The vegetation communities of concern from a fire management standpoint are described below in detail in terms of overall vegetation composition, fire ecology, and management objectives. The communities consist of:

Coastal Scrub and Chaparral
Grasslands
Herbaceous Wetlands
Riparian Forest and Scrub
Native Hardwood Forest
Douglas-Fir and Coast Redwood
Nonnative Evergreen Forest

Coastal Scrub and Chaparral

General Characteristics

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.

Fire Ecology

Most species in the coastal scrub and chaparral communities are adapted to fire, sprouting being the most common adaptation. Species that do not sprout often have fire-resistant seeds that retain viability for years. Almost all of the germination cues identified for these species are related to fire: heat, chemicals leached from charred wood, release from toxic compounds, increased light, and stratification (Parker and Kelly 1989).

Fire is often used to convert brushland, such as coastal scrub and chaparral, to grassland. This can be accomplished through a series of successive burns in close proximity to each other, and may kill new brush seedlings before they produce seed (Emrick and Adams 1977). Vogl (1977) observed that coastal scrub communities can result from premature burning or increased fire frequency within chaparral.

Timing of prescribed burns and the resulting intensity can drastically influence post-fire revegetation (Parker 1987, Florence 1987). Species diversity in coastal scrub and chaparral is best accomplished by late summer or fall burns of medium intensities (Rundel 1982). This fuel type produces a high fire intensity with fast spreading fires involving the foliage and live and dead fine woody material in the

crowns of a nearly continuous secondary overstory. The fire behavior can be expected to be erratic and extreme when live fuel moisture drops below 90 percent.

Decadent stands located on steep slopes, like the one that exists on Bolinas Ridge, present an extreme fire behavior potential.

Young growth chaparral stands, like the one that exists in the Gerbode Valley, show evidence of recent fire and do not present a current potential for extreme fire behavior. Spring burns create higher root and burl mortality, probably due to the phenological state of the dominant plants and their depleted carbohydrate reserves. Carbohydrates are tied up in growing plant parts, and deficiencies in root and lignotuber carbohydrates result in a lack of sprouting activity during this period. Fire can serve to break down litter, which is resistant to decomposition; remove inhibitors of decomposition; and alter the wettability of the soil.

High fire intensities are correlated with high shrub mortality. High-intensity fires in mature chaparral often have flame lengths exceeding 50 feet (Lotan et al. 1981) and temperatures as high as 1,200 degrees F (Sampson 1944b, Bentley and Fenner 1958), with fuel consumption of all but the largest branches.

Indications are that organic and inorganic nutrient levels are increased as a result of fire (Christensen 1973, Christensen and Muller 1975). Soil levels of organic nitrogen are reduced, but the level of available nitrogen increases (Rundel 1981). Post-fire bacteria and fungi are more abundant in burned than unburned soils (Christensen 1973, Christensen and Muller 1975). Mineral levels as well as available nutrients added by ash increase dramatically (Hanes 1977). These characteristics of moderate intensity fires decrease the likelihood of development of hydrophobic soils, lessening associated problems of soil erosion and sedimentation, loss of topsoil, and invasion by nonnative plant species in these uninhabited sites.

The historic role of fire in coastal scrub was most related to manipulation of the vegetation to support other activities, such as farming and ranching. Coastal scrub, while adapted to fire, is not dependent upon it for regeneration, although fire can clear out woody materials and create openings for sub-shrubs and forbs, whereas older stands are more characterized by similarly-statured shrubs with little to no herbaceous or forb component. Fire increases overall species diversity in this community, and can exclude coyote brush to the point that the scrub gives way to grasslands (described below). Fire can also be used to manage and suppress nonnative shrubs such as French broom that have become established in these shrublands. Fires may periodically serve to suppress fungal pathogens and other soil-borne diseases affecting plant species. The host plant for mission blue butterfly, silver-leaf lupine (*Lupinus albifrons*), occurs within coastal scrub (and grassland). Lupines in general are known as disturbance-dependent or -tolerant species, and this lupine may benefit from periodic fires that create openings and soil conditions favorable for establishment within the usually dense stands of coastal scrub in the Marin Headlands.

The fire return interval for chaparral varies between 20 and 45 years, depending on the dominant species. The continued statewide suppression of fires within this community has endangered many plant species that grow in association with it, including 14 threatened and 11 endangered species of manzanita and five threatened and 4 endangered species of ceanothus. Of these, GGNRA has one endangered species of manzanita, two rare manzanita, and one rare ceanothus. The mason's ceanothus *(Ceanothus masonii)* is

state-listed rare, and the only known population of this species occurs at Bolinas Ridge in Marin County. Lack of fire in the habitat has contributed to its decline. Prescribed fire of moderate intensity may be necessary to stimulate germination of this species and other species with hard seed coats.

The coastal scrub fuel type remains in a semi-fire-resistant state until the fall of the year when the live fuel moistures drop and the fuels can produce fire with flame lengths of 12 to 20 feet. The fuel normally does not present a fire behavior problem unless it is in the fall of the year, when live fuel moisture drops below 90 percent, or it is burning in a slope and preheating the fuels above it.

Chaparral produces a high fire intensity with fast-spreading fires involving the foliage and live and dead fine woody material in the crowns of a nearly continuous secondary overstory. The fire behavior can be expected to be erratic and extreme when live fuel moisture drops below 90 percent. Decadent stands located on steep slopes, like the one that exists on Bolinas Ridge, present an extreme fire behavior potential. Young growth chaparral stands, like the one that exists in the Gerbode Valley, show evidence of recent fire and do not present a current potential for extreme fire behavior.

Grasslands

General Characteristics

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 (Savage 1974). It is generally accepted that fires are part of the evolutionary forces affecting grassland (Heady 1972). Native American burning has occurred for at least the last 8,000 years in the San Francisco Bay Area according to early narrative reports (Sampson 1944b). The coastal prairie areas appear to have evolved under light seasonal grazing pressure with occasional fire (Heady et al. 1977).

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 (Bartolome et al. 1986), along with other perennial grasses. The lack of continuous fuels and compactness of the bunches 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 (Savage 1974). 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.

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. Additionally, annual species cure rapidly with the onset of summer drought, resulting in a longer fire season (Langenheim et al. 1983).

Tilling and controlled grazing or clipping experiments have been employed in an attempt to enhance native perennial grasses in rangelands. Dennis (1989) found that the timing of grazing is critical, and concluded that annual vegetation affects the growth of perennials more through its influence on the physical environment than through resource competition.

Exclusion of grazing, extirpation of large native mammals, and suppression of wildfires have caused a marked increase in acreage covered by coyote bush (*B. pilularis*) and the resulting coastal scrub community in the Bay Area (McBride and Heady 1968, Clark 1952). It should be noted that grassland and coastal scrub communities are a dynamic mosaic with changes in dominance over time (Russell 1983), and in some areas these two communities are in equilibrium with no invasion occurring (Davidson and Barbour 1977). The boundary between grassland and coastal scrub is probably maintained by one or more of the following factors: allelopathy, herbivory, limited seed dispersal, and differential use of soil moisture (Davis and Mooney 1985). Invasions of coyote brush are sporadic with the shrub canopy developing quickly, effectively shading out most grassland species and providing shelter for herbivores that further reduce grassland species (Hobbs and Mooney 1986).

Fire Ecology

The native perennial grasses in GGNRA, including purple needlegrass (*N. pulchra*)**,** appear to have evolved under periodic fire (Bartolome 1981). These species thrive when annual grassland is burned in the fall season. Disturbance during other seasons is detrimental, suggesting that the plants have adapted to fall fires, rather than the grazing that is common in any season. Purple needlegrass can be favored by burning in the fall to decrease competition and provide a suitable seedbed, enhancing establishment conditions for residual seeds in the soil seed bank (Bartolome 1981).

Prescribed burning research at Henry Coe State Park supports the hypothesis that the presence of heavy annual mulch residue is an inhibitor to perennial grass (Parker 1989). Fall burning was found to reduce the abundance of annual grasses while increasing the diversity of native species. This research also concluded that reduction in annual grass mulch will potentially increase perennial grass establishment.

Fire can also be used to slow the invasion of coyote brush *(Baccharis pilularis)* into annual grassland (McBride and Heady 1968, McBride 1974). The reintroduction of fire to duplicate natural processes will kill susceptible seedlings and top kill some adult plants. Ford (1991) has found that the rate of cover regrowth is inversely related to fire severity.

Prescribed fires within this community have been conducted for the purposes of maintaining native species diversity, maintaining grasslands (that are being converted to scrubland through the invasion of coyote brush), and controlling nonnative species. When the objective is to reduce nonnative plant densities while encouraging native perennials, it is advantageous to burn in fall or early winter (Bartolome 1984). Germination of annual grasses and forbs often occurs one to three weeks after the first rain (Bartolome 1979). Burning during this period can destroy the annual seed crop, thereby reducing competition of annuals. The perennial rootstock is wet after the first rain and less susceptible to fire intensities (Biswell 1984), supporting the strategy of carefully timed fires to favor reestablishment of native species.

Herbaceous Wetlands

General Characteristics

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 (especially velvet grass [*Holcus lanatus*] and harding grass [*phalaris aquatica*]) and forbs including Cape-ivy (*Delaria odorata*) and Vinca (*Vinca major* and *V. minor*). 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 throughout the park are included. Some special status plant species – locally to regionally rare – occur within this community.

Fire Ecology

While this community is not fire-dependent or -adapted, it is found intermixed with other communities that could be manipulated for fire management purposes, and can be affected by those actions.

Riparian Forest and Scrub

General Characteristics

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 berries – native salmonberry (*Rubus spectabilis*), thimbleberry (*R. parviflorus*), 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 (*Cupressus macrocarpa*) have become successfully established within the riparian forest strands in the park.

Fire Ecology

While this community is not fire-dependent or -adapted, it is found intermixed with other communities that could be manipulated for fire management purposes, and can be affected by those actions, including actions specific to removal of nonnative species.

Native Hardwood Forest

General Characteristics

This variable community extends from 200 to 2,500 feet in elevation, and is dominated by oak *(Quercus* spp.), California bay laurel *(Umbellularia californica)* and/or tanbark oak *(Lithocarpus densiflorus).* 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 (Sawyer et al. 1977).

Coast live oak (Q*uercus agrifolia*) 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 californica*), tanbark oak (*Lithocarpus densiflorus*), and other hardwoods become common.

Fire Ecology

The old-growth oak and bay laurel woodlands are stately California communities where the past occurrence of fire is evident in the multiple-trunked character of most trees, indicating early bole damage and subsequent sprouting (Plumb 1980). As for mature trees, bark thickness is the most important factor contributing to their degree of fire tolerance. Coastal live oak has thick bark and is therefore the most resistant to fire. It sprouts from the main trunk and upper branches following complete charring, as does California bay laurel. Prescribed burns in Cuyumaca State Park have shown that both coast live oak and canyon live oak respond well to low-intensity, backing fires, and new sprouts that appear after fire are palatable and attractive to deer.

