity, or the introduction of fire into generally fire-free seasons, can significantly impact vegetation community dynamics (Christensen, 1994). Variation in the fire regime and post-fire environmental conditions determine vegetation response and maintain biodiversity by variously favoring different species depending on their different regeneration strategies and fire sensitivities.

While fire is the most important natural disturbance in southern California coastal shrublands, vegetation dynamics in coastal southern California are not determined simply by the occurrence of fire. But instead by a complex fire regime, which includes fire frequency, length of the fire free interval, fire intensity and fire seasonality. All of these components are interrelated and interact with post-fire environmental and biotic factors to influence vegetation response. Water stress from summer drought and radiative freezing in the winter are also important in determining post-fire seedling survivorship (Keeley, 1998; Langan *et al.,* 1997).

Fire can also have a significant impact on the chemical properties of surface soils. Loss of nutrients from ecosystems during fire results from gasification and vaporization of compounds in the soil, convection of ash particles in fire-caused winds, leaching of ions out of the soil, and increased post-fire erosion. Nitrogen and sulfur-rich organic compounds are readily oxidized, and gasify during fire. Intense (high temperature) fires can also convert phosphates into gaseous phosphorus oxides. The impacts of fire on the physical and chemical characteristics of soils are magnified by steep terrain and infertile soils that

Channel Islands. Pigs have destroyed native riparian habitat. Elk and deer have overgrazed native grasslands on the islands. The loss of bald eagles and their replacement by golden eagles has significantly impacted the native island fox populations as well.

Direct Human Contact

The final group of anthropogenic stressors relate to human activities which directly affect park resources. These activities include parkland management practices as well as recreation, vehicle, and air traffic, commercial and sport fishing, wildland fire hazard fuel reduction, arson, accidental fire ignitions, and fire suppression activities.

At Cabrillo NM, intense pressure is placed on park resources by the huge volume of visitors to such a relatively small park site more than 1,000,000 annually in the past two decades). Nearby consumptive uses such as fishing and oil/gas extraction may indirectly affect park resources as well. For Channel Islands NP, consumptive uses such as commercial fishing are a significant direct stressor to the marine ecosystem. Visitation to the islands is relatively low, but may increase as mainland recreational opportunities are lost or overused as the population of southern California continues to grow. In the Santa Monica Mountains, proximity to the Los Angeles Metropolitan area and mild climate throughout the year means that there is a steady stream of visitors coming into the mountains. Vehicle traffic, not only from park visitors, but from mountain residents, commuters from surrounding suburban areas, and summer beach-goers all have significant ecological effects.

Past land use practices have also had a major impact on network parks. This is particularly relevant in the channel islands where non-native herbivores have grazed in large numbers. Some of these have been removed but many still remain. Cattle have been removed from Santa Cruz and Santa Rosa Islands. While elk and deer remain on Santa Rosa, deer numbers were recently reduced by 50 percent. Rabbits have been removed from Santa Barbara Island. Feral pigs are being removed from Santa Cruz Island. In southern California in general, natural areas have a long history of human use including Native American burning, agricultural grazing and cultivation. These uses have altered habitat structure, vegetation community structure and composition, and have encouraged the distribution of non-native species (Rundel, 1998a & 1998b; *cf.* Walter, 1998).

2.3.4 Biological Processes

The sclerophyllous vegetation that dominates the coastal southern California flora first appears in the fossil record in the middle and late Eocene (Raven & Axelrod 1978). The current vegetation assemblage is dominated by shrublands whose physiognomy and composition is believed to result from a complex interaction of landscape diversity and climatic fluctuations, but which strongly reflects adaptation to the Mediterranean-type climate of moist winters and hot dry summers. These shrubland community types are responsive to the periodic stand-replacing fires that are a significant characteristic of the environment. However, only non-sprouting (obligate seeding) species are truly fire-adapted. Seed germination requires stimulation by heat and chemicals released during fire. The persistence of these species in the community requires periodic fire events. On the other hand, species that re-sprout following a fire from underground lignotubers are not adapted *per se* to fire. Davis *et al.* (1998) note that sprouters have an advantage in that they have two mechanisms of post-fire recovery: previously acquired position (sprouting) and population expansion (seed germination). They reason that the persistence of non-sprouters is due to a genetic advantage resulting from production after each fire of an entirely new pool of genetically recombined individuals on which natural selection can operate. This would result in greater genetic diversity (*i.e.*, greater potential for speciation) and a quicker pace of evolution that has tracked the recent advent of a drier, fire prone climate in southern California.

As in other Mediterranean climate regions, the vegetation of southern California displays a high degree of adaptive radiation and genetic isolation that has resulted in many species that are endemic to the region (Cowling & McDonald, 1998). This is a distinctive and to some extent peculiar trait of the California Floristic Province (CFP) (*cf.* Raven, 1990). The CFP covers some 324,000 km^2 and has approximately 794 genera with some 4,452 species of native vascular plants. This is more species than the entire remainder of United States and Canada combined (Raven & Axelrod, 1978; *cf.* Arroyo *et al.*, 1995). Raven (1973) reports that 10% of genera and 40% of species from the area of California dominated by a Mediterranean-type characterize Mediterranean-type ecosystems (Christensen, 1994).

Fire can also impact the fundamental properties of animal communities such as species richness, composition, abundance, and energy flow. Soil and litter dwelling invertebrates can experience 50 to 90% mortality during fire and a reduction in diversity that may persist for several years (Quinn, 1994). Fire-induced mortality in reptiles is not well documented, and their susceptibility to fire may be ameliorated by their behavior and by the timing of a fire. Mammals are variably impacted by fire; some species are killed outright while others may be displaced. Those that survive do so by fleeing the fire front or taking refuge in underground shelters or nest sites. Post-fire changes in animal communities vary by taxa. Changes in bird populations are relatively short-lived after a fire. In the time immediately after a fire some small mammals can disappear entirely, others may only decrease, and others may show marked increases in numbers (Quinn, 1994).

2.3.5 Anthropogenic Drivers

As with other Mediterranean climate regions, southern California is favorable to human habitation, agriculture, and recreational activities. Santa Monica Mountains NRA is located adjacent to Los Angeles, California, within a region of more than 16 million residents, the second-largest metropolitan area in the United States. Cabrillo NM is situated within the sixth-largest metropolitan area in the United States. Although Channel Islands NP has been protected to a large extent by its inaccessibility and by its relatively stable historic land ownership patterns, proximity to the densely populated southern California mainland means that anthropogenic impacts and activities continue to pose a significant threat to the islands' ecosystems.

Anthropogenic impacts identified in the network conceptual ecosystem model can be grouped into three major categories: (1) impacts from existing land use practices and development; (2) impacts caused by new development (*i.e.* urbanization); and (3) impacts to natural areas caused by direct human contact with resources in the course of activities such as recreation, land management, consumptive use, and fire. Past land use practices are also a significant cause of environmental degradation at all three parks in the network. While these anthropogenic drivers are major ecosystem forces throughout the network, the extent to which these drivers and related stressors influence natural resources differ for each park.

Within Mediterranean-type ecosystems there is a continuum of impacts ranging from chronic anthropogenic stressors including habitat fragmentation, urbanization, land use conversion, vegetation type conversion, establishment of invasive non-native species, air pollution, and global climate change, and acute stressors including water pollution, increased summer urban runoff, light pollution, overgrazing, and fire.

Land Use

Land use practices introduce a myriad of external pressures on natural systems. Stressors such as livestock grazing, resource harvest, air and water pollution, night-lighting, non-native species introductions, and hydrologic changes. Even localized climatic changes such as heat-island effects, cause significant impacts on natural systems and processes. Stressors may interact to produce complex ecological effects and behavioral modifications in native wildlife. Landscaping of residential and commercial property has introduced many non-native plants that significantly affect the water budget for native communities as they out-compete native plants for available water. Conversely, domestic irrigation in the Santa Monica Mountains has resulted in increased surface-water flow, transforming some ephemeral or intermittent streams to perennially flowing streams and converting areas of native woodlands or chaparral to riparian vegetation. While these new riparian communities are dominated by native species, their presence may not be normal for the area (John Tiszler, personal communication). This additional flow can also facilitate the establishment and spread of introduced plants and animals. Pesticides and fertilizers used in domestic applications may also be transported to undeveloped areas via increased surface-water runoff.

The types of land use and the resulting stressors differ considerably among the parks. Cabrillo NM is isolated from other natural lands by the ocean and surrounding urban development, although it is not subjected to continuing habitat loss and habitat fragmentation, Major anthropogenic stressors and drivers are related to continuing and persistent human activities such as recreation, military use, and surrounding urbanization. This insularization is a potential stressor that may have long-term and ongoing ecological effects such as the loss of species and genetic diversity. Native plants and animals that disappear from the Point Loma Peninsula are not likely to recolonize through any natural process. Similar ecological effects can be expected in the Santa Monica Mountains and surrounding natural areas as development surrounds and isolates remaining natural areas. Insularization is an important influence on the channel islands as well, but it is a natural driver rather than anthropogenic stressor.

Land uses affecting the Santa Monica Mountains include suburban, rural residential, and agricultural areas that surround and are dispersed throughout the mountains. Over 50% of the land in the Santa Monica Mountains NRA is in private ownership. And while much of this privately-owned land is currently undeveloped, regional land values and local population growth ensure that development will continue within the park boundary. As habitat is converted to human uses, ecological effects include reduced wildlife populations, increased wildlife/human interactions, increased fire frequency or intensity in many areas, reduced fire frequency in others, non-native invasive species introduction and spread, and reduced biodiversity due to the loss of species-specific habitat. Major large-scale development has the potential to crowd the outer boundary of the NRA, while smaller internal projects (*e.g.*, single home construction, small housing tracts, vineyards and orchard development, *etc.*) are subdividing and fragmenting the natural habitat throughout the mountains. Aside from effects arising from the actual reduction and subdivision of habitat area, ecological responses to habitat fragmentation may also include increased invasions of non-native species (*e.g.,* from residential landscaping or agricultural plantings), increases in populations of urban-associated species (cats & dogs), loss of dispersal or migration opportunities, increased urban and wildland interface conflicts with concomitant edge effects (*e.g.*, habitat degradation, changes in species composition, impacts from domestic animals, *etc.*), and increased wildlife and human interactions.

While Channel Islands NP is buffered by the ocean from most localized land use impacts, regional impacts associated with urbanization such as air pollution and water pollution may still be critical stressors of natural resources within the park. Additionally, increased recreational use, US Coast Guard and US Navy presence, hunting activities, and past ranching activities on the Channel Islands have introduced significant land-use impacts to these otherwise isolated islands.

Non-native invasive Species Introductions

The extent and intensity of non-native invasive plant species introductions into ecosystems are indicators of the integrity (or disintegrity [Regier, 1993]) of invaded ecosystems. Non-native invasive species introductions can inflict numerous impacts on native ecosystems including alteration of natural disturbance regimes, alteration of nutrient cycling, displacement of native species, facilitation of disease spread, and disruption of native food webs. The presence of such species has the potential to irreversibly change the productivity of the systems they invade. Non-native invasive species represent one of the greatest threats to the integrity of native plant communities within Mediterranean-type ecosystems. In addition, the introduction of herbaceous non-native invasives, particularly annual grasses, has fundamentally altered the fire-ecology of coastal southern California, changed species composition of soil flora and fauna, and significantly affected vegetation dynamics. Annual grasses increase the potential for fire by changing the amount, distribution, and timing of available fuels. When coupled with the increased opportunity for fire starts associated with urbanization, a feedback cycle is introduced that can decrease fire return intervals beyond the capacity for native species to recover. Significant species shifts and even complete loss of native vegetation can occur. This type conversion of shrubland to annual grassland has been widely observed in California (Keeley, 1990; Keeler-Wolf, 1995; Minnich & Dezzani, 1998). Annual grasses support a different assemblage of soil microflora and fauna altering, competitive regimes for the establishment of native annual and perennial plants and non-native invasive flora as well. Fennel in the Channel Islands has completely replaced some native communities and provided refuge habitat for feral pigs on Santa Cruz Island.

Non-native invasive plants are not the only introduced threat to native communities of southern California. With the increased availability of water in the Santa Monica Mountains there is an increase in invasive non-native species such as crayfish, bass, and bluegill. In streams invaded by these pests there has been a concomitant decline in some native amphibians. Domesticated animals allowed to go feral have created problems in the climate are endemic. There is also a high degree of endemism among the channel islands flora and fauna, with many species occurring only on one or several of the islands.

2.4 Graphic Models

While the models presented here (Figures 2.2, 2.3, & 2.4) focus on the Santa Monica Mountains, they are sufficiently general relative to processes in the southern California Mediterranean-type ecosystem to reflect conditions and relationships within Cabrillo NM and Channel Islands NP as well. Differences for the channel islands include: 1) a lower frequency of natural fire; 2) the presence of significant numbers of endemic species and subspecies on the islands; 3) widespread impact of non-native grazing animals resulting in widespread conversion of native plant communities to non-native dominated communities; and 4) a substantially greater importance and influence of the maritime climate. Because of this maritime influence, summer drought is not as extreme an event on the islands. Vegetation is very similar to the mainland, but with beach dune, coastal bluff, and sea cliff communities much more prevalent. Santa Cruz Island also hosts several groves of coniferous forest on some north-facing slopes. Air temperature is moderated by the maritime influence and winter frost is usually not a factor on the islands. Wind pruning of vegetation is more common on the islands than in the Santa Monica Mountains.

Deviations from the general model at Cabrillo NM include: 1) the near total suppression of fire for most of the last century; 2) the occurrence of some Baja succulents that are not found in the Santa Monica Mountains; and 3) the increased significance of the coastal marine environment of Point Loma. A summary of these ecosystems processes and elements are presented and discussed within the sub-models for Cabrillo NM (Appendix J).

2.5 Conclusion

The ecosystems drivers and stressors portray the various elements of the Mediterranean-type ecosystem of southern California, although the relative importance of each may differ among the parks of the network. Because of the relative size and complexity of the Santa Monica Mountains and the lack of an existing prototype monitoring program, the process undertaken in the network focused on developing a model most directly applicable to the Santa Monica Mountains. However, some effort was also given to recapture the conceptual modeling exercise that was completed for the prototype monitoring program at Channel Islands NP. In addition, special attention was given to any unique processes at work in the natural areas of Point Loma peninsula, home to Cabrillo NM. The Mediterranean-type ecosystem, while uniquely identified worldwide, is a highly complex assemblage of vegetation and animal types adapted to hot, dry summers and cool, rainy winters. Significant elements and process within each of the five regions identified worldwide as Mediterranean climate areas are unique to each area and do not overlap with the others (Dallman, 1998). This also holds true within each region of Mediterranean-type climates as is seen in the differences among the three parks of the Mediterranean Coast Network.

End Notes:

[1] http://www.nature.nps.gov/im/monitor/index.htm#Conmodel
[2] http://www.sdnhm.org/research/paleontology/sdgeol.html
[3] http://www.nationalacademies.org/opus/elnino

Chapter 3: Vital Signs

Vital signs are 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.[1]

Vital signs of ecosystem integrity or natural resource health have been likened to the vital signs that a physician would monitor while treating a patient (*cf*. King, 1993). Natural resource managers may then be likened to physicians for ecosystems and park resources; monitoring their health, treating dysfunction, and repairing damage (Davis, 1993). The intent of park vital signs monitoring is to track these elements and processes to assess resource condition and provide broad-based, scientifically sound information needed for management decision-making, research, education, and promoting public understanding of park resources.

Identifying and prioritizing vital signs for the Mediterranean Coast Network of parks was a fundamental exercise in developing the Mediterranean Coast Network monitoring program. In this network, the process of determining vital signs to monitor generally occurred in two stages. Initially, NPS long-term monitoring of vital signs of ecosystem health began in the early-1980s with the development of the prototype monitoring program at Channel Islands NP. The rocky intertidal and vegetation community monitoring components of the Channel Islands NP prototype program were subsequently extended to Cabrillo NM on 1990 and 1994 respectively. In addition, during this period (1990-2000) several informal workshops and resource prioritization exercises were held at Cabrillo NM and Santa Monica Mountains NRA to identify monitoring needs and resource issues of concern. In 2001, the network entered a new phase of planning and development with implementation of the Natural Resource Challenge and funding of vital signs monitoring throughout the National Park Service. This most recent effort focused on designing a program to identify and monitor, on a long-term basis, network vital signs not already addressed through the existing prototype program at Channel Islands NP, the related park-based monitoring at Cabrillo NM, and to a lesser extent, resource condition assessments and studies underway at Santa Monica Mountains NRA.

This chapter describes the process by which the prototype and network vital signs were identified and prioritized beginning with a brief synopsis of vital signs selection for the prototype program. This is followed by a more detailed summary of the recent network-wide effort and concludes with a presentation of the final selected vital signs. Milestone events in the identification and selection of vital signs for the Mediterranean Coast Network are listed in Table 3.1.

3.1 Prototype Monitoring Program

The prototype monitoring program at Channel Islands NP was based on a population dynamics approach because it best met park management requirements of accurately reflecting ecosystem conditions, providing ready interpretation of data and projections of future conditions, utilizing readily available sampling techniques, and providing information applicable to management at the species or population level. Using this approach, population dynamics of selected species are monitored to provide insights into ecosystem structure and function. Targeted species are assumed to integrate the effects of various ecological factors, including predation, competition, and environmental conditions—factors that are expressed as changes in readily measured population parameters such as abundance, distribution, growth, and mortality.

The design of the monitoring program followed a step-down tactical plan (Davis, 1993 & 2005) which included three major components: 1) develop a conceptual model of the ecosystem; 2) conduct design studies; and 3) monitor ecosystem health.

Table 3.1 Milestones in identifying vital sings for the parks of the Mediterranean Coast Network (Channel Islands NP (CHIS); Santa Monica Mountains NRA (SAMO); & Cabrillo NM (CABR).

Date	Event	Vital Signs Milestone	Product
1980s	Two workshops held to identify resource management needs at CHIS and identify critical taxa for developing monitoring program at CHIS.	Step-down process employed to develop tactical plan and conceptual model for long-term monitoring in CHIS.	*cf.* Davis, 1983 & 2005
1990	Significance of protecting marine intertidal recognized and monitoring program recommended.	Monitoring of Intertidal resources at CABR began following the protocol developed at CHIS.	
1994		USGS begin baseline data collection for establishing vegetation community monitoring on Point Loma.	
1995	Significance of protecting terrestrial herpetofauna recognized and monitoring program recommended.	USGS and University of California at San Diego begin herpetological monitoring on Point Loma	Fisher & Case, 2000
Sep 1999	Santa Cruz Islands (CHIS) Scoping workshop.	Natural & Cultural management needs identified.	
Jan 2000	CABR Scoping Workshop	Monitoring project statements for 21 categories of natural resources were developed.	Workshop Report Appendix E
1995 - 2002	15 mini-workshops or monitoring workgroups planned inventory & monitoring exercises within SAMO.	Resource issues of special concern identified and programs to inventory baseline conditions established for terrestrial and aquatic herpetofauna, meso-carnivores, terrestrial vegetation, and invasive plant species.	Busteed, 2004; Riley *et al.*, 2005 and other memos and internal reports.
Dec 2002	Conceptual modeling & vital signs identification workshop held at SAMO.	43 monitoring questions specific to the southern California Mediterranean ecosystem identified and used to refine conceptual model and suggest candidate vital signs for monitoring.	Appendix G
Mar 2003	CABR Vital Sign Workshop	Conceptual Model review and 27 monitoring questions & 37 candidate vital signs directed towards CABR & PLER identified.	Appendix F

To identify taxa for potential monitoring, the park's ecosystems were divided among ecological disciplines into 14 system components (Table 3.2) that could be monitored at the population level. These system components comprised the Channel Islands' conceptual model. Using a Delphi approach, indicator species from each ecosystem component were selected. Scientists went on to identify parameters of population dynamics to measure and then to design monitoring protocols based on five objectives: 1) incorporate historical approaches and data whenever possible; 2) select or develop sampling techniques that are robust to observer variability; 3) utilize standard analytical techniques; 4) design reporting formats to archive and clearly communicate immediate findings; and 5) evaluate the utility of the protocol by field testing the sampling, analytical, and reporting systems for at least one year. Short term design studies were conducted for the indicators and twelve detailed monitoring protocol handbooks were subsequently published.

Table 3.2 Monitoring elements for which protocols have been prepared for Channel Islands NP.

Vital Signs System Components
1. Pinnpeds
2. Information Management
3. Tide Pools
4. Sea Birds
5. Kelp Forests
6. Land Birds
7. Island Plants & Vegetation
8. Island Invertebrates
9. Island Reptiles & Amphibians
10. Island Mammals
11. Park Visitors
12. Fisheries
13. Weather
14. Beaches & Lagoons

The goal of the selection process was to find system components that could represent the entire ecosystem to be monitored. Six criteria were applied to existing species lists to select taxa to meet this goal (Table 3.3). Species were selected to include a broad array of ecological roles and examples of many different trophic levels and life forms. Examples of this ecological and trophic diversity include primary producers to top carnivores, sessile invertebrates to wide ranging pinnipeds and sea birds. Special consideration was given to species that characterized entire communities or were exceptionally common, such as giant kelp (*Macrocystis* sp.)and purple sea urchins (*Strongylocentrotus purpuratus*). Organisms with special legal status, such as State or Federally listed endangered species and marine mammals, were also included. Park endemics and aliens, and those species legally harvested from the park were also selected. Finally, if all other criteria were equal, charismatic or heroic species were selected because they had already garnered public support and understanding. Community-level monitoring was designed for some ecosystem components. Here, the goal was to establish a program that could track changes in system components that integrate many species' responses to natural environmental fluctuation and management treatments.

This process resulted in a monitoring program incorporating 14 elements or "vital signs" (see Table 3.2). Although some of the elements of the Channel Islands' program were monitored prior to the development of the comprehensive program, most monitoring was initiated during the 1980s and early 1990s. Some of the planned monitoring has not been implemented due to budget limitations.

3.2 Initial Vital Signs Planning at Santa Monica Mountains NRA and Cabrillo NM

Planning of inventory and monitoring activities within Santa Monica Mountains NRA began in the early 1990s during development of the 1994 Resource Management Plan. This plan, and particularly the later 1998 Resource Management Plan, explicitly articulated inventory and monitoring activities and objectives as a primary component of the resource management program. Several scoping, monitoring and resource management workshops were held during these years to

Table 3.3 Criteria used to identify taxa for vital signs monitoring at Channel Islands NP.

Channel Islands NP Taxa Selection Criteria
1. Common species that dominate community structure
2. Legal status, e.g., designated endangered species
3. Park or island endemic species
4. Exploited species
5. Alien species (non-native)
6. Heroic, charismatic species with current human constituencies

identify ecosystem indicators and inventory needs. These were followed by workshops focused on rare plants, reptiles and amphibians, and indicators of fragmentation (*e.g.*, carnivores). Initial steps in baseline data collection for some of these key indicators and elements of concern were completed through the use of short-term project funding and park-based support.

