Golden Gate NRA Affected Environment – Natural Resources 4

GOLDEN GATE NRA AFFECTED ENVIRONMENT – NATURAL RESOURCES

INTRODUCTION

The Golden Gate National Recreation Area (GGNRA) is one of the largest urban national parks in the world. The recreation area's 75,398 acres of land and water extend from Tomales Bay in Marin County south into San Mateo County, encompassing 75 miles of bay and ocean shoreline. GGNRA is rich in natural resources; it is comprised of 19 separate ecosystems and is home to 1,273 plant and animal species. With 80 sensitive, rare, threatened, or endangered species. GGNRA ranks fourth among all units in the national park system in the number of federally protected and threatened species found within the park.

Numerous special status designations emphasize the collective importance of GGNRA and Point Reyes National Seashore (PRNS) as areas of biological significance. The Nature Conservancy (TNC) has listed this region as one of the six most biologically significant areas in the United States, a biodiversity "hot spot" recognized by TNC and targeted by the global conservation community as key to preserving the world's ecosystems. Conservation International describes this portion of central California as one of the top 25 hotspots and the most threatened of all biologically rich terrestrial regions in the world. PRNS and GGNRA are jointly designated as a Biosphere Reserve, one of 411 reserves designated by the United Nations Educational, Scientific, and Cultural Organization's (UNESCO) Man and the Biosphere Program to provide a global network representing the world's major ecosystem types (NPS 2007a).

Golden Gate Natural Recreation Area is part of the California Floristic Province (characterized by Mediterranean vegetation) and a zone of overlap of marine provinces (Californian and Oregonian) leading to a wide diversity of terrestrial and aquatic habitats. From the tip of Tomales Point to the southernmost areas of Sweeny Ridge and Phleger Estate, the natural communities of the recreation area support a diversity of habitats: marine environments, coastline, sea cliffs and sand dunes, mud flats and salt marshes, chaparral and coastal scrub, grasslands, redwood forests, and oak woodlands. The recreation area spans two of the largest estuaries on the west coast, Tomales Bay and San Francisco Bay. Aquatic associated habitats include ephemeral and perennial freshwater streams, groundwater seeps and springs, and seasonal wetlands, as well as tidal and brackish saline wetlands grading into estuaries, and the marine environment (NPS 2007a).

(Alcatraz0
Alcatraz Island is a unique part of GGNRA. Accounts of early explorers describe the island as having little plant life and covered with bird guano. Construction of the Civil War military fort and later the federal penitentiary changed the landscape significantly, sharpening the incline of the cliffs and flattening the slopes. Few plants are native to Alcatraz and most of the existing plants are a result of prison gardens or other means of importation including soils brought from Angel Island during the fort construction. Since the closure of the prison, many bird species have made the island home.

Commented [T1]: Is this up to date?

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Commented [T3]: Does this belong here? Will other areas of the park be described in this Introduction?

PHYSICAL RESOURCES

AIR QUALITY

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Section 118 of the 1963 Clean Air Act (42 U.S.C. 7401 et seq.) requires a national park unit to meet all federal, state, and local air pollution standards. Golden Gate NRA and Muir Woods National Monument are in Class II air quality area under the Clean Air Act, as amended. A Class II designation indicates the maximum allowable increase in concentrations of pollutants over baseline concentrations of sulfur dioxide and particulate matter as specified in Section163 of the Clean Air Act. Further, the Clean Air Act provides that the federal land manager has an affirmative responsibility to protect air quality-related values (including visibility, plants, animals, soils, water quality, cultural resources, and visitor health) from adverse pollution impacts.

The Clean Air Act requires the Environmental Protection Agency to identify national ambient air quality standards to protect public health and welfare. Standards were set for the following pollutants: ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), inhalable particulate matter less than 10 microns (PM_{10}) and less than 2.5 microns ($PM_{2.5}$), and lead (Pb). These pollutants are designated criteria pollutants because the standards satisfy criteria specified in the act. An area where a standard is exceeded more than three times in three years can be considered a nonattainment area.

The California Clean Air Act of 1988, as amended, sets ambient air quality standards that are stricter than the federal standards and requires local air districts to promulgate and implement rules and regulations to attain those standards. Under the act, California Ambient Air Quality Standards (CAAQS) are set for all pollutants covered under national standards, as well as vinyl chloride, hydrogen sulfide, sulfates, and visibility-reducing particulates. If an area does not meet the California standards, it is designated as a state nonattainment area.

In 1993, the Environmental Protection Agency adopted regulations implementing Section 176 of the Clean Air Act as amended. Section 176 requires that federal actions conform to state implementation plans for achieving and maintaining the national standards. Federal actions must not cause or contribute to new violations of any standard, increase the frequency or severity of any existing violation, interfere with timely attainment or maintenance of any standard, delay emission reduction milestones, or contradict state implementation plan requirements. Federal actions that are subject to the general conformity regulations are required to mitigate or fully offset the emissions caused by the action, including both direct and indirect emissions that the federal agency has some control over.

Golden Gate National Recreation Area and Muir Woods National Monument are in the San Francisco Bay Area Air Basin, which consists of San Francisco, San Mateo, Santa Clara, Alameda, Contra Costa, Napa, and Marin counties, as well as portions of Sonoma and Solano counties. The Bay Area Air Quality Management District is the air quality agency responsible for the entire basin. The agency monitors criteria pollutants continuously at stations throughout the Bay Area.

Overall, air quality in the basin is better than in other urban areas of California despite widespread urbanization and extensive industrial and mobile source (vehicular) emissions. The Bay Area's coastal location and favorable meteorological conditions help keep pollution levels low much of the year, primarily due to the area's relatively cooler temperatures and better ventilation. However, when temperatures are hot and there are no ocean breezes, levels of ozone and other pollutants can exceed federal and state air quality standards.

The San Francisco Bay Area is designated a federal nonattainment area for ozone and a state nonattainment area for ozone and inhalable particulate matter (PM_{10} and $PM_{2.5}$). Ozone is a principal component of smog. It is caused by the photochemical reaction of ozone precursors (reactive organic compounds and nitrogen oxides). Ozone levels are highest in the Bay Area during days in late spring

through summer when meteorological conditions are favorable for the photochemical reactions to occur, i.e., clear warm days and light winds. (Source? Section added by P.Malone)

Figure 1: County Variation in Attainment Status, Demonstrated by Monitoring station data, 2001-2003

Pollutant	Redwood City San Mateo County		San Francisco San Francisco County		San Rafael Marin County	
	State Standard	Federal Standard	State Standard	Federal Standard	State Standard	Federal Standard
Ozone (1-hour)*	N	NA	A	NA	A	NA
Ozone (8-hour)	NA	NA	NA	NA	NA	NA
Carbon monoxide	A	A	A	A	A	A
Nitrogen dioxide	A	A	A	A	A	A
Sulfur dioxide	ND	ND	A	A	ND	ND
Particulate matter (PM_{10}) (Max. 24-hour)	NA	A	N	A	NA	A

Source: BAAQMD Annual Bay Area Air Quality Summary

Notes:

A = Attainment, N = Nonattainment, U = Unclassified, NA = Not Applicable, ND = No data

*Attainment status is assigned only on an air-basin level. Though specific county monitors indicate attainment with NAAQS, all counties are included in the San Francisco Bay Area Air Basin, which is designated as non-attainment for 1-hour and 8-hour ozone national standards and for state standards for PM_{10}.

Air Quality Monitoring in GGNRA

An air emissions inventory was conducted in 1999 to determine the origins, compositions, and rates of emission of pollutants affecting park lands and resources. In addition to GGNRA activities, the inventory included air emissions associated with park partners and concessionaire operations and visitor activities to the extent that data were available. Standardized emission factors and air quality models from the California Air Resources Board (CARB) and the U.S. Environmental Protection Agency (EPA) were used to develop emission levels for the range of activities and facilities that can emit pollutants in GGNRA (NPS 2005a).

Sources of air emission within GGNRA include all three types identified by the Clean Air Act stationary sources, area sources, and mobile sources. Stationary sources can include fossil fuel-fired space and water heating equipment, backup generators, fuel storage tanks, paint and chemical usage, and woodworking equipment. Area sources may include prescribed burning, campfires, and bonfires. Mobile sources may include vehicles and other equipment operated within the park by visitors, tour operators, GGNRA employees, and concessionaire employees.

The emissions inventory included all lands and uses within the GMP planning area. Included in the inventory were all structures, vehicles, boats, and equipment used by the park, park partners, or concessionaires, such as the Blue and Gold Fleet that was operating~~es~~ the ferry service to Alcatraz Island.

There are no air quality monitoring stations in operation for the coastal areas of the Bay Area Air Basin that are certain to represent air quality conditions within GGNRA. A monitoring station at Fort Cronkhite in the Marin Headlands records levels of toxins present in the air as a by-product of manufacturing, such as acetone and benzene, and does not monitor for criteria pollutants. The closest monitoring stations to GGNRA lands that record levels of criteria pollutants are in the cities of San Rafael, Redwood City, and eastern San Francisco. The levels recorded at these stations, which are based in the midst of urbanized development, would be more representative of the cumulative levels of air pollutants in urbanized areas that contain heavily used roadways, urban and residential sources, and existing stationary sources throughout the air basin. Data collected at these stations can serve as very conservative estimates of ambient air quality affecting the park lands, which are largely coastal and generally upwind (based on prevailing wind direction) of local sources of Bay Area air emissions, but are still subject to pollutant problems, such as ozone, that have a more regional effect on air quality. However, the actual ambient pollutant concentrations within the park lands are anticipated to have lower background levels of these pollutants because the project area and surroundings are more remote and generally upwind of roadways and other emission sources (NPS 2005a).

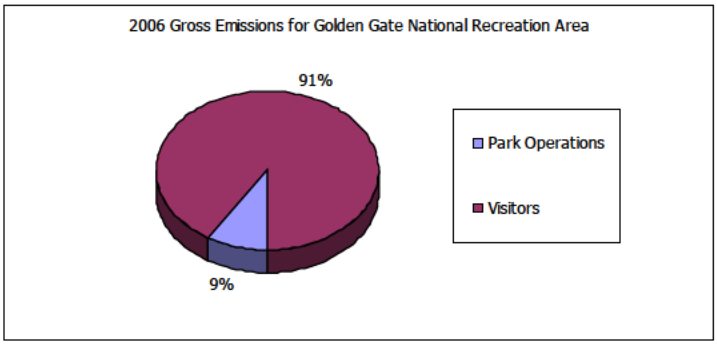
CARBON FOOTPRINT

A "carbon footprint" is a measure of the impact human activities have on the environment in terms of the amount of greenhouse gases produced, and is measured in units of carbon dioxide. The greenhouse effect is a natural phenomenon that keeps the earth's temperature stable at an average of 60 F. Without this natural warming effect our planet would be uninhabitable at an average temperature of 14 F. However, human actions are disturbing this balance through over-production of large amounts of two main greenhouse gases, carbon dioxide (CO2) and methane (CH4). The increase in greenhouse gases is causing an overall warming of the planet, commonly referred to as *global warming*. The term *climate change* describes the variable consequences of global warming over time.

The Park Service has a goal of reducing its contribution to global warming and climate change through the reduction of emissions. To begin tracking the results of their efforts, GGNRA inventoried its emissions in 2006 using the Climate Leadership in Parks (CLIP) tool developed by the Park Service and the EPA. The CLIP tool converts emissions of various greenhouse gases into a common "metric tons of carbon equivalent" unit, which provides a basis for comparison among gases and simplifies reduction tracking. The conversion of a greenhouse gas to metric tons of carbon equivalent (MTCE) is based upon how strongly that particular gas contributes to the greenhouse effect, and how many tons of carbon emission would have the same effect.

The emissions inventory (NPS 2007c) then looked at the relative input of various sectors: stationary combustion (building furnaces, dryers, electrical generators, hot water heaters), purchased electricity, mobile combustion (vehicles, buses, heavy equipment), wastewater treatment, and solid waste disposal (garbage transportation and decomposition) for all park lands in GGNRA, including Muir Woods. Based on the emissions inventory completed in 2006, emissions from visitors (mobile combustion primarily from personal automobile use) represents 91% of gross emissions at GGNRA and emissions from park operations represents 9%.

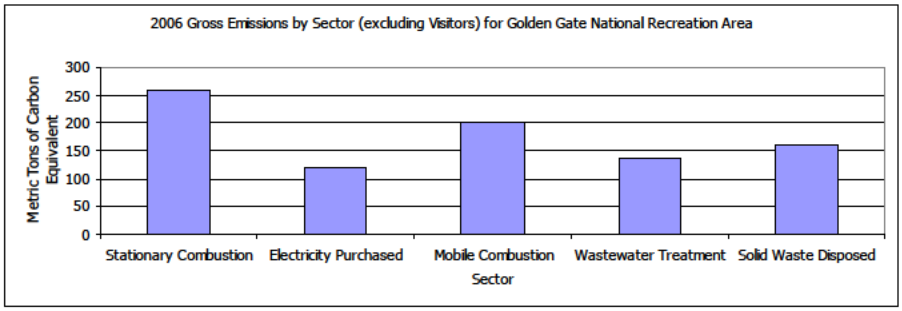
Figure 2: Gross Emission for Golden Gate National Recreation Area



Source: GOGA Climate Change Action Plan, August 2007

The following figure shows how the National Park Service's emissions from park operational activities are distributed among sectors when visitor emissions are excluded.

Figure 3: Park operations (i.e. without visitors), by sector:

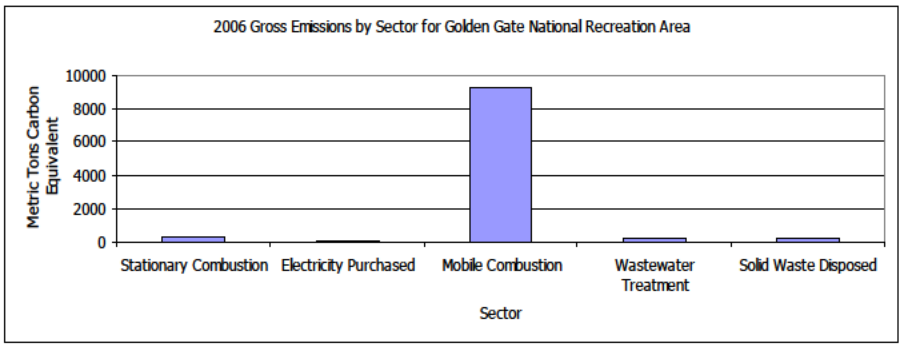


Source: GOGA Climate Change Action Plan, August 2007

Visitor emission totals consist of an approximation of how much gasoline is consumed while driving to various park locations. Using annual visitor vehicle counts to many of the different locations in the park, the total number of miles driven by visitors was approximated (based on the assumption that they were driving from somewhere in the Bay area). The resulting total vehicle miles driven by visitors was put into the CLIP tool. The CLIP tool then used assumptions about the different types of cars and their associated fuel efficiency~~the miles per gallon each had~~ to determine approximate fuel consumption.

The figure below shows how the sectors of emissions are distributed when visitor emissions are included. The vast majority of emissions at GGNRA are attributable to visitor mobile combustion (vehicles) as highlighted in the figure below.

Figure 4: Park Emissions by Sector, Including Visitors:



Source: GOGA Climate Change Action Plan, August 2007

In 2008, GGNRA's emissions inventory was updated and included the following emissions statistics for GGNRA (including parklands in the three-county area and Alcatraz Island) and Muir Woods. These data represent existing baseline conditions.

Table 1: Emission Statistics for Golden Gate National Recreation Area

	Marin County	San Francisco County	San Mateo County	Alcatraz Island	Muir Woods
Statutory combustion				632	5
Purchased electricity				0	17
Mobile combustion				1167	4873
Wastewater treatment				31	1
Solid waste				0	50
Gross emissions				1830	4946

SOILS AND GEOLOGIC RESOURCES AND PROCESSES

Soils

Most of the soils within GGNRA belong to the following complexes: Blucher-Cole, Centissima-Barnabe, Cronkhite-Barnabe, Dipsea-Barnabe, Felton Variant-Soulajule, Gilroy-Gilroy Variant-Bonnydoon Variant, Henneke stony clay loam, Kehoe, Rodeo Clay Loam, and Tamalpais-Barnabe Variant (USDA, Soil Surveys for Marin, San Francisco, and San Mateo Counties). All of these soils are susceptible to sheet and rill erosion when disturbed or exposed. The susceptibility to wind erosion is generally low. In general, these soils are characterized by slow to moderate permeability, rapid storm water runoff, and a high hazard of soil erosion, soil creep, and occasional land sliding. An aerial view of the GGNRA landscape makes clear the threats posed to the park from erosion. Coastal waves rhythmically crash against the shoreline; deep, long gullies originate at old roads; heavily used areas are devoid of vegetation; undesignated social trails crisscross through the natural areas; and landslides or slumps exist in the small valleys (NPS 2005a).

Alcatraz Island is composed of consolidated sandstone sediments, and is the remainder of a mountain that has been highly eroded. Much of the soil on the island is a result of importation from Angel Island during the fort construction or soil amendments added over the years to support the various gardens and landscape areas.

Commented [T5]: Will other areas be described in detail here?

Paleontological Resources

Fossils of tropical and subtropical species of zooplankton (radiolarian) have been found in chert of the Marin Headlands. Mollusk~~s~~ fossils (ammonite, belemnite, bivalve) have also been found here. Alcatraz Island is home to bivalve mollusk fossils and Mori Point rock includes ~~is a source of~~ fossil zooplankton (radiolarian, foraminifera). The area near Devil's Slide includes zooplankton (foraminifera), mollusk (gastropod, bivalve), crustacean, and sea star-like (echinoid) fossils. Fort Funston includes mollusk (gastropod, bivalve), sand dollar, crustacean, marine worm (polychaete), woolly mammoth, giant ground sloth, mastodon, horse, camel, canid and split-toed ungulate fossils. Fossils found on the Phleger Estate include mollusk (freshwater gastropod, bivalve), unnamed vertebrates, and plants (O'Herron 2008).

Shoreline Processes

Commented [T6]: Include a description of the processes

GGNRA's shoreline is made of three distinct shoreline types. The Pacific Ocean shoreline is characterized by steep, rocky headlands, such as Tennessee Point and Point Bonita, and the Rodeo Beach sand spit, which forms Rodeo Lagoon. The Golden Gate Channel shoreline is characterized by rocky headlands, smaller sand and gravel beaches, and strong tidal currents. The third zone is the San Francisco Bay shoreline, which includes Fort Baker's Horseshoe Bay (NPS 2007a)

Commented [T7]: Describe shoreline types Outer coast – rocky bluffs and headlands, sandy beaches, coastal lagoons San Francisco Bay – rocky bluffs, beaches, embayments, marshes

Alcatraz Island is composed of fractured sandstone and is somewhat susceptible to wave-generated erosion.