The native hardwood forests support little ground fuel (probably less than five tons per acre) (Plumb 1980) and as a result associated fire intensities are minimal. The exception is where eucalyptus are invading these woodlands. Here, the community has become more susceptible to fire than it was historically.

Fall burns following rainfall will create erratic fire behavior and effectively reduce small ground fuels. Surface fine fuels typically dry approximately one week after rain, whereas larger fuels take most of the summer to dry out. Thus, the reduction of these larger fuels can be accomplished under low fire intensities when duff layers are moist. Isolated pockets of heavy fuel accumulation can be expected to create erratic but localized fire behavior.

The native hardwood forest has many fire-resistant properties and many species sprout. The gradual incursion of Sudden Oak Death (SOD) into these forests (Figure 3-11) poses a serious threat to their continued existence, and the use of fire may help manage both the forest structure and potentially stall or inhibit the effects of SOD. Recent studies suggest fire can be used to manage the spread of SOD, and may kill off fungal spores.

Douglas-Fir and Coast Redwood

General Characteristics

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 californica),* tanbark oak *(Lithocarpus densiflorus),* California hazel *(Corylus californica),* and madrone *(Arbutus menziesii).*

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 has thick bark that acts as fire insulation to vital cambium tissues. Young Douglas-fir 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 (Ryan et al. 1988).

Douglas-fir seeds ripen in burned cones and require relatively open conditions for reproduction (Franklin and Dyrness 1973); 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 (Sawyer et al. 1977). An open environment is brought about by burning and Douglas-fir germination is enhanced.

Fire Ecology

The many fire-scarred trees in Muir Woods provide evidence of historical fire occurrence. The last recorded fires occurred in 1800 on the valley floor (Sudborough 1966) and 1850 on the slope (Cornelius 1969). The most complete fire history in Marin County redwood communities (McBride and Jacobs 1978) was done using fire scar data from redwood stumps at two study sites: Old Mill Creek and Alpine Dam. Average fire return intervals of 21.7 and 27.3 years occurred respectively, the difference between these intervals being attributed to climatic moisture differences (Jacobs et al. 1985). It should be noted, however, that fire scar data provide conservative estimates of fire frequency, since low-intensity fires would not always scar the trees.

These aforementioned fire intervals are post-human settlement. Available evidence indicates that the "natural" mean fire interval in southern redwood forests is 50 to 300 years, and the presence of humans has caused the decrease in the mean fire interval to today's levels (Langenheim et al. 1983). Recent changes in fire suppression abilities have somewhat increased fire intervals in the redwoods themselves, but Veirs (1980) found that redwood forests in northern California have not significantly changed as a result of fire suppression, since most species have the ability to sprout. Other studies indicate that the exclusion of fire may reduce the opportunity for redwood establishment but not the establishment of many competitors, and long-term fire exclusion could result in redwood replacement by other species.

The effect of fire intensity is important to the role of fire. Low-intensity fires favor redwood rather than Douglas-fir, while high-intensity fires do the opposite (Veirs 1980). However, most large redwoods (greater than 20 centimeters [cm] at breast height [dbh]) survive prescription levels higher than those that have been used in Muir Woods (Finney 1991). Fungal pathogens can enter redwoods through fire scars, creating rot in the heartwood. Although it is not fatal to the redwood, it places stress on the trees and increases the chance of wind breakage and damage by fire (Fritz 1932).

Fire plays a primary role in coast redwood reproduction. Seedling establishment and sprouting are stimulated by burning. Redwood seedling establishment requires bare mineral soil with adequate soil moisture, which protects seedlings from attack by damping-off and root-rotting fungus (Davidson 1971). These conditions exist after fires – which remove ground litter and sterilize the soil – and after floods when soils are exposed and silt deposition occurs on stream banks. Another form of reproduction is vegetative sprouting, which is triggered by mechanical injury, changes in light intensity, and fire (Simmons 1973).

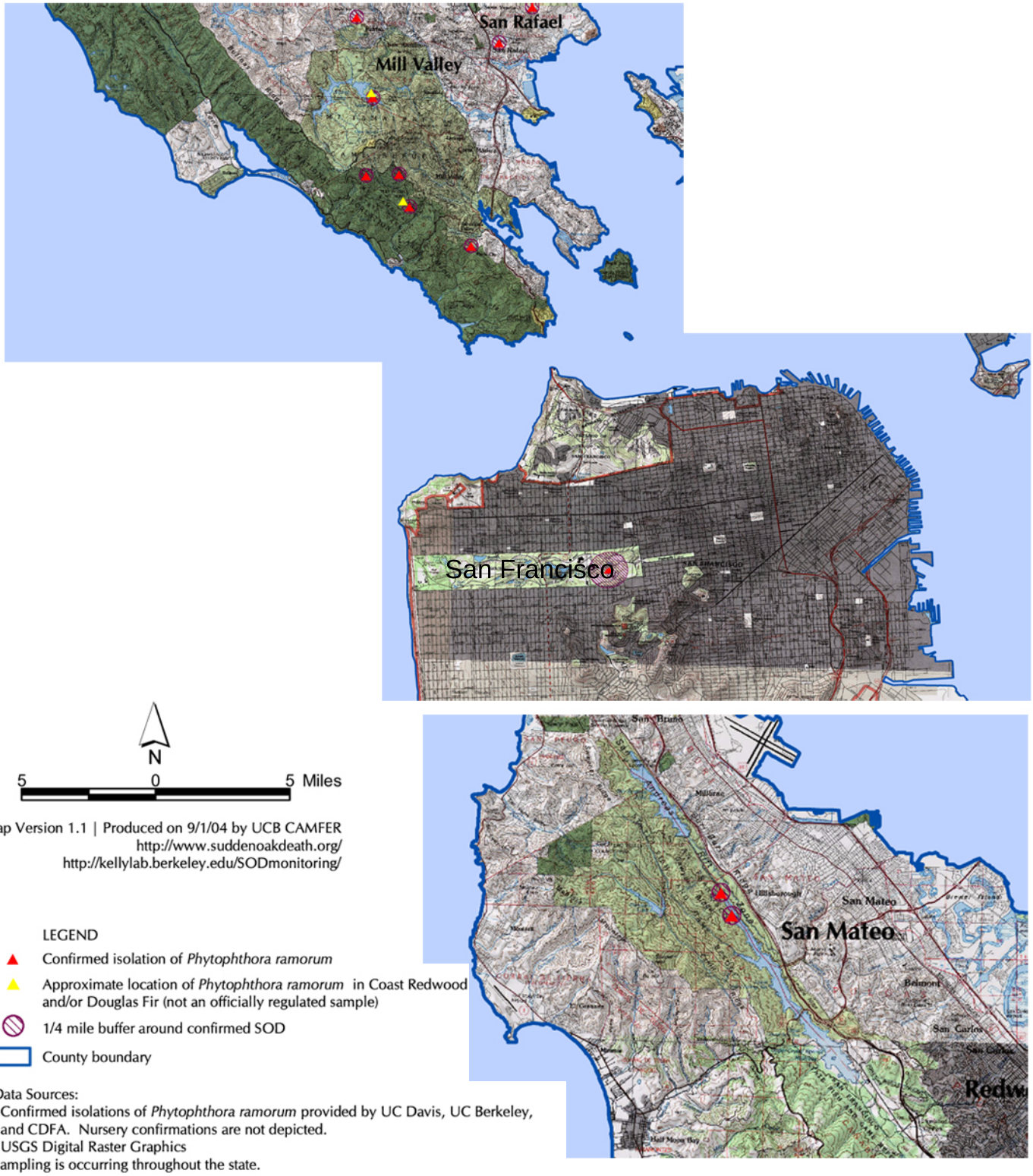
Douglas-fir will generally dominate the post-fire generation in this community. Other tolerant tree species such as redwood develop almost simultaneously (Lotan et al. 1981). The majority of herbs and shrubs associated with this community sprout following crown destruction by fire (Lyon and Stickney 1974). Seeds of some species (e.g., *Ceanothus* spp.*)* require heat treatment before germination. Redwood needles are more flammable than Douglas-fir and will burn with a higher relative humidity. The redwood bark

California Oak Mortality Task Force

Areas of Sudden Oak Death Infestation from Best Available Field Information

Golden Gate National Recreation Area

CAMFER



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5 0 5 Miles

Map Version 1.1 | Produced on 9/1/04 by UCB CAMFER
http://www.suddenoakdeath.org/
http://kellylab.berkeley.edu/SODmonitoring/

LEGEND

- Confirmed isolation of *Phytophthora ramorum*
- Approximate location of *Phytophthora ramorum* in Coast Redwood and/or Douglas Fir (not an officially regulated sample)
- 1/4 mile buffer around confirmed SOD
- County boundary

Data Sources:
- Confirmed isolations of *Phytophthora ramorum* provided by UC Davis, UC Berkeley, and CDFA. Nursery confirmations are not depicted.
- USGS Digital Raster Graphics

Sampling is occurring throughout the state.

Figure 3-11

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chars even with low-intensity fire. Charring can be reduced significantly by limited raking of litter 1 to 2 feet away from trees (Boyd 1984).

The vegetation of the coast redwood and Douglas-fir communities is adapted to the varying effects of fire and can benefit from carefully implemented management actions. Fuel loads within the Douglas-fir-dominated areas present a hazard, and elimination of fire from this environment will only perpetuate and increase this hazard.

These forests have developed a large fuel buildup due to years of fire suppression. The fuel accumulations around the base of redwood trees provide fuels that will produce fire intensity causing fire to climb up the trunks of individual trees. The Douglas-fir trees have very significant ladder fuels that will contribute to fire being carried high into the trees. A fall season fire in this forest can be expected to produce a crown fire. This type of fire is difficult to control, requiring a backing off or containing strategy. Past prescribed fire experience in this fuel type produced fire climbing the bark of trees and burning for hours in the tops of the trees. This fuel type normally produces slow-burning ground fires with low flame heights. The fire may encounter occasional “jackpot” or heavy fuel concentrations that can flare up. Under hot fall weather conditions extreme fire behavior can exist.

The fire hazard at Muir Woods was analyzed by McBride and Jacobs (1978). Five major categories of fire hazard were identified: surface-fuel condition, ladder-fuel condition, downed woody fuel, slope-wind correlations, and ignition risks. The greatest threat of wildfire exists in the alluvial flat and on the northeast and south boundaries of Muir Woods. It should be emphasized that the hazard in this portion of Muir Woods is greater now than when the fire hazard was analyzed and will continue to increase without treatment.