Monitoring was also a part of the Cabrillo NM science program, and in fact intertidal and vegetation monitoring had been initiated in the park in the early 1990s through an extension of the Channel Islands NP prototype program. A more comprehensive assessment of monitoring priorities began in January 2000, when Cabrillo NM resource management staff began a process to identify ecosystem vital signs that could provide an indication the health of natural resources within Cabrillo NM and the surrounding Point Loma Ecological Reserve.

3.3 Network-based Monitoring

Beginning in 2001, the Mediterranean Coast Network received funding to plan and implement a network vital signs monitoring program as part of a servicewide strategy designed to institutionalize natural resource inventory and monitoring on a programmatic basis throughout the NPS. The level of funding was not intended to cover comprehensive monitoring in all parks, but instead to augment existing park and network monitoring efforts and provide a minimum infrastructure upon which parks and networks could build in the future. The funding was network-based to facilitate collaboration, information sharing, and economies of scale in natural resource monitoring. This was the beginning of the current efforts to identify and prioritize network-wide vital signs. Because Channel Islands NP had already gone through an analogous process to identify it's vital signs, the network efforts were focused upon identifying indicators of processes or elements that were not addressed through the Channel Islands NP prototype monitoring program.

3.4 Vital Signs Identification

The development of a primary list of candidate vital signs for the network began with discussions among park resource managers, a review of park general and resource management plans, and a review of results from vital signs workshops at Cabrillo NM and Santa Monica Mountains NRA. From this a series of monitoring goals and objectives, as well as draft conceptual models for the networks ecosystems were developed. These workshops and discussion groups identified significant ecosystem drivers and stressors in the southern California Mediterranean-type ecosystem functioning in the two parks and reviewed current management activities that could help determine the course of monitoring planning within the Mediterranean Coast Network.

Although network and park staffs and some external stakeholders participated throughout the entire process, many potential participants had strong ties to only one of the parks. Thus, the workshops were focused geographically on Cabrillo NM or on Santa Monica Mountains, or (in the case of one water quality monitoring workshop) on both the Santa Monica Mountains and the Channel Islands. It was felt this would encourage participation of external scientists by minimizing travel and by maximizing relevance for the individual participants. Also, for those with broader geographic interests, multiple network workshops provided more schedule flexibility.

Forty-two candidate vital signs specific to the Santa Monica Mountains (Table 3.5, page 3-9) and 58 specific to Cabrillo NM (Table 3.6, Page 3-10) were identified through this process. The complete workshop reports are included as Appendices E, F, & G .

3.5 Vital Signs Prioritization

The number of candidate vital signs identified through the workshops and discussion groups was clearly far beyond the network's ability to implement. The next step was to prioritize the list of vital signs and select the few elements that together could form the basis of a network-wide monitoring program. Once candidate vital signs were identified, 160 partners, cooperators, researchers, regulators, resource managers, and other friends or stakeholders of the three network parks were invited to rank them using an internet-based exercise. Respondents scored vital signs either high (score of 1), medium (score of 0.66), low (score of 0.33), none (score of 0), or no opinion (score of 0) based upon: 1) ecological relevance; 2) feasibility of implementation; and 3) interpretation and utility and relevance to network parks. The initial ranking score for each vital sign was calculated by multiplying the score for each rating criteria by its weighting value (Table 3.4).

Table 3.4 Ranking criteria for candidate vital signs proposed for the Mediterranean Coast Network of national park units.

Criteria	Definition
Ecological Relevance: (50% of Score)	There is a strong, defensible linkage between the indicator and the ecological function, feature, or critical resource it is intended to represent. Based on your understanding of Mediterranean-type ecosystem function and conditions, this ecosystem function, feature, or resource is of high ecological importance. In your opinion, the indicator may provide early warning of undesirable changes to an important function, feature, or resource condition, and is sufficiently sensitive that small changes in the indicator can be used to detect a significant change in the target resource or function. Indicator data, at whatever scale or level of ecological organization it is collected (i.e., individual, population, community, or landscape) may be complementary to data from other indicators collected at other scales or levels of organization.
Feasibility of Implementation: (25% of Score)	Well-documented, scientifically sound protocols exist for measuring the indicator, and implementation of the protocols is feasible given the constraints of site accessibility, sample size, equipment required, etc. Sampling and analysis techniques are cost-effective and are likely to provide data of high value. High value data have low measurement error and are obtained using sampling techniques that are repeatable and comparable when collected by different, but qualified, personnel.
Interpretation and Utility: (25% of Score)	The proposed indicator will provide data that can clearly represent the status and trends of an ecosystem function, feature, or resource and can be understood and accepted by scientists, policy makers, and the public. Data collected will be comparable with data from other monitoring studies being conducted elsewhere in the region by other agencies, universities, or private organizations. The proposed indicator will provide information to support management decisions, to quantify the success of past management actions, or to guide adaptive management strategies in the future.

Results were summed across the three rating criteria. The final prioritization score for each vital sign was obtained by averaging individual weighted scores for candidate vital signs across all scorers for Cabrillo NM and Santa Monica Mountains NRA independently.

A more manageable list was created by selecting candidate vital signs with a score of 80.00 or higher for continued monitoring planning. Because water quality monitoring is funded independently and will be implemented at some level regardless of the prioritization, a lower cut-off score (60.00 or greater) was used to ensure that some water quality related vital signs were identified for continued planning. The result was an intermediate list of 15 candidate vital signs for Cabrillo NM and 20 candidate vital signs for Santa Monica Mountains NRA. Limited water quality monitoring (marine & freshwater) will also be implemented at Channel Islands NP. These sub-sets of vital signs are presented in Table 3.5 (Cabrillo NM) and Table 3.6 (Santa Monica Mountains NRA).

From these lists park technical experts identified a final suite of vital signs based primarily upon the prioritization rank score coupled with park management needs; the opportunity to leverage both NPS and non-NPS resources to perform monitoring; the possibility for economies in scale by combining or coordinating monitoring activities among vital signs; and the anticipated value of the data obtained in evaluating ecosystem health in the respective parks and network. Detailed monitoring protocols will be developed and monitoring activities implemented for these top priority vital signs (see Table 3.7, page 3-11).

3.6 Summary of Selected Network Vital Signs

A total of 17 unique vital signs (Table 3.7) were identified through this network-based selection process. These vital signs focus on ecosystem elements of concern at Cabrillo NM and/or Santa Monica Mountains NRA and will be monitored at one or both of those parks. This will complement the ongoing monitoring programs at Channel Islands NP and Cabrillo NM and to a lesser extent, park-based monitoring within the Santa Monica Mountains. Since the prototype monitoring program at Channel Islands did not address water quality issues for that park the specific water quality vital signs identified for Channel Islands NP are also included in Table 3.7. Freshwater quality will be monitored at Channel Islands NP and Santa Monica Mountains NRA and marine water quality at Cabrillo NM and Channel Islands NP.

Table 3.7 also lists all known monitoring activities within the three network parks and identifies vital signs monitoring, prototype monitoring, monitoring for which protocols have been prepared but have yet to be implemented, on-going park monitoring, proposed future monitoring by the parks, and monitoring done by non-NPS organizations. These monitoring activities are organized according to the vital signs framework prepared by the National Inventory and Monitoring program.

These seventeen vital signs were coalesced into eight monitoring programs for which distinct protocols will be prepared (Table 3.8). Each of these eight monitoring programs is identified with a brief summary of their relationship to the conceptual models.

3.6.1 Vegetation Dynamics

Exotic Plant Species Introduction and Spread.
Monitoring of exotic invasive plant species was consistently ranked as the top priority throughout the network vital signs prioritization process. This ranking reflects both the central role of vegetation in the network conceptual models as well as the importance of exotic invasive plant species as potential drivers of change in plant and animal communities. The conceptual models illustrate the interrelationship between exotic plants and other major stressors within the Mediterranean ecosystem, including fire, habitat fragmentation and urbanization. The high ranking also reflects the opinion of local experts that, for some species at least, there are manageable dimensions to the exotic plant problem and that with effective monitoring, control of exotics and mitigation of their impacts are possible.

Table 3.8 Final identification and grouping of vital signs listed in Table 3.7. Chapter 5 includes a discussion of the proposed process and breadth of monitoring activities for the program elements listed in this table.

Reptile & Amphibian Population Dynamics
Terrestrial Herpetofauna
Aquatic Herpetofauna (Includes Non-native Crayfish & Fishes)
Water Quality
Integrated Freshwater Quality
Integrated Marine Water Quality
Vegetation Dynamics
Invasive Plant Species Introduction & Spread
Riparian Plant Communities
Integrated Native Vegetation
Landscape Pattern
Landscape Pattern

Riparian Plant Communities: Chaparral, Coastal Sage Scrub, & Oak Woodland Communities.
Native vegetation community types were also highly ranked as vital signs. This again reflects the recognition of the importance of vegetation communities both as habitat and as the primary source of energy, for Mediterranean-type ecosystems. The status, distribution and composition of plant species, populations and community types directly reflect the health of these habitats and of the ecosystem as a whole. The two most common vegetation community types in southern California, chaparral and coastal sage scrub, received the highest rankings as vital signs with greater priority given to coastal sage scrub as a result of its recognition as a plant community of general concern throughout coastal southern California and equivalent Mediterranean-type ecosystems throughout the world. Riparian communities, oak woodlands, freshwater wetlands, and native grasslands were also ranked as significant indicators of ecosystem health in southern California. While these latter communities are important in the Santa Monica Mountains, they are of lesser importance on Point Loma where they are absent or present to a very limited extent.

3.6.2 Water Quality

Fresh Water Quality.
The conceptual models identify water as a significant driver in the network. The presence of water determines the presence and abundance of much of the flora and fauna in Mediterranean-type ecosystems—both native and exotic—and human-related changes in stream hydrology and water quality are a potentially important influence on exotic species establishment and community change throughout southern California. These relationships are reflected in our overall conceptual model through the links between urbanization, domestic irrigation and increased runoff, and potential decreases in stream quality through the addition of contaminates from runoff.

In the Santa Monica Mountains, a small number of studies and much observational evidence indicates that both the amount and seasonal availability of water have increased with urbanization in and adjacent to the Santa Monica Mountains causing historically intermittent streams to flow throughout the year. Additionally, increases in impermeable surfaces (i.e., paved surfaces in urban areas) can result in pulses of water and urban pollutants into streams and drainages following storms leading to increased erosion, stream sedimentation, and degraded water quality. These impacts have changed the composition and structure of streamside vegetation and aquatic communities in many areas and are a key factor in the ingression and establishment of exotic plant and animal species that have relatively high water requirements.

On the Channel Islands, grazing pressure from sheep, cattle, deer and elk, and rooting by feral pigs have severely impacted native plant communities, increasing erosion and sedimentation in island streams. These non-native herbivores have also directly affected streamside communities and impacted water quality through preferential grazing in and near riparian areas.

Marine Water Quality.
Water is of course, a fundamental component of the marine ecosystem. In the conceptual models, anthropogenic influences are directly linked to marine water quality. Anthropogenic sources of impact include sewer discharge, urban runoff, beach and shoreline management, increased sedimentation from land disturbance, chemicals and pollutants related to human activities, effects triggered by global climate change, etc. Poor water quality in marine environments can lead to lethal and sub-lethal effects on organisms throughout the ecosystem. These effects can persist long after the source has been eliminated (*e.g.*, DDT contamination along the mainland shore of southern California).
The conceptual models also link natural ocean processes to marine water quality. Nutrient cycling in ecosystems affects the presence and distribution of species, populations, and communities in both marine and terrestrial environments. Small-scale nutrient loadings can lead to eutrophication and exponential phytoplankton or seaweed growth in the marine system. Upwelling periods result in increased growth of opportunistic algal species. Inter-annual climatic phenomena such as El Niño and La Niña can cause significant nutrient depletion or enrichment. All of these alterations in nutrient levels have the potential to cause large changes in marine flora with cascading effects on higher trophic levels.

3.6.3 Reptile and Amphibian Population Dynamics

Terrestrial Herpetofauna.
Reptiles make up an important part of the terrestrial system within the network conceptual

models. Snakes and lizards together represent by far the most species of any of the faunal components of our models. They are important both trophically and in terms of reflecting impacts from urbanization. The interconnections within the reptile community (including larger snakes and lizards eating smaller lizards and snakes) and their role as prey for predatory birds make them sensitive to changes in several animal communities. At the opposite end of the food web, reptiles and amphibians rely heavily on smaller organisms for food, thus they are potential indicators of problems in trophic levels below them. Terrestrial reptiles are also sensitive to the effects of habitat fragmentation, urban encroachment, and habitat alteration. In addition to their importance within the network model, standard herpetofauna sampling techniques have already been used successfully within the network and thus, this taxa ranked high as a practical vital sign of ecosystem health.

Aquatic Herpetofauna.
Population status and dynamics of aquatic herpetofauna were ranked highly as significant and sensitive indicators of ecosystem health. Many amphibian species are declining in various parts of the world, even in remote protected areas, and a number of local amphibian species are also considered sensitive. Their longevity and high permeability of the skin of some species may make them vulnerable to cumulative changes to the ecosystem. In addition, urban encroachment, by altering the hydrology and water availability in the Santa Monica Mountains has resulted in the spread of exotic species and a loss of breeding habitat, and may be leading to a decline in aquatic amphibians. The rarity of some species and their potential for rapid decline makes this group an important resource to monitor in and of itself. Second, amphibian monitoring will provide us with important information about the status of streams in the Santa Monica Mountains, the predominant aquatic resource in the park and a key component in the conceptual models.

Additionally, in the streams of southern California, predation on eggs, larvae and adults by introduced exotic fishes and crayfish has resulted in significant impacts on native amphibian distribution and abundance. Thus, the distribution and abundance of these introduced pests will be monitored as part of the overall monitoring of aquatic amphibians in the Santa Monica Mountains.

3.6.4 Landscape Pattern

Habitat Connectivity, Fragmentation, and Patch Dynamics.
Landscape characteristics, such as land use, land cover, and patterns of habitat fragmentation, habitat connectivity, patch size and patch distribution are all critical determinants of ecosystem function. Changes in these characteristics resulting from urbanization are among the most important anthropogenic stressors known in our human-dominated region. The conceptual models illustrate the direct connections between habitat loss and fragmentation and resulting changes in wildlife communities and populations. Aside from these direct connections, landscape pattern and land use may also have major implications for fire frequency, exotic species distributions, water quality, air quality, and soil erosion.

End Notes:

[1] http://science.nature.nps.gov/im/monitor/glossary.htm

Table 3.5 Candidate vital signs for Cabrillo NM organized by the Nationa Park Service Monitoring Framework and prioritized by their rank score within framework Level 3. Vital signs that scored 80.00 (60.00 for Water Quality related vital signs) are shaded and were identified for further consideration in the selection process; n = the number of respondents scoring a particular vital sign.

Level 1	Level 2	Level 3	Network Vital Sign Name	n	Score
Air & Climate	Air Quality	Ozone	Plant Community Distribution	21	71.03
			Lichen Tissue Chemistry (Ozone)	21	69.84
		Wet & Dry Deposition	Lichens and Native Vegetation	18	64.81
		Visibility & Particulate Matter	Visibility	18	58.33
	Weather & Climate	Weather & Climate	Marine Plant Communities	15	73.89
			Terrestrial Plant Communities	20	73.33
Biological Integrity	At-risk Biota	T&E Species & Communities	Rare Plant Populations and Habitat	18	86.57
	Focal Species or Communities	Marine Communities	Marine Vegetation	14	91.07
		Shrubland Vegetation	Coastal Shrub Community	18	89.35
			Chaparral Community	17	86.76
		Reptiles & Amphibians	Terrestrial Herpetofauna	18	86.57
		Marine Communities	Intertidal Invertebrates	14	86.31
		Mammals	Meso-carnivores	17	82.35
		Grassland Vegetation	Native Grassland Community	18	77.31
		Birds	Birds - Breeding Raptors	16	75.52
			Birds - Endangered, Threatened, Rare and Sensitive Species	16	73.44
		Mammals	Small Mammals	17	71.08
		Birds	Birds - Resident Passerine Species	17	70.59
			Birds - Migratory	16	66.67
		Terrestrial Invertebrates	Terrestrial Invertebrates	16	66.67
		Fishes	Fish	12	60.42
		Mammals	Bat Diversity & Abundance	17	58.82
		Marine Communities	Marine Plankton	12	56.94
		Mammals	Meso-herbivores	18	53.70
		Birds	Birds - Diving and Shorebirds	16	53.65
	Invasive Species	Invasive Exotic Animals	Native Reptiles, Amphibians and Invertebrates	18	86.11
			Native Bird Community	16	80.21
			Intertidal Invertebrates	13	58.97
		Invasive Exotic Plants	Native Vegetation	17	93.63
			Marine Vegetation	13	67.31
Ecosystem Pattern & Processes	Fire	Fire & Fuel Dynamics	Native Plant Communities Structure	18	86.11
	Land Cover & Use	Land Cover & Use	Connectivity	18	81.94
			Habitat Patch Size & Dynamics	18	81.02
			Native Animal Communities	17	75.49
			Native Plant Communities	19	74.56
			Native Plant Restoration Success	18	74.54
			Natural Succession	19	71.93
	Soundscape	Soundscape	Wildlife	18	53.70
Geology & Solis	Geomorphology	Marine Features & Processes	Intertidal Community	13	67.95
		Hillslope Features & Processes	Sediment Transport and Erosion	17	55.39
		Coastal/Oceanographic Features & Processes	Shoreline Stability	17	45.10
		Hillslope Features & Processes	Hill Slope Stability	16	43.75
			Sediment Transport	17	43.63
	Soil Quality	Soil Function & Dynamics	Cryptobiotic Crusts	19	57.46
			Soil Structure & Stability	17	53.43
			Soil Chemistry	16	46.88
			Soil Microbial Biodiversity	18	44.91
Human Use	Consumptive Use	Consumptive Use	Intertidal Community	11	62.88
	Non-point Source Human Effects	Non-point Source Human Effects	Park Management Impacts on 'Native Plant Communities Structure	17	75.49
			Resource Management, Monitoring & Research Impacts on Marine Biota	12	74.31
			Dark Night Sky/Nocturnal Animal Community	18	56.94
	Visitor & Recreation Use	Visitor Usage	Marine Biota	14	75.60
Water	Hydrology	Marine Hydrology	Larval Transport	13	61.54
		Surface Water Dynamics	Fresh Water Seeps	18	57.87
	Water Quality	Aquatic Macroinvertebrates & Algae	Intertidal Community	13	75.64
		Water Chemistry	Marine Water Chemistry	14	71.43
			Marine Nutrient Dynamics	13	63.46
			Water Quality - Ground Water	18	54.17

Table 3.6 Candidate vital signs for Santa Monica Mountains NRA by the Nationa Park Service Monitoring Framework and prioritized by their rank score within framework Level 3. Vital signs that scored 80.00 (60.00 for Water Quality related vital signs) are shaded and were identified for further consideration in the selection process; n = the number of respondents scoring a particular vital sign.

Level 1	Level 2	Level 3	Network Vital Sign Name	n	Score
Air & Climate	Weather & Climate	Weather & Climate	Terrestrial Plant Communities	20	73.33
			Soil Structure & Stability	17	53.43
Biological Integrity	At-risk Biota	T&E Species & Communities	Rare Plant Populations and Habitat	18	86.57
	Focal Species or Communities	Shrubland Vegetation	Coastal Shrub Community	18	89.35
			Chaparral Community	17	86.76
		Amphibians & Reptiles	Terrestrial Herpetofauna	18	86.57
		Mammals	Meso-carnivores	17	82.35
		Amphibians & Reptiles	Aquatic Herpetofauna	16	82.29
		Riparian Communities	Riparian Plant Communities	17	81.86
		Freshwater Invertebrates	Aquatic Invertebrates	15	81.11
		Vegetation Communities	Oak Woodland Community	17	80.88
		Wetland Communities	Wetland Community	16	80.73
		Grassland Vegetation	Native Grassland Community	18	77.31
		Birds	Birds - Breeding Raptors	16	75.52
			Birds - Endangered, Threatened, Rare and Sensitive Species	16	73.44
		Mammals	Mountain Lions	18	72.69
			Small Mammals	17	71.08
		Birds	Birds - Resident Passerine Species	17	70.59
		Riparian Communities	Riparian Aquatic Communities	18	69.91
		Birds	Birds - Migratory	16	66.67
		Terrestrial Invertebrates	Terrestrial Invertebrates	16	66.67
		Fishes	Fish - Steelhead	18	59.72
		Mammals	Bat Diversity & Abundance	17	58.82
	Invasive Species	Invasive/Exotic Plants	Native Vegetation	17	93.63
		Invasive/Exotic Animals	Native Reptiles, Amphibians and Invertebrates	18	86.11
			Native Animal Community	17	84.31
			Native Bird Community	16	80.21
Ecosystem Pattern & Process	Land Cover & Land Use	Land Cover & Land Use	Connectivity	18	81.94
			Habitat Patch Size & Dynamics	18	81.02
			Native Animal Communities	17	75.49
			Native Plant Communities	19	74.56
	Fire	Fire & Fuel Dynamics	Native Plant Communities Structure	18	86.11
Geology & Soils	Geo-morphology	Hill Slope Features & Processes	Hill Slope Stability	16	43.75
			Sediment Transport	17	43.63
	Soil Quality	Soil Function & Dynamics	Cryptobiotic Crusts	19	57.46
			Soil Chemistry	16	46.88
			Soil Microbial Biodiversity	18	44.91
Water	Freshwater Quality	Water Chemistry	Water Chemistry	17	74.51
			Freshwater Nutrient Dynamics	17	69.61
	Hydrology	Ground Water Dynamics	Water Quality - Ground Water	18	54.17
		Surface Water Dynamics	Stream Flow	19	73.25
			Fresh Water Seeps	18	57.87

Table 3.7 A Summary of ecosystem processes or components currently being monitored or proposed for monitoring within the MEDN. Monitoring activities within parks conducted by the parks or other agencies that are not part of this planning effort are also listed.