Commented [T8]: Seems out of place

Coastal Vulnerability and Sea-Level Rise

Sea levels are predicted to rise 13-20 feet over the next 100 years as a result of global warming, inundating low-lying islands and threatening coastal cities and harbors worldwide (Overpeck et.al. 2006). While this forecast has shocking global implications, it raises equally serious concern for many U.S. national parks.

Commented [T9]: TW check for more recent reference

The U.S. Geological Survey (USGS), in cooperation with National Park Service, completed an assessment in 2005 (Pendleton, Thieler and Williams 2005) of GGNRA's vulnerability to sea-level rise

using a tool called the Coastal Vulnerability Index (CVI). The CVI provides insight into the relative potential of coastal change due to future sea-level rise.

The CVI allows six variables (geomorphology, shoreline change, regional coastal slope, relative sea-level rise, mean significant wave height, and mean tidal range) to be related in a quantifiable manner that expresses the relative vulnerability of the coast to physical changes due to future sea-level rise. The CVI highlights those regions where the physical effects of sea-level rise might be the greatest.

The most influential variables in the CVI are geomorphology, coastal slope, and mean significant wave height; therefore, these may be considered the dominant factors controlling how GGNRA will evolve as sea level rises.

While climate change data reflect long-term increases in sea levels, there may be specific sites within GGNRA that could be more vulnerable to rising sea levels even within the lifespan of this GMP, particularly if the melting of the polar ice caps increases more rapidly than expected.

The colored shoreline depicted in Figure 5 represents the relative coastal vulnerability index (CVI) determined from the six variables. The very high vulnerability shoreline is generally located along sandy beaches where significant wave heights are highest and regional coastal slope is shallow, including sites like Ocean Beach, Fort Mason, Land's End, and Fort Funston. The lower vulnerability shoreline is located along rock cliffs mostly along the northern part of GGNRA where wave heights are lower and coastal slope is steep.

Of the 59 miles evaluated at GGNRA [redacted] Pendleton, Thieler and Williams 2005). [redacted] ~~shorelines are located on the southern peninsula~~ Of particular concern is that the most vulnerable of shoreline areas are where the largest concentration of humans and built facilities exist. ~~This area also includes h~~Heavily visited beaches such as ~~including~~ Ocean Beach, China Beach, and Baker Beach, are also among the most vulnerable shoreline areas of the park.

Commented [T10]: Consider [redacted]

Figure 5: Relative Coastal Vulnerability

Predictions of sea-level rise are useful in determining what resources and facilities could be affected. Based on data obtained from the Pacific Institute (2009) and the USGS, combined with modeling of 100-year floodplains, the following map illustrates what areas would be inundated by rising seas. (Need source citations- info added by P. Malone)

Insert park's sea-level rise map

Commented [T11]: Suggest (b) (5)
(b) (5)

WATER RESOURCES AND HYDROLOGIC PROCESSES

Water resources in GGNRA include springs, streams, ponds, lakes, wetlands, lagoons, the San Francisco Bay, and the Pacific Ocean. Many significant watersheds are located wholly or partially within the park. From north to south, the major watersheds are Bolinas Lagoon, Redwood Creek, Tennessee Valley (Elk Creek), Rodeo Lagoon (including Gerbode Valley subwatershed), Nyhan Creek, Lobos Creek, Milagra and Sweeney Ridges, San Pedro Creek, West Union Creek, and the San Francisco watershed lands in San Mateo County (see Figures 6 and 7 Watershed maps). Many smaller watersheds drain the steep coastal bluffs directly into the San Francisco Bay or Pacific Ocean.

The NPS has been monitoring water quality to varying degrees within these aquatic systems. Most water quality sampling to date has focused on specific sites with known or suspected water quality impacts, including beach water quality monitoring. The Park Service is presently designing a more comprehensive monitoring program that should identify any existing impacts and serve as baseline data to determine future impacts. For the lands in the southern part of the park (San Francisco and San Mateo counties), this work will also include an inventory of the ~~largely unknown~~ water resources. The monitoring will be coordinated through the San Francisco Bay Area network of regional national park sites (NPS 2005a).

Freshwater Resources

Surface Water

The watersheds in GGNRA vary in the ratio of forest cover to scrub and grassland vegetation. Watershed in southern Marin, such as Rodeo Lagoon and Tennessee Valley, are dominated by scrub and grassland vegetation with the majority of the trees in the riparian zone. These watersheds also have extensive stream and wetland complexes throughout their valley floors. Other watersheds, such as the Redwood Creek watershed, Bolinas Lagoon watershed, and the San Pedro Creek watershed, have denser forests beyond the riparian zone. These watersheds have steeper slopes and narrower valleys, and thus restrict the extent of wetlands (NPS 2005a).

Freshwater resources include streams, lakes, and freshwater wetlands. Most of the ~~river~~streams in GGNRA are ~~not large~~small and their tributaries are frequently ephemeral. The overall condition of these resources results from more than a century of intensive human uses, combined with the instability associated with soil types and the highly active San Andreas Fault system. The effects of past land use practices (development, logging, agriculture, and grazing) have changed watershed conditions and reduced habitat for many aquatic invertebrates, fish, and amphibians. Loss of native perennial vegetation, soil compaction and loss, hillside trailing, gullying, and incision of swales and meadows have changed the runoff patterns and reduced the capacity of the watershed to attenuate pollutant loading and surface runoff to streams. Dam construction, channelization, water diversions, and the increased water demands of growing urban areas have dramatically diminished the size of many streams and reduced instream and riparian species diversity. Although land use practices having lesser impacts are being increasingly adopted by landowners, present land use continues to influence water quality conditions within many watersheds (NPS 2007a).

Macroinvertebrates are commonly used as indicators of water quality and functional status of freshwater streams, but to date macroinvertebrate sampling has been infrequent and inconsistent across sites. Coho salmon have been more consistently monitored and their use as an indicator of stream condition is being evaluated. Positive signs recently observed are the recolonization of Pine Gulch Creek by coho salmon and population increases in Olema Creek (NPS 2007a).

Ponds and swales are also extremely important aquatic resources. As mentioned earlier, some of the largest endangered red-legged frog populations are in Point Reyes National Seashore and northern GGNRA where there are more than 120 breeding sites with a total adult population of several thousand

Commented [T12]: Suggest quoting directly from the Water Resources Foundation Report that Don Weeks prepared for the GMP process

Commented [T13]: Not really watersheds do we need them here?

Commented [T14]: Check with I&M program for current status

Commented [T15]: Fire Management Plan reference? Should this be 2005c?

Commented [T16]: Right word?

frogs. Most of the breeding sites are artificial stock ponds constructed on lands that have been grazed by cattle for 150 years. There are also fairly large populations in some of the coastal drainages in San Mateo County just south of San Francisco in GGNRA (NPS 2007a)

Commented [T17]: Move to Biological Resources section Consider adding text describing the general value of wetlands?

Due to its relatively small size, Alcatraz Island does not have streams, only ephemeral flows due to rainfall.

Figure 6: GGNRA Watersheds

Figure 7: MUWO Watersheds

Insert 2 Watershed Maps from Fire Management DEIS

Marin County Watersheds. Most Marin County watersheds drain to the Pacific Ocean. Watersheds relevant to GGNRA lands include Bolinas Lagoon, Redwood Creek, (b) (5) [redacted] and others. The Bolinas Lagoon watershed extends from the Bolinas Ridges west to Inverness Ridge. Two-thirds of this watershed is in public ownership. Streams within this watershed are steep and flow through the highly erodible Franciscan Complex. The Redwood Creek watershed extends from the peaks of Mount Tamalpais, through Muir Woods National Monument, to the Pacific Ocean at Muir Beach. Ninety-five percent of the watershed is owned and managed by public agencies. Several threatened animal species also occur in the watershed, including coho salmon, steelhead, California red-legged frog, and the northern spotted owl (Strix occidentalis caurina).

Commented [T18]: I don't generally think (b) (5) [redacted] (b) (5) [redacted]

The Marin Headlands drain into Rodeo Lagoon which provides marine habitat, contact water recreation, non-contact water recreation, saltwater habitat, and wildlife habitat. Rodeo Lagoon is a significant wetland/estuarine resource that provides important habitat for marine birds and other species (NPS 2005a).

Commented [T19]: Include Tennessee Valley, the SF Bay drainages, and the steep drainages into the ocean and Golden Gate strait (Refer to the Fire Management Plan FEIS)

San Francisco City and County Watersheds. The majority of the watersheds in San Francisco are highly urbanized, and their boundaries have been modified by storm drainage projects and other urban infrastructure. The Park Service manages lands in San Francisco draining to San Francisco Bay, the Golden Gate Channel, and the Pacific Ocean. Tennessee Hollow and Lobos Creek, both of which are within the GGNRA and the Presidio, remain in a relatively unurbanized state and are significant water resources in the park. The Tennessee Hollow stream, in the Presidio East watershed, is the main fresh water source for the Crissy Field marsh, a recently completed wetland restoration project. Lobos Creek, in the Presidio West watershed, is the main water supply for the Presidio (NPS 2005a).

San Mateo County Watersheds. The watersheds in San Mateo County have not been comprehensively studied due to piecemeal land management by various agencies and private holdings. The watersheds that wholly or partly contain GGNRA land include Milagra, between Sweeney and Milagra, Sweeney, San Pedro Creek, Crystal Springs (part of the larger San Francisco watershed), and West Union/San Francisquito Creek. The 23-square-mile San Francisco watershed is owned by the San Francisco Public Utilities Commission and is part of the water supply storage for the City and County of San Francisco. This watershed includes San Andreas Lake, Crystal Springs, Pilarcitos Lake, and a portion of the Pilarcitos Creek watershed. The San Pedro Creek watershed drains portions of the San Francisco watershed lands, Picardo Ranch, and portions of Devils Slide. The West Union Creek watershed contains a tributary to the Searsville Lake that drains the Phleger Estate at the south end of GGNRA (NPS 2005a).

Groundwater

Marin County. The underlying Franciscan bedrock is relatively impermeable in Marin County, creating a perched water table. Numerous springs throughout the watershed feed Rodeo Creek well into the summer months. The total volume of water stored in the aquifer is unknown. No wells are in operation within GGNRA managed lands in Marin County. The water table is tidally influenced in the lower areas such as Fort Baker (NPS 2007b)

Commented [T20]: These site-specific statements don't describe the complex groundwater conditions in Marin County parklands

San Francisco County. Groundwater sources in San Francisco County are made up of shallow unconsolidated alluvium underlain by less permeable bedrock of the Franciscan Complex. Average precipitation is approximately 24 inches per year, but due to high impervious cover rates, little infiltration occurs. The primary water-bearing formations are comprised of unconsolidated sediments and include alluvial fan deposits, beach and dune sands, undifferentiated alluvium, and artificial fill. Groundwater within San Francisco County is subject to high concentrations of nitrates and elevated chloride, boron, and total dissolved solids concentrations. High nitrate levels are attributed to groundwater recharge from sewer pipe leakage and possibly to fertilizer introduced by irrigation return flows. Elevated chloride and TDS levels are most likely due to a combination of leaky sewer pipes, historic and current seawater intrusion, and connate water. Current groundwater usage in the City is primarily for irrigation of parks and golf courses. San Mateo County withdraws groundwater for potable uses, resulting in declining water levels of Lake Merced (CWA 2004).

San Mateo County. Much of San Mateo County is part of the Santa Clara Valley Groundwater Basin, with portions in the San Francisco basin. Santa Clara Valley groundwater sources include 1) coastal marine terrace or stream valley alluvial deposits where groundwater is stored in loose, unconsolidated, coarse-grained sand, and 2) upland granitic bedrock of Santa Clara Formation where groundwater is stored in weathered rock openings and in rock fractures. The granite bedrock has limited storage capacity, but the alluvial deposits are good sources of groundwater. Long-term, the marine terraces appear to be in hydrological balance, but in dry years, pumping has reduced the water table to near sea level—increasing the risk of salt water intrusion. The water is slightly alkaline with a mean pH value of 7.3 based on 20 samples. Hardness for the 20 wells sampled averaged 471 milligrams per liter (mg/L) as $CaCO_3$, in excess of the 180 mg/L minimum value for water to be classified as very hard (CWA 2004).

Floodplains

Commented [T21]: Include reference?

Floodplains exist along streams and creeks throughout GGNRA and Muir Woods. In Marin County, 100-year floodplains are located along Redwood Creek and Rodeo Creek. Park facilities at Stinson Beach (parking lots and picnic areas) and Muir Beach (parking lot and Pacific Way) are in the floodplain.

In San Mateo County, 100-year floodplains are located along Denniston Creek, San Vicente Creek, and the Middle Fork of San Pedro Creek. The lower stables at the Rancho Corral de Tierra property are located in the San Vicente Creek floodplain.

Water Quality

The size and nature of the park (including high visitor use, the urban interface, and multitude of land uses) create several water quality-related issues. Accelerated erosion due to roads, trails, and other uses and developments threatens the sediment balance and ecological health of several watersheds. Grazing is no longer allowed on NPS-managed lands in GGNRA (NPS 1999b) but some of the impacts remain. Bacteria and nutrient inputs from equestrian operations, pet waste, agricultural operations, and potentially from sewer and septic systems can affect wildlife and public health as well as the overall ecological balance of water resources. Alteration of channels (including dams and culverts) affects the ecological health of park watersheds. These primary issues occur to varying extents within multiple park watersheds (NPS 2005a).

Many park water quality issues are related to facilities and structures. A roads and trails inventory exists and many structures are documented in the maintenance division's facilities database. However, a comprehensive inventory of park facilities and structures (including dams, culverts, and outfalls) has not been conducted (NPS 2005a).

Work is in progress to document facilities, roads and trails, and other water quality threats more thoroughly. For example, for the Redwood Creek watershed, a sediment budget study and a report of all sediment sources in the watershed were conducted. Trail maps are being updated for the park and erosion surveys continue throughout the Marin Headlands. A dam inventory will be included in an upcoming Water Quality Data Inventory and Analysis Report. Culvert mapping has occurred in Rodeo Valley (NPS 2005a).

Commented [T22]: Who's doing this?

GGNRA has a long history of water quality problems due to its proximity to urban and rural land uses. The park's surface waters and groundwater provide important beneficial uses that serve as a basis for establishing water quality objectives and discharge prohibitions by the California State Water Quality Control Board and the EPA. These "beneficial uses" include: agricultural supply, cold freshwater habitat, fish migration, municipal and domestic water supply, preservation of rare and endangered species, contact water recreation, non-contact water recreation, shellfish harvesting, fish spawning, warm freshwater habitat, and wildlife habitat. Additional beneficial uses for the Pacific Ocean include commercial and sport fishing, industrial service supply, and marine habitat. Some of the management issues facing GGNRA have to do with balancing the historical and cultural traditions of ranching and dairy establishments with the very high water quality needed for endangered species such as coho salmon, steelhead trout, California freshwater shrimp, and California red-legged frogs. In GGNRA, particularly in areas south of the Golden Gate, the primary issues are storm water discharge and legacy contaminants from abandoned military installations (NPS 2007a).

According to the California State Water Quality Control Board[1], eight areas (three creeks, three bays, and two beaches are listed as impaired according to the 303d List. The San Francisco Regional Water Quality

[1] The State Water Quality Control Board's mission is to preserve, enhance and restore the quality of California's water resources, and ensure their proper allocation and efficient use for the benefit of present and future generations.

Control Board (SFRWQCB) has established a timeline for the development of TMDLs associated with the highest priority impairment listings. The TMDL process for Tomales Bay watershed pathogens was completed in 2005 (SFRWQCB, 1995). The National Park Service is currently working with the state and local agencies to develop and implement monitoring and enhancement efforts to address additional impairment issues. Additional water quality programs are associated with the three counties within Region 2: Marin, San Francisco and San Mateo. Water districts and some watershed groups also monitor water quality (NPS 2007a).

Table 2: Impaired water bodies within PRNS and GGNRA as indicated from the 2006 303d list **(adapted from SFWQCB 2009)**

Water Body	Park Unit	Pollutant
Lagunitas Creek	PRNS, GGNRA	Sediment, Nutrients
Richardson Bay	GGNRA	High Coliform, Chlordane, DDT, Dieldrin, Dioxin, Furan compounds, Mercury, PCBs, Exotic Species
San Francisco Bay	GGNRA	Chlordane, DDT, Dieldrin, Mercury, PCBs, PAHs, Nickel, Furan compounds, Exotic Species, Dioxin, Selenium
San Francisquito Creek	GGNRA	Sediment
San Pedro Creek	GGNRA	High Coliform
Tomales Bay	PRNS, GGNRA	Sediment, Nutrients, Mercury
Pacific Ocean at Baker Beach	GGNRA	Indicator Bacteria
Pacific Ocean at Muir Beach	GGNRA	Indicator Bacteria

Source: SFWQCB 2009 adapted from 2006 CWA Section 303d List

Near shore water quality has rarely been monitored by the parks, while freshwater and beach resources are measured principally in areas where problems have been identified, or there is recreational contact with the water. This lack of a probabilistic (randomized) water sampling program means that generalizations should be made with care; a broad summary of park water quality, or even watershed water quality, is likely to overstate problems and overemphasize freshwater resources (NPS 2007a).

Water quality monitoring has been conducted in Redwood Creek and tributaries (including Kent Creek, Camino del Canyon, Banducci Tributary, Green Gulch, and Golden Gate Dairy Tributary) at numerous locations throughout the years. Several data sets exist for discrete (i.e., short-term, focused) monitoring projects. For example, monitoring by the Park Service in the Redwood Creek watershed was conducted in 1986, 1988, 1990-1991, and 1993-1996. Much of the water quality monitoring within the park has

There are nine regional boards in the state. The San Francisco Bay Regional Water Quality Control Board (Region 2)'s jurisdiction covers the area of the two parks assessed in this report, the Point Reyes National Seashore and the Golden Gate National Recreation Area.

focused on lower Redwood Creek due to concerns related to nutrient and bacteria inputs in this locale, including recent data related to the Golden Gate Dairy and Big Lagoon (NPS 2005a).

Marin Headlands/Redwood Creek/Stinson Beach/Bolinas Lagoon Areas. Short-term data sets also exist for Rodeo Creek and Tennessee Valley (1994-1996). Rodeo Creek and Tennessee Valley were monitored along with Green Gulch between 1998 and 2001 as part of intensive sampling related to stable operations and other potential sources of bacteria and nutrients. Parameters typically monitored included flow (though flow data has been sporadic), pH, temperature, dissolved oxygen, conductivity, BOD (Biological Oxygen Demand), salinity, TSS (Total Suspended Solids), fecal and total coliforms, nitrates, ammonia, phosphates, Total P, metals (emphasis on copper), MBAS (Methyl Blue Activated Substances), and chloride. Not all parameters were monitored at all sites (NPS 2005a).

Consultants, the United States Geological Survey (USGS), and other entities have also conducted monitoring. For example, the Stinson Beach County Water Agency currently monitors Easkoot Creek for fecal coliform~~s~~ and nutrients. Limited monitoring has also been conducted in Oakwood Valley and Nyhan Creek as part of an overall storm water monitoring project that includes Redwood Creek, Tennessee Valley, and Rodeo Creek (NPS 2005a).