In 1985 a prescribed burn was conducted in Muir Woods National Monument. This was the first step in reducing fuel loads and reintroducing fire into that environment. Subsequent prescribed burns have been implemented with positive results for both fuel load reductions and control of nonnative species moving into the forest understory from adjacent coastal scrub and grassland communities.

Nonnative Evergreen Forest

General Characteristics

Many nonnative tree species have become established in GGNRA through both intentional and unintentional introductions, including ornamental plantings, wind breaks 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.

Fire Ecology

Blue gum (*Eucalyptus globulus*), other eucalypt species, and acacia are inhabitants of the dry schlerophyll forests of Australia, where they have evolved under a frequent fire regime. Adaptations to moderate and intense fire are many, including rapid growth to great heights, which minimizes lower limb exposure to fire; thick fire-resistant bark; fire-resistant seed capsules that take advantage of the open post-fire seedbed and germinate quickly; and the ability to produce epicormic shoots and lignotubers sprouts after intense fires. Since high-severity fires are more advantageous to species reproduction, these trees are considered to be fire-maintained. Such communities tend to have adaptations that allow them to burn more readily than other communities. Eucalyptus in particular produces a ground fuel with high energy potential (due to the high levels of oils) to insure flammability (Mutch 1970).

Low- to moderate-intensity fires are not as advantageous to these species because fewer seeds germinate, the seedbed is not as open, less light is available due to survival of overstory trees and shrubs, and more native fungal pathogens are present. Prescribed fire in eucalyptus needs to be of low intensity in order to reduce hazardous fuel loadings. Frequent burns are needed to keep regeneration low. Low-intensity spring burns typically inhibit most eucalyptus and acacia regeneration (Mount 1969).

The fuel beneath GGNRA eucalyptus and acacia stands has been accumulating due to slow decomposition. Organic matter in eucalyptus soil accumulates slowly and litter decomposition remains as duff, sometimes one foot deep (Mount 1969). All eucalypt studies indicate that the amount of available fuel on the forest floor is one of the most significant factors influencing fire spread and fire intensity (McArthur 1962, Cheney 1988). An extreme fire hazard is apparent in Marin County (Howell 1982). Similar eucalypt stands in the Berkeley hills showed 45 to 100 tons per acre of ground surface fuels prior to the devastating fires in 1991.

Monterey pine and Monterey cypress, although native to California, are nonnative to GGNRA. These tree stands are generally found in conjunction with developed areas such as batteries and other military installations throughout the park, and represent an historic attribute of the vegetation. However, their adaptation to the climate and soils has enabled these planted trees to spread through seedlings to cover large expanses beyond the cultural landscape, again encroaching upon communities that would otherwise have little to no fuel buildup or potential for more than low-intensity flashy fires, including coastal scrub and grasslands. Many of the stands, similar to eucalyptus and acacia, form a continuous vegetation cover between wildland interior areas of the park and adjacent urban or developed zones, posing a threat to both the natural communities (due to changes in fire frequency and intensity) and cultural landscapes and features. Both species are fire-adapted, with serotinous cones (cones open after intense heating, allowing seeds to fall onto newly fire-cleared soils) and oily needles, scales, and underlying duff and litter.

Eucalyptus can be expected to produce an intense fire any time after the surrounding grasslands have cured. The dead and down fuel buildups can be expected to be 125 tons per acre or higher. This fuel does not have a fuel model that represents it. The trees have ladder fuels of shedding bark that produces torching and the very high potential of a crown fire. In December 1990, GGNRA experienced a hard freeze, causing large-scale leaf and limb damage to eucalyptus groves. This freeze damage has significantly contributed to increases in aerial and ground fuels.

Nonnative evergreen forests have created a fire hazard in GGNRA due to the nature of the fuels, fire behavior, and locations in proximity to both urban/developed areas and sensitive species. A hazard fuel reduction program using prescribed fire and mechanical manipulation will continue to be implemented in GGNRA nonnative evergreen forests to reduce fuel buildups and lessen the fire hazard. Fire may also be used to manage historic stands of nonnative forests to remove saplings and ground and ladder fuels, thus both preserving the historic stand structure and reducing fire hazard and potential spread into adjacent native habitats.

Wetlands

Wetlands in GGNRA

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 (Cowardin et al. 1979). 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. 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.

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.

Effects of Fire Management Activities on Wetlands

The major impact of fire management activities on wetlands will result from increased sedimentation. Excess sediment input into a wetland can alter the hydrology and in turn the vegetation composition. Conversely, heavy scouring from increased runoff could affect wetland hydrology by forming new drainage channels that deplete the site of water.

Wetlands burn infrequently and are unlikely to play a role in fire ignition or maintenance, but are important in inhibiting fire spread. When wetlands do burn, the fire usually spreads into them from adjacent vegetation.

Wildlife

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 (ICE 1999). Terrestrial invertebrates in the park are less well-known, with the exception of butterflies in two areas of the park, Marin Headlands and Milagra Ridge, that support diverse butterfly populations.

Wildlife habitats within the park range from introduced eucalyptus and closed-cone Monterey pine and cypress forests to 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.

Mammals

Terrestrial habitats within the planning area support a high 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 park. 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. 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 fuscipes*). Other mammalian carnivores include the raccoon (*Procyon lotor*), striped (*Mephitis mephitis*) and spotted skunks (*Spilogale gracilis*), long-tailed weasel (*Mustela frenata*), and the recently returned river otter (*Lontra canadensis*).

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 detected 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.

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 at 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 and young whales occasionally wander into San Francisco Bay. Southern sea otters (*Enhydra lutris nereis*) are infrequently seen offshore with numbers increasing as the population spreads north.

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 horned 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. In addition, federally threatened northern spotted owls (*Strix occidentalis caurina*) 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. Numerous species of waterbirds also occur within the park in marine and rocky intertidal habitats, cliffs, beaches, and tidal and wetland areas.

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 (*Junco hyemalis*), dark eyed juncos, 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.

Amphibians and Reptiles

Small populations of the federally threatened California red-legged frog (*Rana aurora draytonii*) occur within the planning area. Within San Mateo County, historic records indicate the presence of the federally 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 for breeding or rearing at streams or ponds include California newts (*Taricha torosa*), rough-skinned newts (*Taricha granulosa*), Pacific treefrog (*Hyla regilla*), and California giant salamander (*Dicamptodon ensatus*). Common reptiles include the Western fence lizard (*Sceloporus occidentalis*), northern alligator lizard (*Gerrhonotus coeruleus*), Pacific gopher snake (*Pituophis melanoleusus*), and western terrestrial garter snake (*Thamnophis elegans*).

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 affinis*). The brackish Rodeo Lagoon in the Marin Headlands supports a large population of the federally endangered tidewater goby (*Eucyclogobius newberryi*).

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 federal Endangered Species Act. Intermittent streams or the intermittent headwater streams may support only steelhead trout.

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 federally 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.

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 federally 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.

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, house cats (*Felis domesticus*), and Norway and black rats (*Rattus norvegicus* and *R. rattus*). Nonnative birds found in the planning area include wild turkeys (*Meleagris gallopavo*), European starlings (*Sturnus vulgaris*), peasows (*Pavo cristatus*), house sparrows (*Passer domesticus*), 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 (*Acanthogobius flavimanus*). Nonnative amphibian and reptile species include bullfrog (*Rana catesbeiana*), red-eared slider (*Chrysemys picta*), and the occasional caiman.

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 NPS. 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 federally endangered, 12 are federally threatened, 1 is state endangered, 3 are state 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 federally endangered, 1 is federally threatened, 13 are federal species of concern, and the remaining 15 species are included or proposed for inclusion by the California Native Plant Society.

The USFWS and NOAA Fisheries provided a list of federally threatened, endangered, and proposed species and any designated or proposed critical habitat for consideration during development of the FMP (see Appendix F). Literature reviews, contacts with local biologists and resource agencies, and field surveys were conducted to evaluate the potential occurrence of special status resources in the planning area. For purposes of analysis, special status resources are biological communities, plants, and animals that are (1) identified by state and/or federal agencies as rare, threatened, or endangered or candidates for such designations; or (2) considered sensitive by recognized monitoring agencies and conservation organizations (e.g., California Department of Fish and Game, California Native Plant Society, USFWS). Species listed as species of concern by the USFWS and species of special concern by the California Department of Fish and Game do not have legal protection under the Endangered Species Act but are considered as species that may be candidates for future listing. The listing as species of concern brings these species to the attention of the public and appropriate agency with the aim of obviating the need for future listing through wise management practices.

Special Status Wildlife Species

To evaluate the effects on special status species, a set of species considered likely or possible to experience impacts from fire management activities was selected for assessment based on the presence of suitable habitat within the project area. Appendix F, Special Status Species, evaluates all listed, proposed, or candidate animal species potentially in the planning area and provides a brief summary of presence/absence of suitable habitat and any distribution notes. Vagrant special status wildlife species (e.g., species where individuals have been documented in the park, but where suitable habitat is lacking within the park) will not be discussed further. In addition, most marine and estuarine species are expected to experience little to no impact from fire management activities, because proposed activities are not planned adjacent to coastal resources. Minor impacts from unplanned wildfire and associated suppression activities could occur if wildland fire facilitates coastal erosion and deposition in coastal waters. These marine and estuarine species will not be discussed further. Brief summaries of federally listed species and any designated critical habitat considered likely or possible to experience impacts from fire management activities are discussed separately in the sections below.

San Bruno Elfin Butterfly (Callophrys mossii bayensis) – Endangered

The larval host plant for San Bruno elfin butterflies 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 on 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.

Mission Blue Butterfly (Icaricia icaroides missionensis) – Endangered

Mission blue butterflies are closely tied to the lupine larval host plants *Lupinus albifrons*, *L. variicolor*, and *L. formosus*, with *L. albifrons* considered to be the preferred host (Lambert 2001). These host plants tend to occur on grasslands on thin, rocky soils within broader coastal scrub habitats (Rashbrook 2002). 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, eucalyptus, Monterey pine, gorse, and broom also threatens lupine host plants (Rashbrook 2002). 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*) (Lambert 2001). Habitat loss is probably the primary threat to mission blue butterflies, with trampling of host and nectar plants, larvae, and pupae also of concern (Lambert 2001). Other threats to mission blue butterflies at various stages of their life cycles include parasites, predators, and desiccation and disease during diapause.

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 (Rashbrook 2002). 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 (Rashbrook 2002). 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.

Northern Spotted Owl (Strix occidentalis caurina) – Threatened

Marin County supports a northern spotted owl 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 (Henke et al. 2003). 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 (Fehring et al. 2002).