Level 1	Level 2	Level 3	Vital Sign	CABR	CHIS	SAMO
Air and Climate	Air Quality	Ozone	Air Quality	•	•	•
		Wet and dry deposition	Air Quality	•	•	•
		Visibility and particulate matter	Visibility	•	–	–
		Air contaminants	Air Quality	•	•	•
	Weather and Climate	Weather and Climate	Weather	•	•	•
Water	Hydrology	Surface water dynamics	Stream Flow	–	+	+
		Marine Hydrology	Waves & Currents	•	•	–
	Water Quality	Water chemistry	Fresh Water Chemistry	–	+	+
			Marine Water Chemistry	+	+	–
		WQ Nutrients	Freshwater Nutrient Dynamics	–	+	+
			Marine Water Nutrient Dynamics	+	+	–
		Toxics	Freshwater	–	+	+
			Marine Water	+	+	–
		Microorganisms	Freshwater *E. coli*	–	+	+
			Marine Water *E. coli*	+	+	–
Biological Integrity	Invasive Species	Invasive/Exotic plants	Exotic Plant Species Introduction & Spread	+	•	+
		Invasive/Exotic animals	Crayfish & Fishes	–	–	+
	Focal Species or Communities	Marine communities	Kelp Forests	–	•	–
			White Abalone	–	•	–
		Intertidal communities	Intertidal Vegetation	•	•	–
			Intertidal Invertebrates	•	•	–
			Intertidal Infauna	–	•	–
		Shrubland vegetation	Chaparral & Coastal Sage Scrub	+	•	+
			Shrubland	–	•	–
		Grassland Vegetation	Grassland/Herbland	–	•	–
		Vegetation Communities	Oak Woodlands	–	•	+
			Woodlands	–	•	–
		Riparian Communities	Riparian Plant Communities	–	•	+
		Marine invertebrates	Sand Beaches & Lagoons	–	•	–
			Tide Pools	•	•	–
		Fishes	Fish	–	•	–
			Giant Sea Bass	–	•	–
			Deepwater Fishes	–	•	–
			Mid-water Trawls	–	•	–
		Amphibians and Reptiles	Terrestrial Herpetofauna	+	✧	+
			Aquatic Herpetofauna	–	–	+
		Birds	Migratory Birds	–	✧	–
			Raptors	–	•	–
			Marine Birds	–	•	–
			Shore Birds	–	•	–
			Breeding Birds	–	•	–
		Mammals	Small Mammals*	–	•	–
			Carnivores	–	•	•
			Pinnipeds	–	•	–
			Humpback & Blue Whales	–	•	–
	At-risk Biota	T&E species and communities	*Pentacheata lyonii*	–	–	•
			Bald Eagle	–	•	–
			California Brown Pelican	–	•	–
Human use	Consumptive Use	Consumptive use	Fisheries Harvest	–	•	–
	Visitor and Recreation Use	Visitor usage	Visitors	•	•	•
Ecosystem Pattern and Processes	Fire	Fire and fuel dynamics	Fire	–	–	•
	Land Cover and Use	Land cover and use	Habitat Fragmentation	–	–	+

+ Network vital signs
• Park or other funded monitoring
✧ High-priority vital sign for which funding to monitor is lacking

Chapter 4: Sampling Design

Sampling consists of selecting some part of a population to observe so that one may estimate something about the whole population.

Steven K. Thompson, Sampling 2nd Edition

4.1 Introduction

This chapter outlines the programmatic sampling approach and constraints to that approach for monitoring vital signs in the Mediterranean Coast Network, particularly in Cabrillo NM and Santa Monica Mountains NRA. The rationale for selecting sampling locations and a description of how the sampling effort may be rotated among those locations is presented. Co-locating of sampling programs is described where it is practical and where such co-location is an integral link for analysis and interpretation of monitoring results between or among vital signs (*i.e.*, aquatic amphibians and water quality). Detailed sampling designs are not included in this chapter, but will be presented in the monitoring protocols for individual vital signs as they are completed. The focus herein is on an overall sampling strategy that will permit statistical inferences to broader areas of protected park lands or individual park resources. The physical, climatic, and political factors that can limit sample site selection are also discussed.

The Channel Islands NP prototype monitoring program is well established and in some cases decades old. Little information on sampling design or sample site selection in the Channel Islands is included in this discussion. Additional information related to sampling design for the Channel Islands NP program can be found in individual monitoring protocols produced by the prototype monitoring program.

4.2 Sampling Concepts and Definitions

The use of sampling concepts and definitions throughout this chapter relies on the underlying concepts and descriptive terms of MacDonald (2003). A short discussion of the concepts behind the recommended sampling designs and definitions of common sampling terms such as sample unit, panel, rotation design, and membership design are provided.

Our working definition of monitoring is the collection and analysis of repeated observations or measurements over a long period of time to document the status and trends in status of selected ecological parameters. Monitoring is usually designed to provide unbiased estimates of status and trends in status over large spatial scales or over specifically delineated "ecosystems" units. Monitoring programs do not set out to investigate a single question or to test a specific hypothesis; rather they attempt to collect objective and scientifically defensible data that address wide ranging hypotheses regarding sensitive aspects of natural systems. In some cases monitoring expectations cannot be finalized at the onset of sampling but unfold as data are collected and analyzed.

The specific monitoring proposed for the Mediterranean Coast Network relies on concepts in finite population sampling where the area for which inferences are to be made (*e.g.*, a park, region, or ecosystem) is generally viewed as a limited collection of sample units (or just units). In general, sample units are the smallest entities upon which measurements are taken. The total collection of sample units is the population from which samples are drawn. Sample units are discrete entities such as stream segments or landscape quadrats. Sample units may also be individual species or communities of species. The subset of units from the population for which we collect responses is called the sample. Responses are measurements taken on or from the sample units. Samples may be selected in a variety of ways. Systematic samples are drawn from a population by placing a regular grid of sample points across the extent of the population to be sampled. Specific samples may be the actual grid points or a subset of points designated in some regular fashion, *i.e.,* every third point *etc*. Samples may also be drawn randomly from a systematic grid or selected randomly from the population independent of a systematic grid. If a sample is chosen using some type of random draw, the sampling scheme is said to be probabilistic in nature.

Selection of sample locations may be constrained by physical factors, such as terrain (elevation, slope or aspect), political factors, such as land ownership or land use, climatic factors, or vegetation habitat. These factors are very unlikely to be equally apportioned across a landscape or population, and therefore, sample locations may be selected in a stratified manner with the number of sample locations in a stratum being dependent upon the proportion in the landscape of the stratum from which they are selected or some other relevant covariant.

Sample locations may also be determined using a representativeness approach. Sample locations are selected based upon their supposed relation to factors considered to be representative of the population or ecosystem component of interest. This type of sampling which is often used in water quality monitoring programs (Ward *et al.*, 1990) may seem to be justified in some situations, but generally provides data with limited value in making population-wide inferences. Still other sample locations will be selected because of unique conditions associated with those samples. A known source of pollution or previously identified stress may dictate selection of a specific watershed or stream for water quality sampling.

Most sample designs proposed for the Mediterranean Coast Network will rotate field sampling efforts through various sets or panels of sample units over time. Sample panels are groups of sample units that are sampled during the same sampling occasion or time period (McDonald, 2003). They are defined spatially by a "membership design," while the temporal pattern of sampling is designated as the "revisit design." Note that this definition does not preclude a given sample unit from being a member of two or more different panels.

The membership design specifies the spatial sampling schedule. For example, if two panels are to be constructed, the membership design might specify that members of Panel 1 be selected at random from the population. For Panel 2, the membership design might dictate that the members of Panel 1 are placed back into the population and another random sample be taken to comprise the units of Panel 2. Under this plan, it is possible to select the same unit for membership in both panels. Another membership design might specify a systematic sample of units be drawn and then placement of every other unit into Panel 1, starting with the first. Every other unit starting with the second would be placed in Panel 2. Under this design, it is not possible to get the same unit in both panels.

The membership design does not specify when each panel is visited. The pattern of visits through time to all panels (the temporal sampling schedule) is the revisit design (McDonald, 2003). For example, if two panels are defined and 10 sampling occasions will occur, the revisit design might specify that units in panel 1 be visited during occasions 1, 3, 5, … $n_{(n+2)}$ and the units in panel 2 be visited during occasions 2, 4, 6, … $n_{(n+2)}$. An alternative revisit design might specify that units in Panel 1 be visited every occasion, while those in Panel 2 are to be visited every third occasion.

McDonald (2003) proposed notation for revisit designs that can help in describing sampling programs. Under this notation, the revisit plan is represented by a pair of digits, the first of which is the number of consecutive occasions that a panel will be sampled, the second of which is the number of consecutive occasions that a panel is not sampled before repeating the sequence. The total number of panels in the rotation design is normally the sum of digits in the notation. For example, using this notation the digit pair [1-2] means that members of three panels will be visited for one occasion, not visited for two occasions, then visited again for one occasion, not visited for two occasions, and so on. If a single panel is to be visited every sample occasion, its revisit design would be [1-0]. The notation [1-1] means a panel is to be sampled every other sampling occasion. The notation [1-n] means a panel is to be visited once and never again. The notation [1-0, 1-5] indicates that one panel will be visited every occasion, while units in 6 other panels will be visited once every 6 years. The schematic representation and notation for five example revisit designs appear in Figure 4.1.

4.3 General Constraints on Sampling Design in the Mediterranean Coast Network

Although each of the parks of the Mediterranean Coast Network have similar geologic underpinnings and share the same Mediterranean-type ecosystem, the factors that potentially impact the development of a sampling design vary widely among the parks. At one end of the spectrum, Channel Islands NP encompasses over 100,000 hectares including significant marine resources. Accessibility is severely limited by distance from shore and island size (*e.g.*, remoteness of some areas of the larger islands). Aside from a very limited amount of water quality monitoring to be implemented at Channel Islands NP, this plan focuses on the new vital signs to be monitored at Cabrillo NM and Santa Monica Mountains NRA. General constraints that will need to be considered in designing a sampling plan to include these two parks are described below.

The small size of Cabrillo NM and the PLER facilitates including the entire park in any sampling scheme or plan and it should be possible to encompass all of the various habitat types, disturbed areas, and unique geo-morphological characteristics. While sampling within Cabrillo NM is generally not restricted due to physical accessibility or other features, there are several areas where the landscape consists of slopes in excess of 45° from horizontal (≥ 100% slope). On the southern end of the peninsula rocky and sandy bluffs bordering the water with cliff faces up to over 90 meters high. These nearly vertical faces are not accessible for sampling and in some cases surround otherwise accessible areas limiting or preventing safe access to them. Additionally, shallow hillside soils are often loosely packed and easily eroded presenting a risk to monitoring staff working on slopes.

Most of Cabrillo NM is easily accessible from trails and roads during the day. In general, no more than a 0.4 kilometer walk would be needed to access any specific area. Outside of park visiting hours (9:00 AM - 5:00 PM), passes must be obtained from the Navy to access locations on Point Loma and within Cabrillo NM. Access to the Point Loma Ecological Reserve (PLER) varies; some areas are accessible with the appropriate Navy pass while others have restricted access. The Navy passes needed for after-hours access to the park and for access to the PLER are available only to US citizens.

	Sample Occasion									
Panel	1	2	3	4	5	6	7	8	9	10
	Design [1-0]									
1	X	X	X	X	X	X	X	X	X	X
	Design [1-n]									
1	X									
2		X								
3			X							
4				X						
5					X					
6						X				
7							X			
8								X		
9									X	
10										X
	Design [2-n]									
1	X	X								
2		X	X							
3			X	X						
4				X	X					
5					X	X				
6						X	X			
7							X	X		
8								X	X	
9									X	X
	Design [2-3]									
1	X	X				X	X			
2		X	X				X	X		
3			X	X				X	X	
4				X	X				X	X
5	X				X	X				X
	Design [1-0,2-3]									
1	X	X	X	X	X	X	X	X	X	X
2	X	X				X	X			
3		X	X				X	X		
4			X	X				X	X	
5				X	X				X	X
6	X				X	X				X

Figure 4.1 Graphic representations of various sampling panel schemes. See text for discussion.

The park boundary of Santa Monica Mountains NRA encloses some 61,000 hectares of land including much of the east/west trending Santa Monica Mountains. Currently, approximately 90% of the land within the NRA boundary remains undeveloped—though about 42% of that is privately owned and vulnerable to future development. The 10% of the area within the NRA that is developed is characterized by rural residential sites, small but exclusive residential developments, agricultural sites, and the City of Malibu along the coast. The Santa Monica Mountains extend some 65 kilometers from Point Mugu in the west to the city of Santa Monica in the east. The park also encompasses a portion of the Simi Hills located just to the north of the central Santa Monica Mountains.

When the NRA was established in 1978, there were already three large state parks in the Santa Monica Mountains. The California Department of Parks and Recreation remains the largest public landholder in the mountains, followed by the National Park Service, the Santa Monica Mountains Conservancy and Mountains Recreation and Conservation Authority. Several other public park agencies own or manage park lands within the boundaries of the recreation area. However, the National Park Service is the only entity with a mandate to protect resources over the entire NRA. Thus, park staff are accustomed to cooperating with these other agencies to implement resource studies throughout the mountains. Monitoring can be conducted on public lands without regard to ownership. Formal agreements with the larger park landowners are in place and additional agreements can be created as needed.

Park managers have identified an area of ecological interest (Resource Management Zone of Figure 4.2) that extends beyond the NRA boundary. The intent of this area is to incorporate into park management strategies the interaction of urban influences surrounding the park that can impact resource conditions within the park. Again, many park natural resource studies have extended onto public land beyond the NRA boundaries to provide information needed to manage land within the NRA. Some limited monitoring is likely to occur on public lands outside the NRA boundary.

Constraints imposed on sampling within Santa Monica Mountains Resource Management Zone (RMZ) relate to physical access to sampling sites and temporal continuity in that access. While a significant portion of the privately owned properties in the park are as yet undeveloped and contribute to the ecological integrity of preserved lands, establishing resource management or monitoring activities on these lands is at best a tenuous prospect. Access to such lands requires the permission of the landowner, may or may not be granted, and may or may not be permanent. Because of this, resource managers must limit long-term research and monitoring activities to lands held in public trust where access can be guaranteed into the future.

There are 350 km of major roads, 1080 km of minor roads, and 650 km of official trails distributed throughout the Santa Monica Mountains NRA. As a result, much of the park is relatively accessible by road or trail. However, travel time, particularly between the eastern and western ends of the park, can be significant due to the narrow, winding nature of many of the smaller park roads and traffic congestion on surrounding urban roads as well as the heavily-used transportation corridors crossing the park.

Other constraints to sampling include vegetation type and terrain. Much of the native chaparral of southern California is quite dense and limits accessibility to the broader landscape as viewed from roads or trails. Staff safety must also be considered. Monitoring activities in areas with slopes in excess of 45^{o} from the horizontal are not possible without the use of specialized safety equipment and training. Unconsolidated soils common in the mountains increases risk in these areas. Additionally, most of the steams in the mountains drain steep deeply incised canyons. Flow is generally intermittent, but can be quite extreme during the winter rainy season.

4.4 Overview of Sampling Approaches

The design of sampling schemes for vital signs monitoring in the Mediterranean Coast Network requires, in addition to consideration of the physical, environmental, and political constraints unique to each park, that the network identify the specific sampling methodology (what value is to be measured and how is it measured) and determine the general analytical process and breadth of interpretation. These considerations, coupled with the funds available for monitoring set the limits for identifying sample panels, membership schemes, revisit designs and replication limits for

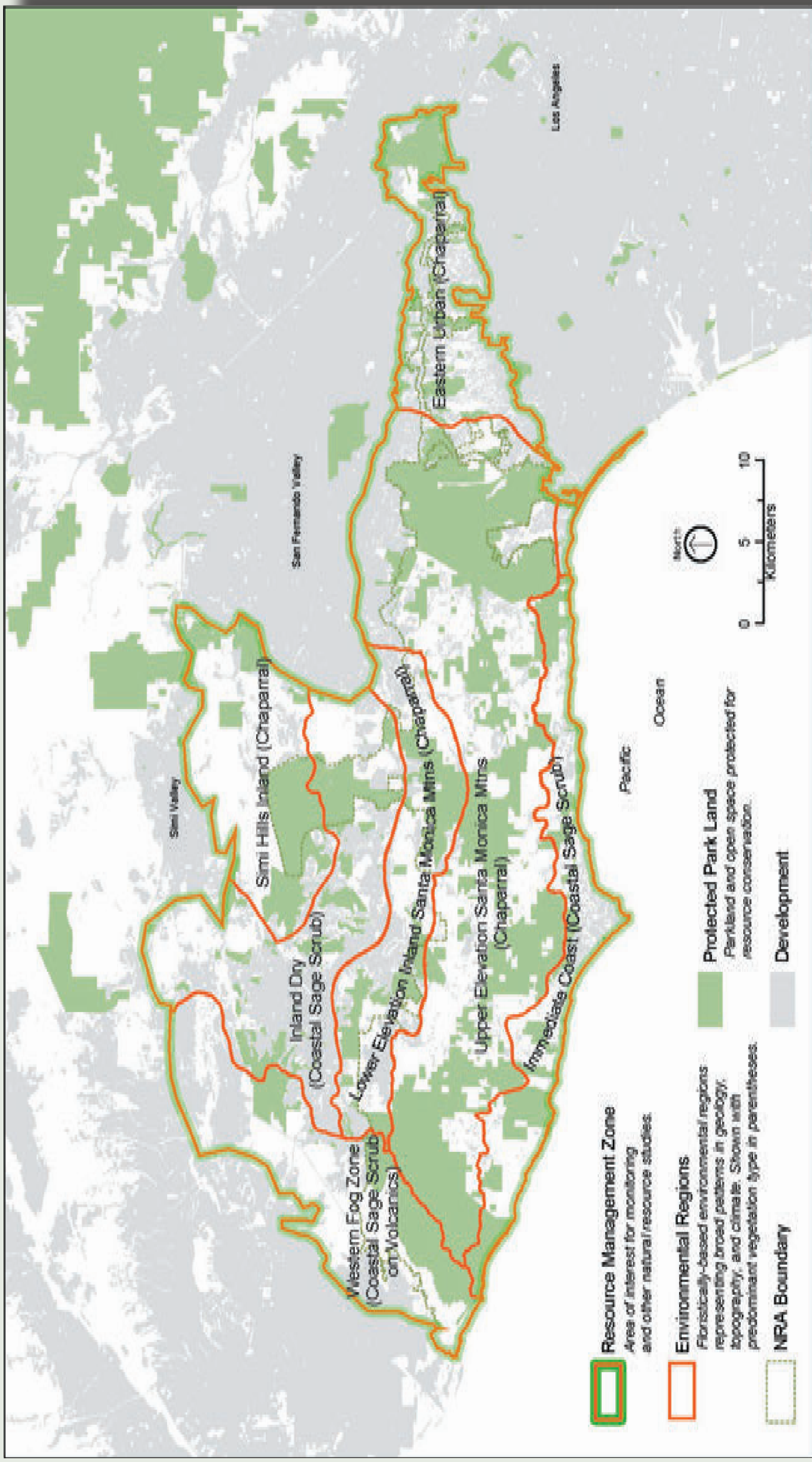

Figure 4.2 Santa Monica Mountains Resource Management Zone within which vital signs monitoring activities will be stratified. This management zone reflects the extent of the vegetation map for the Santa Monica Mountains in its final stage of completion, and captures the landscape level influences important in determining the health of the mountains ecosystem and individual natural resource within the mountains.

monitoring a particular vital sign. The factors that must be considered are not uniformly distributed across the landscapes or natural resource issues at Cabrillo NM and Santa Monica Mountains NRA, but act somewhat independently across the suite of vital signs identified for the individual parks of the Mediterranean Coast Network. Thus, sampling approaches may differ among parks and vital signs.

The overall vital signs selection process for network parks has identified four classes of resources to be monitored. These include:

1. Marine and freshwater water quality,
2. Amphibian and reptile population characteristics and dynamics,
3. Vegetation community characteristics and dynamics including the invasion and spread of non-native plant species, and
4. Changes in landscape pattern due mainly to anthropogenic activities.

Detailed sampling plans will be developed and included in the monitoring protocols as they are written. The following section presents considerations and a general sampling approach for each selected vital sign.

4.4.1 Water Quality Monitoring

The marine waters surrounding the Point Loma peninsula are subject to a myriad of potential pollutants. The activities of the U.S. Navy, commercial shipping, recreational boating, and wastewater treatment are among a few of the potential sources of contamination. As such, monitoring of the marine waters within the intertidal zone on the west shore of the Point Loma peninsula is proposed for Cabrillo NM. This shoreline is presently managed by Cabrillo NM and is one of the last remaining undisturbed rocky intertidal zones along the mainland coast of southern California. The number and location of sampling sites for marine water quality monitoring is yet to be determined. In general, replicate samples will be taken along the managed intertidal zone of Point Loma during the bi-annual intertidal monitoring program and at other intervals co-incident with resource management activities, seasonal climatic patterns, and periodic oceanographic processes (*i.e.,* seasonal changes in micro-currents and upwelling events). *Ad hoc* sampling will be conducted following extreme storms or other stochastic or unexpected events that could affect the quality of the marine waters surrounding Point Loma.

Monitoring of surface water resources is proposed across the Santa Monica Mountains RMZ. This monitoring will focus on two categories of resources; the first being the general quality of the water in the streams themselves to capture the real or possible affects of human-caused stress in mountain streams. Secondly, most, if not all, perennial and intermittent streams in the Santa Monica Mountains RMZ host the spring time recruitment of four species of amphibians. Since the monitoring of aquatic reptile and amphibian species has been identified as an integral component of the overall herpetological monitoring program, water quality monitoring will in part be co-located with the amphibian stream monitoring locations. A list of streams that are representative of management concerns for their potential impact from anthropogenic stressors or for their supposed near pristine condition is being prepared. Sampling will be done on a suite of conventional water quality parameters to include the National Park Service Water Resources Division core variables in at least one site along these streams three to four times a year. Water samples will also be collected coincident with aquatic herpetofauna monitoring and at additional times for these sites throughout the sampling year. This later sampling will include a selection of stream sites that were selected subjectively as being representative of urban and non-urban influenced streams where at least one of the four species of amphibians known to inhabit the mountains completes it's reproductive cycle. The remainder of these sites will be selected randomly from the environmental strata depicted in Figure 4.3 and discussed below.

When combining all the proposed sample collection regimens (representative streams and aquatic herpetofauna monitoring) nearly all intermittent and all perennial streams in the mountains will have at least one sampling station located along its course. The exact scale of spatial and temporal sample replication for analysis purposes is yet to be determined and will vary depending on the purposes for which samples are collected.

While monitoring of both the marine and freshwaters of Channel Islands NP is proposed, there are insufficient funds to launch an in-depth and all-inclusive monitoring program across the entire landscape of this park. Instead, monitoring of marine and surface water resources will be tailored to supplement intertidal and subtidal resource monitoring being done under the prototype monitoring program, or in response to resource impairment caused by past agricultural practices on the islands of the park. Monitoring of marine water quality in the Channel Islands is not as imperative as monitoring the freshwaters of specific islands. The marine waters surrounding the Channel Islands are spatially removed from mainland industrial and urban pollutant sources, and the threats that do exist are being monitored by other federal or state agencies or stakeholders. As indicated above, there has been significant degradation of some freshwater resources in the islands from the presence of domestic livestock. This situation has been ameliorated to a great extent by management practices and by the removal of livestock. Still, a population of feral pigs that is established on Santa Cruz Island continues to impact several categories of resources including riparian vegetation and stream banks. These impacts in turn affect stream water quality through increased run off, increased turbidity, and increased water temperature.