Flow monitoring by various entities, including the National Park Service, the USGS, local universities, and consultants, has also been conducted. Flow monitoring sites have typically corresponded with water quality monitoring sites and include the Redwood Creek watershed (including Camino del Canyon, Kent Creek, Banducci Tributary, and Green Gulch Creek) as well as Easkoot Creek, Rodeo Creek, and Tennessee Valley. The USGS also monitored sediment and stream flow in Audubon Canyon and Morses Creek (near Bolinas) between 1967 and 1969. UC Berkeley monitored Lone Tree Creek (south of Stinson Beach) between 1972 and 1974. Stream gauges were installed by the Park Service at Redwood Creek (Highway 1 Bridge) and Easkoot Creek. Because of high/toxic nutrient loads, algal blooms have occurred in Rodeo Lagoon. In addition to nutrient issues, Rodeo Lagoon sediments may contain elevated amounts of copper from copper sulfate (algaecide) treatment (NPS 2005a).

San Francisco and San Mateo Counties. Water quality monitoring has been conducted periodically at the Presidio for several years. Until very recently, however, no monitoring of surface water had been conducted by the NPS in the southern GGNRA lands.

At Lobos Creek in the Presidio, the Urban Watershed Project (UWP)—a nonprofit group—has conducted fecal coliform monitoring through a contract with the Presidio Trust. The City and County of San Francisco also recently conducted monitoring in Lobos Creek. Limited sampling of Lobos Creek was also conducted through the Environmental Remediation Program. Likewise, basic water quality parameters have been collected in Tennessee Hollow by UWP, and by the Park Service at the Crissy Field marsh. Some limited water quality monitoring has been conducted within the West Union/San Franciscquito Creek watershed (West Union Creek is located within this watershed), but no monitoring has been conducted on NPS lands. The San Francisquito Creek Watershed Council is actively involved in management and monitoring of this watershed. Through the Watershed Council, consultants have monitored the Bear Creek watershed (including West Union Creek). However, no sites have been located within Phleger Estate or the adjacent county park (NPS 2005a).

The Environmental Protection Agency (EPA) and the City of San Francisco Waste Water Treatment Plant conducted water quality monitoring (including several indicator bacteria) in San Pedro Creek. A local high school student has also tested the creek for temperature, pH, conductivity, transparency, and oxygen. The San Pedro Creek Watershed Coalition has submitted a proposal to conduct DNA testing and optical brightener testing to determine the source of high indicator bacteria levels in the creek (San Pedro Creek Watershed Council 2002). San Francisquito Creek is listed on the Section 303d list as being impaired by sediment. Concerns in West Union Creek, a San Francisquito Creek tributary within Phleger Estate,

include erosion and runoff from trails. Landslides and significant bank erosion have been observed (NPS 2005a).

Issues in Milagra, Sanchez, and Calera creeks are mostly unknown due to the lack of water quality data. However, suspected issues in these urban creeks include fertilizer or pesticide runoff from lawns and a golf course. In addition, pet waste, oil and chemical runoff from roads, and bacteria and nutrient inputs from leaky sewer pipes are also suspected concerns (NPS 2005a).

Marine Resources

Marine Environment – Regional Overview

The GGNRA coastal waters include coastal and marine habitats of central and northern California, adjacent to Gulf of Farallones National Marine Sanctuary (NMS) and Monterey Bay NMS. The area shares many characteristics of ~~other features with~~ the sanctuaries due to its proximity and the influence of similar currents, seasonal upwelling, and weather patterns. ~~Geological features include~~The region is characterized by a broad continental shelf; rocky shores; sandy beaches; coastal estuaries such as San Francisco Bay, Elkhorn Slough, and Tomales Bay; offshore banks; and the sloping edges of the continental shelf, dissected by deepwater canyons, such as the Monterey Submarine Canyon (NMS, NOAA 2006).

This unique combination of oceanographic conditions and undersea topography make the area rich and diverse in a variety of marine species, including a wide array of temperate cold-water species and occasional influxes of warm-water species. The species diversity is directly related to the diversity of habitats and oceanic conditions, which are described in the following section, and the location of the sanctuaries within a broad transition zone providing a complex gradient of changing environments in which the relative proportions of species changes from north to south (NMS, NOAA 2006).

The species north of Point Conception, encompassing the entire study region and extending right up through Washington State, are part of the Oregonian biogeographic province. The relative amount and location of upwelling and downwelling and, consequently, the amount of productivity seen along the coast are affected by seasonal weather patterns and the influence of the California and Davidson currents. The distribution of each species in the ocean is determined by a multitude of factors, including temperature, salinity, oxygen content, nutrient availability, current speed and direction, species interaction, frequency of perturbation, and food availability (NMS, NOAA 2006).

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Habitats

The nearshore marine environment includes bay and estuarine habitats created by mudflats, tidal wetlands and rocky shorelines and extends through the intertidal to the subtidal zone of the continental shelf. This shelf extends far from the coast and upwelling occurs near shore, so the coastal zone offers a relatively shallow highly productive habitat for fish, invertebrates, marine mammals and seabirds. The subtidal zone abuts the federally protected Gulf of the Farallones National Marine Sanctuary to the north and the Monterey Bay National Marine Sanctuary to the south. The area is considered a biological hot spot and data that is available for some species (seals, invertebrates (abalone) fish (rockfish), shorebirds) indicate that most populations are slowly recovering from historic declines. Rocky and sandy substrates predominate with kelp communities occurring in scattered areas predominantly along the PRNS and GGNRA coastline north of San Francisco Bay. Research on physical processes is underway with promising new approaches for coastal benthic mapping, such as multibeam sonar, helping to elucidate nearshore habitat complexity. This knowledge is important for resource assessments as an aid to locate and predict species distributions (NPS 2007a).

Along the open coast, intertidal habitats are likely the most heavily impacted aquatic areas. Despite park protection, these habitats are impacted by recreational activities including boating, clamming, fishing, diving, and trampling. The principal water quality threats include bacterial and nutrient pollution (ranches, dairies, septic and stormwater discharges), occasional oil spills from offshore tankers, and legacy military landfills. Though beach sampling and damage incident reports have identified many of these problems, the extent of these impacts on intertidal organisms is not well studied (NPS 2007a).

Intertidal Zone. Intertidal habitat, by definition, is found between the lowest and highest tidal level. This transitional area between sea and land is the strip of shore between the uppermost surfaces exposed to wave action during high tides and the lowermost areas exposed to air during low tides. Intertidal habitats vary in type of material and the degree of exposure to surf. Bottom habitat types include those of fine mud, sand, gravel, shale, cobble, boulders, and bedrock. Intertidal habitat within the GGNRA includes rocky and sandy beaches (NMS, NOAA 2006).

The south side of the Alcatraz Island contains a sheer rock wall that terminates on a narrow rock reef about 10-15 m wide. This narrow intertidal reef extends only for a short distance (about 200 m) but represents one of the few rocky reefs within the San Francisco Bay. Other rocky intertidal portions of the island are comprised of riprap and rubble similar to the shorelines of much of the San Francisco Bay.

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Subtidal and Nearshore Waters. Subtidal and nearshore waters refer to the area from the lowest low tide line to the point where the seafloor drops and the deeper offshore waters begin. This is on the land side of the continental shelf slope transition. The substrate can be sand, mud, or rock, providing essential habitat for various algae, zooplankton, and phytoplankton species (NMS, NOAA 2006). The nearshore coastal environment is highly variable along the parks' shorelines, with a complex spatial distribution of marine resources due to diverse lithologies, active tectonic and geomorphic processes, topographic relief, and dynamic nearshore currents. This physical diversity coupled with high productivity results in an equally diverse distribution of organisms (NPS 2007a).

Because the continental shelf extends far from the coast and upwelling occurs nearshore ,the coastal portion of the park offers a shallow, highly productive habitat for sea birds, fish, and marine mammals. Currents, bathymetry (depth), and substrate determine the distribution of marine communities in the subtidal zone. These factors in turn affect more inland habitats, such as the intertidal zone, bays, and estuaries, to varying degrees. Though much of this discussion focuses on coastal subtidal areas, it should be noted that estuarine areas also include subtidal areas. Subtidal habitats are particularly threatened in San Francisco Bay and the surrounding coastline due to intense coastal development and expansion of marine transportation systems. Dredging for port modernization, sand mining, and alteration of rocky reef habitats near navigation channels can severely impact subtidal habitats and affect trust resources (NPS 2007a).

Continental Shelf and Slope. The continental shelf is the zone bordering a continent extending out from where there is permanent immersion, usually at about 328 to 656 feet (100 meters to 200 meters), where there is a marked or rather steep descent toward greater depths. The continental shelf is basically the extended perimeter of each continent. This area can be covered by relatively shallow seas (shelf seas) and gulfs. The shelf usually ends at a gradual slope called the shelf break, where the bottom sharply drops off into a steep slope; the sea bottom below the break is the continental slope. It usually begins at a depth of 430 feet (130 meters) and can be up to 12.5 miles (20 km) wide (NMS, NOAA 2006).

The continental slope, which is still considered part of the continent, together with the continental shelf, is called the continental margin. GGNRA waters extend (b) (5) [redacted] (b) (5) [redacted] from the shoreline to a depth of about 328 to 492 feet (100 to 150 meters), the shelf is nearly horizontal, with rocky outcrops, gravel, sand, clay, silt, and deposits of broken shells covering it. About 25 miles (40 km) from the coast, the seafloor drops off, creating the continental slope with a grade of about 3 degrees. The slope is from 328 to 492 feet (100 to 150 meters) to about 2 miles deep (3,200 meters) and is covered with uniform sandy sediment (NMS, NOAA 2006).

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[Insert Coastal Shoreline Habitats Map here]

Estuarine Resources. Approximately 59 miles of ocean and bay coastline are included in GGNRA (NPS 2007a). Coastal and bay resources compromise biologically diverse and complex ecosystems, which contain a rich array of marine invertebrates and algae. Intertidal communities within or adjacent to the boundaries include islands, islets, reefs, rocks, straits, lagoons, mudflats, beaches, piers, wharves, the Gulf of Farallones and the San Francisco Bay Estuary (NPS 1999b).

GGNRA estuaries, bays, and lagoons have endured considerable physical disturbance and pollution due to their proximity to the highly urbanized City of San Francisco. Some areas were heavily modified in past eras, causing major changes in habitat structure, including Big Lagoon at Redwood Creek, Horseshoe Bay, and Crissy Field. Restoration is either planned or already initiated in these areas. In the recent past, the San Francisco Peninsula experienced significant bacterial pollution from storm water runoff; however, treatment since the 1990s has significantly reduced pollution levels. High levels of PCBs, PAHs and heavy metals are still major issues facing San Francisco Bay coastal waters and restoration is likely to improve local water quality conditions in some areas like the nearshore Presidio (NPS 2007a).

While active restoration efforts are reclaiming wetlands, some embayments are accreting too much sediment. Though sedimentation is a natural process, Tomales Bay, Drakes Bay and Bolinas Lagoon appear to be experiencing higher than normal sedimentation rates. The evaluation of these complex tidal system dynamics and the possible impacts due to climate change will depend on accurate habitat mapping procedures. Currently, there is significant emphasis in PRNS and GGNRA on mapping wetland extent and quality; however, these efforts are not yet completed and historical information on wetland habitats is limited. Where efforts are being made to restore tidal marsh habitat, such as at Redwood Creek and the Giacomini Ranch. our understanding of these systems is improving (NPS 2007a).

There are several entities interested in tidal generated energy projects within the SF Bay and GOGA off-shore waters, as well as wind energy projects on GOGA coastal lands. Impact on habitats and wildlife will be dependent on the type and location of construction, if any.

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BIOLOGICAL RESOURCES

HABITAT (VEGETATION AND WILDLIFE)

Marine and Estuarine

Intertidal Zone

The intertidal habitat (the area between high tide and low tide lines) is biologically rich, supporting diverse assemblages of organisms. It is characterized by extreme conditions caused by wind, waves, and the fluctuation of tides. The animals inhabiting intertidal zones are subject to periodic immersion in water, followed by exposure to air. They must withstand varying degrees of wave shock, dramatic temperature changes, changes in moisture, attacks from both marine and terrestrial predators, and human-caused effects, such as trampling and collecting (NMS, NOAA 2006).

Four zones of rocky intertidal organisms are traditionally associated with different tidal heights. Species distributions are restricted according to physiological tolerance along the thermal and moisture gradient in the intertidal zone. The splash zone is almost always exposed to air, and has relatively few species. The high intertidal zone is exposed to air for long periods twice a day. The mid-intertidal zone is exposed to air briefly once or twice a day, and the low intertidal zone is exposed only during the lowest tides (NMS, NOAA 2006).

On unconsolidated muddy or sandy shores, algae are rare, and benthic diatoms are the only marine algae that may be present. On sandy beaches, much of the invertebrate life, such as worms, crustaceans, snails, and clams, dwell under unconsolidated substrate. Common crustaceans and mollusks include the beach hopper *(Megalorchestia californiana),* spiny mole crab *(Blepharipoda occidentalis),* and sand crab *(Emerita analoga).* Common marine worms include *Anatides groenlandica, Eteone dilate,* and *Euzonus* spp. (NMS, NOAA 2006).

Rocky shores support a richer assortment of plants and animals. Algae include numerous species of green, brown, and red algae, as well as beds of surfgrass. A wide variety of invertebrates, including anemones, barnacles, limpets, and mussels, compete for space with the algae in the intertidal zone. Mobile invertebrates, such as sea stars, snails, and crabs, often hide in crevices or under rocks, emerging to graze on algae or prey on other animals. Small fishes may also live in the small pools of water that fill up with each tidal cycle. Typical intertidal invertebrate species of central and northern California include lined shore crab *(Pachygrapsus crassipes),* purple shore crab *(Hemigrapsus nudus),* isopods *(Idotea* spp.*),* California mussels *(Mytilus californianus),* periwinkles *(Littorina* spp.*),* lemon nudibranch *(Anisodoris nobilis),* troglodyte chiton *(Nuttallina californica),* bat star *(Asterina miniata),* black turbin snail *(Teynla funebralis),* the giant green anemone (Anthopleura xanthogrammica), aggregating anemone (Anthopleura elegantissima), and other species of bryozoans, nudibranchs, sponges and tunicates. Intertidal fishes, such as the crevice kelpfish (*Gibbonsia montereyensis*) and the tide pool sculpin (*Oligocottus maculosus*), are limited to tide pools or to passing through the intertidal zone at high tide (NMS, NOAA 2006).

Birds forage in the intertidal zone at low tide or roost in the cliffs just above the shore. There are a great many species of shorebirds along the beaches, including sanderlings (*Calidris alba*), short-billed dowitchers (*Limnodromus griseus*), western gulls *(Larus occidentalis),* glaucous-winged gulls (*Larus glaucescens*), and California gulls (*Larus californicus*). Shorebirds, such as sanderlings and dowitchers, routinely forage in the receding surf, an indication that there are sand-dwelling crustaceans available. Another bird found in this area is the snowy plover (*Charadrius alexandrinus nivosus*), whose threatened status has resulted in some significant resource management actions in central California, including restrictions on access or types of use in some shoreline areas. Some typical shorebird breeders in this habitat include the snowy plover, black oystercatcher *(Haematopus bachmani),* killdeer (*Charadrius vociferus*), sanderlings, willets (*Catoptrophorus semipalmatus*), and marbled godwits (*Limosa fedoa*).

Brown pelicans *(Pelecanus occidentalis)*, surf scoters, grebes (family *Podicipedidae*), cormorants (*Phalacrocorax spp.),* and many seabird species can be found in water beyond the breaking waves or flying through the area. Caspian terns (*Sterna caspia*) and Forster terns (*Sterna forsteri*) and whimbrels (*Numenius phaeopus*) are some of the summer migrants that forage along the coastal beaches. Winter migrants include loons (*Gavia spp.),* willets, black-bellied plovers (*Pluvialis squatarola*), godwits (*Limosa spp.),* and turnstones (*Arenaria melanocephala*) (NMS, NOAA 2006).

Marine mammals are also found in this habitat. Pacific harbor seals *(Phoca vitulina),* and California sea lions (*Zalophus californianus)* are frequently seen seaward of the surf zone; sea otters *(Enhydra lutris)* and Steller sea lions *(Eumetopias jubatus)* are occasional visitors. Seals and sea lions haul out on intertidal shores for warming and breeding (NMS, NOAA 2006).

(Alcatraz)At Alcatraz Island, the rocky intertidal community on the Alcatraz reef is characterized by attached flora and fauna such as rockweed *(Fucus gairdneri),* turfweed *(Endocladia muricata),* and barnacles. Areas with crevices are overhangs are often harboring mobile species such as shore crabs and seastars.

Subtidal and Nearshore Waters

Subtidal habitats (shallow-water areas below mean low water) and nearshore waters (shallow inshore waters of the continental shelf) support many different species. Krill (*euphausiids*) is a crucial or "keystone" species in the area. They are small, shrimp-like crustaceans that congregate in large dense masses called swarms or clouds. Two krill species form the primary forage for upper tropic levels in the adjacent sanctuary. Krill feed on phytoplankton and are very important in the food web since many other species of bird, fish, and animals feed on krill. Krill form a key trophic link in coastal upwelling systems between primary production and higher trophic level consumers. Most marine predators subsist at least part of the year on krill, which is the primary prey of seven of the ten most important commercial fishes on the central California coast. Krill are also very important food sources for baleen whales and seabirds (NMS, NOAA 2006).

The nutrient-rich sanctuary waters near GGNRA provide forage for the largest concentration of breeding seabirds in the continental US. More than 120 species of birds use these three sanctuaries for shelter, food, or as a migration corridor. Of these, over 40 species are known to use the sanctuary during their breeding season (NMS, NOAA 2006).

These same productive waters also support a variety of marine mammals, including gray whales (*Eschrichtius robustus*), humpback whales (*Megaptera novaeangliae*), blue whales (*Balaenoptera musculus*), Dall's porpoise (*Phocoenoides dalli*), harbor porpoise (*Phocoena sinus*), Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), northern right whale dolphins (*Lissodelphis borealis*), Risso's dolphins (*Grampus griseus*) and killer whales (*Orcinus orca*). Some species, such as the gray whale, are only seasonal migrants; others travel to the area to feed (blue and humpback whales, killer whale); yet others can be found in these areas year round (harbor seals, sea lions) (NMS, NOAA 2006).

Six species of pinnipeds are found in the waters offshore of GGNRA, some of which are federal listed. Pinnipeds spend a large amount of time in offshore waters, or on offshore islands, but some of the rookeries (breeding places or breeding colonies usually crowded with the same species) or haul-out areas occur in this habitat. Species found in the area are California sea lion, Pacific harbor seal, Steller sea lion, northern elephant seal *(Mirounga angustirostris)* , northern fur seal *(Callorhinus ursinus),* and on occasion, the Guadalupe fur seal (*Arctocephalus townsendi*). The various species have numerous seal rookeries or colonies and are found at different times of the year, feeding on the abundant fish and invertebrate resources of the island shelves or hauling out on rocks and beaches (NMS, NOAA 2006).