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 tanbark oak (*Lithocarpus densiflorus*), coast live oak (*Quercus agrifolia*), and California bay (*Umbellularia californica*) (Fehring et al. 2002). 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 fuscipes*) in addition to other forest dwelling small mammals and songbirds (Chow 1996). Within the planning area, known spotted owl locations are currently limited to Muir Woods and the Stinson Gulch area.

California Red-Legged Frog (Rana aurora draytonii) – Threatened

The California red-legged frog is found primarily in wetlands and streams in coastal drainages of central California (USFWS 1994a). 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 (USFWS 1994a). 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 (USFWS 1994a). Aestivation sites are located up to 26 meters from water in dense riparian vegetation (USFWS 1994a).

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. The primary constituent elements for critical habitat are summarized in Table 3-11.

Table 3-11: Primary Constituents of Critical Habitat for California Red-Legged Frog

Essential Aquatic Habitat	Essential Dispersal Habitat	Essential Upland Habitat
Still/slow water	No barriers	Within 90 meters of aquatic habitat
≥0.5 meter freshwater depth	>90 meters wide upland/aquatic area	
Space, food, cover for all life stages		
≥2 suitable breeding sites and permanent water with no more than 2 kilometers between breeding sites		

Source: USFWS, 2001.

San Francisco Garter Snake (Thamnophis sirtalis tetrataenia) – Endangered

This snake 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 (USFWS 1985). It is considered semi-aquatic and is found along the margins of ponds, lakes, streams, and estuaries (above tidal influx) (Barry 1978). It feeds on small amphibians and fish, especially the federally threatened California red-legged frog (*Rana aurora draytonii*) (USFWS 1985). 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 for the snake and habitat assessments 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 NPS and the USFWS are currently planning inventory and enhancement activities for the San Francisco garter snake at Mori Point/Sharp Park.

California Freshwater Shrimp (Syncaris pacifica) – Endangered

The California freshwater shrimp is endemic to 17 coastal streams in Marin, Sonoma, and Napa counties north of San Francisco Bay. The shrimp is found in low-elevation (less than 116 meters), low-gradient (generally less than 1 percent), perennial freshwater streams where banks are structurally diverse with undercut banks, exposed roots, overhanging woody debris, or overhanging vegetation. Existing populations are threatened by introduced fish, deterioration or loss of habitat because of water diversions, impoundments, livestock and dairy activities, agricultural activities and developments, flood control activities, gravel mining, timber harvesting, migration barriers, and water pollution. Within PRNS and GGNRA, reproducing populations are found within the Lagunitas Creek watershed along the mainstem from Shafter Bridge in Samuel P. Taylor Park to roughly 1.6 kilometer below the confluence with Nicasio Creek (Serpa 1991) and in lower Olema Creek (Fong 1999). Recent surveys in 2002 at various coastal streams at PRNS have not found any new populations of the shrimp (LoBianco and Fong 2003). However, all shrimp observations have been restricted to sites managed by PRNS. No shrimp have been found on GGNRA-managed lands despite presence of suitable habitat (Fong 1999).

Tidewater Goby (Eucyclogobius newberryi) – Endangered

The tidewater goby is a small benthic fish that occurs in the upper end of California coastal lagoons in salinities less than 10 parts per thousand (USFWS 1994b). 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 (Irwin and Soltz 1984). Within the planning area, tidewater goby is known only from Rodeo Lagoon in the Marin Headlands.

Coho Salmon, Central California Coast (Oncorhynchus kisutch) – Threatened;
Steelhead Trout, Central California Coast (O. mykiss) – Threatened

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.

Central California coast coho salmon (hereafter referred to as coho) 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). 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.

Central California steelhead trout (hereafter referred to as steelhead) 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.

Both species are 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. Adult steelhead enter planning area streams in the late winter through spring to reach spawning sites, typically well-aerated areas with small- to medium-size gravel. Most adult coho return to freshwater systems to spawn in fall and winter months after spending 1.5 years in the ocean. Optimal habitat conditions for juvenile coho seem to be deep pools created by rootwads and boulders in heavily shaded stream sections. Habitat preferences for juvenile steelhead are similar, although young-of-the-year steelhead are often forced into shallow-water habitats. Most juvenile coho leave the streams for the estuary and ocean after 1.5 years of residence. The amount of time steelhead rear in freshwater and marine/estuarine habitats is variable, ranging between one to three years.

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.

Special Status Plant Species

Within the areas considered under the GGNRA FMP, 26 special status plant species[2] are supported by existing habitat (see Appendix F for species listing status). Three are listed by the federal Endangered Species Act as either threatened or endangered; 20 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 2001 (NPS 2000a) states that the NPS will inventory, monitor, and manage state and locally listed species in a manner similar to its treatment of federally listed species. The policies also state that the NPS will inventory other species that are of special management concern to parks such as locally rare, declining, sensitive, or unique species.

Federal Threatened, Endangered, Candidate, and Proposed Plant Species that May Occur in Affected Areas

All three federally listed species within the planning area have the potential to be affected by FMP actions. These species are described below, and are included in the Biological Assessment that has been prepared in conjunction with the EIS for review by the U.S. Fish and Wildlife Service and NOAA Fisheries.

Raven's manzanita (*Arctostaphylos hookeri* ssp. *ravenii*) is a perennial prostrate to low-growing shrub. It exists as a single individual east of Lincoln Boulevard (in Area B) of the Presidio on a serpentine outcrop. Clones of this individual have been out planted west of Lincoln Boulevard in suitable serpentine coastal prairie habitat. The management of this species is guided by the Recovery Plan for Coastal Plants of the Northern San Francisco Peninsula (USFWS 2003), which suggests the species is stress-tolerant with sparse competing vegetation, but is relatively intolerant of direct vegetative competition such as shading from shrub or tree canopies. Although most manzanita species benefit from fire – the hard-coated seeds in the soil typically germinate post-fire, and most species also stump sprout – the effects of fire on this one individual and its clones are unknown. Raven's manzanita lacks burls (lignotubers), specialized flattened trunk-like structures that are adapted to rapid vegetative regeneration following fires. There have been no reports of natural seedling establishment around the remnant wild Raven's manzanita nor from the clones, which may indicate a lack of viable seed, seed predation, or lack of sufficient seedling microsites. No data are available on the natural germination ecology of this species, but the Recovery

[2] Additional special status species occur within the park's administrative and legislative boundaries and are managed by other agencies. These agencies include the Presidio Trust for Area B of the Presidio, the City and County of San Francisco for San Francisco watershed lands, the United States Air Force at the Mill Valley Air Force Base on Mount Tamalpais, and the NPS – PRNS for GGNRA lands north of the Bolinas-Fairfax Road that are managed by PRNS staff. These species are monitored regularly by staff at GGNRA and PRNS, but are not included in the following discussion because they are managed by other entities.

Plan suggests that seed germination could be stimulated by burns as with other manzanita taxa farther south on the San Francisco peninsula.

Marin dwarf-flax (*Hesperolinon congestum*) is an annual herb that is found in GGNRA as a small population west of Lincoln Boulevard of the Presidio. It grows within the serpentine coastal prairie-grassland habitat, and is somewhat affected by nonnative plant encroachment and trampling of offtrail use. Population trend monitoring of this and adjacent populations indicates that this species is stable to increasing in numbers in the area, although trends are difficult to interpret due to the wildly fluctuating annual population sizes typical for annual species. Other areas, not under direct management of the NPS, suggest that overall impacts on the species are from nonnative and native plant species encroachment, particularly from shrubs. These species encroach on suitable habitat and limit the annual display of this species. Management of the Marin dwarf-flax is guided by the Recovery Plan for Serpentine Soil Species of the San Francisco Bay Area (USFWS 1998). This plan suggests that primary protection and recovery actions should focus on removing nonnative plant species and minimizing trampling of plants, population areas, and suitable habitat around the population. Key research needs in the plan include the need to determine the effects of burning on the species – an issue being investigated in test populations outside GGNRA-managed lands (Thomas 2004).

San Francisco lessingia (*Lessingia germanorum*) is a low-growing, slender-stemmed annual herb of the sunflower family (Asteraceae). Robust plants have diffusely branched stems and grow up to one foot high, spreading close to the ground. Small plants may be very short and nearly erect, with few or no branches. Leaves are narrowly lance-shaped, lobed and toothed or entire, mostly an inch or less long. The leaves and stems are covered with grayish, wooly, loosely interwoven hairs. San Francisco lessingia is now narrowly associated with either sparse vegetative cover or substantial vegetation gaps, usually related to past artificial disturbance of the substrate or the vegetation. Historic populations were probably associated with early stages of succession following natural dune blowouts, or other local disturbances within coastal dune scrub. The management of this species is also guided by the Recovery Plan for the Coastal Plants of the Northern San Francisco Peninsula (USFWS 2003), which indicates that primary impacts on this species are related to the edge effects of adjacent vegetation, including shading, nonnative plants, and wind blockage. This plan suggests that primary protection and recovery actions should focus on removing nonnative plant species, minimizing edge effects, and increasing or enhancing suitable habitat around the population.

Federal Plant Species of Concern, California-Listed Species, and Additional Plant Species of NPS Management Concern that Occur in Areas that May be Affected by the GGNRA FMP

Twenty-three additional special status plant species occur within areas considered by the FMP. These species are briefly described below in relation to their habitat occurrences.

Chaparral. Marin manzanita, Glory brush, and Mason’s ceanothus are evergreen shrubs that grow in the limited chaparral community on Bolinas Ridge south of the Bolinas-Fairfax Road. Threats to these species are excessive shade from overcrowding from high shrub densities, lack of disturbance to trigger seed germination and reproduction, nonnative species encroachment (particularly French broom), and possibly suppression of fire.

Grassland and Coastal Scrub. Coast rock cress is a perennial herb found throughout GGNRA, including the Marin Headlands, Presidio, Milagra and Sweeney Ridges, and Pedro Point. It grows on rocky outcrops and serpentine bluffs in coastal grasslands, where it is relatively common within the park. Habitat loss through urbanization (on a statewide scale), nonnative plant species encroachment, and alteration of coastal grasslands to coastal scrub through the establishment of coyote brush and other scrub species are the primary threats to this species. Oakland star-tulip is a perennial lily that was recently discovered in the vicinity of Muir Woods in non-serpentine grasslands, whereas larger and well-documented populations exist in the San Francisco watershed and on Mount Tamalpais. The species is threatened by nonnative plant species encroachment into suitable habitat. San Francisco wallflower is a short-lived perennial forb and is found throughout the Marin Headlands, and at Fort Point and the Presidio, Fort Funston, Sweeney and Milagra Ridges, and Pedro Point in scattered populations. It is found within coastal grassland and coastal scrub communities, as well as on rocky outcrops and coastal dunes. It thrives on new ground disturbances and is threatened by encroachment of dense shrubs. San Francisco gumplant is a perennial forb endemic to San Francisco County, where it inhabits serpentine coastal bluffs and grasslands. It occurs at the Presidio, where threats are confined to nonnative plant encroachment into suitable habitats and the development of (unplanned) social trails that increase natural erosion rates and increase trampling of individual plants. Arcuate bush-mallow, a small perennial shrub, was last observed on Sweeney Ridge in 1994. It does not occur elsewhere within GGNRA. This plant may not be present, or present in very small numbers due to lack of fire. However, seeds of species in this plant family (Malvaceae) typically lie dormant for decades and germinate vigorously after fire.