The temporal and spatial scale of water quality sampling in the Channel Islands is yet to be determined. Logistical difficulties in accessing the islands and specific sampling sites and the level of funding available to support sampling will proscribe an extensive distribution of sample sites throughout the islands. Sample locations will be chosen from streams with a known history of impact from the past grazing of livestock and managed wildlife (elk & deer), and from streams thought to be free of anthropogenic impacts or stressors. The intent will be to track potential improvement in water quality of impacted streams following management action to ameliorate these impacts, and to track water quality in streams that have no history of human-induced stressors.

4.4.2 Amphibian and Reptile Monitoring

Monitoring of terrestrial amphibians and reptiles is occurring at Cabrillo NM and Santa Monica Mountains NRA. While this monitoring uses pitfall trapping procedures defined by the USGS Western Ecological Research Center following a protocol formalized by the Mediterranean Coast Network, the process of identifying specific sample locations and sampling panel design are much different for the two parks. At Point Loma (Cabrillo NM & the PLER) virtually all accessible regions and habitat types are included in the sampling program, and all sampling sites are monitored every sampling period. Sampling sites were chosen to represent the range of habitats found within the reserve. The PLER was stratified by vegetation type and pitfall arrays were placed in each habitat type in approximate proportion to the proportion of that habitat type within the PLER. Pitfall arrays were also installed within unique landscape features such as open sandy washes (Atkinson, *et al.*, 2003). Locations of pitfall arrays on Point Loma and the underlying habitat type are presented in Figure 4.4.

Equivalent monitoring in the Santa Monica Mountains includes the additional considerations of degree of urbanization, habitat patch size, and habitat connectivity. Within the Santa Monica Mountains RMZ five sampling regions were identified and a rotating panel design was selected to sample 20 independent pitfall trap sites in a given region each month for four consecutive years. Sampling is then halted for six years after which a given region is again sampled as before for four consecutive years. Sampling occurs in two of the five regions in any given year.

The five sampling regions selected for the pitfall-trapping sites were chosen because they are unique in the intensity and location of urban development and broad climatic characteristics (coastal vs. inland), and because they allow for simultaneous sampling of approximately 20 pitfall trap arrays given the constraints of personnel and access. Sampling regions are generally broken down further into two groups of around 10 sites each, groups which often relate to watershed boundaries or geographical proximity for purposes of effective sampling (Figure 4.5).

1. **Simi Hills Region** (20,987 ha) – Inland region north of the 101 Freeway with about 50% urbanization and a highly fragmented landscape. Urban development in this region occurs in valleys, and most remaining open space consists of intervening hills and ridges.
2. **Western End** (13,442 ha) – This is the least urban region of the park, consisting largely of protected state park land, specifically Point Mugu State Park.
3. **Central Coast Region** (11,423 ha) – Coastal hillsides with generally south facing slopes and steep canyons that are more mesic than other portions of the Santa Monica

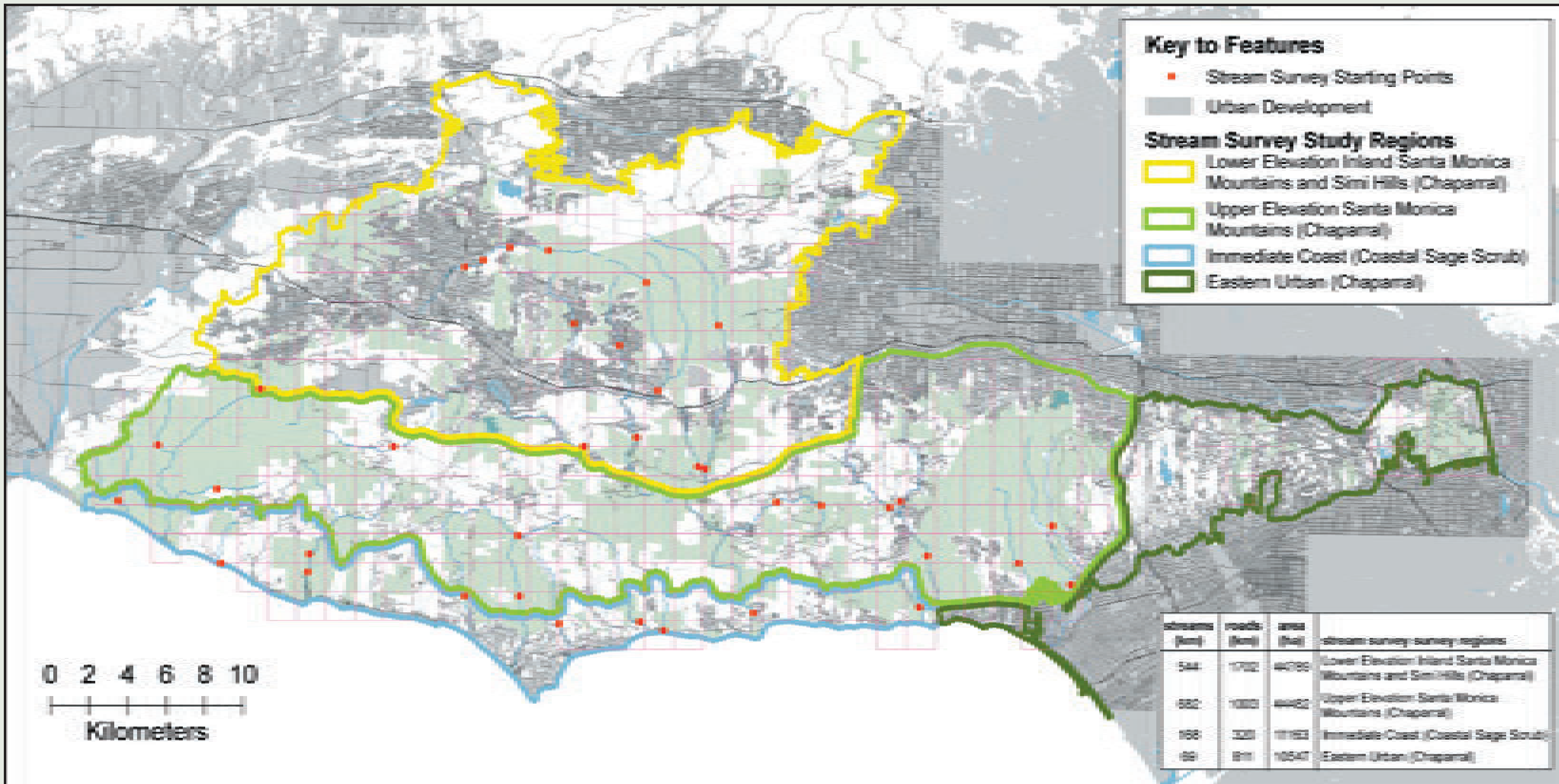

Figure 4.3 1.5 km^2 grid pattern superimposed over habitat strata from which random stream segments will be selected for water quality and amphibian distribution monitoring. Because of the distribution of streams within the mountains the seven habitat regions of Figure 4.2 have been collapsed into the four regions identified in the figure. Grids selected for inclusion in the stratification were required to have stream segments within public lands that could be routinely accessed for sampling. An unequal sample size approach will be used to identify random grids from within each stratum. Within each randomly selected grid, technicians will locate the first accessible point on a stream that meets the sampling location requirements for run, riffle & pool over a minimum distance of 250 m.

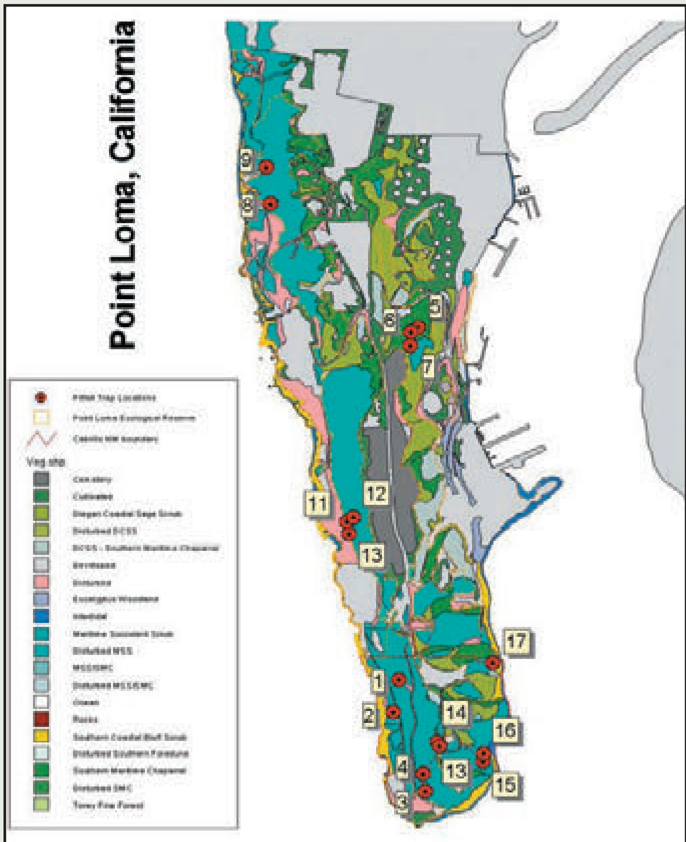

Figure 4.4 Locations of the seventeen pitfall traps within the lands managed for natural resources protection on the Point Loma Peninsula.

Mountains. Urban development in this region is scattered and focused primarily near the mouth of the watersheds.

4. **Malibu Creek Watershed** (19,714 ha) – This inland region is south of the 101 Freeway but north of the backbone of the mountains. It has protected parkland in Malibu Creek State Park and some National Park lands, but these are adjacent to recently urbanized areas in the upper portions of the watershed.
5. **Eastern End** (15,239 ha) – Similar in terrain to the Central Coastal Region, but with a higher density of hillside urbanization and much older development. There is a large protected area in Topanga State Park, adjacent to highly fragmented canyons to the east.

Within regions, potential pitfall- trap sites were selected for being representative of the general habitat characteristics of the region to be sampled according to the following criteria: In each region five or six of the most common habitat types that are relevant for terrestrial herpetofauna were selected and three to four pitfall arrays were placed in each habitat type. Stratification by vegetation type is important because some reptile and amphibian species are habitat-specific. Replication of vegetation types is desirable within sampling regions whenever possible, although some uncommon vegetation types are replicated across regions.

The exact location of sampling sites within habitat types within regions is determined by a number of factors including terrain, proximity to public trails, proximity to archaeological sites, and year-round accessibility. Archaeological sites are avoided to protect cultural resources. Steep slopes are avoided because capture success is lower, trap maintenance is more difficult, and erosion can fill buckets and pile dirt and debris against drift fences. Trap arrays are installed away from roads and trails, but within reasonable walking distance of improved roads to ensure accessibility during inclement weather when mud and rain make vehicular travel difficult on unimproved roads. Because sample site locations were selected subjectively, the large number of sites (20 per region) and temporal replication (once each month for four consecutive years) is thought to provide sufficient data to justify conclusions that might be made about the community dynamics and species distribution and abundance of reptiles and amphibians in relation to the primary factors thought to affect reptiles in the Santa Monica Mountains.

Baseline data on aquatic amphibian distribution, abundance, and reproductive success are currently being collected at 37 locations in streams within and around the Santa Monica Mountains (Figure 4.5). The sites were chosen from specific watersheds determined to be representative of a continuum of impact from high urban development to some with little or no urban development. Data collected at these sites follows the USGS

Amphibian Research and Monitoring Initiative apex sampling guidelines. In the transition from baseline data gathering to vital signs monitoring, a subset of these sites (probably 10 or so) will be sampled each year on a rotating panel design that is yet to be determined. Additional monitoring sites will be identified using a stratified approach that will select 250 meter long stream segments from randomly selected 1.5 km^2 grids within habitat and climatic strata loosely modified from the environmental regions of the ecological area that encompasses the Santa Monica Mountains (see Figure 4.4 and discussion in water quality monitoring section above). Data to determine the "Proportion Area Occupied" (PAO) by the four species of amphibians that reproduce in mountain streams will be collected at these sites. In addition, data on invasive aquatic species (crayfish and fishes) distribution, abundance, & PAO will be gathered to correlate with observations on native amphibians. There are essentially no surface water resources at Cabrillo NM and no monitoring of aquatic amphibians is proposed there.

4.4.3 Vegetation Monitoring

Monitoring of native vegetation and invasive exotic plant species is proposed for both Cabrillo NM and Santa Monica Mountains NRA. Native and non-native vegetation monitoring is presently underway at Cabrillo NM by park staff and scientists from the USGS Western Ecological Research Center following protocols and procedures developed for the prototype monitoring program at Channel Islands NP. Because of the small size of Cabrillo NM, virtually all habitats within the park and the PLER are currently being monitored. It is unlikely that resources will be available to sample all communities across the Santa Monica Mountains RMZ with the power necessary to discern change in the monitored vegetation attributes at an acceptable level of resolution. For this reason, we intend to prioritize major community types for monitoring based on 1) proportion of the total park vegetation represented; 2) global rarity; 3) biodiversity (*i.e.,* species richness); 4) potential for change (*e.g.,* sensitivity to environmental stressors, invasibility, *etc.*); and 5) existing knowledge base (less understood communities will be ranked higher). The highest priority for monitoring will be coastal sage scrub followed by riparian, chaparral, and woodland/grassland communities.

Our general approach will be to use a stratified random sampling scheme to sample priority communities. Seven environmental regions have been identified based on large scale floristic patterns related to differences in moisture availability, temperature, and soil parent material (see Figure 4.2). In order to account for the full range of vegetation response, sample groups will be stratified across each environmental

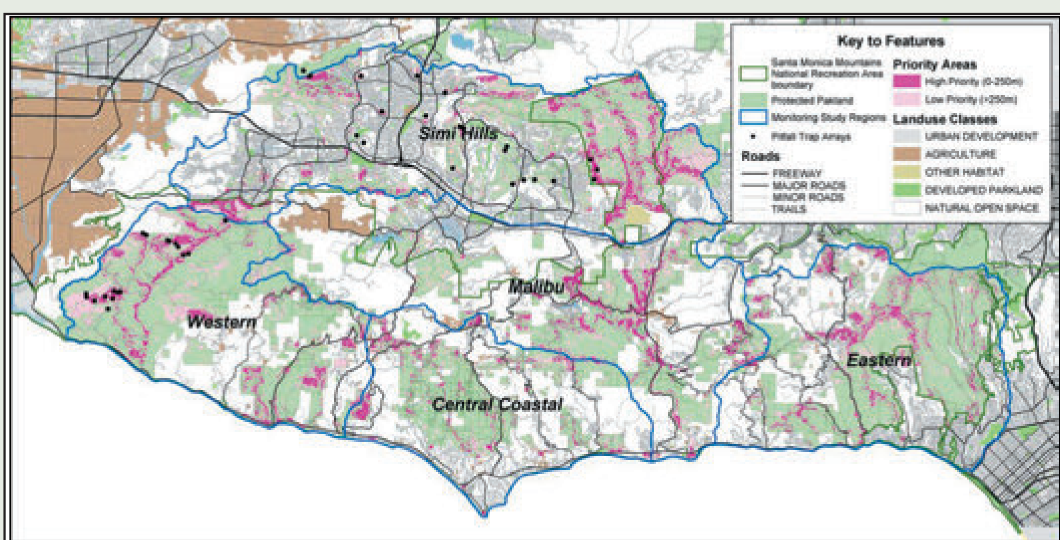

Figure 4.5 Herpetological sampling regions with the Santa Monica Mountains. Black dots show the locations of active pitfall-trap arrays. Areas of the mountains that meet sampling location criteria are indicated in two shades of pink.

region in which a community type occurs. Since several of these regions are large, we will stratify within regions to assure good sample dispersion. Replicate sites will be chosen from within each sub-region.

We believe that the most significant agents of vegetation change in the Santa Monica Mountains are anthropogenic. In order to differentiate potential anthropogenic changes from natural variability and/or global changes, a spatially explicit sampling scheme will be developed that "pairs" sampling sites in areas of heavy urban influence (adjacent to development) with sites of similar environmental characteristics (*e.g.*, aspect, position in the landscape) in areas of only moderate influence (greater distance) and in undisturbed, more remote parklands. This sampling approach will be particularly useful for assessing non-native species dynamics, as exotic species establishment has been observed to be associated with disturbance and propagule sources connected to urban development.

It is not anticipated that all regions or even all areas will be sampled equally, but rather samples will be collected in a manner that maximizes our potential to capture the desired level of change based on our analysis of sampling intensity necessary and perceived potential agents of change.

Sampling methodology, sample site locations, sample panel organization, and revisit schedule for vegetation monitoring at both the Santa Monica Mountains and Point Loma peninsula will be determined during the protocol preparation process. No integration of sampling sites with other monitoring programs is envisioned.

Non-native plant species will be monitored as a component of the plant community monitoring discussed above. If resources allow, Santa Monica Mountains NRA will add monitoring of new or expanding invasions with the objective of providing an "early warning system" for managing incipient problems with non-native species. Sites of likely invasion will be identified based on data from current non-native species maps and vegetation sampling data. This information will be used to select sites of high risk for invasion for intensive monitoring efforts. Although the exact drivers of invasion by non-native plant species are unknown, previous research shows the importance of several factors in predicting what sites are likely to be invaded by non-native species. Habitat disturbance that creates openings within the plant community such as gopher mounds, wildfires, flood events, road building and maintenance, and trails provide spatial opportunity for invasion (Lake & Leishman 2004; Gelbard & Belnap 2003; Bashkin *et al*., 2003). Life history habits that include copious seed production as exhibited by many invasive non-native plants in combination with nutrient rich soils are identified as forces facilitating successful invasion (*e.g.*, Levine 2000, Stohlgren *et al.,* 1999). Finally, the diversity of the habitat being invaded is also known to influence invasibility. The direction of the influence depends on the scale of measurement. Small scale experiments show a negative correlation between diversity and invasibility while large scale pattern analysis shows a positive correlation between native diversity of plant communities and the number of non-native species present in the community (Stohlgren *et al*., 1999; Lyons *et al*., 2001; Levine, 1999). All of these factors provide hints as to where one should look when trying to detect new invasions across a broad landscape.

In searching for new invasive non-native species,we will use the same stratifying factors as in our vegetation sampling protocols. In addition to this stratification, we will focus on areas where a high number of invasive non-native species have successfully colonized. This indicates that these areas are regularly disturbed and are exposed to a diverse seed rain making them likely places to find novel invasive species. Sites that host a single invasive species may be more representative of particular conditions conducive to the establishment and growth of that species while areas that contain a large suite of non-native species clearly have experienced the conditions favorable for the establishment of non-native species on numerous occasions. These sites may be hotspots for non-native species invasion. We will focus one portion of our non-native species sampling plan on these sites (sites with high non-native species diversity). Existing data on non-native species distribution and abundance and vegetation sampling data identify areas of high non-native species richness. These areas will be targeted for sampling. At a chosen subset of these sites we will monitor for invasion of new non-native species as well as spread of invasive non-native species populations already present at each site. The specific subset of sites to be sampled will be based on ease of access, ability to sample (slopes less than 90%), and, geographic distribution of the target species throughout the Santa Monica Mountains RMZ.

Sites with high non-native species diversity also typify habitat conditions that are likely to result in invasion and thus draw attention to habitats that may be particularly sensitive to non-native species invasion. Locations that are similar to highly invaded sites in terms of level of disturbance (near roads or trails, subject to frequent fires, *etc.*) and biotic and abiotic conditions (type of plant community, level of native diversity, soil type, slope, aspect, position within the mountains), but do not currently contain non-native invasive species may be the most at risk for invasion and will be one of the focus points for monitoring.

4.4.4 Landscape Pattern Monitoring

The proposed method for monitoring of landscape dynamics within the network parks is a laboratory exercise that includes repeated collection of published land use data, the gathering of updated aerial imagery, fire occurrence and extent data, *etc.,* and the integration and analysis of these data on a temporal scale that is relevant to the processes that are occurring (proposed to be updated every five years). No field sampling is proposed for this monitoring program. Integration of this information with other monitoring programs will be an analytical exercise conducted *a posteriori* and will be used to support conclusions from the other components of the network monitoring program where appropriate, to forecast impacts upon wildlife from land use changes,

Panel	Framework: Level 2	Level 3	Revisit Schedule	1	2	3	4	5	6	7	8	9	10	11	12	Membership Design
				Sample Occasion (Months)												
1	Hydrology	Surface Water Dynamics	[1-3]	X				X				X				Representative/Stratified Random
2	Water Quality	Water Chemistry	[1-3]	X				X				X				Representative/Stratified Random
3	Water Quality	Nutrients	[1-3]	X				X				X				Representative/Stratified Random
4	Water Quality	Toxics	[1-3]	X				X				X				Representative/Stratified Random
5	Water Quality	Micro-organisms	[1-3]	X				X				X				Representative/Stratified Random
				Sample Occasion (3 Year Intervals)												
				1	2	3	4	5	6	7	8	9	10	11	12	Membership Design
1	Biological Integrity	Invasive/Exotic Plants	[1-0]	X	X	X	X	X	X	X	X	X	X	X	X	Representative/Stratified Random
				Sample Occasion (Months)												
		Fishes & Crayfish		1	2	3	4	5	6	7	8	9	10	11	12	Membership Design
1	Biological Integrity	Invasive/Exotic Animals	[1-11]	X												Representative
2	Biological Integrity	Invasive/Exotic Animals	[1-2,8]	X			X									Stratified Random
				Sample Occasion (3 Year Intervals)												
				1	2	3	4	5	6	7	8	9	10	11	12	Membership Design
1	Biological Integrity	Shrubland Vegetation	[1-0]	X	X	X	X	X	X	X	X	X	X	X	X	Representative/Stratified Random
2	Biological Integrity	Vegetation Communities	[1-0]	X	X	X	X	X	X	X	X	X	X	X	X	Representative/Stratified Random
3	Biological Integrity	Riparian Vegetation	[1-0]	X	X	X	X	X	X	X	X	X	X	X	X	Representative/Stratified Random
				Sample Occasion (Months)												
		Aquatic		1	2	3	4	5	6	7	8	9	10	11	12	Membership Design
1	Biological Integrity	Amphibians & Reptiles	[1-11]	X												Representative
2	Biological Integrity	Amphibians & Reptiles	[1-2,8]	X			X									Stratified Random
				Sample Occasion [Years (SAMO) or Months (CABR)]												
		Terrestrial		1	2	3	4	5	6	7	8	9	10	11	12	Membership Design
1	Biological Integrity	Amphibians & Reptiles (SAMO)	[4-6]	X	X	X	X							X	X	Representative
2	Biological Integrity	Amphibians & Reptiles (CABR)	[1-0]	X	X	X	X	X	X	X	X	X	X	X	X	Representative
				Sample Occasion (5 Year Intervals)												
				1	2	3	4	5	6	7	8	9	10	11	12	Membership Design
1	Land Cover & Use	Land Cover & Use	[1-0]	X	X	X	X	X	X	X	X	X	X	X	X	Inclusive

Figure 4.6 Depiction of sampling effort by vital sign for the Mediterranean Coast Network. See text above for a discussion of each element of this figure. This is a modified McDonald (2003) depiction intended to present the largest grain size of sampling effort for each of the vital sings to be monitored. For instance water quality samples will be collected four times a year (first flush [this sampling event not included in figure] following a significant rain fall and three other specified times) for each pollutant category from each stream identified for sampling. Invasive plant and native vegetation monitoring will occur on a three year rotation. Specifics of this sampling effort are still being developed and will be finalized in the monitoring protocols when completed. Aquatic amphibians will be sampled according to USGS Amphibina Research & Monitoring linitative methods yearly at representative streams and twice yearly at randomly selected streams during the spring and early summer reproductive season when streams are flowing and these species are present in the streams. Terrestrial herpetofauna are sampled in specific regions of the Santa Monica Mountains RMZ once each month. Sampling is a given region will be suspended region after four years and restarted after a six year suspension. Terrestrial Herpetofauna sampling at Cabrillo NM occurs in each month of the year. Monitoring of land cover and land use will occur on a five year rotation.

to propose resource management programs in response to landscape level perturbations, and to quantify changes in landscape dynamics such as fragmentation, habitat patch size, and wildlife corridors.