A variety of fish species occur within these habitats, including rockfishes, cabezon, surfperch (family *Embiotocidae*), wrasses (family *Labridae*) and senorita (*Oxyjulius californica*). Commercially harvested

species include salmon, tuna, crab, squid, and various rockfish. Both the salmon and crab fisheries are the most important fisheries in the sanctuaries. The West Coast Dungeness crab fishery is considered the most sustainable large-scale commercial crab fishery in the world. Both chinook and coho salmon are coastal migrants. (NMS, NOAA 2006).

Kelp forests support a variety of species, including sea otters and sea urchins. Other marine mammals, such as harbor seals and California sea lions, are common in and around kelp forests, as are a variety of fishes, such as the señorita *(Oxyjulius californica)*, the kelp surfperch *(Brachyistius frenatus)*, blue rockfish *(Sebastes mystinus)*, blacksmith (*Chromis punctipinnis*), and olive rockfish *(S. serranoides)*. The kelp canopy, stipes, and holdfasts increase the available habitat for nearshore species and offer protection to juvenile finfish. Bat star *(Asterina miniata)*, sea lemon *(Anisidoris nobilis)*, barnacles *(Balanus spp.)*, red volcano sponge *(Acarnus erithacus)*, and urchin are a few of the many types of invertebrates that inhabit the kelp forest and rocky subtidal habitats (NMS, NOAA 2006).

GGNRA has an abundant array of sandy beaches, some barely accessible narrow strips along the shoreline while others are large expanses readily accessed and heavily used. Beach wrack, thick tangles of kelp and sea grass that wash ashore during high tides, supports an intricate food web and community. Until recently, beach wrack was removed from many park beaches although this practice has been discontinued. Recreational activities on park beaches, unleashed dogs, and kayaks impact both shorebird and pinniped populations. Efforts to minimize disturbance during the past 5 to 10 years appear to have met with some success and certain species such as snowy plover and harbor seal populations seem stable after years of decline (NPS 2007a).

Although local data are not comprehensive, notable trends and observations for key indicators in California nearshore marine and estuarine habitats likely to occur in the parks include the following:

- decline populations of all California abalone
- northern spread of the ricketsial like bacteria responsible for withering syndrome in black abalone which was recently observed just south of GGNRA.
- decline in rockfish species such as bocaccio (*Sebastes paucispinus*)
- decline in the extent of kelp forests from pollution, wave damage due to storms, and El Niño warming
- stable Dungeness crab populations as a result of successful fisheries management.
- increase in dune and beach dependent snowy plovers after significant declines observed in the mid 1990s resulted in protective management
- stable population levels for harbor and elephant seals
- decline in pelagic sea birds due to climate regime shifts and human disturbance including bycatch, nest disturbance, and oil spills
- increase in tidal marsh lands due to restoration activities and protective measures (NPS 2007a)

Estuarine and Lagoon

Estuaries and lagoons serve as important habitats for many fishes, birds, and mammals. They provide suitable habitat for reproduction, feeding, resting, and cover. Estuaries and lagoons support unique biological communities with both aquatic and terrestrial characteristics. Halophytic vegetation, such as pickleweed *(Allenrolfea occidentalis)*, grows higher in the marsh where flooding occurs less frequently and salt may become concentrated. However, little vegetation can grow in areas characterized by high evaporation and high soil salinity. A diverse assemblage of wetland plants grows in areas near tidal creeks

where fresh water input is high. As the plant matter breaks down into detritus, it is consumed by various filter feeders, deposit feeders, and other omnivores and scavengers. These species, inturn, provide abundant food resources for other species of fish, birds and mammals. Brackish water supports a distinctive assemblage of invertebrate and fish species, including the endangered tidewater goby *(Eucyclogobius newberryi),* delta smelt *(Hypomesus transpacificus),* and the stickleback *(Gasterosteus aculeatus leiurus).* Other estuarine species can include jacksmelt *(Atherinopsis californiensis),* Pacific sardine, Pacific herring *(Clupea pallasii),* staghorn sculpins *(Leptocottus armatus),* several rockfishes, salmonids, clupeids *(Clupeleonella* ssp.*),* and embiotocids *(Embiotocidae)* (NMS, NOAA 2006).

The estuaries and bays of coastal California are part of the Pacific Flyway, one of the four principal bird migration routes in North America. San Francisco Bay supports a large number of migratory and resident birds. Also important for birds are Tomales Bay, Bolinas Lagoon, Pescadero Marsh, and Elkhorn Slough. Bolinas Lagoon and Tomales Bay are designated wetlands of significant international importance under the Convention on Wetlands. Marine mammals, including harbor seal, harbor porpoise, and sea otter, occur in these bays (NMS, NOAA 2006).

Seagrass beds, which occur in the bays and lagoons, are highly productive habitats that support a unique assemblage of invertebrates and fishes. Many fishes, including Pacific herring, spawn in seagrass beds among other habitats. The structure of seagrass beds provides protection from predation for juvenile invertebrates and fishes. Large numbers of shorebirds and waterfowl are attracted to seagrass beds, where they feed on the seagrass, fishes, and invertebrate eggs and young (NMS, NOAA 2006).

The water around Slide Ranch includes exposed outer coastlands with a rich display of sponges, hydroids, bryozoans, and tunicates. Muir Beach is home to a variety of submarine sponges, hydroids, bryozoans, and tunicates. Tennessee Cove contains unique geological features including the only California central coast display of highly polished shells of *Collisella digitalis*. Sea caves contain unusually large isopod *(Ligia occidentalis)* specimens. Kirby Cove contains giant isopods of unusually large size and high densities of starfish (*Pisaster ochraceous* and *Patria miniata).* Bird Island, with its guano-covered sea stack, produces abnormally sized marine invertebrates and plants, including large California mussels and surfgrass, marine kelp and giant kelp, sea anemones and purple seastar, as well as high densities of chilipepper shrimp (*Tigriopus californica*). The underwater marine life is abundant and includes high densities of sponges, hydroids, bryozoans, and tunicates. The Alcatraz intertidal zone ranks high in its abundance and diversity of marine algae (NPS 1999b).

Estuaries, bays, and lagoons provide rich habitats including subtidal seagrasses, tidal mudflats, and marshes that support a rich diversity of wildlife. Historical construction of levies and seawalls disrupted tidal regimes and dramatically reduced the extent of tidal marsh coverage in both parks. Inherently lower rates of hydrologic mixing in estuaries and especially in lagoons, enhances their vulnerability to pollution and invasive species (NPS 2007a).

Though not as well studied as San Francisco Bay, invasive species are established in estuaries and lagoons in northern GGNRA, but at much lower level than in San Francisco. Despite these threats, Tomales Bay and Drakes Estero are considered relatively pristine and support variable but healthy biological communities. Wetland restoration projects, such as the 563-acre Giacomini Ranch Restoration Project, will further enhance resource condition (NPS 2007a).

Due to its favorable currents and nearshore foraging areas, the waters around Alcatraz Island provide rich sources of food for the colonial waterbirds that nest on the island (NPS 2001). These waters are subject to the same influences as the rest of San Francisco Bay.

Benthic Communities

The benthic community is made up of organisms that live in and on the bottom of the ocean floor. Benthic species include worms, clams, crabs, lobsters, sponges, and other tiny organisms that live in the

bottom sediments. Benthic species are divided into the filter feeders and the deposit feeders. Filter feeders filter their food by siphoning particles out of the water.

Various benthic habitats and substrates are found within the waters off GGNRA. In addition, benthic communities occur in a variety of the habitats described in this section, including subtidal rocky reefs, kelp forests, soft bottom habitats, and deep ocean floor habitats. The continental shelf descends gradually from the coast to the shelf break. Benthic communities along the continental shelf are covered in part by a layer of mud. Outcropping bedrock and sand cover the continental shelf at depths greater than 295 feet (90 meters). Benthos play a critical role and make up a diverse group that are a major link in the food chain (NMS, NOAA 2006).

The south side of Alcatraz Island contains a sheer rock wall that terminates on a narrow rock reef about 10-15 m wide. This narrow intertidal reef extends only for a short distance (about 200 m) but represents one of the few rocky reefs within the San Francisco Bay. Other rocky intertidal portions of the island are comprised of riprap and rubble similar to the shorelines of much of the Bay. The rocky intertidal community on the Alcatraz reef is characterized by attached flora and fauna such as rockweed (*Fucus gairdneri*), turfweed (*Endocladia muricata*), and barnacles. Areas with crevices are overhangs are often harboring mobile species such as shore crabs and seastars.

Terrestrial/Freshwater

Plant Communities

The vegetation of GGNRA is a result of the juxtaposition of physical landforms and water masses, and associated geology, climate, and history. The moist maritime climate along the coastline is a dominant influence, while the park's east-facing sites are subject to drier inland conditions. Distinct changes in soils from the rich conditions of the Franciscan melange to the unique chemistry of serpentinitic outcrops have created a diverse mosaic of vegetation communities. Natural processes that affect these patterns add another layer of complexity to the system, with landslides, rainfall patterns, and fires. GGNRA is known to support 572 native and 336 nonnative terrestrial plant species, including 25 federal-listed threatened and endangered plant and wildlife species (NPS 2005a).

Alcatraz Island generally consists of grassland, shrubs, historic gardens, nonnative trees, and cliffs and other barren areas, along with buildings and other paved areas. The landscape vegetation consists of a diverse group of nonnative ornamental shrubs and trees, which provide the vegetative structure and habitat for wildlife on the island (NPS 2001).

Coastal Scrub and Chaparral. The coastal scrub community is dominated by coyote brush (*Baccharis pilularis*), California sagebrush (*Artemisia californica*), bush lupine (*Lupinus arboreus*), and poison oak (*Toxicodendron diversilobum*), with variations in dominant species based on moisture levels, soil types and slopes, and past land use history (Howell 1970). This community intergrades and creates a mosaic with the grassland community, and is found throughout the .park from near sea level to 2,500 feet. The coastal scrub community also contains large numbers of nonnative species, and at times is dominated by nonnative shrubs such as French broom (*Genista monspessulana*) and thoroughwart (*Ageratina adenophora*). Chaparral stands, although not abundant at GGNRA, contain a high number of locally to regionally rare species of concern for the park, and are contiguous with coastal scrub stands. Small communities of chaparral exist in Muir Woods and the Marin Headlands, as well as larger areas on Bolinas Ridge. There are several types of chaparral in GGNRA, including chamise chaparral, ceanothus chaparral, and manzanita chaparral (NPS 2005a).

[Insert Vegetation Communities Map here]

Grasslands. The grassland community at GGNRA extends from sea level to nearly 2,600 feet. It forms a mosaic with the coastal scrub community and mixed evergreen forests. It is generally accepted that fires are part of the evolutionary forces affecting grassland. Burning has occurred for at least the last 8,000 years in the San Francisco Bay Area according to early narrative reports. The coastal prairie areas appear to have evolved under light seasonal grazing pressure with occasional fire (NPS 2005a).

Pristine grassland was thought to have been composed of evenly spaced bunchgrasses with annual forbs occupying areas between tussocks. It has been shown that purple needlegrass *(Nasella pulchra)*—the California state grass—was a major dominant of that grassland type along with other perennial grasses. The lack of continuous fuels and compactness of the grasses themselves would have resulted in fires of moderate intensity with low to moderate rates of spread. These grasslands have had the greatest disturbance of any natural habitat in this area. Four main factors have contributed to this disturbance: (1) an increase in grazing pressures, (2) the introduction of highly competitive nonnative plants, (3) cultivation, and (4) the elimination of fire (NPS 2005a).

Today, the grasslands are dominated by nonnative annual grasses and forbs adapted to Mediterranean conditions. These dense stands of annual grasses burn with greater intensity and more rapid rates of spread than native grasses. Additionally, annual species cure rapidly with the onset of summer drought, resulting in a longer fire season (NPS 2005a).

The exclusion of grazing, extirpation of large native mammals, and suppression of wildfires have caused a marked increase in acreage covered by coyote bush (*Baccharus pilularis)* and the resulting coastal scrub community in the Bay Area. It should be noted that grassland and coastal scrub communities are a dynamic mosaic with changes in dominance over time, and in some areas these two communities are in equilibrium with no invasion occurring (NPS 2005a).

Riparian Forest and Scrub. These streamside forests and shrub lands are dominated by broad-leaved deciduous trees or shrubs, most commonly willows *(Salix lasiolepis* or S. *lucida* ssp. *lasiandra)* and occasionally red alder *(Alnus rubra).* The understory is typically dense, with a variety of shrubs including native berries—native salmonberry *(Rubus spectabilis),* thimbleberry *(R. parvijlorus),* and California blackberry *(R. ursinus)*—as well as nonnative Himalayan blackberry and Cape-ivy. Numerous herbaceous species, including ferns, rushes, and sedges, dominate the shrub understory. Nonnative trees, including eucalypts *(Eucalyptus* spp.) and Monterey cypress *(Cupresslls macrocarpa),* have become successfully established within the riparian forest strands in the park (NPS 2005a).

Native Hardwood Forest. This variable community extends from 200 to 2,500 feet in elevation, and is dominated by oak (*Quercus* spp.), California bay laurel (*Umbellularia calijornica*), and tanoak (*Lithocarpus densijlorus*). Along the mesic boundary of this mixed evergreen forest is the redwood-Douglas-fir community and along the xeric boundary is the coastal scrub and grasslands. Coast live oak (*Quercus agrijolia*) dominates this community at elevations below 1,000 feet. It is often the only species present on hills frequented by a cool, foggy, coastal climate. Interior live oak (*Q. wislizenii*) sometimes replaces coastal live oak in canyon bottoms and north-facing slopes. As the community approaches 1,000 feet in elevation, California bay (*Umbellularia calijornica*), tanoak (*Lithocarpus dens~florus*), and other hardwoods become common (NPS 2005a).

Douglas-Fir and Coast Redwood. The majestic old-growth redwood forest at Muir Woods, with Redwood Creek peacefully flowing through groves of tall trees, attracts much visitor attention. This tranquil scene is a rare sight close to a large metropolitan area. Preservation of the pristine character of these woods is a management priority. Many species contribute to this ecosystem. Major overstory and understory trees include coast redwood (*Sequoia sempervirens*), Douglas-fir (*Pseudotsuga menziesii*), California bay laurel (*Umbellularia calijornica*), tanoak (*Lithocarpus densiflorus*), California hazel (*Corylus calijornica*), and madrone (*Arbutus menziesii*) (NPS 2005a).

Douglas-fir communities are found on Bolinas Ridge and within Muir Woods. The communities on Bolinas Ridge have been logged. Douglas-fir in Muir Woods sites have a brush understory and a significant component of dead fuel. When mature, Douglas-fir have thick bark that acts as fire insulation to vital cambium tissues. Young Douglas-fir trees are susceptible to fire and are often killed. Mortality increases with scorch height, percent crown scorch, and bole damage, but decreases with trunk diameter. In addition, mortality following fall fires is slightly higher than following spring fires. Douglas-fir seeds ripen in burned cones and require relatively open conditions for reproduction; the species is considered shade-intolerant. It takes a severe fire to destroy the seed bank of Douglas-fir. Following a light to moderate burn, an adequate seed bank remains. An open environment is created by burning and Douglas-fir germination is enhanced (NPS 2005a).

Nonnative Evergreen Forest. Many nonnative tree species have become established in GGNRA through both intentional and unintentional introductions, including ornamental plantings, plantings for windbreaks or shade for pastures, and escapes from cultivated and developed areas. Many of these trees—including a number of eucalypts *(Eucalyptus* spp.), acacia *(Acacia* spp.), Monterey pine *(Pinus radiata),* and Monterey cypress *(Cupressus macrocarpa)*—have invaded native communities. Most are very flammable, or significantly change the fire potential in areas that otherwise would support low-intensity or minimal fires, such as the coastal scrub and grassland areas of the park. Some stands of trees are located in close proximity to urban areas, or are within areas that would otherwise support rare communities or species (such as the mission blue butterfly). Both situations pose a threat to park neighbors and to these sensitive species due to the highly flammable nature of the nonnative trees and the changes they cause in environmental conditions including shade, duff and litter loads, moisture levels, and chemical additions to the soil (NPS 2005a).

Plant Communities of Alcatraz Island. Before occupation by Europeans, Alcatraz Island was sparsely vegetated. Trees and shrubs were planted as part of military fort and penitentiary life on the Island. Soils brought from the mainland and surrounding islands in the bay contained seeds of native plants, including coyote brush *(Baccharis pilularis),* California poppy *(Eschcholzia californica)* and California blackberry *(Rubus ursinus),* which have become established on the island. Only about 5% of the island is native coastal prairie or coastal scrub community, the rest is dominated by nonnative species (NPS 2001).

The landscape vegetation is nonnative, but it provides significant shelter ad habitat on the island. Shrubs are common and include rose, mirrorbush, fig, blackberry, agave, Australian tea ivy, mimosa, coyote brush, plume acacia, and Monterey cypress. A small stand of native grassland dominated by creeping wildrye *(Leymus triticoides)* is located on the Northeast Perimeter Trail near the Power House complex. Another smaller stand is present in the Cistern area. Ruderal vegetation occurs along the edges of walkways, buildings, and building remains. Dominant species in these areas are wild oats, wild radish, mustard and cheeseweed. Rocky cliffs and bluffs are found primarily along the island perimeter. The southwestern cliffs support various succulents, agave, sourgrass, sweet asylum, wild radish, and large shrubs in areas where Brandt's cormorants, western gulls, and pigeon guillemots nest. These plants provide nesting material and protection for the birds (NPS 2001).

***Wetlands*.** Herbaceous wetlands are known as emergent wetlands in the Cowardin wetlands classification. They consist of a mix of low-growing species of sedges *(Carex* spp.), rushes *(Juncus* spp.), and other wetland- dependent species *(Scirpus microcarpus, Typha* spp. *Cyperus eragrostis, Equisetum* spp.), as well as some nonnative species of grasses and forbs. The non-native grasses include velvet grass *(Holcus lanatus)* and harding grass (*fphalaris aquatica)* and the forbs include Cape-ivy *(Delaria odorata)* and Vinca *(Vinca major* and *V. minor).* Also included are areas covered with various reeds along the shores of lagoons and ponds, herbaceous strips of vegetation along perennial and ephemeral stream courses, and isolated wetland patches where seeps spring from the hill slopes. Some special status plant species—locally to regionally rare—occur within this community (NPS 2005a)

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GGNRA has abundant wetland resources, including wet meadows, seeps, streams, riparian forests, lakes, ponds, and lagoons. Wetlands, according to the definition developed by the U.S. Fish and Wildlife Service and adopted by the NPS, are lands transitional between terrestrial and aquatic systems, where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands generally include marshes, riparian zones, mudflats, rocky intertidal zones, and gravel beaches. Deepwater habitats such as rivers, lakes, and estuaries are not technically wetlands but are classified as aquatic sites using the same classification system. Wetland ecosystems act to buffer hydrologic and erosional cycles, control and regulate cycles of nitrogen and other key nutrients, and create valuable habitat for animal species.