Forested Areas. California bottlebrush grass is a perennial bunchgrass that appears to be locally common where it occurs within the planning area, although its overall distribution is restricted in California. It occurs in the Marin Headlands, on moist western slopes of Bolinas Ridge, in Muir Woods, and in Oakwood Valley, where it inhabits the understory of Douglas-fir forests and native hardwood (California bay laurel) stands. Known populations appear to be stable with little threat from surrounding plant species or developments.

Wetlands and Riparian Areas. Choris's popcornflower is a small annual forb found in moist depressions in the coastal grasslands of Sweeney Ridge. It is threatened by the establishment and spread of nonnative plant species, especially oxe-eye daisy (*Leucanthemum vulgare*), and by soil disturbance (such as through trail maintenance) while the plant is growing and flowering. Franciscan thistle is a short-lived perennial herb found in freshwater seeps and drainages in the Marin Headlands, Fort Point, and Presidio coastal bluffs. Primary threats to the species are nonnative plant species encroachment – particularly bull thistle (*Cirsium vulgare*), poison hemlock (*Conium maculatum*), and Cape-ivy (*Delaria odorata*) – and changes in the water table from manipulations to trails, fire roads, and culverts above extant populations.

Coastal Dune and Marsh. The majority of special status species within this habitat are restricted to specific sites on the Presidio in areas unlikely to sustain fire management activities. These species include pink sand verbena, Nuttall's milk-vetch, California saltbush, coast Indian paintbrush, north coast bird's-beak, California croton, San Francisco dune gilia, Kellogg's horkelia, coast rein-orchid, Mission Dolores (San Francisco) campion, and pacific cordgrass. Two additional species – San Francisco spineflower and dune tansy – occur at both the Presidio and Fort Funston in sandy coastal scrub and dune habitats.

3.5 Social Environment

Cultural Resources

The NPS recognizes five categories of cultural resources for management purposes.

Archeological resources are the remains of past human activity and records documenting the scientific analysis of these remains. They are typically buried but may extend aboveground; they are commonly associated with prehistoric peoples but are also commonly products of more contemporary society. They shed light on often otherwise unrecorded questions, such as social organization, and have helped researchers to understand the spread of ideas over time and the development of settlement from place to place.

Cultural landscapes are environmental settings that human beings have created in the world that reveal the fundamental ties between people and the land and reflect the human need to grow food, give form to settlements, meet a need for recreation or work, or bury the dead.

Structures are material assemblies that extend the limits of human capabilities, such as buildings to keep people warm and dry. Bridges to cross barriers, ships and trucks to carry goods over long distances, fortifications for protection, and statues and monuments to commemorate human achievement, all are types of structures.

Ethnographic resources represent basic expressions of human culture and contribute to the continuity of tangible and intangible cultural systems, such as traditional arts, native languages, religious beliefs, and subsistence activities. In parks, they include special places in the natural world, structures with historic associations, and natural materials.

Museum objects are tangible manifestations and records of behavior and ideas that span the breadth of human experience and the depth of natural history. They are evidence of intellectual and technical development, of scientific observation, of personal expression and curiosity, and of common enterprise and daily habits. They are invaluable and irreplaceable samples of the world through time and place and of the multitude of life therein.

Cultural Resource Context for GGNRA

These five categories of cultural resources are the tangible manifestations of human beings interacting with their environment and with each other throughout some 100 centuries of time, up to the present day, in the lands now known as GGNRA. To understand the effects of the alternatives on the cultural resources of the park, it is necessary to concisely trace the contexts within which these interactions occurred and within which they were created.

Native American populations in California were once among the densest in all of North America. The lands around San Francisco Bay were occupied by scores of tiny tribes, each of which held territories some 8 to 12 miles across, that are now grouped into two major communities primarily because of linguistic similarities – the Coast Miwok north of the Golden Gate and the Ohlone to the south of the

Golden Gate. Because they lived off the seeds, fish, and animals of their local environments, details of their lives differed somewhat among coastal, bay shore, riverine, and interior valley homelands. Intermarried extended families grouped together in tribes that protected their tiny territories fiercely against the encroachment of neighbors. But adjacent tribes were also bound together by a complex web of intergroup marriages and trading alliances. Coast Miwoks and Ohlones were integrated so seamlessly into their environment that it is easy to overlook just how sophisticated and extensive were their techniques of managing the lands for food, shelter, and other purposes.

The era of Spanish exploration and settlement brought great disruption to the traditional Native American ways of life. Indeed the interaction between the two cultures decimated native populations and brought an end to the Bay Area tribal world. Motivated by a global rivalry for political, military, and economic dominance, Spain's New World colony in Mexico entered a period of expansion, spurred by news of Russian and British activity in the far northwest. In 1769 the Portola Expedition discovered and claimed San Francisco Bay on behalf of the Spanish Crown, and in 1775-1776 the Anza expedition brought settlers from Sonora overland to found a mission and a presidio.

Spanish colonial settlement followed a rather rigid and complex system that had developed over 200 years of northern expansion beginning in 16th-century Mexico City. The Presidio functioned, here as elsewhere, as the military and civil complex and advance guard of territorial settlement, and shared a social and economic function with the mission (Langellier 1992).

Mexico became independent of Spain in 1822, as one consequence of widespread anti-colonial revolution in Latin America. But outward change came slowly to the isolated, neglected, and poor garrison at the Presidio of San Francisco. Within the decade, the Mexican government had decreed the secularization of the missions, dividing their holdings into self-supporting ranchos and replacing the Franciscan missionaries with regular parish priests. The political center of power thus shifted more and more toward a landed elite, and regional land use patterns still recognized today were set in place. The vast ranchos with their equally vast herds of cattle became the basis for much of the economic activity in the area. Decentralized trade became more common, encouraged by visits from "Boston ships" carrying the American flag, and overland parties from the expanding nation far to the east began to intrude more and more on the Hispanic society of California, culminating with its annexation to the United States in 1848.

The westward expansion of the young United States in the name of "manifest destiny" is reflected in the central role of the Golden Gate as the grand entrance by sea to the Pacific West and all its potential. The California Gold Rush of 1849 transformed that future potential into a very sudden, very busy era of settlement, urbanization, industrial growth, resource extraction in the gold fields and forests, and rapid establishment of a world-renowned city at the tip of the San Francisco peninsula.

To the north of the city, new settlers began to develop a regionally significant dairy industry in the 1850s that thrived for 100 years; a number of the original dairy ranches continue to operate, as cattle ranches, within the park boundaries. These dairy ranches played an instrumental part in the development of the industry in California. They were at the forefront of industry modernization; they led the state in dairy production into the 1890s, they became a primary destination for immigrants from Switzerland and the Azores, and they brought a rich ethnic mix to the area that remains to this day. As the ranch complexes

stayed in use until quite recently, they continue to impart a pastoral, scenic, and distinctive regional flavor to the rural historic landscape of west Marin and the northern lands of GGNRA (Livingston 1995).

As the population and economic development in the San Francisco Bay Area soared in the years following the Gold Rush, the transportation network grew apace in order to move people and goods more efficiently. The growth of the port was paralleled by construction of aids to navigation at crucial points along the Golden Gate and along the coast – lighthouses, fog signal stations, life-saving stations, and Coast Guard stations. On land, ancient trails used by the native tribes sometimes became wagon roads and, eventually, paved roadways; some still survive in the form of contemporary hiking trails. Other farm roads, rural highways, streetscapes, ferry piers, and railroad rights-of-way developed in response to local and regional transportation needs.

San Francisco Bay was described by the first European explorer to see it as wide enough to shelter all the navies of the world. Ever since, it has been an important strategic consideration in the military and political balance of power in the Pacific. The Spanish built the first fortifications at the harbor entrance in 1794, and the Americans began their impressive network of seacoast defenses at Fort Point and on Alcatraz even before the Civil War broke out in 1861. By the turn of the 20th century, the major naval base at Mare Island and the widespread port and industrial facilities throughout the area impelled the U.S. Army to build modern concrete and steel fortifications along the Golden Gate on a scale unmatched in the Pacific. Only the much larger city of New York had fortifications on a scale equaling those at San Francisco Bay.

At the start of the 20th century, as the United States assumed control of territories across the Pacific Ocean in the Philippines, in Hawaii, and in the Panama Canal Zone, Fort Mason became the major port of embarkation for troops and supplies going to these overseas outposts. After the attack on Pearl Harbor propelled the United States into World War II, the West Coast became an official theater of war and its defenses were reinforced accordingly for “the duration.” During the long tense years of the Cold War that followed, the Army deployed Nike anti-aircraft missiles around the Golden Gate hinterlands – the last in a long line of defenses that date back nearly 200 years.

As these great social, political, and economic trends unfolded, they were enabled and enhanced by technological and engineering advances. These are manifested by the great prisms lit by whale oil, then kerosene, at the Point Bonita Lighthouse; the contrast between the seemingly numberless and intricately layed bricks at Fort Point and the massive concrete gun batteries of the Marin Headlands; and, especially, by the turbulent waters of the Golden Gate spanned by the world-famous bridge that bears its name.

The development of architecture and landscape architecture was informed by, and related to, these technological and engineering advances. The park today contains archeological remains of adobe brick structures, utilitarian and ornamental wooden homes and barracks, and brick and concrete buildings; the profusion of historic structures within the park is a veritable catalog of architectural style over some 200 years. The massive warehouses at lower Fort Mason and the curving row of artillery barracks at Fort Winfield Scott vie for the honor of introducing Mission Revival to the architectural palette of northern California’s public structures. The Cliff House at Lands End reflects the early use of reinforced concrete

in the rebuilding of San Francisco after the great earthquake and fire of 1906. The cellhouse on Alcatraz Island was the largest reinforced concrete building in the world when it was completed in 1912.

Great cities require civic amenities, and San Francisco was in the forefront of opening parks and seaside recreational areas for its citizens. Indeed Adolph Sutro's gardens at Sutro Heights overlooking the fanciful Sutro Baths at Nyad Cove are noteworthy in providing healthy and educational outdoor opportunities for people of all social and economic strata. The Presidio in San Francisco and Fort Baker in Marin County also played important roles as pleasant, well-landscaped recreational areas for the local citizenry and for national and international visitors too – presaging their roles in the present national park. Urban areas also have their dark side, and nowhere does that underworld more eloquently speak from the past about prisons, prison life, and penology than at Alcatraz Island.