4.5 Conclusion

Generalized sampling schemes proposed for the vital signs described above are presented in Figure 4.6 and generally follow the notation of McDonald (2003). More detailed descriptions of sampling schemes (panel design, revisit schedule, and membership design) will be included in individual monitoring protocols. Hydrology and water quality sampling is proposed for several streams once every four months each year. Some streams will be selected for their representative impacts and resource value and some selected randomly from an array of climate/vegetation strata in the Santa Monica Mountains Resource Management Zone. The actual pattern of vegetation sampling (invasive and native species), while decidedly more complex than depicted, will occur on a three year rotation schedule. Invasive animal species and aquatic herpetofauna will be sampled once each year intensively at sites representative of factors thought to impact their distribution and abundance. Additional sampling will occur once in the spring and once two months later from sites selected randomly from climate/vegetation strata.

Random stream and herpetofauna sampling will be co-located so that water quality data may be considered in covariate analysis of factors impacting amphibian distribution. Pitfall-trapping of terrestrial herpetofauna will occur in five habitat/climatic regions consecutively each month for four years then closed for six years before reopening for another four consecutive years of sampling. Landscape level assessment of land cover and land use (fragmentation & connectivity) will occur over a five-year interval. All data sources on land use changes or development will be incorporated into the analysis every five-year cycle.

Chapter 5: Monitoring Protocols

Monitoring protocols are detailed study plans that explain how data are to be collected, managed, analyzed, and reported, and are a key component of quality assurance for natural resource monitoring programs.

Oakley, Thomas & Fancy, 2003

The Mediterranean Coast Network is developing monitoring protocols for 17 vital signs planned for implementation in the next three years. Table 5.1 presents these 17 vital signs in the context of the National Park Service Ecological Monitoring Framework. The relationship between these vital signs and the protocols to be prepared is illustrated in Table 5.2. Twelve vital signs monitoring protocols have been developed and implemented or are awaiting implementation at Channel Islands NP (Table 5.3). These protocols were prepared under the auspices of the Channel Islands NP prototype monitoring program and will not be discussed further in this chapter. Copies of these protocols can be found on the National I&M Program Protocol Database[1], from the Chief of Natural Resource Science at Channel Islands NP[2], or from the Mediterranean Coast Network Monitoring Coordinator[3].

All monitoring protocols for the Mediterranean Coast Network will be prepared in the format required by the national program to include a narrative section and attached standard operating procedures (Oakley *et al.*, 2003). Each protocol developed will include a series of standard operating procedures (SOP) to cover at least the following topics:

1. Identification of specific variables, substrates, parameters, or organisms to be monitored.
2. Specific locations where monitoring will occur with detailed instructions on how to locate or access these locations.

Table 5.1 Mediterranean Coast Network vital signs as identified in Chapter 3 organized according to the National Park Service Ecological Monitoring Framework. Parks where these vital signs will be monitored are noted.

Level 1	Level 2	Level 3	Vital Sign	CABR	CHIS	SAMO
Water	Hydrology	Surface Water Dynamics	Stream Flow		✓	✓
	Water Quality	Water chemistry	Fresh Water Chemistry		✓	✓
			Marine Water Chemistry	✓	✓	
		Nutrients	Freshwater Nutrient Dynamics		✓	✓
			Marine Water Nutrient Dynamics	✓	✓	
		Toxics	Freshwater		✓	✓
			Marine Water	✓	✓	
		Microorganisms	Freshwater Microorganisms		✓	✓
			Marine Water Microorganisms	✓	✓	
Biological Integrity	Invasive Species	Invasive/Non-native plants	Non-native Invasive Plant Species Introduction & Spread	✓		✓
		Invasive/Non-native animals	Crayfish & Fishes			✓
	Focal Species or Communities	Shrubland vegetation	Chaparral & Coastal Sage Scrub	✓		✓
		Vegetation Communities	Oak Woodlands			✓
		Riparian Communities	Riparian Plant Communities			✓
		Amphibians and Reptiles	Terrestrial Herpetofauna	✓		✓
			Aquatic Herpetofauna			✓
Ecosystem Pattern and Processes	Land Cover and Use	Land cover and use	Habitat Fragmentation			✓

Table 5.2 The 17 vital signs selected for monitoring by the Mediterranean Coast Network are summarized into eight monitoring protocols targeted for implementation in the next three years.

Vital Sign	Protocol	Proposed Implementation
Stream Flow Fresh Water Chemistry Freshwater (Toxic Pollution) Freshwater Nutrient Dynamics Freshwater Microorganisms	Integrated Fresh Water Quality	2nd Quarter FY 2006
Marine Water Chemistry Marine Water (Toxic Pollution) Marine Water Nutrient Dynamics Marine Water Microorganisms	Integrated Marine Water Quality	4th Quarter FY 2006
Non-native Invasive Plant Species Introduction & Spread	Invasive Plant Species Introduction & Spread	1st Quarter FY 2008
Chaparral & Coastal Sage Scrub Oak Woodlands	Integrated Native Vegetation	1st Quarter FY 2008
Riparian Plant Communities	Riparian Plant Communities	2nd Quarter FY 2008
Terrestrial Herpetofauna	Terrestrial Herpetofauna	Implemented
Aquatic Herpetofauna Crayfish & Fishes	Aquatic Herpetofauna	3rd Quarter FY 2006
Habitat Fragmentation	Landscape Pattern	3rd Quarter FY 2007

Table 5.3 Monitoring protocols prepared at Channel Islands NP under the prototype monitoring program.

	Protocol Name	Date Completed	Implemented
1	Fishery Harvest Monitoring	1988	✓
2	Information Management	1998	✓
3	Kelp Forest Monitoring Handbook, Vols. 1 & 2	1997	✓
4	Landbird Monitoring Handbook	1988	✓
5	Pinniped Monitoring Handbook	1988	✓
6	Rocky Intertidal Communities Monitoring Handbook	1988	✓
7	Sand Beach & Coastal Lagoon Monitoring Handbook	1990	✓
8	Seabird Monitoring Handbook	1988	✓
9	Terrestrial Invertebrates Monitoring Handbook	1991	
10	Terrestrial Vegetation Monitoring Handbook	1988	✓
11	Terrestrial Vertebrates Monitoring Handbook*	1988	✓
12	Visitor Monitoring Handbook	1988	✓
13	Weather Monitoring Handbook	1988	✓

***The Vertebrates Monitoring Handbook includes Reptiles, Amphibians & Mammals**

3. Office or pre-sampling procedures for preparing to go into the field.
4. Equipment needs and operation, sampling techniques, sample preservation and handling and logistics.
5. Equipment calibration and sample analysis quality control/quality assurance procedures.
6. Sampling procedures for both *in situ* field measures and sample collection for post-collection (laboratory) analysis by NPS personnel or professional analytical laboratories.
7. A quality control SOP documenting QC objectives for measurement sensitivity (detection limits), measurement precision, measurement systematic error (bias as percent recovery), data completeness (including adequacy of planned sample sizes and statistical power) and, if applicable, blank and duplicate sample controls.
8. Data management and analysis describing how data will be managed from the field to its final permanent repository and chain of custody documentation for samples to be sent out to professional analytical laboratories will also be included. This SOP will include examples of field forms and will describe how data will be entered, managed and archived in a relational database or spatial Geographic Information System (GIS).

Table 5.4 lists the protocols to be prepared, vital signs addressed in each of these protocols, and the parks where specific protocols will be implemented. A Protocol Development Summary (PDS) has been prepared for each protocol to be prepared and is included in Appendix O. Each PDS document expands on the information in Table 5.4, including justification for selecting a prticular vital sign, measurable objectives for monitoring, personnel requirements, development costs, timeline for development of the protocol, expected interim products, and a proposed date for implementing the protocol.

Monitoring of terrestrial herpetofauna (reptiles and amphibians) at Cabrillo NM and terrestrial and aquatic herpetofauna in the Santa Monica Mountains Resource Management Zone (RMZ) has been ongoing for several years. This monitoring began through the initiatives of staff form the Western Ecological Reserch Center of the USGS, and following interagency workshops and analysis by park scientists prior to the availability of Natural Resource Challenge funding. Monitoring protocols and methodology were developed by adapting existing USGS monitoring protocols in consultation with regional academic and agency experts. The USGS methodology has been widely applied to the monitoring of terrestrial reptiles and amphibians in California, and served as a template for the development of a network-specific monitoring protocol for terrestrial herpetofauna of the Santa Monica Mountains RMZ and Cabrillo NM, and a protocol for monitoring aquatic herpetofauna in the Santa Monica Mountains RMZ.

The Mediterranean Coast Network terrestrial herpetofauna monitoring protocol has undergone regional and peer review and is attached to this document as Appendix T. A draft version of the aquatic herpetofauna protocol is also attached as Appendix L and is expected to be submitted to the Pacific West Region Protocol Review Coordinator for peer review by the end of December 2005.

Proposed water quality monitoring protocols, including specific sampling and analysis procedures, are being prepared by agreement through the Californian Cooperative Ecosystems Study Unit with Dr. Barry Hibbs from California State, University Los Angeles and will be detailed in the completed monitoring protocols. A draft of the Integrated Fresh Water Quality Monitoring protocol is included as Appendix S.

Endnotes:

[1] http://science.nature.nps.gov/im/monitor/protocoldb.cfm
[2] Kate Faulkner, Channel Islands NP, 805-658-5709
[3] Lane Cameron, Santa Monica Mountains NRA, 805-370-2347

Table 5.4 Monitoring protocols to be prepared for the Mediterranean Coast Network.

Protocol Name	Vital Signs Being Addressed	Monitoring Objectives	Parks	Protocol or PDS Location
Terrestrial Herpetofauna	Terrestrial Herpetofauna	Periodically determine status and long term trends in the distribution, abundance, and morphometrics of focal terrestrial herpetofauna in five regions of the Santa Monica Mountains Resource Management Zone (SMMRMZ) defined to represent increasing amounts of human disturbance and in the Point Loma Ecological Reserve (PLER).	CABR SAMO	Protocol as Appendix T, Summary in Appendix O
Aquatic Herpetofauna	1. Aquatic Herpetofauna 2. Non-native Species Introduction & Spread in the Streams of the Santa Monica Mountains	1. Annually determine status and trends in stream morphology such as changes in substrate characteristics, average width and depth, amount of pool habitat, *etc.* 2. Determine relationships among stream morphology (run, riffle, & pool) and changes in number of egg masses or tadpoles of selected focal species (*Hyla regilia, Hyla cadaverina, Tarica tarosa* & *Bufo boreas*) in selected streams in the SMMRMZ. 3. Monitor distribution of these species in the SMMRMZ by determining the proportion of area occupied (PAO) statistic within a suite of randomly selected streams throughout the SMMRMZ. 4. Determine the relationships among changes in the abundance and distribution of focal aquatic herpetofauna (*Hyla regilia, Hyla cadaverina, Tarica tarosa* & *Bufo boreas*) at stream water quality sampling locations and seasonal and/or annual trends in nutrient concentration (N and P), pollutants, bacterial/biological concentrations, and standard water chemistry parameters. 5. Determine the relationship between the abundance and distribution of non-native aquatic species (largemouth bass, carp, bluegill, and crayfish) and the abundance and distribution of focal native amphibians.	SAMO	See Draft Protocol as Appendix L, Summary in Appendix O
Integrated Fresh Water Quality	1. Stream Flow 2. Water Chemistry 3. Toxic Pollution 4. Nutrient Dynamics 5. Microorganisms	1. Determine the seasonal and annual trends in stream flow at selected sampling stations in the SMMRMZ and the annual trends in stream flow at selected sites at CHIS. 2. Determine relationship of stream flow with water quality parameters measured at the same sites. 3. Determine the seasonal and annual status and trends in nutrient concentration (N and P) at selected sites in the SMMRMZ and annual status and trends in N and P concentrations at selected sites at CHIS and compare status to state designated beneficial uses or impairment thresholds. 4. Determine the seasonal and annual status and trends in bacterial concentrations (Total Coliform, Fecal Coliform, and/or Enterococcus) at selected sites in the SMMRMZ and annual status and trends of bacterial concentrations at selected sites at CHIS and compare status to state designated beneficial uses or impairment thresholds. 5. Determine seasonal and annual status and trends in concentration of selected pollutants such as metals, pesticides, and herbicides in selected streams in the SMMRMZ and annual status and trends in concentration of same pollutants in selected streams at CHIS; compare status to state designated beneficial uses or impairment thresholds.	CHIS SAMO	See Draft Protocol as Appendix S, Protocol Development Summary in Appendix O
Integrated Marine Water Quality	1. Water Chemistry 2. Toxic Pollution 3. Nutrient Dynamics 4. Microorganisms	1. Determine the seasonal and annual status and trends in marine water chemistry (standard field parameters, Chlorophyll *a*, Water Resources Division core variables) at selected intertidal sites along Point Loma (CABR) and CHIS and compare to State designated beneficial uses or impairment thresholds. 2. Determine relationships between marine water chemistry and data collected on the abundance & distribution of marine intertidal (CABR & CHIS) and subtidal (CHIS) flora & fauna (*i.e.,* owl limpet, abalone, California mussel, barnacles, intertidal algae, *etc.*) at the same sites. 3. Determine the periodic and annual status and trends of pollutants such as metals, pesticides, and herbicides at selected intertidal sites along Point Loma and CHIS and compare to state designated beneficial uses or impairment thresholds. 4. Determine relationships among marine water pollutants and data collected on the abundance & distribution of marine intertidal (CABR & CHIS) and subtidal (CHIS) flora & fauna at the same sites. 5. Determine the periodic and annual trends in nutrient concentration (Nitrogen and Phosphorous Species) at selected intertidal sites at CABR and CHIS and compare to concentrations recommended for state designated beneficial uses or impairment thresholds. 6. Determine relationships between nutrient concentrations in marine waters and data collected on the abundance & distribution of marine intertidal and subtidal flora & fauna (*i.e.*, owl limpet, abalone, California mussel, barnacles, intertidal algae, *etc.*) at the same sites. 7. Determine the seasonal and annual status and trends of bacterial concentrations at selected intertidal sites along Point Loma (CABR) and CHIS and compare to state-designated beneficial uses or impairment thresholds.	CABR CHIS	Protocol Development Summary in Appendix O
Invasive Plant Species Introduction & Spread	Non-native Invasive Plant Species Introduction & Spread	1. Determine long term trends for high priority new or re-invading non-native plant species in occurrence, abundance, distribution and population extent in selected high-priority sites ≤ 5 ha in the SMMRMZ. High priority sites may include disturbance prone sites, weed-free sites, sites where park management is planned, restoration sites. 2. Determine the relationship of any invasion patterns that may exist to habitat disturbance and management related attributes such as unstable slopes, fire, park operations, *etc.*	SAMO	Protocol Development Summary in Appendix O
Riparian Plant Communities	Riparian Plant Communities	1. Periodically determine trends in the species composition and structure (*e.g.*, cover by species, density, cover of life forms, abundance by vertical layers, *etc.*) of riparian vegetation at sites parallel to and spanning selected stream segments throughout the SMMRMZ. 2. Determine status and trends in morphological characteristics of stream segments (such as % run, riffle pool) selected for monitoring riparian plant community structure.	SAMO	Protocol Development Summary in Appendix O
Integrated Native Vegetation	1. Chaparral Plant Communities 2. Coastal Sage Scrub Plant Communities 3. Oak Woodlands Plant Communities	1. Periodically determine status and long term trends in the species composition and structure (*e.g.,* cover by species, density, cover of life forms, abundance by vertical layers, *etc.*) of stands of native chaparral, coastal sage scrub, and oak woodlands ≤ 5 ha in size throughout SMMRMZ. 2. Annually determine from acquired weather data status and trends in temperature, precipitation, length of summer drought, duration of frost events, and other primary and derived weather attributes likely to be related to vegetation composition and structure at CABR and the SMMRMZ.	CABR SAMO	Protocol Development Summary in Appendix O
Landscape Pattern	Habitat Connectivity, Fragmentation, & Patch Dynamics	Periodically capture data from state & local government agencies on changes in land use (*i.e.,* habitat conversion, development, use intensity, open space easements, *etc.*) to monitor trends in open space connectivity, patch size, and dynamics within the SMMRMZ.	SAMO	Protocol Development Summary in Appendix O

Chapter 6: Data Management

Rule No. 9. Code all your data and enter it on a computer in some machine-readable format.

Rules for the collection of ecological data, Krebs, 1998

One of the primary goals of the National Park Service is to improve park management through greater reliance on scientific knowledge. The ability of park managers to make decisions about the resources within and around park boundaries depends on the knowledge of the surrounding ecosystem. Understanding the ecosystem within the parks often begins with the collection of natural resource data from stewardship projects within the National Park system. These projects may include, for example, park planning, resource inventories, short- and long-term monitoring, restoration, control of invasive species, native species management, fire management, trail and road maintenance, law enforcement, and the communication of natural resource information to the public. Through these projects, data are analyzed, synthesized, and interpreted providing information park managers need to make informed decisions about the natural resources within the park.

The Mediterranean Coast Network Inventory and Monitoring (I&M) Program represents a long-term commitment by the National Park Service to assess and document the status and trends of ecological resources within three southern California park units—Cabrillo NM, Channel Islands NP, and Santa Monica Mountains NRA. As part of this program, the network must identify, catalog, organize, structure, archive, and provide high-quality natural resource data for park researchers, managers, and administrators. The network must also secure and maintain the quality of these data for the long-term. To accomplish this task, the Mediterranean Coast Network has developed a modern information management infrastructure comprising personnel, hardware, and software to (1) integrate natural resource inventory and monitoring information into National Park Service planning, management, and decision making; and (2) share accomplishments and information with other natural resource organizations to achieve common goals and objectives. This infrastructure includes procedures to ensure that relevant natural resource data collected by National Park Service staff, cooperators, researchers, and others will be recorded, quality-checked, analyzed, reported, archived, documented, cataloged, and made available to others for management decision-making, research, and education.

6.1 Data Management Goals and Objectives

Data and information are the basic and most important products of scientific research and represent valuable, and often, irreplaceable resources (Brunt, 2000). As field experiments and associated data collection are typically time and budget consuming, management of data and information products is a critical component in any scientific program. Data management is an active process with the ultimate goal of ensuring and maintaining the integrity, utility, security, and availability of data. A good data management strategy will ensure that all data:

- Meet acceptable accuracy standards,
- Are accessible to users,
- Are meaningful,
- Contain clearly defined relationships to other relevant data,
- Are protected from corruption, loss, and unauthorized changes, and
- Are maintained with integrity – indefinitely.

Good data management can be accomplished through data organization, documentation, and quality control procedures. For example, organization of data in well thought out directory and file structures ensures data are physically accessible to users. Good database design facilitates data exploration and analysis. Documentation of data, or metadata, is critical in maintaining the usefulness and meaning of data through time. Essential metadata elements include description of the extent and purpose of data; why, when, where data are collected; how and by whom data were collected; what was done to the data; and references indicating how data have been used. Quality control procedures will help to ensure data accuracy and quality throughout the life of the data from initial collection to storage and archiving. And backup strategies and data access controls will protect from data loss, including corruption and unwanted changes whether inadvertent or malicious.

6.2 Scope of the Mediterranean Coast Network I&M Information Management Plan

The Mediterranean Coast Network has developed an information management plan to address the data and information management needs of the network (see Appendix K). To ensure that this plan is "user friendly" and relevant, it has been developed using three basic guidelines:

- Keep the plan simple, flexible, and evolving,
- Make it useful to all – from park GIS and data management staff, to regional technical staff, resource management staff, and cooperating scientists, and
- Include the data users in the decision making process whenever possible.

This plan reflects the network's commitment to the collection, maintenance, description, accessibility, and long-term availability of high-quality data and information. It also identifies the process by which the network will develop more detailed operational guidelines and where those guidelines will be documented. Further, the plan provides both for the preservation of the quality and integrity of resource data collected under the network I&M program and the management of currently existing "legacy" data, with the ultimate goal of ensuring that data and information will be available to assist resource managers in daily operations, make informed park management decisions, and facilitate scientific exploration and research.

6.2.1 Data Management Roles and Responsibilities

In addition to procedures, applications, and technology, data management relies upon the people and organizations using or managing data and information. To serve the National Park Service and its constituents well, Mediterranean Coast Network staff must understand the overall flow of data and information, as well as their own specific roles and responsibilities throughout the data management process. A successful data management system is maintained by reinforcing communication, awareness and acceptance among everyone with responsibilities related to the origin, quality, disposition, and use of the data.

All individuals connected with the Mediterranean Coast Network I&M program have data management roles and responsibilities (Table 6.1). Each vital sign monitoring protocol and inventory study plan will contain specific instructions for assignments and tasks relating to data management. Individuals who carry out monitoring protocols and inventory study plans are responsible for reading and understanding these instructional guidelines.