The wetlands in GGNRA have been field-mapped in several watersheds, including the Rodeo Creek watershed, the Presidio of San Francisco, and portions .of the Redwood Creek and Bolinas Lagoon watersheds. The remainder of the park has not been field-mapped but contains areas of wetland vegetation that can be extracted from the parkwide vegetation mapping results. The majority of wetlands in GGNRA are located in the valley bottoms, with seeps and small intermittent streams reaching into the higher portions of the watersheds (NPS 2005a).

Detailed wetland classification in the Rodeo Valley watershed will enable GGNRA to begin to assign the important functions of the wetland resources throughout the park. By documenting the vegetation type and life form, as well as the hydrogeomorphic characteristics of a wetland, a functional assessment can be completed that determines each wetland's relative importance in surface water detention, streamflow maintenance, nutrient transformation, sediment retention, fish and wildlife habitat, and other important wetland functions. This information could be used to identify high-value wetlands that require special considerations (NPS 2005a).

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Wildlife

The entire Golden Gate NRA is included within the Central California Coast International Biosphere Region. The park's diverse habitats support a rich assemblage of wildlife. At least 387 vertebrate species are known to occur within the park boundaries. Species lists compiled from a variety of sources and incomplete inventories include 11 amphibians, 20 reptiles, 53 fish, 53 mammals, and 250 birds. Terrestrial invertebrates in the park are less well-known; however, two areas of the park, Marin Headlands and Milagra Ridge, support diverse butterfly populations. Wildlife habitats within the park include introduced eucalyptus and closed-cone Monterey pine and cypress forests; hardwood, mixed evergreen, Douglas-fir, redwood, and riparian forests; coastal scrub; annual and perennial grasslands; freshwater and saline wetlands and wet meadows; and estuarine, lacustrine, marine, and riverine aquatic habitats (NPS 2005a).

Alcatraz Island is a valuable natural habitat for colonial waterbirds due to favorable currents and nearshore foraging areas. The island supports a diverse assembly of marine and estuarine colonial nesting birds within GGNRA. Species of particular interest are black-crowned night herons, pigeon guillemots, Brandt's and pelagic cormorants, and western gulls (NPS 2001).

Mammals. Terrestrial habitats within the planning area support a diversity of mammals. Meso-carnivores, including the gray fox *(Urocyon cinereoargenteus),* bobcat *(Felis rufus),* and the recently reestablished coyote *(Canis latrans)* inhabit coastal scrub and grasslands. Mountain lions *(Felis concolor)* have been sighted in some undeveloped areas of the recreation area. These carnivores feed on a variety of small and large mammals such as the Pacific black-tailed deer *(Odocoileus hemionus columbianus),* broad-footed mole *(Scapanus larimanus),* pocket gopher *(Thomomys bottae),* deer mouse *(Peromyscus maniculatus),* western harvest mouse *(Reithrodontomus megalotis),* California vole *(Microtus californicus),* and brush rabbit *(Sylvilagus bachmani).* Badgers *(Taxidea taxus)* are also infrequently encountered. Some species, such as the western harvest mouse, appear to be restricted to areas where native perennial grasses persist (NPS 2005a).

In addition to many of the mammals listed above, Muir Woods and other forested areas within the planning area support vagrant shrew *(Sorex vagrans),* Trowbridge's shrew *(Sorex trowbridgii),* Sonoma chipmunk *(Tamius sonomae),* western gray squirrel *(Sciurus griseus),* opossum *(Didelphis virginiana),* and dusky-footed woodrats *(Neotoma jUscipes).* Other mammalian carnivores include the raccoon *(Procyon lotor),* striped skunk *(Mephitis mephitis)* and spotted skunk *(Spilogale gracilis),* long-tailed weasel *(Mustelafrenata),* and the recently returned river otter *(Lontra canadensis)* (NPS 2005a).

Seventeen species of bats have been detected within the park. Ten species of bats have been documented in Muir Woods, including four federal and/or state species of concern: Townsend's western big-eared bat *(Corynorhinus townsendii townsendii),* fringed myotis *(Myotis thysanodes),* long-legged myotis *(M. volans),* and Yuma myotis *(Myotis yumanensis).* Many of the bats in Muir Woods have been observed using redwood fire-scar cavities for roosting. At the Marin Headlands, several historic World War II structures were found to be occupied by the Townsend's western big-eared bat and the Yuma myotis, both federal species of concern. The Brazilian free-tailed bat *(Tadarida brasiliensis)* forages over coastal scrub habitat within the Marin Headlands (NPS 2005a).

Isolated coastal rocks, beaches, and lagoon sand flats in the park serve as haul-outs for harbor seals *(Phoca vitulina)* and California sea lions *(Zalophus californianus).* Up to 250 harbor seals haul out in Point Bonita Cove along the slopes of the Marin Headlands. As the northern elephant seal *(Mirounga angustirostris)* population rapidly increases, the seals are encountered more frequently on sandy beaches throughout the region. California gray whales *(Eschrichtius robustus),* humpback whales *(Megaptera novaeagliae),* and harbor porpoises *(Phocoena phocoena)* use offshore waters; young whales occasionally wander into San Francisco Bay. Southern sea otters *(Enhydra lutns nereis)* are infrequently seen offshore with numbers increasing as the population spreads north (NPS 2005a).

Alcatraz Island is home to deer mice and several bat species. Small numbers of seals and sea lions haul out on the island's rocky areas (NPS 2001).

Birds. Located along the Pacific Flyway, GGNRA provides habitat for a great diversity of breeding, overwintering, and migratory birds. Nineteen species of diurnal raptors have been detected in migration over the ridges of the Marin Headlands. Red-tailed hawks (*Buteo jamaicensis*), red-shouldered hawks (*Buteo lineatus*), and great homed owls (*Bubo virginianus*) nest in many of the large nonnative eucalyptus trees in the park. A wide range of other raptors and at least ten owl species occur within the planning area. Numerous species of waterbirds also occur within the park in marine and rocky intertidal habitats, cliffs, beaches, and tidal and wetland areas (NPS 2005a).

Point Reyes Bird Observatory (now PRBO Conservation Science) encountered 83 bird species during 1997 breeding landbird censuses in coastal grassland, coastal scrub, riparian, and mixed hardwood habitats. From point count censuses in 1999 and 2000, white-crowned sparrows (*Zonotrichia leucophrys*), red-winged blackbirds (*Agelaius phoniceus*), savannah sparrows (*Passerculus sandwichensis*), and song sparrows (*Melospiza melodia*) were the most commonly detected species in grasslands. The most abundant species in coastal scrub were white-crowned sparrows, spotted towhees (*Pipilo maculatus*), and wrentits (*Chamaea fasciata*). In forested habitats, bushtits (*Psaltriparus minimus*), chestnut-backed chickadees (*Poecile rufescens*), dark eyed juncos (*Junco hyemalis*), Pacific-slope flycatchers (*Empidonax difficilis*), and winter wrens (*Troglodytes troglodytes*) were commonly detected. Based on songbird nest monitoring in riparian habitats along Redwood and Lagunitas creeks, the song sparrow, Swainson's thrush (*Catharus ustulatus*), warbling vireo (*Vireo gilvus*), and Wilson's warbler (*Wilsonia pusilla*) were the most commonly observed nesters. The brown-headed cowbird (*Molothrus ater*) is a nest parasite that negatively affects the reproductive success of open-cup nesting songbirds and occurs throughout the planning area. Many of the landbirds in the planning area are Neotropical migrants, with others identified as species of management concern and riparian species of conservation priority by California Partners in Flight (NPS 2005a).

Alcatraz Island is a particularly important site for birds in GGNRA. A number of colonial waterbird species inhabit Alcatraz Island. Waterbird species of interest include Brandt's Cormorants (*Phalacrocorax penicillatus*), Pelagic Cormorants (*P. pelagicus*), Western Gulls (*Larus occidentalis*), Pigeon Guillemots (*Cepphus columba*), Black Oystercatchers (*Haematopus bachmani*), Black-crowned Night Herons (*Nycticorax nycticorax*), Snowy Egrets (*Egretta thula*), Great Egrets (*Casmerodius albus*), Great Blue Herons (*Ardea herodias*), and California Gulls (*Larus californicus*). The Brandt's Cormorant colony on Alcatraz is one of the few known estuarine breeding sites for this species. Pigeon Guillemots breed nowhere else in the San Francisco Bay, and the Western Gull and Black-crowned Night Heron colonies are among the largest in the Bay (Acosta et al. 2008).

This diversity of species, although protected by the Migratory Bird Treaty Act, National Park Service management policies, and NPS-77, "Natural Resource Management Guidelines," exists in a delicate balance with the considerable human presence both on and around Alcatraz Island. Colonial waterbird populations on Alcatraz experience substantial disturbance from a number of different sources. About 1.4 million visitors tour the island annually, and associated historic preservation and safety construction projects, public access to breeding areas, gardening activities which are part of a new historic garden restoration program, and special events may disrupt the breeding efforts of Alcatraz seabirds. Encroachment near the Alcatraz shoreline by large numbers of commercial or recreational boaters (e.g. tour boats, fishermen, kayakers), and uncontrolled aircraft overflights (e.g. air tour operators), may have similar effects. In addition, dredging and other projects that disturb and alter the subtidal environment are potentially disruptive to seabird populations, as these activities may remobilize contaminants, increase turbidity, and destroy essential foraging habitat (Acosta et al. 2008).

In 1993, GGNRA completed a management plan for Alcatraz Island, which included provisions for maintaining breeding populations of colonial waterbirds. This plan emphasized protection of the island's natural resources, while maintaining opportunities for visitor access, special events, and other island uses. The plan called for natural resource monitoring and the development of protocols to determine baseline information for key wildlife populations (Acosta et al. 2008).

Amphibians and Reptiles. Small populations of the federal-listed threatened California red-legged frog *(Rana aurora draytonii)* occur within the planning area. Within San Mateo County, historic records indicate the presence of the federal-listed endangered San Francisco garter snake *(Thamnophis sirtalis tetrataenia).* More common terrestrial amphibians in the planning area include ensatina *(Ensatina eschscholtzii)* and California slender salamander *(Batrachoseps attenuatus).* Common species spending a substantial amount of time at streams or ponds for breeding or rearing purposes include California newts *(Taricha torosa),* rough-skinned newts *(Taricha granulosa),* Pacific treefrog *(Hyla regilla),* and California giant salamander *(Dicamptodonensatus).* Common reptiles include the Western fence lizard *(Scelopoms occidentalis),* northern alligator lizard *(Gerrhonotus coemleus),* Pacific gopher snake *(Pituophis melanoleusus),* and western terrestrial garter snake *(Thamnophis elegans)* (NPS 2005a).

Alcatraz Island has large populations of California slender salamanders, which are small lungless salamanders that do not require water for breeding. The northern end of the island has moist substrate, which supports the salamanders. Neither the eggs nor the salamanders can tolerate salt spray, so they are limited to upland areas of the island (NPS 2001).

Fish. The planning area includes both resident and transitory fish species that occupy marine, estuarine, and freshwater habitats. Common, nearshore resident estuarine and marine fish include Pacific staghorn sculpin *(Leptocottus armatus),* arrow goby *(Clevelandia ios),* and topsmelt *(Atherinops afjinis).* The brackish Rodeo Lagoon in the Marin Headlands supports a large population of the federal-listed endangered tidewater goby *(Eucyclogobius newberryi)* (NPS 2005a).

Freshwater streams within the planning area are characterized by naturally low species diversity. Perennial streams may include resident fish such as threespine stickleback *(Gasterosteus aculeatus)* and prickly sculpin *(Cottus asper).* Several important anadromous fish species are present in the creeks and

watersheds within the planning area. Anadromous species are those that spawn or breed in streams and rivers and then migrate to and mature in the ocean. Anadromous species that breed and rear in streams within the planning area include coho salmon *(Oncorhynchus kisutch)* and steelhead trout *(Oncorhynchus mykiss).* Both species are listed as threatened under the Endangered Species Act. Intermittent streams or the intermittent headwater streams may support only steelhead trout (NPS 2005a).

Invertebrates. Two coastal grassland/scrub areas in the park are known for their high numbers and diversity of butterflies: Marin Headlands and Milagra Ridge. The federal-listed endangered mission blue butterfly *(Icaricia icarioides missionensis)* occurs at both sites, while the San Bruno elfin butterfly *(Euphydryas editha bayensis)* is found at Milagra Ridge, where it inhabits rocky outcrops. At least 44 species of butterflies occur in the Marin Headlands and 34 species occur at Milagra Ridge, illustrating the importance of habitat fragments within largely developed landscapes. Various species of skippers, swallowtails, hairstreaks, blues, ladies, admirals, and crescents inhabit these areas. Monarch butterflies *(Danaus plexippus)* are found in clusters overwintering in many areas of the park, often in groves of nonnative trees. Other terrestrial invertebrates have not been well documented (NPS 2005a).

Limited information is available regarding the freshwater invertebrates that are present within the planning area. Targeted inventories have been conducted in streams such as Redwood Creek. A total of 223 freshwater taxa are known. The only federal-listed species is the endangered California freshwater shrimp, which is found within the Lagunitas Creek watershed, an area managed by Point Reyes National Seashore (PRNS). Limited information is also available regarding invertebrates from marine and estuarine habitats within the planning area. A total of 279 marine and estuarine taxa are known (NPS 2005a).

Alcatraz Island includes a small but significant site used briefly by Monarch butterflies in their fall migration. The butterflies are usually on the Island for 1-5 days during this period and have been reported on vines on the east side of the island and near the chapel (NPS 2001).

Nonnative Wildlife. Many species of nonnative wildlife have been identified as problem species within native wildlife habitat in the park. These species negatively affect populations of native animals through competition for resources, predation, and as vectors for disease. Nonnative terrestrial mammals include fallow deer *(Cervus dama),* feral hogs *(Sus scrofa),* red fox *(Vulpes vulpes),* opossum (*Didelphis virginiana),* house cats *(Felis domestiells),* and Norway and black rats *(Rattus norvegieus* and *R. rattus).* Nonnative birds found in the planning area include wild turkeys *(Meleagris gallopavo),* European starlings *(Sturnus vulgaris),* peasows *(Pavo eristatus),* house sparrows *(Passer domestieus),* and rock doves *(Columba livia).* Nonnative invertebrates present in the planning area include Argentine ant *(Iridomyrmex humilis).* Nonnative fish present within various human-made ponds include mosquitofish *(Gambusia affinis)* and various sunfish, while estuarine areas may support yellowfin goby *(Aeanthogobius j/avimanus).* Nonnative amphibian and reptile species include bullfrog *(Rana catesbeiana),* red-eared slider *(Chrysemys pieta),* and the occasional caiman (NPS 2005a).

Norway rats have been observed on Alcatraz Island since 1998. The Norway rats are a concern because of their potential as predators on waterbird eggs and chicks on the island. These rats have been known to reduce native rodent populations (NPS 2001).

Special Status Species

Twenty-five species in GGNRA are protected under the Endangered Species Act as amended (16 USC 1536 [a] [2] 1982) and are managed by the National Park Service. Within the park's legislative boundary, there are 69 rare or special status wildlife species currently identified as permanent or seasonal residents of the park, or dependent upon park lands and waters for migration. Of these, 12 are listed as federal-listed endangered, 12 are federal-listed threatened, 1 is state-listed endangered, 3 are state-listed threatened, 31 are federal species of concern, and 10 are state designated species of special concern.

Numerous other wildlife species (birds in particular) are considered sensitive by the Audubon Society, Partners in Flight, or the California Department of Forestry, or are designated Migratory Nongame Birds of Management Concern by the U.S. Fish and Wildlife Service (USFWS). Nearly all of the native birds documented in the park are protected under the Migratory Bird Treaty Act (16 USC 528-531). Thirty-eight rare or special status plant species are currently identified within GGNRA. Of those species, 9 are federal-listed endangered, 1 is federal-listed threatened, 13 are federal species of concern, and the remaining 15 species are included or proposed for inclusion by the California Native Plant Society (NPS 2005a).

The USFWS and NOAA Fisheries provided a list of federal-listed threatened, endangered, and proposed species for consideration during development of the fire management plan in 2005 (see Appendix ///). This list was used in the development of this general management plan, since the planning areas for the two plans are identical (NPS 2005a).

To evaluate the effects on special status species, a set of species considered likely or possible to experience impacts from GMP actions was selected for assessment based on the presence of suitable habitat within the project area and discussions with NPS biologists. Appendix ///, Special Status Species lists, all proposed, or special status candidate species potentially in the planning area and provides a brief summary of presence/absence of suitable habitat and any distribution notes (NPS 2005a).

{Appendix: Add complete table of T&E and candidate species from FMP DEIS report}

[Insert Special Status Species Habitat Map here]

Special Status Species of Marin County

Mission Blue Butterfly – Federal Endangered. Mission blue butterflies (*lcaricia icaroides missionensis*) are closely tied to the lupine larval host plants *Lupinus albifrons, L. variicolor*, and *L. formoslls*, with *L. albifrons* considered to be the preferred host. These host plants tend to occur in grasslands on thin, rocky soils within broader coastal scrub habitats. Lupine are susceptible to fungal outbreaks, which have been documented to cause rapid contractions of lupine distribution at the Marin Headlands. Competition from nonnative plants, including eucalyptus, Monterey pine, gorse, and broom, also threatens lupine host plants. Lupine is a fire-adapted species, and fire may enhance suitable lupine habitat for mission blue butterflies. Adults feed on nectar, from numerous plants, though they may prefer wild buckwheat (*Erigonum latifolium*), golden aster (*Chrysopsis vilosa)*, blue dicks (*Brodiaea pulchella*), and Ithuriel's spear (*Brodiaea laxa)*. Habitat loss is probably the primary threat to mission blue butterflies, with trampling of host and nectar plants, larvae, and pupae also of concern. Other threats to mission blue butterflies at various stages of their life cycles include parasites, predators, and desiccation and disease during diapause (NPS 2005a).

Adults have one generation per year, with a flight period from mid-March to mid-May at the Marin Headlands and late May to mid-June at San Bruno Mountain. Analyses suggest that warmer air temperatures are associated with higher numbers of adults at the seasonal peak and that rainfall is not related to the peak number of adults. Eggs are usually laid on the dorsal surface of larval host plants. Ants *(Prenolepis imparis* and *Formica lasioides)* may tend the later-instar mission blue larvae. Mission blue butterflies occur at the Marin Headlands, Tennessee Valley, Milagra Ridge, and Sweeney Ridge within the planning area (NPS 2005a).