These diverse and significant historical threads are all related in some way to the land use patterns that developed in the region and to the use of the land for settlement, for production, and for its resource values. The native tribes affected the resources of the area in a sophisticated manner that is perhaps so subtle, compared to what followed, that it appears they had no impact at all upon the "wilderness." Yet the detailed composition of the regional ecosystems was clearly influenced by human beings for thousands of years. Widespread cattle grazing is widely perceived to have brought the earliest broad changes by European peoples to the Bay Area landscape. These changes accelerated dramatically in the American era with widespread logging deforesting most of the timber stands within present park boundaries. Siltation from increased erosion in logged areas affected natural wetlands, while San Francisco Bay on a larger scale was affected by silt-laden runoff from water-cannon mining in the Sierra foothills and by purposeful filling of the shoreline for development projects such as the 1915 Panama Pacific International Exposition. The abundant natural resources of the area, as in the West as a whole, were the fuel for the economic engine that built houses and ships, drove vehicles, watered mouths and fields, and gave mineral riches to the economy. They are the historical foundation of the West that today's generation has inherited.

Where resource exploitation was most egregious, however, it became the rallying point for a small but growing national conservation movement, one that, in many ways, can rightly call the Bay Area its birthplace. In 1908 Congressman William Kent donated the largest old-growth redwood grove in the north bay to the nation as a national park on the condition that it be named for naturalist John Muir. It was one of the first uses of the Antiquities Act, formulated to protect archeological sites, to preserve natural wonders. In 1916, the Sierra Club, founded in the Bay Area, lost its bitter battle to preserve Hetch Hetchy Valley in Yosemite from being filled as a reservoir. But in losing a battle, it may have won a war, for the organization thrived in future years on a crest of national outrage over the outcome. In 1928, Mount Tamalpais State Park was established to preserve some of the most scenic natural acres in the Bay Area. And about the same time, one of the best local park organizations in the country, the East Bay Regional Park District, began to create a greenbelt along the crest of the East Bay hills.

Thus the stage was set for the establishment of GGNRA in 1972. As post-war suburban sprawl threatened the open space in the region, the once-powerful military-industrial complex in the area began to subside. The historic coincidence of the anti-growth movement with a revitalized conservation movement took

advantage of the unparalleled opportunity created by the closure of the large and largely undeveloped Army posts ringing the Golden Gate headlands. Thus was formed GGNRA, as community activism met public need and created a great national park to preserve open space, natural habitat, scenic wonders, and historic values in the San Francisco Bay Area (Rothman 2002).

Cultural Resources by Category

Fire management actions such as prescribed fire, suppression activities, and mechanical treatments have the potential to affect cultural resources such as archeological sites, structures, ethnographic resources, and cultural landscapes within National Landmark and National Register Historic Districts, as well as museum collections and other properties managed by the park as cultural resources. For a listing of historic properties within GGNRA, excluding archeological sites, see Appendix D. Cultural resources in Golden Gate are subject to the provisions of the National Historic Preservation Act (NHPA), which requires identification and assessment of park resources for their eligibility for the National Register of Historic Places (Section 110) and consideration of the effects of any undertaking on resources that are on, or determined eligible for, the National Register (Section 106). It is NPS policy that every effort be made to minimize the effects of such undertakings and avoid adverse effects on historic resources (NPS 2000a).

The environment with potential to be affected – both positively and negatively – by fire management activities at GGNRA may now be discussed by specific resource category with an understanding of their historical context.

Archeological Resources

There are 52 archeological sites included in the Archeological Survey Management Information System for Golden Gate National Recreation Area, and numerous additional sites are presumed to exist. Their significance is assessed through the use of research agendas based upon historical contexts. Archeological resources from indigenous populations of Native Americans within the present boundaries of GGNRA typically consist of sites, such as village sites, camps, rock shelters, procurement sites such as food gathering and hunting spots or quarries for tool making, food processing sites such as shell middens, funerary sites, and trails. Isolated artifacts relating to many of the above functions may appear in areas with greater or lesser association to these sites. Human remains have been identified in association with shell middens within the park, and it may have been a widespread cultural practice to associate the burial of the dead with the activities of the living.

Historic period archeological resources are of a different nature, and consist primarily of two types: remains of buildings and structures, and trash or refuse dumps. Besides the known archeological resources from the prehistoric and historic eras, there are almost certainly numerous archeological resources that remain to be discovered within park boundaries. This is because only a small percentage of the lands within GGNRA have yet been surveyed to professional standard, because archeological sites within surveyed areas are so numerous, and because such resources regularly are brought to the park's attention through maintenance activity, development, visitor use activity, and other means. At present, the park uses a model based upon soil type slope ratio and proximity to sources of water to predict areas of potential archeological sensitivity.

A low-intensity fire may actually be beneficial to the management of archeological resources, in the sense that the removal of dense vegetation may open up previously inaccessible areas for survey and identification. However, removal of ground cover, whether by fire or mechanical methods, may make sites more vulnerable to looting or erosion. In general, quick-moving fires, in which the heat impulse is directed largely upward, have relatively little impact on buried archeological resources, while fires that move slowly and direct heat downward have greater impact, with sites consisting of inorganic material being less sensitive to low and medium temperatures than those containing organic material. Alterations to drainage patterns through ground disturbance or change in vegetative cover may have impacts on archeological and other cultural resources. Archeological sites on the surface or subsurface could be damaged by heat from prescribed burning or wildfires, disturbed by the clearing of containment lines around prescribed burns or wildfires, or damaged by the operation of heavy equipment over sites or into sites if heavy equipment use includes soil disturbance as part of fuel reduction projects. The use of staging areas for fire management activities and equipment also has potential to damage archeological resources if the staging areas are not sited away from areas of known and predicted sensitivity.

Much as they may affect landscape resources in unanticipated ways, the application of fire-retardant chemicals during wildland firefighting may have unforeseen effects upon buried and unburied archeological resources. More research is needed in order to be able to identify these effects at any useful level of detail.

Cultural Landscapes

Parklands contain extensive areas of historic period cultural landscapes, significant in the areas of farm life and agriculture, military affairs, and designed landscape architecture. In particular, many of the dairy ranches of West Marin, the former Army posts along the Marin and San Francisco headlands, and the public parks and recreational complexes along the San Francisco shoreline retain a high degree of integrity relating to their period of historical significance. The most extensive cultural landscapes are the former military lands and the rural agricultural landscapes. These are also the areas where fire management activities will have the most effect on historic landscape resources through wildfires, by prescribed burns, by provision of access for fire equipment and vehicles, and by mechanical fuel load reduction activity.

These landscapes consist of clusters of, and individual, buildings, structures, and small-scale features; the circulation networks connecting them; the land use patterns characteristic of the landscape type; boundaries and boundary markers; water features; depositional features; vegetation patterns and components; and the topography upon which all these lie. Particular activities, lack of activity in some cases, and certain fire conditions have the potential to put at risk a broad range of values that directly affect the integrity of landscape resources. (See Figures 3-12, 3-13, and 3-14.)

The very existence of historic buildings and the safety of their occupants are affected by lack of defensible space, excessive fuel loading nearby, and proximity to sources of water. Creating defensible space and reducing dangerous fuel loads have the obvious beneficial effect of reducing structural fire danger, but must take historic vegetation material, boundary demarcations, and land use patterns into account in order to avoid adverse impacts on these character-defining features of historic landscapes.


Golden Gate National Recreation Area
Cultural Landscape Inventory -- Marin
National Park Service
U.S. Department of the Interior
Bolinas Copper Mines
Wilkins Ranch
Bolinas Lagoon
Muir Woods
Dipsea Trail
Camp Monte Vista
Druid Heights
Stinson Beach
Hill 640 Military Reservation
Camino del Canyon
Miwok Trail
Miwok Trail
Banducci Flower Farm
Miwok Trail
Marin County
Golden Gate Dairy
Sausalito
Pacific Ocean
D Ranch & Rapozo Ranch
Fort Cronkhite
Fort Baker
Fort Barry
Point Bonita Lifesaving Station
Point Bonita Lighthouse Complex
Cultural Landscapes
Area Managed by Golden Gate NRA
Other Public Lands
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Figure 3-12

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Golden Gate National Recreation Area
Cultural Landscape Inventory -- San Francisco
National Park Service
U.S. Department of the Interior
Alcatraz
San Francisco Bay
Fort Mason Historic District
Presidio of San Francisco
Land's End
Presidio of San Francisco
Fort Miley
Point Lobos
Adolph Sutro
Historic District
Ocean Beach
Fort Funston
Pacific Ocean
Cultural Landscapes
Area Managed by
Golden Gate NRA
Other Public Lands
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Figure 3-13