Network data managers must work with local network personnel, park staff, and cooperators to promote and develop workable standards and procedures that result in the integration and availability of datasets. Key contacts for the network data manager include park GIS and data managers and the project leaders for each monitoring or inventory project. Consistent and productive communication among these personnel is necessary for a common understanding and better synchronization of network and park data management activities. In addition, the successful development of planning materials, inventory study plans, and monitoring protocols is dependent on involvement and input of park scientists and resource information management staff.

6.2.2 Data Management Program Overview

By describing the progressive stages of a project and the life cycle of the resulting data, we can more easily communicate the overall objectives and specific steps of the data management process. A generalized project work flow model (Figure 6.1) depicting the production of natural resource data, including how natural resource data are generated, processed, finalized, and made available, provides a basic framework for data management. During the development of monitoring protocols and study plans, this model will help to identify the staffing resources needed to produce, maintain, and deliver quality data

Table 6.1. Roles and responsibilities for data stewardship.

Role	Primary responsibilities related to data management
Project Crew Member	• Record and verify measurements and observations based on project objectives and protocols. • Document methods, procedures and anomalies.
Project Crew Leader	• Supervise crew members to ensure data collection and management obligations are met, including data verification and documentation.
Data/GIS Specialist or Technician	• Perform assigned level of technical data management and GIS activities, including data entry, data conversion, and documentation. • Work on overall data quality and stewardship with project leaders, resource specialists, and the network data manager.
IT/Systems Specialist	• Provide and maintain an information systems and technology foundation to support data management.
Project Leader/ Resource Specialist	• Oversee and direct operations, including data management requirements, for one or more network projects. • Understand the objectives of the project, the resulting data, and their scientific and management relevance. • Maintain communication with project staff and network data manager regarding data management. • Ensure useful data are collected and managed by integrating natural resource science in network activities and products, including objective setting, sample design, data analysis, synthesis, and reporting. • Make decisions about data with regard to validity, utility, sensitivity, and availability. • Describe, publish, release, and discuss the data and associated information products.
GIS Manager	• Coordinate and integrate local GIS and resource information management with park-, network-, and national-level standards and guidelines.
Network Data Manager	• Provide overall network support for the coordination of data and information management activities. • Serve as point-of-contact for National Park Service-wide database applications. • Coordinate internal and external data management activities. • Apply particular knowledge and abilities related to database software and associated applications.
Network Coordinator	• Ensure programmatic data and information management requirements are met as part of overall network business.
I&M Data Manager (National Level)	• Provide service-wide database design, support, and services, including receiving and processing data for storage in service-wide databases.
Other End Users	• Assume responsibility for the appropriate use and application of data and derived products and for providing feedback for improvements. End users may include park managers and superintendents, researchers, staff from other agencies, and the public.

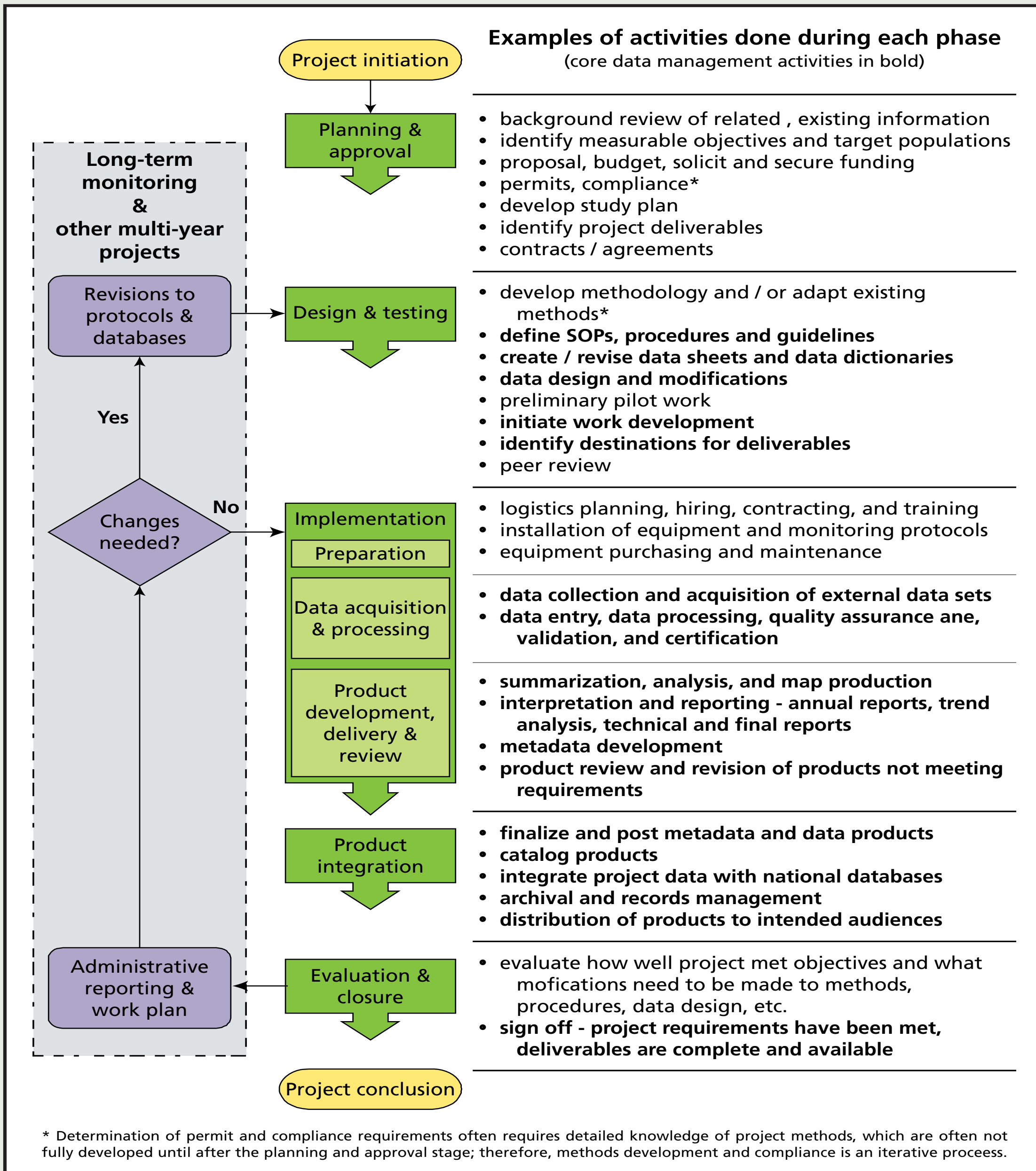

Figure 6.1 Overview of the generalized work flow of model for the Mediterranean Coast Network.

and information. While the work flow presented in this plan may not apply to all situations, it does address both the long- and short-term data collection efforts currently anticipated by the Mediterranean Coast Network.

6.2.3 Data Management Infrastructure

The ability to actively maintain an efficient information systems infrastructure depends on adhering to common systems components and architecture at the park-, network-, and national-level. This standardization will help to maintain continuity in datasets through time, simplify database maintenance, promote uniform working environments, and facilitate the sharing of limited resources among parks. Systems architecture represents the applications, database systems, repositories, and software tools that make up the framework for any data management strategy. The Mediterranean Coast Network will adopt and remain current and compatible with a systems architecture that follows National Park Service and national-level I&M program structure. These include using (1) recommended version standards for applications and software programs (*e.g.,* MS Access for databases, ArcGIS for spatial data management); (2) local and working datasets of national applications (*e.g.,* NPSpecies, Dataset Catalog), and working files of network products (*e.g.,* databases, geospatial themes, reports, administrative records); (3) network data servers that host common lookup tables, project tracking databases, and a network digital library for final versions of project deliverables; and (3) servers maintained at the national level for master applications (*e.g.,* NatureBib, NPSpecies, NR-GIS Metadata Database), centralized repositories (*e.g.,* NR-GIS Data Store, the Protocol Clearinghouse), and public internet access sites (*e.g.,* NPFocus).

6.2.4 Data Acquisition and Processing

The acquisition of I&M data, typically by park and network staff, cooperators and/or contractors, is usually connected to either a natural resource inventory or a long-term vital signs monitoring project. These data might be the result of data discovery (*i.e.,* data mining) or field studies. While data discovery activities are often associated with the initiation of a new project, data discovery is a continual process and should occur on a regular basis. All information collected as a result of data discovery is maintained by the network either electronically or in hard copy format and must be documented with metadata following network guidelines. The data will be cataloged in appropriate standardized databases (*e.g.,* Dataset Catalog, NPSpecies).

Field studies are a primary component of the I&M program and essentially involve the collection of new data based on a scientific protocol or study plan. Project leaders and the network data manager must work closely together to develop the most appropriate procedures and guidelines. After establishment of data collection procedures or protocols, alterations are discouraged but will inevitably be required. Changes may result from comprehensive reviews of monitoring projects, technological change, or problems unforeseen during protocol development. All significant changes to the protocols must be approved by the project leader who will evaluate the proposed changes and determine if additional peer review is required.

Data managed by the Mediterranean Coast Network will include both data collected through the network I&M programs as well as data originating with other, non-program, sources. Non-program data, which may be internal to the National Park Service (*i.e.,* data collected by an individual park or regional park program) or external (*i.e.,* data produced by non-National Park Service sources such as other government agencies or academic institutions) are often very relevant to network activities. These data may be used in projects conducted by the network or may be critical to the development of project SOPs. It is important that both the data manager and project leaders are aware of all existing data sources that could strengthen the scientific foundation of the program. The network data manager is responsible for ensuring that the information is properly documented and stored and accessible to network staff.

6.2.5 Quality Assurance and Quality Control

Preservation of ecological data and related information resulting from Mediterranean Coast Network activities is justified only if those data may be used with confidence, free from error and bias. Data of poor quality can result in loss of sensitivity to subtle changes and incorrect interpretations and conclusions. The potential for problems with data quality increases with the size and complexity of the dataset (Chapal & Edwards, 1994). A critical goal of the Mediterranean Coast Network is to ensure that data of the highest possible quality are used as the basis for park resource management decisions and that the long-term quality and integrity of the data are maintained.

Quality assurance (QA) is defined as “an integrated system of management activities involving planning, implementation, documentation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the consumer” (Palmer, 2003). Quality assurance procedures ensure quality in all stages of the data development process. Quality control (QC) is defined as “the overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that they meet the stated requirements established by the customer” (Palmer, 2003). Quality control procedures monitor or evaluate the resulting data products. Both QA and QC are designed to prevent data contamination, which occurs when a process or event other than the one of interest affects the value of a variable and introduces errors into a dataset.

The network's overarching data quality goal is to ensure that a project produces data of the right type, quality, and quantity to meet project objectives and user needs. To preserve data integrity, the Mediterranean Coast Network will follow QA/QC standards specifically stated in the standard operating procedures of each monitoring protocol. These will include the identification and reduction of error at all stages in the data lifecycle, but particularly during data collection, data entry, verification and validation, and dissemination.

6.2.6 Data Documentation

Effective long-term data maintenance requires proper data documentation and accompanying explanatory materials are an essential part of any data or project archive (Olson & McCord, 1998). All datasets—whether collected last week or 20 years ago—must be accompanied by sufficient documentation (*e.g.*, purpose and intention of the project, how and why data are collected) in order to be reliably used into the future. Without concerted effort to create and maintain proper documentation, data users are often left with little to no information regarding the quality, completeness, or lineage of a particular dataset or project. Such ambiguity results in lost productivity since the user must invest time in searching for information and may even render the dataset useless because answers to critical questions cannot be found. Good data management requires an upfront investment in data documentation.

Typically, the process of documentation involves the collection of metadata—information about the content, quality, condition and other characteristics of data. Metadata provide the means to catalog datasets within intranet and internet systems, thus making these datasets available (and usable) to a broad range of potential data users. Executive Order 12906, signed by President Clinton in 1994, mandates federal agencies to "…document all new geospatial data it collects or produces, either directly or indirectly…" using the Federal Geographic Data Committee (FGDC) Content Standard for Digital Geospatial Metadata (CSDGM) and directs agencies to plan for legacy data documentation as well as providing public access to metadata and data. This directive applies to all data collected or maintained by the National Park Service. Additionally, all National Park Service GIS data layers must be described using the National Park Service Metadata Profile.

The process of dataset and project documentation for the Mediterranean Coast Network will follow the standard procedures for the production and distribution of metadata described in the National Park Service Integrated Metadata System Plan (http://science.nature.nps.gov/im/datamgmt/metaplan.htm). Although there are numerous tools available for collecting metadata, three main desktop software applications are core elements in the creation and maintenance of metadata within this plan: Dataset Catalog, Spatial Metadata Management System (SMMS), and ArcCatalog. Data and metadata are typically created and maintained within one or more of these core applications and then periodically uploaded to service-wide clearinghouses. Through Dataset Catalog and NR-GIS Metadata, park resource managers, researchers, and others with a potential interest in park management and research will be able to access available data and metadata. Project documentation will be tracked with a database (hosted at each network park) that will maintain a comprehensive list of projects, deliverables, and accomplishments.

6.2.7 Data Analysis and Reporting

To be useful data must be analyzed, interpreted, and reported in a form that speaks to the appropriate audience. There are many approaches for analyzing ecological data (see Chapter 7). In general, the Mediterranean Coast Network will periodically report the results of monitoring efforts once sufficient data become available for reliable analysis. The development of data products resulting from analyses will be guided by individual monitoring protocols. Reports will include recommendations for action or non-action based upon the findings. Additionally, all reporting will contain an executive summary from which park and resource managers can draw specific findings and recommendations and from which interpreters can bring together stories to pass along to the public. Results will also be evaluated for their value to the general scientific community and specific products (*e.g.,* peer reviewed literature, program specific reports) will be prepared and disseminated.

6.2.8 Data Dissemination

One of the most important goals of the Mediterranean Coast Network is to make natural resource information available for National Park Service planning and management, as well as providing the public access to data and information of interest (Freedom of Information Act, 5 U.S.C. § 552). The Freedom of Information Act, or FOIA, is intended to establish a right for any person to access records and datasets that are owned or controlled by any federal agency, regardless of whether or not the federal government created the records. Under the terms of FOIA, agencies must make records available for inspection and copying in public reading rooms, the internet, or via requests through a specified process. Further information on the Department of the Interior's FOIA regulations and the Department's Freedom of Information Act Handbook can be accessed at http://www.doi.gov/foia/.

However, some records and sensitive data are protected from disclosure. The National Park Service is directed to protect information about the nature and location of sensitive park resources, thus public access to these data can be restricted [Director's Order #66B, the National Parks Omnibus Management Act (16 U.S.C. 5937), the National Historic Preservation Act (16 U.S.C. 470w-3), the Federal Cave Resources Protection Act (16 U.S.C. 4304) and the Archaeological Resources Protection Act (16 U.S.C. 470hh)]. All data and associated information from Mediterranean Coast Network activities must be assessed according to these regulations to determine their sensitivity. Where disclosure of information could result in harm to natural resources, including endangered or threatened species, data and other information can be classified as 'protected' or 'sensitive' and may be withheld from public release.

In general, though, it is the intent of the Mediterranean Coast Network that data should be easily discoverable and obtainable. To ensure that quality natural resource data collected by the Mediterranean Coast Network are made accessible in a timely manner, a number of distribution methods have been identified. Non-sensitive data, including datasets and reports, can be requested (following the procedures detailed on the network website), or accessed through the network and park websites, or online repositories

6.2.9 Data Maintenance, Storage and Archiving

Digital and analog products, including datasets, documents, and objects (*e.g.,* specimens, photographs), that result from Mediterranean Coast Network projects and activities must be maintained and managed for the long-term to ensure that (1) loss of information over time is avoided; (2) information and data are properly interpreted by a broad range of users; and (3) information can be easily obtained and shared through future decades. Specific recommendations for long-term management are dependent on the type of data products being maintained. For example, digital datasets should be converted to a non-specific software format (*i.e.,* ASCII tab-delimited files) and quality checked for transcription errors before being archived or disseminated to potential users. Directory structures for final and working files should be intuitive to users, even those not familiar with the project. Servers or computers where data reside should be backed up on a regular basis with on- and off-site storage of backup tapes. Also, every effort should be made to archive final network data products in park or network museums.

Chapter 7: Data Analysis and Reporting

As biological entities are counted or measured, it becomes apparent that some objective methods are necessary to aid the investigator in presenting and analyzing research data.

Zar, 1999

The broad-based, scientifically sound information obtained through natural resource monitoring has multiple applications for management decision-making, research, education, and promoting public understanding of park resources. The primary audience for the results of vital signs monitoring are park managers. Monitoring data can provide superintendents, park resource chiefs, and other managers with the data they need to make and defend resource management decisions. The data help them work with others for the benefit of park resources. Other primary audiences for monitoring results include park planners, interpreters, researchers and other scientific collaborators, the general public, Congress, and the President's Office of Management and Budget (OMB). To be most effective, monitoring data must be analyzed, interpreted, and provided at regular intervals to each of these audiences in a format they can use, which means that there must be several different scales of analysis, and the same information needs to be packaged and distributed in different formats to the different audiences.

The scientific data needed to better understand how park systems work and to better manage the parks will come from many sources. In addition to new data collected through this monitoring program, data to help determine the status and trends in the condition of park resources will also come from other park projects and programs, other agencies, and from the general scientific community (Figure 7.1). To the extent that staffing and funding is available, the network monitoring program will collaborate and coordinate with these other data collection and analysis efforts, and will promote the integration and synthesis of data across projects, programs, and disciplines.

In this chapter we describe approaches to how data collected by the monitoring program will be analyzed, including who is responsible and how often analysis will occur. We also describe the various reports and other products of the monitoring effort, including their content, the intended audience, the frequency of production, report format, and the party responsible for producing the products.

In general, data analysis and reporting for the Mediterranean Coast Network will follow an annual monitoring cycle coincident with the National Park Services' fiscal year (October through September), facilitating budgetary planning. This cycle also corresponds with the climatic cycle of cool wet winters and hot dry summers that define Mediterranean-type ecosystems and the general phenological cycle in native vegetation.

7.1 Data Analysis

For the purposes of this program, we define data analysis as the processes by which observations of the environment are turned into meaningful information. We define data analysis broadly to include all evaluations of data after the data are collected and entered into a digital data file. Data analysis includes quality control checks that occur during summarization and exploratory analysis, as well as analytical procedures leading to interpretation of the data and the development of conclusions. We present some general considerations for analysis of monitoring data and outline the general strategy that the Mediterranean Coast Network will follow for all vital signs data analysis and reporting.

7.1.1 Analysis of Monitoring Data—General Considerations and Network Strategies

One central tenet of the Mediterranean Coast Network monitoring program is that data be analyzed and reported promptly. Park resource managers need to be alerted to changes in park ecosystems as soon as changes are detected—not several years after the fact. In addition, timely data summary is a critical part of quality control. Generally annual analysis and reporting of monitoring results will be due by March (end of the 2nd quarter) of the fiscal year following data collection. Mechanisms to support prompt analysis and reporting have been built into the data management plan (*e.g.*, data must be entered into the database within one month of returning from the field). Additional mechanisms will be established in the data analysis procedures described in the monitoring protocols.

working closely with statisticians throughout the initial monitoring protocol design process and during subsequent analyses of program data.

Additionally, many of the difficulties typically encountered in analysis of monitoring data can be avoided by proper planning, including the use of probabilistic sampling strategies. Appropriate analysis of monitoring data is directly linked to the monitoring objectives for each target vital sign, the spatial and temporal aspects of the sampling design employed, and the proposed management

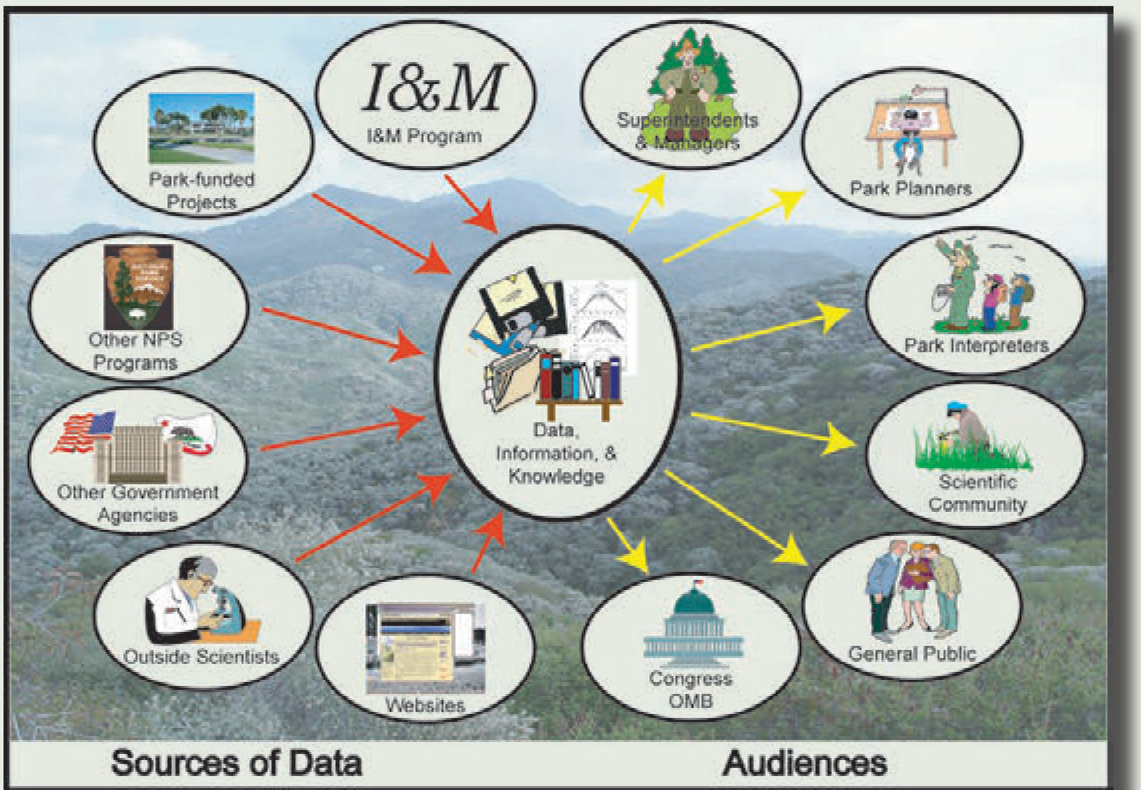

Figure 7.1. Scientific data for determining the status and trends in the condition of selected park natural resources will come from multiple sources and will be managed, analyzed, and disseminated to multiple audiences in several different formats in order to make the results more available and useful.