California Red-legged Frog – Federal Threatened. The California red-legged frog (*Rana aurora draytonii*) is found primarily in wetlands and streams in coastal drainages of central California. Red-legged frogs found north of the Marin-Sonoma county border exhibit intergrade characteristics of the California red-legged frog and the northern red-legged frog. The frog requires specific aquatic and riparian features. Adult require a dense, shrubby, or emergent riparian vegetation closely associated with deep (>0.7 meters) still or slow-moving water The highest densities of California red-legged frogs have

been associated with deep-water pools with dense stands of overhanging willows and an intermixed fringe of cattails. Aestivation sites are located up to 26 meters from water in dense riparian vegetation. A recent court decision has eliminated critical habitat within the planning area by changing the habitat definition. Critical habitat had been defined to include essential aquatic habitat, associated uplands, and dispersal habitat connecting essential aquatic habitat (NPS 2005a).

Tidewater Goby – Federal Endangered. The tidewater goby (*Eucyclogobius newberryi*) is a small benthic fish that occurs in the upper end of California coastal lagoons in salinities less than 10 parts per thousand. While generally found in coastal embayments, gobies are also known to occur in streams. In San Antonio Creek in Santa Barbara County, the goby is known to occur up to five miles upstream of the lagoon habitat. Within the planning area, tidewater goby is known only from Rodeo Lagoon in the Marin Headlands (NPS 2005a).

Chinook Salmon – Federal Threatened. Chinook (*Oncorhynchu tshawytscha*) **s**pawning and juvenile rearing habitatoccurs in the Sacramento River and tributaries, and large streams and rivers connected to the Pacific Ocean. Adult and juvenile migratory corridors exist along the San Francisco Bay portion of GGNRA lands. Critical habitat includes Bay waters to the Golden Gate Bridge.

Recent data indicate that most juvenile chinook salmon are using the Central Bay as a migratory corridor with most juvenile chinook moving along the northern corridor through Raccoon Strait and around the Tiburon peninsula, by Fort Baker, and out to the Golden Gate. Based on the occurrence of juvenile chinook at the Delta pumps and a one month transit time from Chipp's Island to the Golden Gate, winter-run chinook juveniles would be present near the Fort Baker area from January through June, while spring-run chinook juveniles would be present from March through June (MacFarlane 2002).

Coho Salmon – Federal Threatened . Coho salmon *(Oncorhynchus kisutch)* occur in several creeks within the planning area, as well as the nearshore waters of the Pacific Ocean and estuarine sites such as Bolinas Lagoon and San Francisco Bay. Coho salmon are found in Redwood Creek (Marin County). A single cohort of coho salmon was found in Easkoot Creek (Marin County). Coho are an anadromous species. Born and reared in freshwater streams, as juveniles they migrate to estuaries, adjust to saltwater, and then migrate to the ocean to mature into adults. Designated critical habitat for coho in GGNRA includes accessible estuarine and stream areas in the coastal watersheds of Marin County except areas above longstanding naturally impassable barriers. Optimal habitat conditions for juvenile coho seem to be deep pools created by rootwads and boulders in heavily shaded stream sections (NPS 2005a).

Steelhead Trout – Threatened . Steelhead trout *(Oncorhynchus mykiss)* occur in several creeks within the planning area. Steelhead are found in Redwood Creek in Marin County, as well as in the drainages to Bolinas Lagoon and Rodeo Lagoon. In San Mateo County, steelhead are found in West Union Creek, a tributary to San Francisquito Creek. Like coho, steelhead are an anadromous species. Adult steelhead enter GGNRA area streams in the late winter through spring to reach spawning sites, typically well-aerated areas with small- to medium-size gravel. Habitat preferences for juvenile steelhead are deep pools created by rootwads and boulders in heavily shaded stream sections, although young-of-the-year steelhead are often forced into shallow-water habitats. The amount of time steelhead rear in freshwater and marine/estuarine habitats is variable, ranging between one to three years. For most drainages, presence/absence salmonid surveys have been conducted, while in watersheds supporting coho salmon, abundance data on both species are available. The variable life cycle of steelhead makes population analysis more difficult, but also makes steelhead more resilient to adverse environmental conditions. In general, if the habitat requirements for coho were met, steelhead habitat requirements would also be met (NPS 2005a).

In April 2002, the U.S. District Court for the District of Columbia approved a NMFS? consent decree withdrawing a February 2000 critical habitat designation for steelhead trout. Designated critical habitat for coho includes all accessible estuarine and stream areas in the coastal watersheds of Marin County except areas above longstanding, naturally impassable barriers. Through this designation, NOAA

Fisheries identified ten essential features of critical habitat: substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, space, and safe passage conditions (NPS 2005a).

California Brown Pelican – Federal Endangered. The California brown pelican (*Pelecanus occidentalis californicus*) is federal-listed as endangered. Nesting is restricted to islands in the Gulf of California and along the outer coast from Baja California to West Anacapa and Santa Barbara islands in southern California. Non-breeding California brown pelicans range northward along the Pacific Coast from the Gulf of California to Washington and southern British Columbia. The California brown pelican is common in coastal areas of Golden Gate National Recreation Area from April through December. From January through March, pelicans are less frequently seen in the park and in much smaller flocks. The park has significant roost areas for brown pelicans, and they have been observed roosting at Seal Rocks, Alcatraz Island, and in the Marin Headlands at Bird Island and Rodeo Beach (at the western end of Rodeo Lagoon). Bird Island is one of the largest roosting sites in northern California, with up to several thousand pelicans. Pelicans by the hundreds also bathe, feed, and roost in nearby Rodeo Lagoon. When they are on the lagoon, the pelicans tend to use the western two-thirds of the water area, occasionally using the eastern third of the lagoon. The pelicans primarily roost at the west edge of the lagoon in the early morning; during storms they roost on a point of sand near the southwest corner. Brown pelicans prey almost exclusively on surface schooling fishes, especially Northern anchovies and Pacific sardines on the West Coast (NPS 2005a).

Northern Spotted Owl - Federal Threatened. Marin County supports a northern spotted owl (*Strix occidentalis caurina*) population of possibly 75 pairs. This population is isolated from spotted owl populations to the north by large areas of grassland and shrubs and constitutes the southern end of the subspecies range. Genetic analysis has shown low levels of genetic diversity within and low levels of gene flow between spotted owl populations in Marin County and Mendocino National Forest. The Marin County population supports the highest known density of northern spotted owls rangewide. Threats to spotted owls in the planning area include urbanization, intense recreational pressure, disturbance from wildlife photographers and birders, genetic isolation, West Nile virus, possible catastrophic wildfire, expansion in the range of the barred owl *(Strix varia),* and habitat changes due to Sudden Oak Death.

Spotted owls in Marin inhabit coniferous forest, including second growth and remnant stands of Douglas-fir *(Pseudotsuga menziesii),* bishop pine *(Pinus muricata),* coast redwood *(Sequoia sempervirens),* and mixed conifer-hardwood habitats comprised of tanoak *(Lithocarpus densiflorus),* coast live oak *(Quercus agrifolia),* and California bay *(Umbellularia californica).*

Spotted owls tend to nest in older stands of conifer and hardwood trees that create a tall overstory. Spotted owls often select larger trees with defects, such as broken tops or mistletoe *(Arceuthobium spp.)* infestations, for nesting, but also have been found nesting in young bay trees in smaller stands. Preliminary pellet analyses indicate that spotted owls forage primarily on dusky-footed woodrats *(Neotoma fuscipes)* in addition to other forest dwelling small mammals and songbirds. Within the planning area, known spotted owl locations are currently limited to Muir Woods and the Stinson Gulch area (NPS 2005a).

Special Status Species of San Francisco County

Chinook Salmon – Federal Threatened. Chinook (Oncorhynchu tshawytscha) spawning and juvenile rearing habitat in Sacramento River and tributaries and large streams and rivers connected to the Pacific Ocean. Adult and juvenile migratory corridors exist along the San Francisco Bay portion of GGNRA lands. Critical habitat includes Bay waters to the Golden Gate Bridge. See further description under Marin County. Chinook within the vicinity of Alcatraz are assumed to be present as migrating juveniles and adults. Research indicates that juvenile Chinook salmon are using the Central Bay as a migratory corridor. The waters around Alcatraz have been designated as critical habitat for Chinook salmon (NPS 2001).

Western Snowy Plover – Threatened. The Pacific coast breeding population of the western snowy plover *(Charadrius alexandrinus nivosus)* is federal-listed as threatened. On March 22, 2004, the U.S. Fish and Wildlife Service determined that substantial information existed to support the possible delisting of the species, and a status review was initiated (USFWS 2004b). This population of snowy plovers occurs along coastal beaches; they nest primarily on sand spits, dune-backed beaches, beaches at creek and river mouths, and salt pans at lagoons and estuaries. Snowy plovers nest in coastal Marin County. The western snowy plover occurs within the park at Ocean Beach and Crissy Field from mid July through early May. Snowy plovers have been observed on rare occasions and for short periods of time (over a few days) at Rodeo Beach (May & Associates 2007), overwintering on Ocean Beach, and have been periodically sighted at other beaches. Snowy plovers breeds primarily on coastal beaches from southern Washington to southern Baja California, Mexico (NPS 2005a).

Bank Swallow – State Threatened. Bank swallows *(Riparia riparia)* are colonial nesters, nesting primarily in riparian and other lowland habitats west of the desert. Bank swallows require vertical banks or cliffs near streams, rivers, lakes, or the ocean; they need fine textured or sandy soils in which to dig nesting holes. Erosion by water and wind is important in creating and maintaining banks and bluffs suitable for nesting. Proximity to water is important at all seasons. During migration and in winter, wetlands provide a steady source of insects and a buffer against extreme temperatures. This species nests in the Fort Funston cliffs (NPS 2005a).

Special Status Species of San Mateo County

Mission Blue Butterfly – Federal Endangered. See prior discussion under Marin County. (Habitat in San Mateo?)

San Bruno Elfin Butterfly – Federal Endangered. The larval host plant for San Bruno elfin butterflies ***(****Callophrys mossii bayensis)* is *Sedum spathulifolium*, a succulent that grows on rocky, north-facing slopes along the coast (Lambert 2002). Adults are thought to stay within about 100 meters of host plants. Adults have one generation per year, with flight season from late February to early April. Eggs are laid on the ventral surface of the leaves of host plants. The fourth instar larvae pupate at the base of host plants where they remain through the summer, fall, and early winter. Habitat loss and trampling of host plants, larvae, and pupae are the primary threats to these butterflies. The San Bruno elfin butterfly is known to occur only at Milagra Ridge within the planning area (NPS 2005a).

San Francisco Garter Snake – Federal Endangered. This San Francisco garter snake *(Thamnophis sirtalis tetrataenia)* is endemic to the San Francisco peninsula and is currently restricted to localities within San Mateo County. This listed species is primarily threatened by the loss and alteration of suitable wetland habitat due to urban development, freeway and road construction, illegal collection, agricultural practices, and trampling. It is considered semi-aquatic and is found along the margins of ponds, lakes, streams, and estuaries (above tidal influx). It feeds on small amphibians and fish, especially the federal-listed threatened California red-legged frog *(Rana aurora draytonii)*. The planning area contains three sites (Sweeney Ridge, Milagra Ridge, Mori Point/Sharp Park) that appear to have suitable habitat for the San Francisco garter snake; however, recent surveys specifically to locate the snake and assess habitat have not been conducted. Only Mori Point/Sharp Park has had a documented occurrence of the San Francisco garter snake; however, no recent population data are available. The Park Service and the USFWS are currently planning inventory and enhancement activities for the San Francisco garter snake at Mori Point/Sharp Park (NPS 2005a).

California Red-legged Frog - Federal Threatened. See prior discussion under Marin County. Habitat in San Mateo?

Steelhead Trout – Federal Threatened. See prior discussion under Marin County. Habitat in San Mateo?

Marbled Murrelet – Federal Threatened. The marbled murrelet (Brachyramphus marmoratus) nests in old-growth forests or on the ground at higher altitudes where trees cannot grow. The marbled murrelet has experienced a decline in their numbers due to loss of nesting habitat. This member of the auk family feeds at sea in pelagic offshore areas and inshore in protected bays.

Special Status Plant Species. Within the areas considered under the GGNRA fire management plan, 26 special status plant species are supported by existing habitat (see Appendix /// for species listing status). Three are listed by the federal Endangered Species Act as either threatened or endangered. Twenty are listed as federal species of concern or federal species of local concern (species for which the USFWS is collecting additional information to determine. if they warrant consideration for future listing); some of these species are also listed on the California endangered species list; and three species are of management concern to the park and are listed by the California Native Plant Society on List 4 – Plants of Limited Distribution (locally rare). Although these species are not actually listed as threatened or endangered under the federal Endangered Species Act, NPS *Management Policies 2006* states that the National Park Service will inventory, monitor, and manage state-listed and locally listed species in a manner similar to its treatment of federal-listed species. Management policies also state that the Park Service will inventory other species that are of special management concern to parks such as locally rare, declining, sensitive, or unique species (NPS 2005a).

San Francisco Lessingia – Federal Endangered. The San Francisco lessingia **(***Lessingia germanorum***)** is federal-listed endangered. It is found in open sandy soils and dunes in coastal scrub. San Francisco Lessingia has historically been endangered by competition with invasive nonnative vegetation and native scrub vegetation, development, sand quarrying, trampling and recreational activities, incidental use of fertilizers, and other activities (NPS 2005a).

Montara Manzanita – State Threatened. The Montara manzanita **(***Arctostaphylos montaraensis***)** is listed as threatened by the state of California. This plant is found in coastal scrub and chaparral habitats. It is endemic to San Mateo slopes, specifically Montara Mountain and found at elevations between 150 and 500m. It is threatened by development and vehicles (NPS2005a).

MUIR WOODS NM AFFECTED ENVIRONMENT – NATURAL RESOURCES

INTRODUCTION

Muir Woods National Monument is a part of Golden Gate International Biosphere Reserve—one of the planet's richest and most threatened reservoirs of plant and animal life. Muir Woods National Monument (referred to hereafter as Muir Woods) occupies 558 acres of the Central California Coast Range in Marin County, California, only a few miles north of San Francisco.

Muir Woods National Monument preserves one of the last remaining ancient redwood forests on the Pacific Coast and in the world. The Monument was established in 1908 to protect unique redwood forests that were spared from logging due to their inaccessibility. Specifically, it was created in recognition of the "extraordinary scientific interest and importance because of the primeval character of the forest in which it [the Monument] is located, and the character, age, and size of the trees" (Proclamation No. 793, Jan. 9, 1908, 35 STAT. 2174). These protected redwoods are the "last contiguous stand of old-growth coastal redwood (*Sequoia sempervirens*) and Douglas fir (*Pseudotsuga menziesii*) in Marin County." From its inception, the Monument was designed to protect the "primeval character" of the redwood forests, and today, "ecological integrity" is a major driving force. (Hall 2009).

Surrounding Muir Woods are mostly protected lands, including other units of the GGNRA and lands managed by California State Parks (Mt. Tamalpais State Park) and Marin Municipal Water District (MMWD). Muir Woods is located entirely within the watershed of Redwood Creek, which originates on Mt. Tamalpais (over 2,400 feet in elevation), flows through the heart of Muir Woods, bisects Frank Valley, and discharges into the Pacific Ocean at Muir Beach, approximately three miles below Muir Woods. The Redwood Creek watershed—that extends from Mount Tamalpais to Muir Beach—is a delicate ecosystem that demands utmost care and vigilance.

In addition to being the home of the California Coast Redwood, Muir Woods is home to several federal endangered and threatened species, including the Northern Spotted Owl, Coho Salmon, and Steelhead Trout. Sudden Oak Death (SOD) is a common name given a pathogen (*Phytophthora ramorum*) responsible for widespread tree death throughout northern and central California. This pathogen first appeared in Muir Woods during the mid-1990s, and although many plants in the redwood forest are affected, the tanoaks have suffered the most.

PHYSICAL RESOURCES

AIR QUALITY

Like GGNRA, Muir Woods is within a Class II air quality area and is located in the San Francisco Bay Air Basin.

Air Quality Monitoring

No air quality monitoring stations are located at or near Muir woods. Therefore, no specific data are available. See GGNRA for a description of monitoring information for the general area.

CARBON FOOTPRINT

See description under GGNRA.

SOILS AND GEOLOGIC RESOURCES AND PROCESSES

~~Much like the adjacent GGNRA,~~ Muir Woods is subject to many of the same geologic processes as the rest of GGNRA. Slopes are inherently unstable. Intense shearing associated with faulting along the plate margin has reduced the strength of the rock. Ongoing uplift of the mountains causes continued erosion as the landscape strives to become stable. Surface disturbances, such as cuts for trails and roads, vegetation clearing, and alteration of surface water drainages, can trigger or lead to slope failures (NPS 2005a).

Auwaerter and Sears (2006, p. 18-19) describe the California Coast Range as:

> "a narrow band of low mountains along four hundred miles of coastline on the western edge of the North American tectonic plate… characterized by bedrock formed from ancient sea floor sediments and igneous rock that was heavily folded and uplifted due to lateral slipping along the juncture of the North American and Pacific plates."

Within Muir Woods, elevations range from 120 to 1,340 feet. Redwood Creek loses approximately 50 feet in elevation from where it enters the Monument on the north to where it exits approximately 0.5 miles downstream. Redwood Creek Canyon is the major topographical feature within the Monument, and its hillslopes are quite steep, often exceeding 65%. These steep slopes provide considerable shade within the canyon. The Monument extends a short distance into Kent Canyon on the northwest, and the newer additions on the southeast occupy a side canyon. Throckmorton Ridge separates Muir Woods from Mill Valley to the east, curving southwest to form the southern slopes of Frank Valley (Hall 2009).

Soils

Based on the lands included within the Monument in 1978, six soil complexes were identified within Muir Woods, which are distinguished by their soil type and slope. Howell et al. (no date, p. 2) noted that the primary types are Centissima-Barnabe (derived from chert), basalt, and Franciscan formation sandstones. The Redwood Creek canyon floor is characterized as consisting of mostly "gray-podzolic soils" with clay-silt and clay-sand (Hall, 2009).

Geology

Faulting and uplift in the Coast Range have left relatively unstable slopes subject to landslides and mass wasting. Valley bottoms have deep alluvial or colluvial fills. The mainstem alluvial valley fill in lower Frank Valley (about 4 miles downstream of Muir Woods) is at least 37 feet deep, and may be locally as deep as 90 feet. Nearly half of the Redwood Creek watershed's hillslopes are landslide deposits. There are

outcrops of rock dispersed throughout the watershed, and in the headwaters, rocks have weathered to soils that can be very thin (<1 ft), although there are reports that soils in the upper Redwood Creek watershed can be as deep as 10 feet (Hall 2009).