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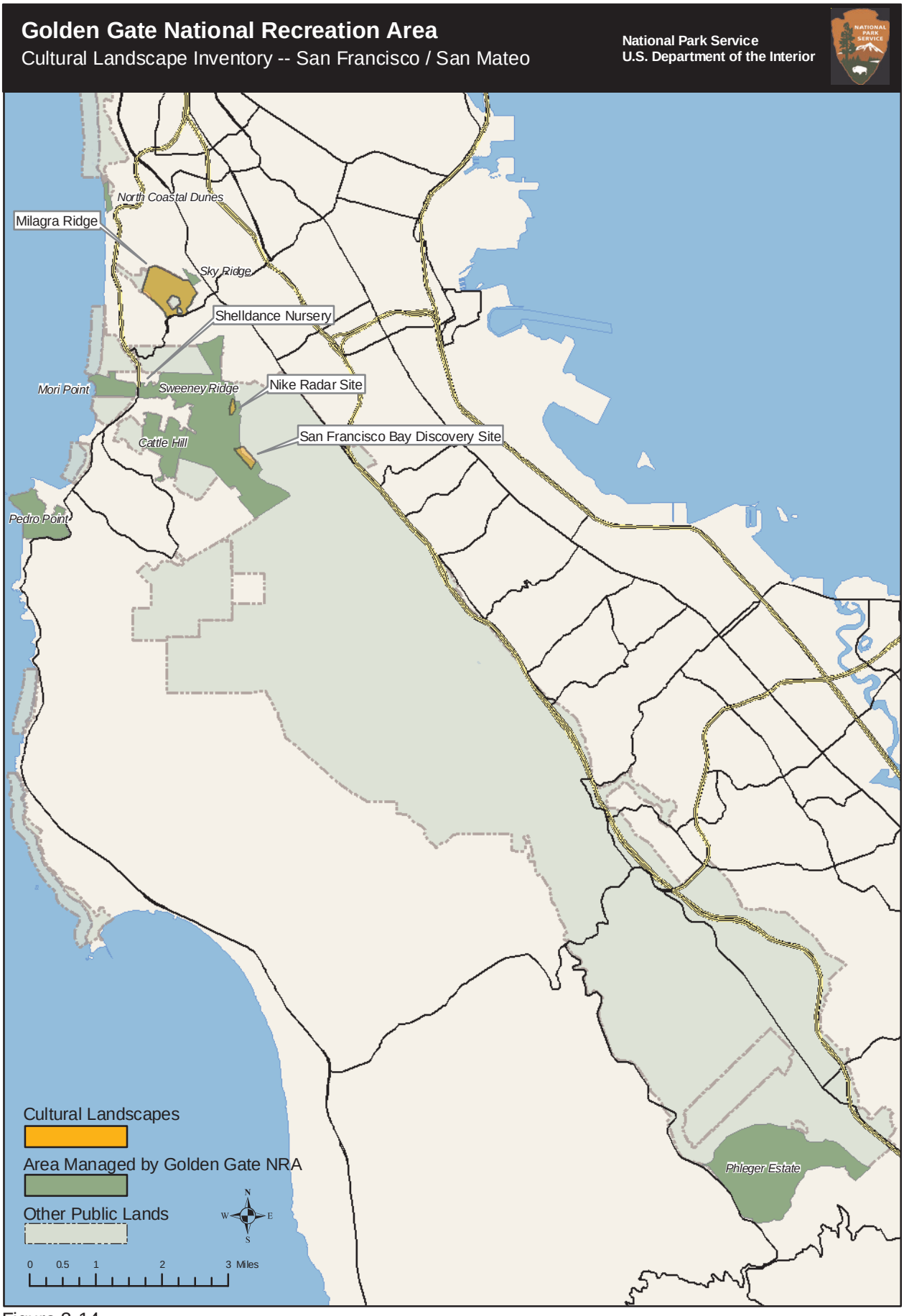
Golden Gate National Recreation Area
Cultural Landscape Inventory -- San Francisco / San Mateo
National Park Service
U.S. Department of the Interior
North Coastal Dunes
Milagra Ridge
Sky Ridge
Shelldance Nursery
Mori Point
Sweeney Ridge
Nike Radar Site
Cattle Hill
San Francisco Bay Discovery Site
Pedro Point
Phleger Estate
Cultural Landscapes
Area Managed by Golden Gate NRA
Other Public Lands
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Figure 3-14

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The use of power tools, motor vehicles, and heavy equipment without careful allowance for the integrity of roads, pathways, tracks and trails, plantings, and drainage features could adversely affect features such as road surfaces, road prism, circulation network alignment, gates, fences, and cattle guards. Properly informed by cultural landscape information, however, such equipment can be of enormous value in providing access to overgrown areas, especially fire roads, and restoring the historic feel of long-neglected areas.

Historic patterns of land use have a tendency to change over time and to be obscured by neglect and by uncultivated vegetation growth. Landmark trees, open vistas, ease of walking, field and garden planting patterns, the open spacing of orchards, evidence of grazing, and specific species composition all diminish without active human management. Fire and fire management activities can have both beneficial and detrimental effects on historic land use patterns. Fire set under proper prescription can keep open fields in grassland, avoid the choking feel and high fire hazard of spreading scrub, and avoid damage to historic fence lines, significant vegetative species, and important trees. Where fire use is not appropriate, mechanical fuel reduction activities can have the same beneficial effect provided cultural resource values are taken into account. Mechanical fuel reduction is particularly beneficial in managing the spread of planted trees, such as eucalyptus, Monterey cypress, and Monterey pine, beyond their intended extent.

Erosion, whether because of the denuding of soil cover after fire or because of human-caused fire management activity, has the potential for major adverse effect on cultural landscape resources such as the quality and alignment of water features, the circulation patterns, roads, paths and trails, the integrity and function of drainage systems, the suitability of the land for historic grazing and growing purposes, and the very feeling of the pastoral landscape.

The application of fire-retardant chemicals during wildland firefighting may have unforeseen effects upon the post-fire growth of vegetation within an historic landscape, but more research is needed in order to be able to identify these effects at any useful level of detail.

Structures

Fire management actions, or lack of action, will clearly affect the safety of many of the park's approximately 700 historic structures. Basic fire safety measures such as regular inspections, provision of emergency exits, and installation of smoke alarms and sprinkler systems have a great deal of positive benefit for the preservation of historic buildings. But these structural fire safety actions, important as they are, lie largely outside the scope of the affected environment for the FMP, and are addressed through NPS Director's Order 58.

The most substantial beneficial impacts of wildland fire management activities can be anticipated from the creation and maintenance of defensible space around historic buildings and structures through pruning or removal of dense, overgrown, and highly flammable vegetation growing nearby. The maintenance of access for firefighting equipment and personnel via fire roads, alleys, and adjacent spaces is also of importance in the preservation of historic building resources. Direct negative impact of such activities on the historic integrity of buildings themselves is unlikely, although indirect adverse effects on nearby landscape elements are possible if activities are not planned and carried out with sensitivity.

Ethnographic Resources

Ethnographic sites within GGNRA that have the potential to be affected by fire management activity are largely considered to be places, landscapes, and features with specific cultural meaning to Ohlone and Coast Miwok peoples. No such sites have presently been identified by the NPS or have been brought to the park's attention to date by Ohlone or Coast Miwok tribal members. However, the NPS is presently developing an ethnohistory study, in association with notable scholars, to better formulate an ethnographic context for Native American cultural associations within GGNRA. In addition, as part of the NEPA process for the FMP FEIS, the GGNRA consulted with representatives of local tribes to determine if such sacred sites are located within GGNRA lands. Through the course of implementing the FMP, the NPS will consult with the tribes as appropriate. Additional ethnographic sites, such as traditional gardens, may be associated with the predominant Azorean culture of the West Marin dairy ranching families.

As ethnographic resources are identified, the effects of fire management activities on those resources will be defined through the disciplines of ethnography, cultural landscapes, archeology, horticulture, and natural sciences, as appropriate. In every case, culturally associated groups will be consulted to the extent feasible and required by law, regulation, and policy. Fire management activities may have positive effects, such as restoring significant vistas or triggering growth in fire-dependent species of interest, as well as negative effects, such as increasing erosion or harm to individual signature trees.

Museum Objects

Structural fire management actions aside, there is little chance for fire management activities to directly affect park museum collections. However, indirect effects of fire management activities on museum collections may include increased curation responsibilities due to additional pre- and post-fire management and fire incident surveys, additional collecting of museum objects revealed during fire management activities, and additional consultation from subject matter experts that may be required in order to properly identify and assess potential museum artifacts.

Human Health and Safety

Public Safety and Wildland Fire Hazard

Marin County lands in the wildland urban interface zone are at risk for catastrophic fire such as a repeat of the Mount Tam fire in 1929, the Oakland Hills fire in 1991, and the Vision Fire in 1995. Approximately 40 percent of the land in Marin County (332,928 acres) is in public ownership, much of it contiguous to privately held properties at the edge of the wildland urban interface (Marin County Civil Grand Jury 2003). GGNRA has an expansive and complex boundary with many Marin County residential areas including Tam Valley, Homestead Valley, Muir Beach, Stinson Beach, Marin City, and Sausalito. In San Mateo County, GGNRA lands border San Bruno, Pacifica, Woodside, and King's Mountain. San Francisco lands are within the boundary of the City and County of San Francisco.

Numerous factors have contributed to the high fire hazard level:

- Wildfire suppression efforts creating current high fuel loads. The natural vegetation in California is adapted to fire and relies on periodic low-intensity fires to maintain a healthy balance. The

removal of fire from the landscape has resulted in huge accumulations of fuel, overcrowded forests, and decadent chaparral stands (MCFD 2000).

- Continued expansion of tracts of highly flammable, nonnative plants such as *eucalyptus globulus* that can successfully out-compete less flammable native plants, especially in disturbed areas.
- Spread of Sudden Oak Death, increasing fuel loads and hazards in the oak woodland forests, especially in Marin County.
- Construction of new housing on the perimeters of developed areas up to the interface with open space.
- Restricted access to communities due to narrow roads and roadside parking.
- Limited funding for vegetation management projects, staffing, and equipment purchases.

In evaluating wildfire risk in 2003, the Marin County Civil Grand Jury cited statistics that a repeat of the 1929 Mill Valley fire, which destroyed 116 homes valued at $1 million, would today destroy 850 homes in approximately the same footprint. Fuel loading prior to the 1929 fire was estimated at 12 tons per acre; the same area and acreage today has an estimated fuel load of 25 tons per acre. The Grand Jury concluded that "Mill Valley, Corte Madera, Larkspur, Kent Woodlands, San Anselmo, Ross, Fairfax, Novato, Woodacre and parts of West Marin especially appear vulnerable, although other communities are also at risk" (Marin County Civil Grand Jury 2003). Many of the risk factors present in Marin County today – narrow roads, restricted access, extensive tracts of blue gum eucalyptus – are similar to those that contributed to the devastating 1991 Oakland Hills fire (Tunnel Fire).

The potential property damage for a fire spreading from the wildland urban interface is equally high. While the 1929 fire caused $1 million damage, the more recent Vision Fire of 1995 resulted in structural damage of $23 million with the loss of 48 homes and damage to 18 others. Utility repairs following the Vision Fire were $1.3 million and rehabilitation of slopes and roads to control erosion cost approximately $1.3 million (MCFD 2004). Suppression of the fire exceeded $6 million.

A new factor is the presence of Sudden Oak Death (SOD), which is widespread in the interface lands of Marin County and recently appeared in both San Mateo and San Francisco counties. SOD has left thousands of trees dead in the oak woodlands adjacent to and within residential areas of Marin, greatly increasing the volume of hazardous fuels and elevating the potential intensity of a wildland fire. The partially collapsed, dead, and weakened trees present areas with higher fuels scattered in the woodlands that can create hot spots as they burn, providing a means for a ground fire to spread to convert to a crown fire – one of the most difficult wildfire types to control (MCFD 2000). As trees become infected with SOD, they become susceptible to secondary insect infestations and pathogens that speed decay. The sudden collapse of SOD-infected trees poses a new and significant threat to the public and firefighters and, if collapse occurs within range of a power line, could present a new source of fire starts as well (Shelley 2002).