The analysis of monitoring data can be challenging because of inherent temporal associations in the estimates. It is essential that we use statistical analyses that accommodate these associations. Analytical approaches may include time series analyses, longitudinal data analysis (including repeated measures), trend estimation (many methods), direct estimation of change, and cumulative summary (CUSUM) techniques. Application of these analytical methods will require

uses of the data. Thus, analysis methods need to be considered when the objectives are identified and the sampling design is selected rather than after data are collected. Failure to adequately consider analysis methods during program development could result in implementation of sampling designs that are either inadequate or too complex to meet monitoring objectives. While this chapter presents general considerations for analysis of monitoring data, the specific Standard

Operating Procedures (SOP) for data analysis developed for each monitoring protocol will ensure that the sampling designs and analysis methods we propose will allow us to meet monitoring objectives.

7.1.2 Analysis Approaches for MEDN Vital Signs

The first step in data analysis is summarization (Mulder *et al*., 1999). This step is a critical part of overall control of data quality. Data need to be summarized promptly to identify missing values, outliers, and other problems related to the data collection and entry process (Jeffers, 1994; Reid, 2001). Routines for summarization will be prepared and codified in the SOP for each vital sign monitoring protocol. The exact form of summary procedures will be specific to each particular monitoring protocol. In general, however, the approach will include graphic techniques to show the data in space and time with measures of central tendency and estimates of variation. This first step will be undertaken annually at the close of the field season and documented in each annual monitoring report.

The second step in analysis of monitoring data will employ methods that allow immediate determination of results that are outside the bounds of expected variation. Potential analytical techniques include the conformance metric developed by Debevec & Rexstad (2000) and the cumulative summary (CUSUM) approach as described by Manly & Mackenzie (2003). The conformance metric separates out sampling variation from total variation to provide a measure of the natural variation in an attribute. Once we establish a baseline of "normal" variability, we can view new observations of the attribute to determine how well they conform to the documented history of the attribute. The conformance metric is the probability that a new observation comes from the same underlying process as the baseline. Hence, a small conformance indicates a change. Using conformance as a metric of change allows data to be translated to a common reporting system (*i.e.*, is everything going about as expected or not?). Data can be also be pooled hierarchically at any desired level. In the similar CUSUM approach, charts are created to facilitate visual perception of systematic deviations. Both approaches are relatively easy to carry out and can complement other approaches to analysis of changes and trends in condition. As the program builds multi-year data sets, this type of analysis can be automated and reported in the annual monitoring reports. Initially, it will be done for periodic trends reports.

The third step in analyzing monitoring data will be in-depth analyses of change over time. Specific methods of change, trend, or temporal pattern detection for each vital sign will be employed and reported at predetermined intervals. When appropriate, other analyses such as species-habitat relationships or community ordinations may be performed.

There are several techniques for evaluating trends in ecological data. These include regression analysis, *t*-tests, or analysis of variance methods. Each of these parametric methods makes assumptions about the data being collected. When these assumptions are violated (*e.g.*, the non-normal distribution of data) the robustness of the analytical procedure is diminished. For each of the analytical procedures listed above there are parallel non-parametric methods that do not rely on the assumptions required for parametric analysis procedures. If appropriate, non-parametric procedures will be employed in the analysis of trend and condition in vital signs data.

Population time series data collected over five or more years can be regressed against the temporal scale of collection to look for significant departures from zero slope. Data that show a zero slope may be presumed to be static and not changing over the time period examined. If there is an increasing slope then we might interpret the condition of the variable measured as getting better i.e. population number (or other measured variable) increasing. If the slope is decreasing then there is a negative trend in the population variable measured and the condition of the population or variable measured is worsening. An inverse corollary to this method of interpretation might be for water quality data where a decrease in a given variable (or negative slope) such as turbidity or nutrient levels might indicate an increase in the quality of the water body being monitored.

Using regression techniques to determine trend condition can also provide a rudimentary rule-of-thumb test for analyzing subsequent year's data. Once sufficient data have been acquired (*e.g.,* five years or more) for which no apparent trend is noted, the 95% confidence interval for those data can be used to establish a frame for evaluating newly collected data. If the mean value of a variable in subsequent years falls within the 95% confidence interval of the previously analyzed data then it can be stated with reasonable assurance that the observed condition of no trend in the variable is being maintained. After making such a preliminary determination it is advisable to reanalyze the complete set of data to ensure that in fact no change in the previously observed condition of the variable measured has occurred.

Residuals analysis, which is an outgrowth of regression analysis, can provide some insight into the original data that can be used to support the validity of applying the regression model for analysis. Residuals are the difference in the measured response from the response as fitted by the calculated regression equation (sometimes referred to as ε or the error term in the regression model $Y_i = \alpha + \beta X_i + \varepsilon_i$), and when plotted can give an indication of the goodness of fit of the regression model to the data. If the "Normal Plot of the Residuals" is a straight line, the residuals are normally distributed. This is important because a departure from a straight line can indicate that the assumptions of the regression model have been violated.

Additionally, time series data can be aggregated into beginning and ending groups. By performing a *t*-test (two time periods) or analysis of variance (grouped time periods) differences between (among) groups can indicate a trend in condition of the variable measured. A significant difference in means with the larger mean in the ending group indicates an increasing trend. A smaller mean in the ending group indicates a decreasing trend. Accepting the null hypothesis of no difference between (among) means indicates that there is insufficient evidence from the data to state that a trend in condition has been observed.

It is also possible to use time series analysis to forecast trends in observed data that could help managers anticipate future condition of resources if present conditions remain unaltered. Performing basic trends analysis upon static (no seasonal component to the data) time series data using one of several predictive models: linear, quadratic, exponential or S-curve, can be used to extend the observed trend line well into the future. This predictive process could help resource managers forecast when the condition of a given resource might cross the threshold from an acceptable to unacceptable state, to plan actions that could alter the course of the trend, or to forecast the condition of a given resource or ecosystem process if no remedial action is taken or no ameliorating process is implemented to temper the effects of ecosystem drivers or stressors.

Techniques for forecasting short term condition in dynamic (i.e. data with a seasonal component) time series data also exist. These employ methods of data smoothing to extract an overall linear trend if it exists. The predictive power of these methods is not as robust as those for static time series data. Mixed linear models use information from the variance and covariance structure of the data to reduce correlations typical in repeated measures and time series data.

We expect the analysis methods used in the program to change over time. During the first five to ten years of the program, the focus will be on summary of findings for a given year across the spatial scale of the network. Comparisons to previous years will be made if data are available. Once measurements have been made over three points in time, conformance can be calculated and analyses of trend can begin. After measurements have been made for longer periods, modeling of relationships among vital signs can begin, and time series analyses can be approached.

The initial analysis approach and individual responsible for analysis for each vital sign to be monitored will be identified in the monitoring protocol for that vital sign. In most cases the actual steps in data analysis cannot be prescribed *a priori* and will be determined during protocol preparation. The standard operating procedures for data analysis for each vital sign will provide the proposed procedures for data analysis.

7. 2 Communications and Reporting

The ultimate goal of the vital signs program is to link focused monitoring with flexible and responsive resource management in an "adaptive management" process. As adaptive management relies on the incorporation of timely feedback, it is crucial for the monitoring program to develop and institutionalize effective means of communication both within and outside of the network. The Mediterranean Coast Network monitoring program is not a decision making process, but supports informed management through clear presentation of monitoring results.

Programmatic reporting for the Mediterranean Coast Network's monitoring program will include several reporting venues for each implemented protocol and periodic summary reports of the cumulative results of the monitoring program according to a schedule which varies depending on the report (Table 7.1). Target audiences for the results of specific monitoring programs include National Park Service resource management supervisors and program managers, park superintendents, state and local government resource managers and stakeholders, and the general public. Results will be disseminated through informal and formal reports, publication in scientific journals, presentations at scientific meetings, and park education and interpretative programs.

Principal investigators for each component of the monitoring program will be responsible for data analysis and reporting. As needed, they may enlist help from other network or park staff or cooperators. Ultimately, the network monitoring coordinator is tasked with ensuring reports are completed in a timely manner, that data analysis meets appropriate scientific standards, and that the results of each monitoring program are disseminated appropriately.

There will be two annual reports produced by the program. An annual administrative report and work plan will account for program funds and present the annual network Inventory & Monitoring work plan. Annual monitoring status and summary reports will document monitoring activities for the year and archive data. Completing these reports annually ensures that data are entered into a database and undergo quality control procedures in a timely manner. The status and summary reports will also document changes to protocols or SOP. Queries to produce summary statistics and database reports will be automated as much as possible to facilitate report production.

Each year, in an effort to increase the availability and usefulness of monitoring results for park managers, the network coordinator will take the lead in organizing a one-day science briefing for park managers (possibly in conjunction with a Board of Directors' meeting) in which network staff, park scientists, USGS. Scientists, collaborators from academia, and others involved in monitoring the parks' natural resources will provide managers with a briefing on the highlights and potential management action items for each particular protocol or discipline. These briefings may include specialists from the air quality program, fire ecology program, Research Learning Center, and collaborators from other programs and agencies to provide managers with an overview of the status and trends in natural resources for their parks. Unlike the typical science presentation that is intended for the scientific community, someone representing each protocol, program, or project will be asked to identify key findings or highlights from the past year's work, and to identify potential management action items. The scientists will be encouraged to prepare a one- or two-page briefing statement that summarizes the key findings and recommendations for their protocol or project; these written briefing statements will then be compiled into an annual "Comprehensive Trend Analysis and Synthesis Report" for the network. In the process of briefing the managers, the various scientists involved with the monitoring program will learn about other protocols and projects, and the process will facilitate better coordination and communication ultimately promoting integration and synthesis across disciplines.

Periodic programmatic and protocol reviews will ensure that monitoring objectives are being met. The need for changes in program operations or protocols will be evaluated in light of data collected to date, new sampling methodologies, or technologic advances. The network will also produce periodic trends analysis and synthesis reports to interpret data within a park, network, or regional context. These reports will highlight resource conditions, patterns and trends in vital signs, and may recommend changes for management of resources. Reports may focus on a single vital sign or may seek to synthesize data from many sources—both external or internal. As the monitoring program matures and multiple years of data have been collected, processed, and made available, the network will also rely on outside scientists for much of this kind of in-depth or broad analysis.

Other products will be produced on an occasional, as-needed, or as-indicated basis. These may require special funding and may include such materials as unusual or interesting findings, or information of specific staff or public interest, *etc*.

Executive summaries of the above reports, *etc.* will be prepared to communicate monitoring program status and results to park superintendents, interpreters, general public and other stakeholders. In addition, summaries of notable findings and program highlights will be submitted to the national I&M program for inclusion in various national

Table 7.1 Summary of written reports to be prepared by the Mediterranean Coast Network (MEDN) to present the results and interpretation of monitoring activities.

Table

Type of Report	Purpose of Report	Primary Audience	Frequency	Author(s)	Reviewed By
Annual Administrative Report & Work Plan	Account for funds expended, & work plan tasks completed during fiscal year. Describe work plan & budget for following fiscal year.	Superintendents, technical committee, MEDN staff, regional coordinators, & service-wide program managers. Provides basis for annual report to Congress.	Annual	Network coordinator	NPS Pacific West Regional I&M Coordinator & NPS Water Resources Division Program Manager
Program & Protocol Review Reports	Document the quality of protocols both overall & specifically in three key areas: implementation, effectiveness, & data management. Provide recommendations for necessary changes. Review operations & program products including the effectiveness of reporting procedures & the use of monitoring results in guiding management decisions.	Superintendents, park resource managers, MEDN staff, service-wide program managers, stakeholders & external scientists.	Review within 3 years of implementing protocols, & then every 5-10 years. Coordinate program reviews with protocol reviews at approximately 5 year intervals.	Network coordinator, data manager & project PI.	Network & Region
Vital Signs Monitoring Status Reports	Document monitoring activities & results for each monitoring year. Document changes or modifications in monitoring protocols. Communicate monitoring efforts to resource managers.	Park Resource Managers, MEDN Staff, Stakeholders & External Scientists.	Annual	Network coordinator, data manager & project PI.	Network
Executive Summary of Vital Signs Status Reports	Publish & distribute executive summary of VS monitoring status reports to non-technical audiences.	Superintendents, Park Interpreters, General Public, Monitoring Cooperators & Partners.	Annual	Network coordinator	Network
Comprehensive Trend Analysis & Synthesis Reports	Park Level: Describe & interpret results of individual monitoring activities. Highlight resources in need of management action & recommend types of actions. Network Level: Describe & interpret monitoring results among network parks. Interpret trends in the context of the network or eco-region.	Park resource managers, MEDN staff, external stakeholders	Every 5 years	Network coordinator, technical committee, project PIs, & external scientists	Network
Summary of Trend Analysis & Synthesis Reports	Publish & distribute executive summary of comprehensive analysis & synthesis reports highlighting key findings and recommendations for non-technical audiences.	Park superintendents, interpreters, general public, & stakeholders.	Every 5 Years	Network coordinator, technical committee & project PIs	Network Staff & Park Interpreters.

continued on next page.

reports including "State of the Park" reports and reports to Congress. All final (reviewed and approved) products will be formatted for the web and placed on the Mediterranean Coast Networks' Inventory & Monitoring web site.

Table 7.1 (continued) Summary of written reports to be prepared by the Mediterranean Coast Network to present the results and interpretation of monitoring activities.

Type of Report	Purpose of Report	Primary Audience	Frequency	Author(s)	Reviewed By
Scientific Journal Articles & Book Chapters	Document & communicate significant results of monitoring effort.	External scientific community & NPS resource managers.	Variable	Network coordinator, data manager, monitoring PIs, park resource managers	Peer review by target publication.
Symposia, Workshops & Conferences	Review & summarize monitoring results to peers & stakeholders. Identify emerging issues and generate new ideas.	NPS resource mangers, stakeholders, & academic community	Variable, according to sponsoring organization schedule.	Network coordinator, data manager, monitoring PIs, & park resource managers.	As required by venue.
State of the Parks Report	Describe current conditions of park resources. Reports interesting trends and highlights of monitoring activities. Identifies situations of concern, explores future issues and directions.	Congress, budget office, NPS leadership, superintendents, & general public.	Annual	Compiled by NPS Washington Support Office (WASO) from data provided by networks and parks.	WASO - NPS
Web-based Media	Make all reports accessible through a centralized web-based repository.	Park superintendents, resource managers, MEDN staff, external stakeholders, scientists, students and the general public.	At finalization of report or document.	Reports will be formatted and posted to web by Data Manager.	Only reviewed, finalized products will be posted.

Chapter 8: Network Administration

The Board of Directors is committed to operate in and foster an atmosphere of fairness, trust, and respect throughout the Network. It will pursue a holistic approach in implementing the Network Inventory and Monitoring (I&M) Program using scientifically credible standards while addressing needs in all parks.

MEDN Charter

8.1 Board of Directors

The organization of the Mediterranean Coast Network includes a chartered Board of Directors (Appendix P), an advisory Technical Committee, the Network Coordinator, the Network Data Manager, and three bio-technicians to help conduct field work for vital sign monitoring protocols (Figure 8.1). Network funded positions will work closely and in coordination with park base-funded staff to implement vital signs monitoring and to insure the program's long-term sustainability. The board of directors includes the superintendents of the three parks in the network with the network monitoring coordinator and Pacific West Region inventory and monitoring coordinator participating as *ex officio* members. The board meets a minimum of twice a year.

8.2 Technical Committee

The Network Technical Committee functions in accordance with an approved charter (Appendix Q). It provides assistance and advice to the Network Board of Directors and the network coordinator, evaluates and prioritizes network monitoring activities, and coordinates park participation in network activities. The technical committee consists of four permanent members: the Network Coordinator, the Chief of Natural Resource Science at Cabrillo NM, the Chief of Planning, Science, and Resource Management

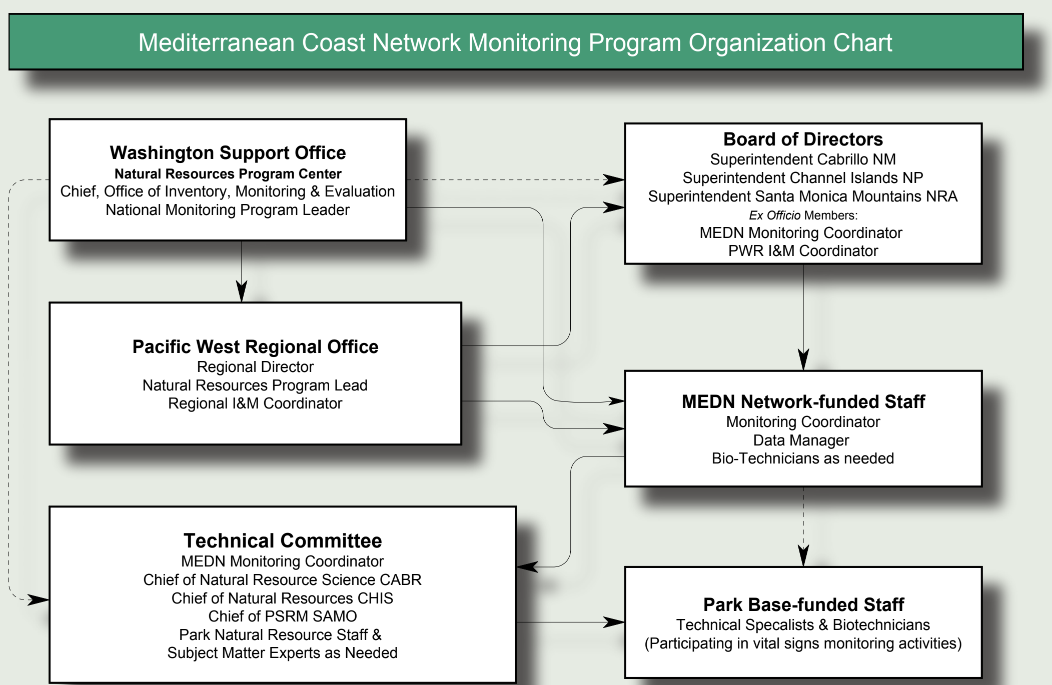

Figure 8.1 Mediterranean Coast Inventory & Monitoring Network organization chart.

Table 8.1 Staffing plan for network-funded positions in the Mediterranean Coast Network monitoring program.

Title	GS Level	Type*	Network FTE	Duty Station	Role in Monitoring Program
Network Coordinator	12	P	1.0	SAMO	Directs the Vital Signs and Water Quality Monitoring Programs in the network. Provides program liaison with the Board of Directors and national/regional monitoring staff. Administers the monitoring budget. Responsible for in-depth analysis and synthesis of monitoring data. Captures results of monitoring activities in reports, peer-reviewed publications, and presentations and publications directed at a range of audiences. Responsible for leveraging program funds and seeking additional support for monitoring activities. Serves as principal investigator for the network Water Quality Monitoring Program.
Data Manager	9/11	P	1.0	SAMO	Manages monitoring data, including creating and maintaining digital databases for monitoring, research, and management; ensures quality of all program data through QA/QC program. Maintains servicewide databases (*e.g.*, NPSpecies, Dataset Catalog, NRBib). Works closely with the network coordinator and park program managers to produce annual reports and periodic in-depth analyses of monitoring data. Responsible for working with park data management and GIS staff to establish and maintain data standards and management procedures throughout the network.
Biological Technician	7	T	1.0	CABR	Implements vital signs and water quality monitoring at CABR. Specifically responsible for conducting the terrestrial reptile and amphibian monitoring program at CABR including field work, data entry, and preparation of text and graphics, as needed, for annual and periodic reports. Provides field support for development and implementation of the marine water quality monitoring program. Assists with data liaison to network data manager.
Biological Technician (Wildlife)	7	T	1.0	SAMO	Implements vital signs and water quality monitoring for the network. Specifically responsible for conducting the terrestrial reptile and amphibian monitoring program at SAMO including field work, data entry, and preparation of text and graphics, as needed, for annual and periodic reports. Provides field support for development and implementation of the water quality monitoring program (particularly at SAMO and CHIS). Assists, as needed, with vegetation monitoring. Works closely with park program staff, and the network coordinator and data manager to accomplish monitoring objectives.
Biological Technician (Vegetation)	7	T	1.0	SAMO	Implements vital signs and water quality monitoring for the network. Specifically responsible for conducting the vegetation monitoring program at SAMO including field work, data entry, and preparation of text and graphics, as needed, for annual and periodic reports. Provides field support for development and implementation of the water quality monitoring program (particularly at SAMO and CHIS). Assists, as needed, with reptile and amphibian monitoring at SAMO and vegetation inventories, monitoring, and management at CABR. Works closely with park program staff, and the network coordinator and data manager to accomplish monitoring objectives.

***P = Permanent, T = Term, CABR = Cabrillo NM, SAMO = Santa Monica Mountains NRA**

at Santa Monica Mountains NRA, and the Chief, Natural Resources Management at Channel Islands NP (Table 8.1).

The technical committee invites program cooperators, park resource managers, technicians, or other support staff to participate on the committee or to attend committee meetings as needed. The Technical Committee is primarily responsible for providing direction to and implementing the Vital Signs Monitoring Program within the Mediterranean Coast Network. The committee insures the scientific integrity of all network activities, and that network planning and implementation activities meet program technical requirements and time constraints.

8.3 Network Staff with Specific Responsibilities

Long-term network-funded staff will include a permanent network coordinator and data manager supported by a maximum of three term appointment bio-technicians. As the monitoring program develops, specific funding allocations and position priorities may vary. For example to develop and implement animal monitoring protocols, the network will fund a one-year term wildlife biologist position during portions of FY 2005 and FY 2006. FY 2006 and FY 2007 funding will also be directed towards preparation of vegetation and water quality monitoring protocols. Network-funded positions will work in coordination with park base-funded staff to implement the vital signs monitoring program in the Mediterranean Coast Network. Each of the proposed network positions with their primary responsibilities is identified in Table 8.1.

8.4 Program Integration with Park Operations

Integration of the vital signs monitoring program into park activities will include the regular and ongoing participation of the chiefs of resource management from each of the network parks (the technical committee) in all aspects of network planning and monitoring implementation. Network-funded staff will work closely with park base-funded staff to implement monitoring, and will work together or in concert with cooperators to implement the Network Vital Signs Monitoring Program (see Table 8.2). Park base-funded biologists will serve as program leads (Principal Investigators) for implementing most monitoring activities. The network Board of Directors is also exploring ways to integrate the monitoring program with the California Mediterranean Research Learning Center[1]. The Mediterranean Coast Network vital signs monitoring program is designed to function seamlessly with park base-funded programs and will be included as an integral component of natural resource science and management at Cabrillo NM and Santa Monica Mountains NRA.

8.5 Key Partnerships

The proximity of network parks to large urban centers with major academic institutions, conservation associations, state and federal resource management agencies, and other governmental entities presents both a challenge and an opportunity for partnering in resource stewardship, management, and research. Cabrillo NM has entered into a memorandum of understanding with several other federal agencies to implement a joint resource management plan for the Point Loma Ecological Reserve (Table 8.3). Channel Islands NP has also entered into several agreements and associations for the management of natural resources within the park. Included among these partners are the USGS, California Department of Fish and Game, The Nature Conservancy, US Fish and Wildlife Service, National Marine Fisheries Service, US Navy, University of California at Santa Barbara, Santa Barbara Botanic Gardens, and others (Table 8.3). An agreement also exists among Channel Islands NP, the Santa Barbara County Air Pollution Control District, Naval Air Warfare Center, Environmental Protection Agency, and California Air Resources Board for meteorological and ozone monitoring on Santa Rosa Island.