Commented [T32]: suggest moving this statement to the Soils section Include rock-types here -- Franciscan sandstone and chert

WATER RESOURCES AND HYDROLOGIC PROCESSES

Surface Water

The Redwood Creek watershed extends from Mount Tamalpais to Muir Beach. Redwood Creek is the dominant hydrologic feature within the Monument. The Redwood Creek watershed encompasses approximately 8.9 square miles (including Green Gulch Creek, which flows into Big Lagoon). Above Muir Woods, the precipitous headwater tributaries of Redwood Creek (Fern, Spike Buck, and Rattlesnake) descend the steep south slope of Mt. Tamalpais with many waterfalls. These upper tributaries flow through deep, steep canyons, with step-pool channel morphology. Redwood Creek, which is formed by the confluence of Bootjack and Rattlesnake Creeks, flows through the heart of the Monument for approximately ½ mile, being fed by several intermittent streams. Fern Creek, which originates on Mt. Tamalpais, flows into Redwood Creek just within the northern boundary of the Monument. Once Redwood Creek enters Muir Woods, the channel flattens considerably, to less than a 2% grade, with a bed comprised of mixed gravel and cobble. During the 1930s, Redwood Creek within the Monument was lined with rock revetments, and check dams were installed to channelize the creek and protect the old growth redwoods. Since this time, most of the check dams have been removed and the creek is being returned to a more natural state. Consequently, the Muir Woods section of Redwood Creek has more riffles and fewer deep water pools than would occur in a highly natural creek with a similar slope (Hall 2009).

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Below the Monument, Redwood Creek is joined by Kent Canyon Creek as it flows through Frank Valley and becomes a relatively broad alluvial floodplain. This stretch has experienced significant impact from agriculture and pasturing and is incised and isolated from its floodplain. Below Frank Valley, the creek enters the ocean at Muir Beach, through a 2.2-acre intermittent tidal lagoon, typically referred to as "Big Lagoon," which is also fed by Green Gulch Creek. During winter and spring the lagoon experiences tidal influences. As streamflow declines in late spring or summer, the beach berm builds up across the mouth of the creek, blocking surface flow from Redwood Creek to the Pacific Ocean and tidal exchange between the lagoon and Pacific Ocean. Lower Redwood Creek in the Muir Beach area has been altered through water diversions, agricultural levees, the construction of an NPS parking lot, and stream bank alterations. One outcome of this cumulative change has been significant aggradation of the channel (Hall 2009)

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Groundwater and Municipal Water Use

Although most of the Redwood Creek watershed is managed as state and federal park lands, it also provides water for local firefighting, residential, and agricultural uses. Marin Municipal Water District stores water from springs in the upper watershed (upstream of the Monument) for firefighting. Downstream of the Monument, the Muir Beach Community Services District supplies the Muir Beach Community with water from a well near the creek, and Green Gulch Farm impounds and diverts flow in the Green Gulch sub-watershed. Diversions in Big Lagoon have been abandoned, though the water right remains in place (Hall 2009).

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Floodplains

Within Muir Woods, 100-year floodplains are located along Redwood Creek. As a result of natural weather events and the topography and soil characteristics of the area, runoff in the Redwood Creek

watershed is high in the winter, with occasional flash floods. Two-year flood magnitudes are estimated at approximately 800 cfs, while the 50-year estimate was just over 4,000 cfs. However, during summer**,** flows are much lower – often below 1 cfs at the Highway 1 bridge – and many tributary streams are intermittent (NPS 2005c).

Much of the Monument infrastructure – such as the trails, administrative buildings, gift shop, and parking lot – are within the 100-year floodplain of Redwood Creek. There has long been concern about how these structures may impact riparian and aquatic habitats both directly and indirectly. Various planning efforts including the 1980 GMP, have placed a priority on reducing such impacts through relocation of facilities. Impervious surfaces, such as the paved trail and parking, may reduce infiltration of precipitation and cause a reduction in bank contribution to streamflow, as well as increased peak flows of streams (Hall 2009).

Water Quality in the Redwood Creek watershed

Water quality monitoring has been conducted at various times and with differing intensity within Redwood Creek and its tributaries, with most of this being below the Monument, because most inputs are from agricultural uses and other sources associated with land use below Muir Woods (NPS 1991; NPS2005b). However, in 2005, Stillwater Sciences designed a water quality monitoring protocol for the watershed that can be used to isolate general areas of contaminant sources. This protocol was implemented once in 2005 as a baseline and may be implemented in future years depending on the availability of funding. A review of a history of water quality sampling in the watershed is compiled in the Existing Conditions Report for the Big Lagoon Wetland and Creek Restoration (Philip Williams & Associates 2003). Weeks (2006) issued the Water Resources Foundation Report, a background document on water resources that also identifies relevant laws and policies. Lendvay and Benning (2004) collected baseline water quality data, including pH, alkalinity, metals and ions, temperature, dissolved oxygen, nutrients, and turbidity, at five locations throughout the watershed. Their extensive study compares findings to an earlier, similar study by Madej (1989). In 2008, the Regional Water Quality Control Board established monitoring sites along the length of Redwood Creek as part of their Surface Water Ambient Monitoring Program that is focusing on benthic macroinvertebrates, periphyton, nutrients, and basic water quality parameters (Hall 2009).

Field surveys and aerial photograph analysis have been conducted to identify and quantify current and potential future sediment supply from roads, trails, culvert stream crossings, and (to some extent) bank erosion in the Redwood Creek watershed. Sediment sources were assessed for 27 miles of roads and 40 miles of trails, leading to recommendations for erosion control priorities to protect fish and other aquatic species within the watershed. This was done by walking roads and trails and searching for sites of potential sediment delivery. These results were incorporated into a more comprehensive watershed sediment budget developed for the Lower Redwood Creek Restoration Project (Hall 2009).

Madej (1989) summarized water quality monitoring that was done between 1986 and 1989 in the lower Redwood Creek watershed (below Muir Woods). Most metals were not detected, although there was one unusually high reading for copper (80 μg/L). Later reports attribute this to pesticide use, although this appears to be speculation (NPS 1991). Park staff report that this may have been related to the use of copper hoof treatment used at the stables, a practice that has been discontinued. Levels of coliform bacteria and nitrogen were high, evidently due to horse pastures and agricultural activities at Green Gulch Farm, as well as septic leach. Phillip Williams and Associates (1995) reported the lowest levels of nutrients and bacteria in the headwaters of Redwood Creek and the highest downstream of Muir Woods; the number of organisms per 100 ml was 50 upstream of Banducci, 300 below Banducci, and 1900 at Pacific Way. Stillwater Sciences (2005) also report that NPS testing during the 1990s at Muir Woods found fecal coliform levels within the Monument to be within California state thresholds (Hall 2009).

Several studies have found that temperatures in Redwood Creek are within the tolerances of salmonids. Lendvay and Benning (2004) reported temperatures across their sample locations to range from 10.8 to 11.0 C in early March and from 14 to 16 C in late April. They concluded that temperatures during spawning season should be cool enough for coho. Their study, conducted from March through April, found dissolved oxygen levels to be adequate for insects and salmon. However, others have found dissolved oxygen levels to be reduced in Big Lagoon in the summer, and this is considered a "key factor" limiting juvenile fish survival (Hall 2009).

Lendvay and Benning (2004) determined that most water quality parameters were within EPA standards for aquatic life. Here pH ranged from 7.3 at Muir Beach to 8.0 at Bootjack Creek. Nitrate, though variable, was far below the standard of 90.0 mg/L, suggesting little concern about eutrophication. Somewhat high ammonia readings at specific sites on specific dates might suggest some concern, but the authors said that typical levels were well below the threshold for salmonids in most parts of the watershed. Sulfate levels were extremely low. This study found low levels of copper, in contrast to the levels reported by Madej (1989). Turbidity levels were high on sampling dates following storms, but quickly fell to levels within EPA standards. "The low turbidity levels found in the Redwood Creek watershed suggest conditions suitable for salmonids, aquatic vegetation, and benthic macroinvertebrate populations" (Hall 2009).

Other parameters reported by Lendvay and Benning (2004) were out of compliance with EPA standards. Alkalinity measures exceeded the EPA minimum standard for freshwater aquatic habitat of 20.0 mg/L (even the lowest reading, 42.8 at Fern Creek, was significantly above the standard). Phosphate readings, though highly variable, exceeded the guideline of 0.1 mg/L at every site. Aluminum concentrations exceeded the recommended limit for fish at all sites on one date and at two sites on other dates, and the authors concluded that "aluminum may be a threat to aquatic species in Redwood Creek." Similarly, zinc concentrations were frequently above the EPA limit for freshwater ecosystems, indicating possible negative effects (Hall 2009).

Overall, Lendvay and Benning (2004) conclude that the water quality of Redwood Creek is excellent. Despite the fact that some parameters were elevated, in the context of other parameters, such as very healthy benthic macroinvertebrates, these do not seem to be posing significant threats (Hall 2009).

BIOLOGICAL RESOURCES

Muir Woods was created to protect coastal redwood forests, and most of the Monument (approximately 80%) is occupied by old-growth coastal redwood/Douglas-fir forests in uneven aged stands (NPS 2005c). Although it is difficult to age old-growth redwoods, individual trees on alluvial flats in Muir Woods are estimated to be as much as 1,000 years old. The coastal redwood forests of California were isolated from surrounding redwoods during the last glacial retreat, during which much of the California coast became oak savannas (Howell et al. no date).

The NPS (1999a) locates GGNRA within the "center of the California Floristic Province, one of only five regions in the world with a Mediterranean climate." At the landscape scale, plant associations are shaped by aspect, marine influence, and elevation (NPS 2005b). Generally, within San Francisco Area Network, the three provinces represented are the California Coastal Chaparral Forest and Shrub, the California Dry Steppe, and the California Coastal Steppe, Mixed Forest and Redwood Forest. Muir Woods' redwood forests fall within the last of these, while around the edges of the Monument are small patches of other plant communities that are much more common in other parts of Mt. Tamalpais and the Marin headlands (NPS 2005b). On the southwest is coastal scrub dominated by coyote bush (*Baccharis pilularis*), grasses and forbs, and to the northeast is a mosaic of coast live oak (*Quercus agrifolia*), California bay (*Umbellularia californica*), and chaparral. At the south end of the Monument, the Redwood Creek riparian area loses the redwoods and becomes dominated by deciduous trees like red alder (*Alnus rubra*) and broadleaf evergreen trees such as California bay and tanoak (*Lithocarpus densiflora*) (Hall 2009).

Muir Woods is within the California Floristic Province—a biological hotspot of high endemism and diversity. The Monument provides important habitat for federal-listed threatened or endangered species, namely northern spotted owls (*Strix occidentalis caurina*), coho salmon (*Oncorhynchus kisutch*) and steelhead (*O. mykiss*), and several species of bats that are listed as sensitive species. All of these species breed within the Monument. Redwood Creek has been identified as "a high priority restoration area for coho salmon" under the California Department of Fish & Game's 2004 Recovery Strategy. While suitable marbled murrelet habitat has been identified in the Monument, there has been no confirmation that this species uses the park for breeding (Hall 2009).

HABITAT (VEGETATION AND WILDLIFE)

Plant Communities

Muir Woods is the only old-growth coastal redwood forest in the Bay Area and one of the last on the planet. It is estimated that nearly 2 million acres of forest just like Muir Woods once covered a narrow strip along the coasts of California and Oregon. Today, 97% of this area has been impaired or altered and most coastal redwoods now grow on protected second and third growth forests or managed timber plantations. Muir Woods remains as a very accessible yet prime example of an old-growth forest. Sudden Oak Death (SOD) is a common name given a pathogen (*Phytophthora ramorum*) responsible for widespread tree death throughout northern and central California. This pathogen first appeared in Muir Woods during the mid-1990s, and although many plants in the redwood forest are affected, the tanoaks have suffered the most.

NPSpecies, a National Park Service database, documents 263 vascular plant species present in Muir Woods. Twenty-nine other species are probably present, but have not been verified, and 17 species are unconfirmed. Forty-four species are listed as historic, meaning they were previously present but are believed to be extirpated. The basis for this determination is staff knowledge of the site, although no field inventory of plants has yet been completed. A 1966 lichen inventory identified 7 fruticose lichens, 9 foliose lichens, and several unidentified species of crustose lichens (Hall 2009).

There do not appear to be many native plant species of concern in Muir Woods. The 1980 GMP (NPS 1980) identified the San Francisco wallflower (*Erysimum franciscanum var. franciscanum*) and Presidio clarkia (*Clarkia franciscana*) as being species of special status at Muir Woods, but no further mention is made of these in subsequent planning documents, and they are not mentioned in current Species of Management Concern lists. They have never been documented within the Monument, and evidently their inclusion on the list and in the 1980 plan was an error. Oakland star tulip or mariposa lily (*Calochortus umbellatus*) is described in the fire management plan (NPS 2005b) as a California Native Plant Society – listed species, which has been found "in the vicinity of Muir Woods" in grasslands. Additionally, the California bottle-brush grass (*Elymus californicus*) is a federal species of concern; this species prefers coniferous forests and riparian woodlands, and has been documented in the Monument (NPS 2005b). The only active management for rare plant species within the Monument has been some fencing along the valley floor to protect the California bottle-brush grass, which appears to have been effective (Hall 2009).

Coast Redwood/Douglas-fir Forests

As noted earlier, most of the monument—472 (85%) of its 558 acres—is comprised of mixed age coast redwood and Douglas-fir (NPS 2005b). In Muir Woods, the redwood forest "extends along the canyon floor north beyond the Monument, across most of the northeastern-facing canyon wall up to the Dispsea Trail, and along portions of the lower southwest-facing wall and adjoining side canyons extending to the Ocean View Trail. In these areas, the redwoods thrive in a cool microclimate with loamy soils and ample moisture from fog, rain, and groundwater" (Hall 2009).

Although this forest is largely isolated within the larger landscape, due to natural conditions such as physiography and the restricted environmental requirements of redwoods, as well as logging and conversion of lands in the surrounding area, the tracts of forest within the Monument have had a serendipitous history of protection that has preserved many of the structural and functional ecological features. The Monument's redwood forests were never logged (McBride & Jacobs 1978), although logging did occur in Conlon Canyon and there has been little road construction or other major development (other than Park Service facilities near the entrance). While it is true that substantial impacts were historically imposed by recreation and tourism (e.g., trampling, campfires, and collecting plants) and park management (stream alteration, removal of woody debris), some of these impacts are of the type that are recoverable from within years or decades. Indeed, studies have shown that areas formerly devoid of vegetation along Redwood Creek have recovered to the point that it is not possible to discern restoration plantings from natural vegetation. On the steep hillsides away from Redwood Creek, it appears that impacts to ecosystems were even more limited. Stillwater Sciences (2005) observe that "understory cover today is probably the most extensive that it has been in a century." NPS staff considers the functional connectivity within the redwood forests of Muir Woods to be good, although the forests are largely isolated from other redwood stands in northern California, most of which have disappeared due to extractive uses.

Public ownership of surrounding lands is an aspect that helps maintain certain ecosystem functions within the Monument's redwood forests. These protected lands provide contiguous habitat, especially for some animal species. Nevertheless, developments such as those at the Muir Woods Park neighborhood, Green Gulch Farm, and Muir Beach have impacts that affect faunal species occurring in Muir Woods. For instance, residential development within Marin County may affect northern spotted owl populations. Howell et al. (no date) also note that the "island" characteristics of the Monument have influenced some mammal populations. Gray squirrels, for example, have increased in Douglas-fir forests, and spotted skunks—normally a grassland species—were observed mostly in the forest. Such types of impacts are not well documented (Hall 2009).

Other Terrestrial Vegetation Types

Outside the redwood and Douglas-fir forests, there are small patches of other vegetation types in the Monument that are much more extensive in other parts of the watershed outside the Monument. McBride and Jacobs (1978) described five vegetation types: hardwoods, brush, grassland/brush, hardwood/brush, and grassland. These include the habitat types identified in the fire management plan (NPS 2005b) as native hardwood (59 acres), coastal scrub/chaparral (2 acres), grassland (2 acres), nonnative evergreen (2 acres), and developed (6 acres). While the redwood forests are largely intact or recovering, these other habitat types have been more extensively altered (Hall 2009).

The native hardwood forest (or mixed hardwoods) covers 800 acres of the Redwood Creek watershed (Stillwater Sciences 2005), of which only 59 are within Muir Woods. These forests have not been well studied. In places like the Monte Vista tract, where development and residential uses have occurred, the hardwood forests have been substantially reduced in extent. Presumably, under NPS management, these areas will begin to return to a more natural state, although there are concerns about invasive species such as eucalyptus, which can dramatically alter forest structure and composition. In areas along Camino del Canyon, various landscape plants have escaped, and invasive exotics such as yellow starthistle (*Cenaurea solstitialis*) and French broom (*Genista monspessulana*) are problems. Additionally, the native hardwoods are at great risk from sudden oak death (Hall 2009).

The remaining native vegetation types—coastal scrub/chaparral and grassland—have been highly altered, due to a combination of fire suppression, land use practices, and invasion by nonnative species (Stillwater Sciences 2005; NPS 2005b). The coastal scrub/chaparral occurs at upper elevations, and seems to be invading grasslands as a result of fire suppression (NPS 2005b). In turn, coniferous forests are invading the lower elevations of the scrublands. Within the Redwood Creek watershed, most native grasslands, which occupy ridge tops and slopes, have become dominated by nonnative, Mediterranean annual grasses (Stillwater Sciences 2005). Remaining native grasslands in the watershed have not yet been inventoried or mapped, so priorities have not yet been set for protection (Hall 2009).

Invasive Plants

Invasive exotics are a considerable problem within all other habitat types. In fact, approximately one-third of the plants (108 species) identified within the Monument are nonnatives, many of which are landscape plants found in the Monte Vista additions. A 1999 field mapping project found 39 invasive plant species occupying 921 acres (16%) of the entire Redwood Creek watershed, but many of these are likely to occur outside Muir Woods (Hall 2009).

Within the redwood forests, McBride and Jacobs (1978) identified three exotic forbs, but considered them to be rare and not a threat. There are isolated patches of exotic aquatic plants, but these seem to be limited in extent and are relatively stable. Today, there are two main exotic species of concern in the riparian redwoods: the forget-me-not *(Myosotis sylvatica and Myosotis latifolia)* and panic veldtgrass *(Ehrharta erecta)*. Originally introduced to “improve” the aesthetics of the forest, forget-me-nots quickly spread throughout the Monument. Fortunately, diligent work by park staff and volunteers has kept this species in check along the canyon floor, although there is concern about the ability to eliminate it from steep, inaccessible slopes. Along Redwood Creek, removal of this species has led to an increase in native plant cover. Outside the riparian forests, the park has worked to eliminate other invasive species, including cape-ivy *(Delairea odorata)*, brooms (*Genista monspessulana*, *Cytisus scoparius*, *Spartinum junceum*), acacia (*Acacia melanoxylon*, *Acacia decurrens*), and other species (Hall 2009).