Santa Monica Mountains NRA benefits from numerous formal agreements for the management of natural resource within the Santa Monica Mountains Resource Management Zone (Table 8.3), and informal links and project-based cooperative agreements with area academic institutions including University of California, Los Angeles, California State University, Northridge, Pepperdine University, University of California, Santa Barbara, University of Southern California, San Diego State University, California State University, Los Angeles, Mountains Restoration Trust, and Santa Monica Mountains Resource Conservation District.

The above cooperators and partnerships do not necessarily represent the complete list of partnerships that the network may develop over the next few years. The unfolding process of developing the monitoring program may identify other partnerships that can facilitate the protocol development and monitoring implementation process.

8.6 Program Review

Program review will occur at two levels. The Annual Administrative Report and Work Plan, as required by the national inventory and monitoring program, will be supplemented every five years with the publication of a detailed analysis of program results. This review will include:

1. A review of all monitoring activities to date.
2. An evaluation of adherence to project schedule.
3. A review and analytical summary of the data collected to date.

Table 8.2 Proposed vital signs for the Mediterranean Coast Network and the involvement of network and park staff with cooperators in field monitoring activities.

National Framework		Vital Sign	Network & Park	Network, Park & Cooperator
Level 1	Level 2			
Water	Hydrology	Stream Flow		✓
	Water Quality	Fresh Water Chemistry		✓
		Marine Water Chemistry		✓
		Freshwater Nutrient Dynamics		✓
		Marine Water Nutrient Dynamics		✓
		Freshwater		✓
		Marine Water		✓
		Freshwater Coliform Bacteria		✓
		Marine Water Coliform Bacteria		✓
Biological Integrity	Invasive Species	Non-native Invasive Plant Species Introduction & Spread	✓	
		Crayfish & Fishes	✓	
	Focal Species or Communities	Chaparral & Coastal Sage Scrub	✓	
		Shrubland	✓	
		Riparian Plant Communities	✓	
		Oak Woodland Community	✓	
		Terrestrial Herpetofauna		✓
		Aquatic Herpetofauna		✓
Ecosystem Pattern and Processes	Land Cover and Use	Habitat Fragmentation	✓	

4. An analysis of the efficacy of monitoring protocols with recommendations for modification of protocols if necessary.
5. A review of all monitoring protocols that have been previously modified and an analysis of the effects of the modification on monitoring results.
6. A five year evaluation of budget expenditures.
7. An evaluation of cooperator or partnership activities.
8. A listing of all monitoring reports or publications from the previous five years.

Additionally, this report will include a program plan and schedule of activities for the next five years. It will also include a five-year budget forecast with an evaluation of possible shortfalls in funding and an identification of potential leveraging opportunities.

The network coordinator working, in conjunction, with the technical committee, will take the lead in preparing all program review reports. The network Board of Directors will have the final signatory authority for approving these reports.

End Notes:

[1] http://www.nature.nps.gov/learningcenters/main_map3.html

Table 8.3 Partners, cooperators and stakeholders of natural resources within the three parks of the Mediterranean Coast Network.*

Park	Agency/Partner	Type of Agreement*	Focus
CABR	Department of Veterans Affairs	MOU	Management of Pt. Loma Ecological Reserve
CABR	U.S. Coast Guard	MOU	Management of Pt. Loma Ecological Reserve
CABR	U.S. Fish & Wildlife Service	MOU	Management of Pt. Loma Ecological Reserve
CABR	U.S. Navy (Pt. Loma Naval Complex)	MOU	Management of Pt. Loma Ecological Reserve
CHIS	California Air Resources Board	MOU	Meteorological & Ozone Monitoring Santa Rosa Island
CHIS	California Dept. of Fish & Game	MOA	Santa Cruz Island Preserve
CHIS	Environmental Protection Agency	MOU	Meteorological & Ozone Monitoring Santa Rosa Island
CHIS	Naval Air Warfare Center	MOU	Meteorological & Ozone Monitoring Santa Rosa Island
CHIS	Santa Barbara County Air Pollution Control District	MOU	Meteorological & Ozone Monitoring Santa Rosa Island
CHIS	National Marine Fisheries Service	MOU	Channel Islands National Marine Sanctuary
CHIS	The Nature Conservancy	MOA	Santa Cruz Island Preserve
CHIS	The Nature Conservancy	MOU	Research, Education and Management of Natural Resources, Santa Cruz Island Preserve
CHIS	U.S. Fish & Wildlife Service	MOA	Conservation of Biodiversity
CHIS	U.S. Fish & Wildlife Service	MOA	Protection of Special Status Species
CHIS	U.S. Navy	MOA	Administration of San Miguel Island
CHIS	U.S.G.S. Biological Resources Division	IA	Channel Islands Field Station
SAMO	California Dept. of Fish & Game	MOU	Resource Management (Mountain Lions, etc.)
SAMO	California Dept. of Food and Agriculture	MOU	Resource Management
SAMO	California Dept. of Parks & Recreation, The Santa Monica Mountains Conservancy, The Mountains Recreations & Conservation Authority	CA	Cooperative Resource Management of the Santa Monica Mountains
SAMO	California Dept. of Transportation	MOA	Resource Management (Habitat Fragmentation & Linkage Corridors)
SAMO	California Invasive Plant Council	MOU	Resource Management
SAMO	California Native Plant Society	MOU	Resource Management
SAMO	California State Polytechnic University, College of Agriculture, Pomona, California	MOU	Resource Management
SAMO	Las Virgenes Institute for Resource Management	MOU	Resource Management
SAMO	Los Angeles & San Gabriel Rivers Watershed Council	MOU	Resource Management
SAMO	Los Angeles County Weed Management Area	MOU	Resource Management
SAMO	Pt. Mugu Naval Air Weapons Station	IA	Mugu Lagoon Resource Protection
SAMO	Rancho Simi Recreation & Park District	IA	Pitfall Trap Monitoring of Reptiles & Amphibians
SAMO	Resource Conservation District of the Santa Monica Mountains	MOU	Resource Management of Carnivores, Reptiles & Amphibians
SAMO	San Gabriel Mountains Regional Conservancy	MOU	Resource Management
SAMO	U.S. Army Corps of Engineers	MOU	Resource Management
SAMO	U.S. Department of Agriculture Natural Resources Conservation Service	MOU	Resource Management
SAMO	U.S. Geological Survey	MOU	Geological Resources Management

MOU = Memorandum of Understanding; MOA = Memorandum of Agreement; CA = Cooperative Agreement, IA = Interagency Agreement.

Chapter 9: Schedule

This chapter describes the plan for implementing the Mediterranean Coast Network Vital Signs Monitoring Program. Through the process described in this document seventeen ecosystem vital signs have been selected for monitoring within Cabrillo NM, Channel Islands NP, and Santa Monica Mountains NRA. Water quality monitoring only is proposed for Channel Islands NP to complement the ongoing prototype monitoring program begun in the early 1990's. Eight monitoring protocols will be completed for these vital signs by the first quarter of FY 2008. Table 9.1 lists the target year of completion, the protocol name, and key tasks or issues that must be addressed for completion of each protocol. The complete schedule for developing monitoring protocols is presented in Figure 9.1.

Table 9.1 Key issues to be addressed in preparing vital signs monitoring protocols in the next three years for the Mediterranean Coast Network.

Target Year for Protocol Completion	Vital Sign	Key Issues to be Addressed Before Monitoring Protocols are Submitted for Review
FY 2006	Integrated Fresh Water Quality	Identify sampling locations, determine the breadth of parameters to be monitored, identify the scale of temporal and spatial replication for statistical inference.
	Integrated Marine Water Quality	Identify sampling locations, determine the breadth of parameters to be monitored, identify the scale of temporal and spatial replication for statistical inference.
	Terrestrial Herpetofauna	Complete final revision of peer reviewed monitoring protocol in early FY 2006. Continue monitoring as prescribed in the protocol.
	Aquatic Herpetofauna	Select sampling sites, determine specific metrics for monitoring, and identify the spatial and temporal scale of sample replication for statistical inference.
FY 2007	Landscape Pattern	Identify all sources of spatial data on land use, establish procedures for acquiring update data, determine specific metrics to be prepared from GIS database, and prepare protocol for peer review.
FY 2008	Riparian Plan Communities	Conduct baseline evaluation of sampling methods and prepare monitoring protocol for peer review.
	Invasive Plant Species Introduction & Spread	Conduct baseline evaluation of sampling methods and prepare monitoring protocol for peer review.
	Integrated Native Vegetation	Conduct baseline evaluation of sampling methods and prepare monitoring protocol for peer review.

Monitoring of terrestrial reptiles and amphibians at both Santa Monica Mountains NRA and at

Cabrillo NM (Point Loma) will continue in FY 2006. The final peer reviewed protocol for monitoring terrestrial reptiles and amphibians is attached as Appendix S and includes the monitoring strategy, processes, and data expectations for monitoring already initiated at Cabrillo NM and Santa Monica Mountains NRA. Monitoring of aquatic amphibians, begun through the biological inventory program, is currently underway in the Santa Monica Mountains following a protocol developed in cooperation with the USGS. Western Ecological Research Center, Pepperdine University, and other regional experts. This monitoring is a cooperative effort among the Mediterranean Coast Network, the USGS, Pepperdine University, and the Resource Conservation District of the Santa Monica Mountains. Based on a review of the first four years of data, the network protocol for this program is being revised to reflect vital sign monitoring objectives of the Mediterranean Coast Network and to be consistent with the format requirements of the National Park Services' I&M program. This protocol will be submitted for peer review early in FY 2006 (see Figure 9.1). Water quality monitoring protocols for both fresh water and marine water quality will be completed in FY 2006 and monitoring will be initiated network-wide upon peer review and final approval of the protocols. Figure 9.1 presents a detailed schedule for development and completion of all vital signs protocols along with expected dates for initiation of monitoring of each vital sign.

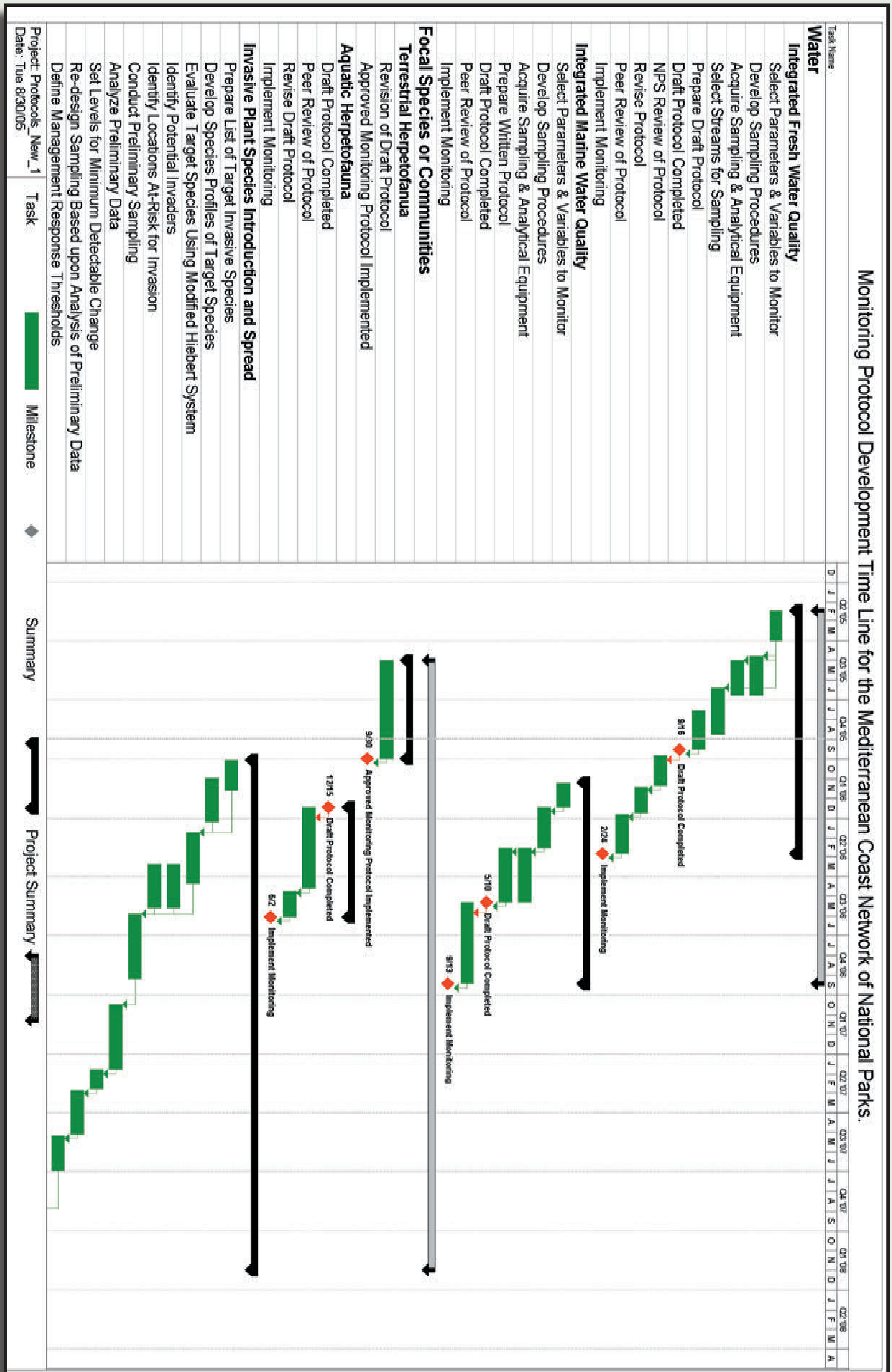

Figure 9.1 Gantt chart output from Microsoft Project® program management software presenting the vital signs monitoring protocol development schedule for the Mediterranean Coast Network. Red diamonds indicate draft protocol completion or expected implementation date for monitoring protocol following peer review.

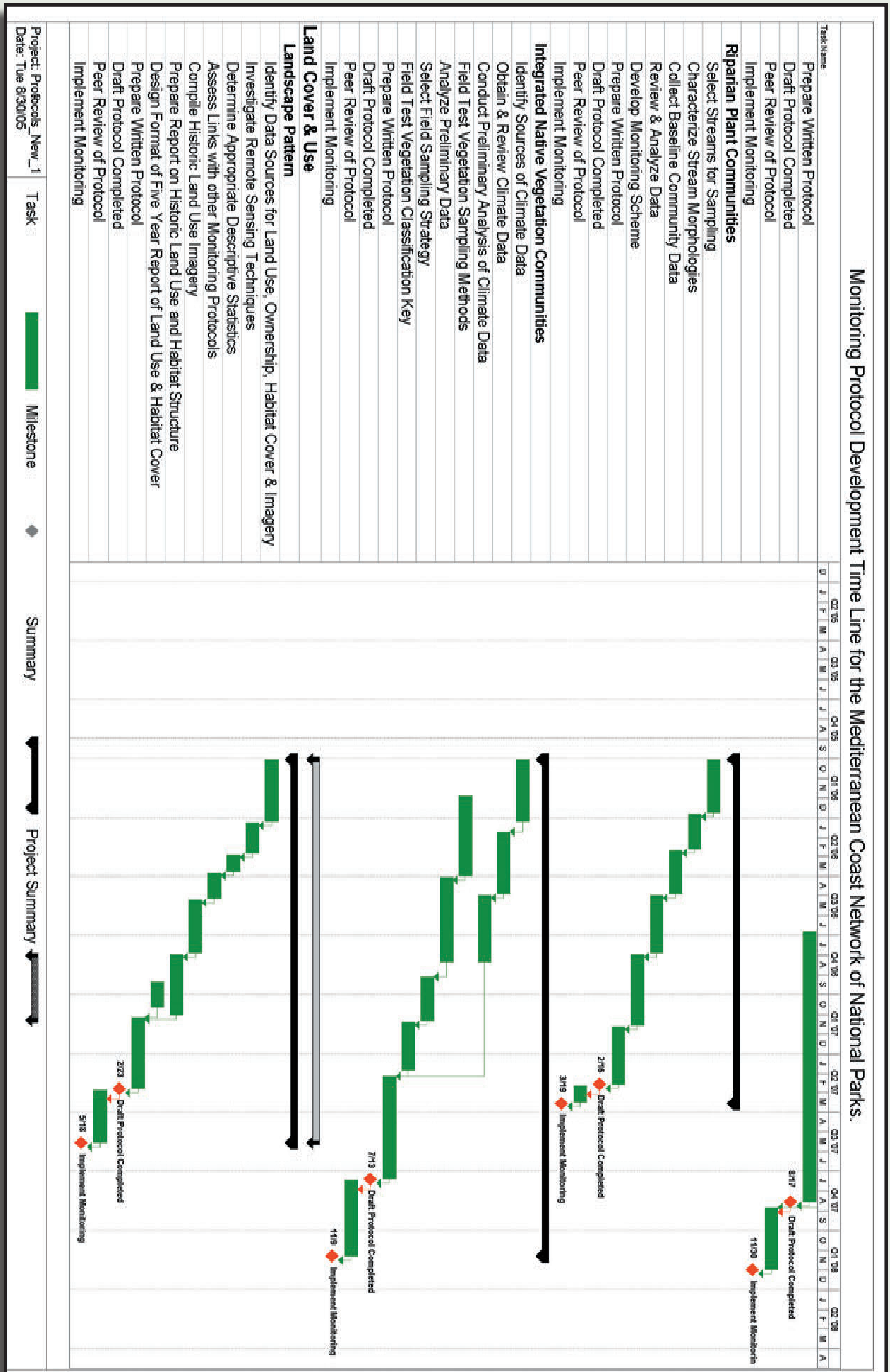

Figure 9.1 Continued. Gantt chart output from Microsoft Project® program management software presenting the vital signs monitoring protocol development schedule for the Mediterranean Coast Network. Red diamonds indicate draft protocol completion or expected implementation date for monitoring protocol following peer review.

Chapter 10: Budget

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Glossary of Terms

Airshed. The air supply in a given region. The geographical area associated with a given air supply; an airshed is a geographic area where air pollutants from sources "upstream" or within the area flow and are present in the air

Chaparral. A low precipitation vegetation community whose domination by a rich variety of hard woody evergreen shrubs with small, leathery (sclerophyllous) leaves and thick cuticles reflects its fire history. These deep and wide rooted shrubs include chamise, ceonothus, mountain mahogany, sumac, toyon, manzanita and in some areas, dwarfed oaks and drought-resistant, closed-cone pines.

Ecological Integrity implies the presence of appropriate species, populations and communities and the occurrence of ecological processes at appropriate rates and scales as well as the environmental conditions that support these taxa and processes.

Ecosystem is defined as a spatially explicit unit of the Earth that includes all of the organisms, along with all components of the abiotic environment within its boundaries.

Ecosystem Drivers are major external driving forces such as climate, fire cycles, biological invasions, hydrologic cycles, and natural disturbance events (*e.g.*, earthquakes, droughts, floods) that have large scale influences on natural systems.

Ecosystem Integrity. A living system exhibits integrity if, when subject to disturbance, it sustains an organizing, self-correcting capability to recover toward an end-state that is normal and "good" for that system. End-states other than the pristine or naturally whole may be taken to be normal and "good" if they do not degrade the capabilities of the system.

Ecosystem Management. The process of land-use decision making and land-management practice that takes into account the full suite of organisms and processes that characterize and comprise the ecosystem. It is based on the best understanding currently available as to how the ecosystem works. Ecosystem management includes a primary goal to sustain ecosystem structure and function, a recognition that ecosystems are spatially and temporally dynamic, and acceptance of the dictum that ecosystem function depends on ecosystem structure and diversity. The whole-system focus of ecosystem management implies coordinated land-use decisions.

El Niño. A climatic change marked by shifting of a large warm water pool from the western Pacific Ocean towards the east. Nutrient-rich upwelling currents along the coast of South America are blocked by this sea change and fisheries fail catastrophically. An El Niño event normally is accompanied by droughts in Australia and Southeast Asia together with heavy rain and snow in western North America.

El Niño Southern Oscillation ENSO. Flip-flopping pressure systems in the South Pacific that trigger short-lived global changes in climate. Warm waters from the western Pacific move across the ocean, just below the equator, and significantly warm the eastern tropical Pacific.

Focal Species. Species whose requirements for survival represent factors important to maintaining ecologically healthy conditions.

Fragmentation. Habitat fragmentation is a process that results in habitat conversion or habitat discontinuity that eventually leads to the isolation or insularization of the original habitat.

Herpetofauna. All amphibians and reptiles species.

Indicators are a subset of monitoring attributes that are particularly information-rich in the sense that their values are somehow indicative of the quality, health, or integrity of the larger ecological system to which they belong (Noon 2002). Indicators are a selected subset of the physical, chemical, and biological elements and processes of natural systems that are selected to represent the overall health or condition of the system.

La Niña
A climatic change marked by shifting of a large cold water pool from the eastern Pacific Ocean towards the west. La Niña is characterized by unusually cold ocean temperatures in the Equatorial Pacific.

Lignotuber. Large, underground, woody swelling composed of starchy stem tissue. An adaptation to fire that remains intact underground and from which a species can resprout after a burn.

Mesic. Referring to a region that receives adequate precipitation to maintain biological productivity.

Monitoring. Periodic or continuous surveillance, sampling or testing to determine the level of compliance with statutory requirements and/or pollutant levels in various media or in humans, plants, and animals.

Riparian. Relating to or situated on the bank of a river or stream, generally refers to the plant community along a river or stream.

Sclerophyllous Vegetation. Trees and shrubs characterized by thick leathery leaves with abundant sclerenchyma cells.

Stressors are physical, chemical, or biological perturbations to a system that are either (a) foreign to that system or (b) natural to the system but applied at an excessive [or deficient] level (Barrett et al. 1976:192). Stressors cause significant changes in the ecological components, patterns and processes in natural systems. Examples include water withdrawal, pesticide use, timber harvesting, traffic emissions, stream acidification, trampling, poaching, land-use change, and air pollution.

Vital Signs. 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 elements and processes that are monitored are a subset of the total suite of natural resources that park managers are directed to preserve "unimpaired for future generations," including water, air, geological resources, plants and animals, and the various ecological, biological, and physical processes that act on those resources. Vital signs may occur at any level of organization including landscape, community, population, or genetic level, and may be compositional (referring to the variety of elements in the system), structural (referring to the organization or pattern of the system), or functional (referring to ecological processes).

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