Aquatic Systems

The major ecosystem elements within the original Monument that have been altered include the aquatic and riparian systems. For decades, concerted efforts were made to "clean up" the Redwood Creek valley to alleviate problems with flooding and provide an aesthetically pleasing visitor experience. This amounted to removing woody debris from the forests and engineering the creek to create a more consistent gradient and protect its banks from erosion. Most of this was a result of intensive Civilian Conservation Corps (CCC) work during the 1930s, when Redwood Creek within the Monument was leveled and rock revetment was installed (Auwaerter & Sears 2006; Stillwater Sciences 2005). The revetment occupies 57% of the total stream bank length (3,541 feet) within the Monument. As late as the early 1990s, woody material was being removed from the stream to prevent logjams that might increase flooding. Channelization has decreased flooding and, consequently, deposition. It has also drastically altered instream morphology, reducing the number and depth of pools and eliminating undercut banks (Fong 2002). Fong's survey showed that pools occupied only 32% of the primary Muir Woods reach length, with flatwater or shallow riffles being much more extensive. In summer, some riffles become so shallow that fish are forced downstream. A survey in 2003 showed a lower biomass of salmonids was associated with the presence of riprap. The channel immediately downstream of the Muir Woods boundary, where riprap was never installed, appears more natural than the area within Muir Woods. However, Redwood Creek within the Monument has the least amount of fine substrate and more riffles, and therefore the largest number of spawning areas. (Hall 2009).

Other impacts to Redwood Creek, both upstream and downstream of Muir Woods, have impacted ecosystem functions. Sedimentation from upstream associated with roads and culverts have impacted the entire length of the creek. However, sedimentation from roads and culverts is not the major player in channel habitat downstream of Muir Woods. The watershed sediment budget identified and quantified sediment sources to Redwood Creek for three historical periods and included future projections. In the recent past, channel incision was the largest source of sediment to the creek downstream of Muir Woods (57% of total supply 1921-1980). As channel incision slows or ceases, erosion from roads and trails is expected to contribute 23% to total sediment yield to the lower creek. In addition to roads and trails, future sediment sources include hillslope erosion (19%), tributary bank erosion (29%), and channel incision (28%). Additionally, changes at Lower Redwood Creek at Muir Beach appear to have had a significant impact on habitat characteristics necessary for salmon, steelhead, and red-legged frogs. Nevertheless, despite its degraded condition, Lower Redwood Creek "appears to be a major holding area for run-back steelhead adults" (Fong 2002), and its important ecological role has led to it being a high priority for restoration (NPS 1999b; NPS & Marin County 2007; Hall 2009).

Philip Williams and Associates (1995) characterized the Redwood Creek watershed as a whole as

> "unique among California coastal watersheds of its size in that it remains largely undeveloped and is protected as state and federal park lands. The creek has largely recovered from historical grazing activities in the watershed, and now supports sustainable populations of coho salmon,

Thus, while there have clearly been alterations to cover and habitat, which have influenced ecological functioning, within the larger landscape the Redwood Creek watershed is a primary target for restoration and maintenance of important habitats. The facts that there are no impoundments, except in the Green Gulch sub-watershed (Martin 2000; Philip Williams & Associates 2003), which would severely fragment habitat, and most watershed land is in local, state, or federal government ownership, create opportune conditions for protection (Hall 2009).

Wildlife

Within the Redwood Creek watershed, riparian woodlands provide breeding habitat and forage for 85 bird species and 16 mammal species. Two mammals, the shrew-mole and the broad-footed mole, were only found in this habitat. Nineteen of the bird species and one mammal are species of management concern. Cape-ivy, which is present in the Monte Vista tract, but not yet in the redwoods, has had documented impacts on the diversity of bird species (Hall 2009).

Redwood/Douglas-fir forest in the Redwood Creek watershed provide habitat for 30 bird species and 20 mammals. Hall observed that "this habitat supports an average-to-high bird diversity and low bird abundance compared to other habitat types in the watershed." Mammals that are preferentially associated with these forests include deer mouse *(Peromyscus maniculatus)*, gray fox *(Urocyon cinereoargenteus)*, opossum *(Didelphis virginiana)*, trowbridge shrew *(Sorex trowbridgii)*, Sonoma chipmunk *(Tamias sonomae)*, western gray squirrel *(Sciurus griseus)*, and raccoon *(Procyon lotor)* (Howell et al. no date); 17 species of concern (4 bats and 13 birds) have been detected in this habitat type (Hall 2009).

Mammals

According to NPSpecies, 27 mammal species are confirmed present in Muir Woods, while 9 are unconfirmed. Domestic cats are the only species identified as a pest, although park staff report that feral pigs were formerly a problem, and feral cats, turkeys, and local dogs are presently considered pests. None of the mammals is considered at risk of exploitation. Howell et al. (no date), in a mammal survey, documented black-tail deer (*Odocoileus hemionus*), meadow vole *(Microtus pennsylvanicus)*, and opossum, which do not appear in the NPSpecies list. Additionally they documented domestic dogs ("unconfirmed" in NPSpecies) and western spotted skunk *(Spilogale gracilis)* ("false report" in NPSpecies). NPSpecies lists no "historic" (extirpated) species, but various historic documents suggest that several large mammals, like bears, were historically present but disappeared as long ago as the late 1800s. The NPSpecies data provide no information on nativity, abundance, or residency for the mammals in the Monument (Hall 2009).

Among the mammal species, only bats have received significant investigation. Habitat for bats in Muir Woods is considered high quality, and the diversity of species is notable—Heady and Frick (2004) reported 10 species foraging and/or roosting in the Monument; this number represents 69% of the species that are likely to occur in the region. Redwoods are particularly good habitat because they provide hollows and crevices for roosting. There are four federal species of management concern (SOMC) and one species on the US Forest Service sensitive species list. The Townsend's big-eared bat (also called the Pacific western big-eared bat) (federal SOMC) occupies humid coastal regions of California, roosting in caves, mines, buildings, and fire scars (NPS 2005b). It is very sensitive to disturbance and suffers from a lack of suitable roosting sites; because of their large cavities, large diameter redwoods offer some of the only suitable habitat. The fringed myotis (federal SOMC) occurs in a wide variety of habitats, although it prefers foothill hardwoods and hardwood-conifer forests and has been considered preferentially associated with redwood forests. The long-legged myotis (federal SOMC) is most common above 4000 ft in primarily coniferous forest habitats. It uses trees as day roosts and creates nursery colonies in hollow trees. This has led to increased protection of fire scars. The Yuma myotis (federal SOMC) prefers open woodlands and forests, and requires still water sources that attract prey insects. It is quite tolerant of human habitation. Little is known about the western red bat (Forest Service sensitive species), although it is known to roost in cottonwoods and willows and is thought to be migratory (Hall 2009).

Birds

Over 50 species of birds have been identified in Muir Woods over a year's time. Their abundance and periods of song vary with time of day, season, and weather conditions. A deep, wooded redwood canyon

is a specialized habitat. Although this old growth forest supports spotted owls *(Strix occidentalis caurina)* and pileated woodpeckers *(Dryocopus pileatus)*, the overall lack of food is the primary reason for the apparent scarcity of birds. There are few insects in a redwood forest as the tannin repels insects and the deep shade limits the number of flowers and fruits produced.

In addition, federal-threatened northern spotted owls nest in coniferous and mixed-hardwood forests surrounding Muir Woods. Muir Woods also contains potential marbled murrelet *(Brachyramphus marmoratus)* habitat, but no breeding murrelets have been detected in two years of surveys.

The following quotation from the superintendent's annual report for 1923 indicates little change during the past 80 years in the bird life found in Muir Woods:

> "Birds, as is generally the case in a redwood forest, are conspicuous by their absence—Steller's jays being the only bird seen in any numbers."

Fifty-nine bird species are confirmed present in the Monument, according to NPSpecies, although the 1999 Resource Management Plan indicated that "at least 69 bird species occupy Muir Woods" (NPS 1999b). Seven are migratory species, and 23 are known to breed within the Monument. The only federal-listed threatened species is the spotted owl, which breeds in and near the Monument. Although Muir Woods appears to provide habitat suitable for marbled murrelets, which nest only in redwood trees, none have been detected, despite a focused inventory of Muir Woods. Appendix /// which provides detailed information about all special status species, lists two State Species of Concern in Muir Woods: Cooper's hawk (*Accipiter cooperi*) and sharp-shinned hawk (*A. striatus*). Inventories in 2000 did not detect either hawk species. However, Allen's hummingbird (*Selasphorus sasin*) and hermit thrush (*Catharus guttatus*), both species of management concern, were observed as well as the chestnut-backed chickadee (*Parus rufescens*), which is on the Audubon watch list. According to their point count data, the Pacific-slope flycatcher (*Empidonax difficilis)*; a species of management concern, was the most common bird; it was observed at 93% of census points. The other most common species were winter wrens (65%), chestnut-backed chickadees (56%), golden-crowned kinglets (54%), brown creepers (47%), and dark-eyed juncos (30%) (Hall 2009).

Amphibians and Reptiles

NPSpecies lists five amphibians as present within Muir Woods along with two species that were documented historically, but are no longer present, the foothill yellow-legged frog and yellow-eyed ensatina (*Ensatina eschscholtzii xanthoptica*). Yellow-legged frogs were collected in 1954, but they were not found in 1993 within the Monument, and Hall noted that this species is "now very rare or absent" in areas where it formerly was abundant. Very little information is available about the abundance or status of many of these amphibian species (Hall 2009).

The nonnative signal crayfish has long been established in Redwood Creek and Fern Creek. It is the only nonnative aquatic species in the Monument. It is possible that this species displaced the native sooty crayfish (*Pacifastacus nigrescens*) (Hall 2009).

The California giant salamander (*Dicamptodon ensatus*) is found from Sonoma to Santa Cruz County, particularly in humid coastal conifer forests. A recent survey found that salamander larvae were rare in the main stem of Redwood Creek, but more abundant in tributaries. Fong and Howell noted that the signal crayfish and giant salamander were rarely found together in any stream habitat type, but they were unable to determine whether the crayfish were displacing the salamanders from preferred habitats. They noted that, because crayfish tend to favor pools, actions that might be taken to restore stream features such as pools could increase the abundance of crayfish (Hall 2009).

NPSpecies lists 12 reptile species as present within Muir Woods. The abundance, residency, and nativity of most of these species are unknown. Very little is reported about any of these species in any planning or

research reports. However, the Pacific (western) pond turtle (*marmorata,* formerly *Clemmys marmorata),* a federal species of concern, is listed as present in the monument, although none of the recent aquatic habitat assessments make mention of it (Hall 2009).

Fish

An old-growth forest is very interconnected;through time, many of the plants and animals become reliant on one another. One example at Muir Woods is found in Redwood Creek. The redwoods depend on the creek for most of their water and the trees help keep the gravel in the creek clean by stabilizing the soil. The trees also help keep the temperature of the stream cool and constant. As the trees die and fall into the creek, they create pools and enrich the stream with their nutrients. Since salmon need clean gravel, constant water temperature, and pools for spawning, Redwood Creek provides good habitat for salmon. It is one of the last streams in California to still have its native stock of salmon, due largely to the undisturbed forest surrounding it. Both coho (*Oncorhynchus kisutch)* and steelhead trout *(Oncorhynchus mykiss)* are found in Redwood Creek.

There are four native fish species present in Muir Woods, although additional species, including some nonnative fish, occupy lower reaches of Redwood Creek. The two most significant species—targets of extensive monitoring—are coho salmon (recently upgraded federally to endangered status) and steelhead (federal-listed as threatened). Redwood Creek is critical habitat for both; Muir Woods provides good spawning habitat but, due to loss of pools and structure, juvenile rearing habitat is very limited. Both runs have been considered stable, although significantly reduced from historic times (Hall 2009).

The Redwood Creek coho are part of the Central California ESU, found in three watersheds in the Park Serivice's San Francisco Bay Area Network (NPS 1999a). However, genetic analysis shows that the coho in Redwood Creek are a genetically distinct subgroup that is not closely related to other coho in the same ESU (NPS & Marin County 2007). Spawning occurs between December and February, depending on when storm flows increase enough to permit returning adults to breach the sandbar at Big Lagoon. Emergence occurs in March and April, and the juveniles remain in fresh water for approximately 15 months, before heading to the ocean for 16 months. This cycle creates three "year-classes" of fish; for instance, the fish returning to spawn in 2007-08 were from the 2004-05 year class. Given their lifecycle, habitat requirements vary; fish need habitat for spawning, juvenile rearing and migration, growth to adulthood, and adults need migration corridors (NPS & Marin County 2007). Juvenile rearing habitat with refugia and shelter appears to be especially limiting in Redwood Creek. Big Lagoon's altered environment does not provide high quality salmonid rearing habitat (Hall 2009).

Nonnative Wildlife

A few nonnative mammals have been of concern to the park. In the past, feral hogs (*Sus scrofa*) were widespread in GGNRA (including Muir Woods), but they have been largely controlled (NPS 1999b). They can seriously degrade habitat, disturb soils, compete for food, and transmit diseases. Feral cats and domestic dogs (unconfirmed), though not major concerns, can present problems for native wildlife (Hall 2009).

There have been anecdotal reports of chukars (*Alectoris chukar*), an exotic species, near Muir Woods, though not yet within the Monument. Also, wild turkeys are considered non-native and increasing in and around Muir Woods. This species was introduced by California Department of Fish and Game for hunting, but GGNRA considers it invasive and uncontrolled. It competes with native species for food and has been known to harass people. NPS Staff are contemplating small pilot removals (Hall 2009).

SPECIAL STATUS SPECIES

Coho Salmon – Federal Threatened

Coho salmon **(***Oncorhynchus kisutch***)** occur in several creeks within the planning area, as well as the nearshore waters of the Pacific Ocean and estuarine sites such as Bolinas Lagoon and San Francisco Bay. Coho salmon are found in Redwood Creek in Muir Woods. A single cohort of coho salmon was found in Easkoot Creek (Marin County). Coho are an anadromous species; born and reared in freshwater streams, as juveniles they migrate to estuaries, adjust to saltwater, and then migrate to the ocean to mature into adults. Designated critical habitat for coho in GGNRA includes accessible estuarine and stream areas in the coastal watersheds of Marin County except areas above longstanding naturally impassable barriers. Optimal habitat conditions for juvenile coho seem to be deep pools created by rootwads and boulders in heavily shaded stream sections (NPS 2005a).

Steelhead Trout – Federal Threatened

Steelhead ***(****Oncorhynchus mykiss****)*** are found in Redwood Creek which flows through Muir Woods, as well as the nearshore waters of the Pacific Ocean and estuarine sites such as Bolinas Lagoon and San Francisco Bay. Like coho, steelhead are an anadromous species. Adult steelhead enter GGNRA area streams in the late winter through spring to reach spawning sites, typically well-aerated areas with small- to medium-size gravel. Habitat preferences for juvenile steelhead are deep pools created by rootwads and boulders in heavily shaded stream sections, although young-of-the-year steelhead are often forced into shallow-water habitats. The amount of time steelhead rear in freshwater and marine/estuarine habitats is variable, ranging between one and three years. For most drainages, presence/absence salmonid surveys have been conducted, while in watersheds supporting coho salmon, abundance data on both species are available. The variable life cycle of steelhead makes population analysis more difficult, but also makes steelhead more resilient to adverse environmental conditions. In general, if the habitat requirements for coho were met, steelhead habitat requirements would also be met (NPS 2005a).

In April 2002, the U.S. District Court for the District of Columbia approved a National Marine Fisheries Service consent decree withdrawing a February 2000 critical habitat designation for steelhead trout. Designated critical habitat for coho includes all accessible estuarine and stream areas in the coastal watersheds of Marin County except areas above longstanding, naturally impassable barriers. Through this designation, NOAA Fisheries identified ten essential features of critical habitat: substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food, riparian vegetation, space, and safe passage conditions (NPS 2005a).

Northern Spotted Owl – Federal Threatened

Marin County supports a northern spotted owl ***(****Strix occidentalis caurina****)*** population of possibly 75 pairs. This population is isolated from spotted owl populations to the north by large areas of grassland and shrubs and constitutes the southern end of the subspecies range. Genetic analysis has shown low levels of genetic diversity within and low levels of gene flow between spotted owl populations in Marin County and Mendocino National Forest. The Marin County population supports the highest known density of northern spotted owls rangewide (NPS 2005a).

Spotted owls tend to nest in older stands of conifer and hardwood trees that create a tall overstory. Spotted owls often select larger trees with defects, such as broken tops or mistletoe *(Arceuthobium spp.)* infestations, for nesting, but also have been found nesting in young bay trees in smaller stands. Preliminary pellet analyses indicated that spotted owls forage primarily on dusky-footed woodrats *(Neotoma jUscipes)* in addition to other forest dwelling small mammals and songbirds. Within the

planning area, known spotted owl locations are currently limited to Muir Woods and the Stinson Gulch area (NPS 2005a).

Northern spotted owls in Muir Woods are at the southernmost extreme of the species range, and the population in Marin County is genetically isolated, although relatively large; 161 distinct nests were been documented between 1998 and 2003 (Stillwater Sciences 2005). This species was federally listed as threatened in 1990. Monitoring in the county over the past several years has shown stable fecundity, with approximately 0.5 female young fledged per breeding female and nearly 90% of nests being occupied for the past several years. Old redwood forests are important nesting habitat; 43% of nests in Marin County are in redwood trees and 36% are in Douglas-fir trees. Across northern California, owls were found to select locations with large diameter conifer overstory and an understory of large hardwoods. The mean diameter of platform nest trees in Marin County is 91 cm. Two pairs have historically nested within Muir Woods or immediately adjacent to the Monument (Hall, 2009).

There are several threats to spotted owls in the region, although the habitat conditions within Muir Woods itself are presently of high quality. Urban development destroys habitat, owls are especially susceptible to West Nile virus (first confirmed in Marin County in 2005), and Sudden Oak Death may affect both nesting habitat and prey species. Additionally, there are anecdotal reports of people disturbing nests and luring owls with mice. Finally, the barred owl is suspected of displacing spotted owls in Marin County. This species, once limited to the eastern United States, has been extending its range over the past century and is now found throughout the Pacific Northwest and in California. Aggressive behavior toward spotted owls has been documented in Marin County, and in 2005 a male barred owl was detected in Muir Woods for the fourth year in a row, which coincided with the second year of spotted owl nest failure in the Monument. In 2007, the first breeding pair of barred owls was observed, and breeding was observed again in 2008 (Hall 2009).

Kelly et al. (2003) conducted extensive historical analysis of the location of spotted owl and barred owl territories at five study areas in Oregon and Washington from 1987 to 1999. They concluded that there had been a steady increase in the number of barred owls at all long-term spotted owl monitoring sites, and that when barred owls invade, the occupancy of territories by spotted owls declines significantly. They believe that “land managers and regulatory agencies should regard barred owls as a threat to spotted owls.” There is some debate about whether the barred owl in Muir Woods should be considered native or not (it is listed as such in NPSpecies, but other park planning documents list it as invasive and uncontrolled). Nevertheless, barred owls have been identified as the primary threat to spotted owl recovery in the US Fish & Wildlife Service’s final recovery plan. NPS staff consider the barred owl to be a species of concern, with a need to track and potentially manage the species due to its potential impact on spotted owls. It appears that the presence of the breeding barred owls in MuirWoods has displaced the historically nesting spotted owls (Hall 2009).

Marbled Murrelet – Federal Threatened

See description Habitat in San Mateo County

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