Federal Government Response

Fire management planning in the NPS is based on the policies and philosophy set forth in the National Wildland Fire Management Policy (2001), which places public and firefighter safety as the primary goal of federal wildfire management programs. Federal policy acknowledges the public safety hazard existing in critical areas of the wildland urban interface between federal lands and private holdings. In 2001, following a catastrophic wildland fire season in 2000,[3] President Clinton asked the Secretaries of Interior and Agriculture to develop a joint implementation plan for reducing fire hazard and high fuel loading in the wildland urban interface and reintroducing fire back into the environment in federal wildlands as an important ecological element. The ensuing report, *Managing the Impact of Wildfires on Communities and the Environment, A Report to the President In Response to the Wildfires of 2000*, provided an implementation plan based on a cooperative approach to reducing fire hazard, the incremental success of which could be gauged by monitoring the progress of a series of measurable objectives. The report, its accompanying budget request, Congressional direction for substantial new appropriations for wildland fire management for the subsequent fiscal years, and resulting action plans and agency strategies have collectively become known as the National Fire Plan.

The National Fire Plan requires that all Department of the Interior (DOI) and U.S. Forest Service (USFS) areas with burnable vegetation have fire management plans that keep pace with changes in federal wildland policy. This required new FMPs to be developed reflecting changes in federal policy such as the increased emphasis on interagency cooperation and hazard reduction in the wildland urban interface.

To increase progress in implementing the principles of the new federal wildland policy, funding of the Wildland-Urban Interface Initiative of the National Fire Plan was increased and eligible projects expanded to cover both agency and local community projects. This program has allowed homeowners' associations, local fire agencies, and federal land managers to tackle longstanding fire hazards in Marin County, including strategically reducing areas of high fuel loading, improving access for emergency vehicles, and constructing shaded fuel breaks. Funding has also been provided for fire education programs that encourage homeowner participation in reducing fire hazard around their homes and in their communities. Cooperation and communication have been facilitated by the leadership of FIRESafe Marin, a nonprofit agency formed in 1991 in response to the Oakland Hills fire. FIRESafe Marin provides a forum for exchange of information on projects and funding opportunities among federal, state, and local land management and fire agencies and nonprofits such as homeowners' associations. NPS staff has also attended Fire Safe San Mateo County meetings through 2004.

Since fiscal year 2001, the federal government has funded 60 projects in Marin County throughout the interface zone on national parklands, private parcels, water district lands, and state and county parklands (M. Prado 2004). Projects have been located in the interface zone of federal lands and the neighboring communities of the Marin City, Sausalito, Muir Beach, Mill Valley, Tam Valley, Homestead Valley,

[3] The 2000 fire season was one of the worst in 50 years. Approximately 123,000 fires burned more than 8.4 million acres. The total acreage burned was more than twice the 10-year national average. At times, nearly 30,000 personnel were on the fire lines, including the military and firefighters from other countries. More than $2 billion from federal accounts was spent suppressing wildland fires; this amount does not include state and local firefighting suppression costs, direct and indirect economic losses to communities, loss of property, and damage to ecosystems (Waggoner 2004).

Stinson Beach, and Kent Woodlands. Where federal lands adjoin locally managed open space lands, the potential exists for a fire to spread from one area of undeveloped land to another and then into the more developed areas of Marin. Wildland-Urban Interface Initiative funding has been used by the Marin Municipal Water District, the Marin County Open Space District, and the Marin County Fire Department to implement the series of shaded fuel breaks envisioned by the Mount Tamalpais Vegetation Management Plan. Zones of reduced fuels are to created on both sides of ridgetop fire roads to provide firefighters with a defensible space from which to launch fire suppression actions, and lower branches of larger trees are pruned while retaining as much forest canopy as possible (MCFD 2004). Future project proposals may include fuel reduction in national parklands in San Mateo County near the cities of Pacifica and San Bruno and the community of King's Mountain on Skyline Boulevard.

Human Health

The principal impact of FMP activities on public health is the inhalation of particulate matter generated as smoke from prescribed fires and unintended wildland fire. Particulate matter is considered such a significant health hazard that it is one of the six criteria pollutants monitored under the Clean Air Act. (See also the air quality discussion in this chapter.) Particulate matter, found in the air-liquid droplets and small solid particles of minerals and soot, can penetrate deep into the lungs. Studies indicate that 90 percent of all smoke particles emitted during wildland burning are PM_{10}, and 90 percent of PM_{10} is $PM_{2.5}$ (Sandburg et al. 2002).

Healthy adults are not usually at risk from particulate matter; they may experience runny noses and coughing but these symptoms usually subside as the smoke disperses. People with heart or lung diseases, such as congestive heart disease, chronic obstructive pulmonary disease, emphysema, or asthma, can be at risk. People with these conditions may find it difficult to breathe, or may cough or feel short of breath. Children and the elderly are generally more susceptible to the harmful effects of smoke (CARB 2003).

Ninety percent of fire emissions are in the form of carbon and water vapor. The portion of carbon not converted to carbon dioxide becomes particulates, carbon monoxide, and volatile organic compounds. Carbon monoxide (CO) is the most abundant air pollutant (Agee 1993) and is a criteria air pollutant under the Clean Air Act and monitored in the Bay Area Air Basin by the Bay Area Air Quality Management District (BAAQMD). The more efficiently a fire burns, the less CO is produced. Impacts of CO on firefighter safety depend on the amount of CO produced, the duration of the exposure, and the level of physical activity. Firefighters working strenuously in a smoldering fire may become dizzy, weak, and disoriented. They can quickly recover by moving to fresher air away from the blaze (DeBano et al. 1998). Volatile organic compounds (VOCs) that are considered a health hazard are polynuclear aromatic hydrocarbons (PAHs). Though not a criteria pollutant, PAHs can have impacts on human health at higher concentrations. Backing fires[4] and smoldering fires produce higher levels of particulates and PAHs since the gases have higher residence times in these types of combustion conditions (DeBano et al. 1998).

BAAQMD is responsible for monitoring PM_{10} and $PM_{2.5}$ levels under the Clean Air Act and issuing permits for stationary sources, such as power plants, that contribute particulates to the ambient air quality

[4] Fires set by firefighters to burn against an advancing fire to deprive it of fuels.

of the Bay Area Air Basin. Smoke from wildfires is inventoried and managed differently from smoke from prescribed fires. Wildfires are natural events and their emissions are addressed by the Environmental Protection Agency (EPA) Natural Events Policy. Emissions from prescribed fire are addressed by EPA's Interim Air Quality Policy on Wildland and Prescribed Fire. The states use these policy documents and other information to develop State Implementation Plans (SIP) and Smoke Management Programs (SMP). In accordance with the California Smoke Management Guidelines, BAAQMD manages smoke emissions from prescribed burning by regulating allowable burn days, reviewing burn plans, and coordinating the number of allowable burns per day. The goal of BAAQMD's smoke management program is to continue prescribed burning as a resource management tool while minimizing smoke impacts on public health in populated areas.

Firefighter safety standards fall under the Occupational Safety and Health Act. Exposure to carbon monoxide and individual particulate matter compounds in wildland fire smoke are of primary firefighter safety interest. Limiting firefighter exposure to smoke is the best way to improve a firefighter's working environment. This is best done by smoke management techniques and crew rotation.

The amount and type of smoke and particulates produced will vary during each phase of combustion of a fire. During pre-ignition, the fuel's temperature is being raised to ignition temperature and all the moisture present in the fuel is being evaporated. During pre-ignition, only small amounts of white smoke are produced by combustion and the white smoke is predominately water vapor. In the flaming phase, fuel reaches the ignition temperature and erupts into flames. The fuel goes through a chemical change and large amounts of heat and gases are released. Rapid oxidation occurs and large amounts of smoke are produced. The smoke is lifted off the ground by the heat that is being produced and begins to disperse. The combustion process is very efficient during this phase. The residual (smoldering) phase occurs when the flaming front has moved on and some of the unconsumed fuel is still going through the combustion process – slowly, with little heat being released. A convection smoke column does not form and smoke is not readily dispersed. Instead it is concentrated close to the ground (PFMT 2004).

Smoke management techniques for prescribed burning include temporary and permanent fuel exclusion, implementation under specific moisture regimes, mass ignition techniques and other means of increasing combustion efficiency, and emissions redistribution. Each strategy is intended to reduce the generation of particulate matter or redistribute emissions. When fire is used to reduce fuel loadings, eliminating an undesirable species, disposing of quantities of biomass waste in advance, and isolating stumps that are prone to smoke can help in meeting state standards and resource management objectives. Conducting prescribed burns when small fuel moisture is low and large fuel and forest floor moisture levels are high can reduce emissions by making less fuel available overall for combustion. Also important is to mop up a prescribed fire quickly and efficiently to reduce smolder. Avoidance and dilution are strategies that direct smoke away from sensitive receptors or dilute the concentration of smoke. Based on the results of pre-fire modeling, prescriptions are set to take advantage of meteorological conditions that maximize mixing and direct smoke away from developed areas (DeBano et al. 1998).

Firefighter equipment can also play a key role in limiting an individual's exposure to fine particulates. Recent studies find that firefighters are exposed to the highest levels of particulate matter during mop-up

when areas of residual burning are controlled. Wearing respiratory protection greatly reduces exposure to particulate matter and air toxins but also makes breathing more difficult under heavy physical exertion, as respirators tend to increase resistance to air flow, making breathing more difficult (R. Bible 2002).

When fire is needed for ecosystem maintenance or restoration, especially in those ecosystems that are fire-adapted or maintained, these strategies are less applicable because they all alter the necessary or ecological fire regime. Altering an ecosystem's fire regime (intensity, frequency, seasonality, or spatial distribution) is manifested by changes in community structure and function and species diversity and distribution to some degree, and is well documented.

Herbicide Use

Fire management and vegetation management projects in GGNRA use herbicides, on a case-by-case approval basis, to control nonnative plant species within specific management areas. The NPS Integrated Pest Management Manual, Director's Order #77-7 (NPS 1991) requires that all park pesticide use be reviewed each calendar year prior to the application season to ensure that the product and the proposed use for it are still legally registered. NPS requests for herbicide use are written for site- and time-specific applications and do not remain valid beyond one yea. The GGNRA IPM program, consistent with NPS Director's Order #77-7, states that the purchase, storage, and application of any herbicide will follow all federal, NPS, state, and local regulations. If California regulations are more stringent than federal, the former will supersede the applicable federal regulations. The potential for multiple applications of herbicides to any one site is considered very low. Historically, the GGNRA has been able to control the target vegetation with only one application.

Various brand names of herbicides containing glyphosate are used to prevent resprouting of cut tree stumps within nonnative evergreen forests or shrub lands, especially on blue gum eucalyptus, acacias, cotoneaster, and various brooms. Foliar applications are approved in limited scenarios where nonnative vine or shrub species create a dense and dominant component of the site, and have included Cape-ivy and eupatory. These species can form dense thickets of impenetrable vegetation near developments and other critical resources, posing a fire hazard.

If there are trees within a grove that are to be retained due to cultural resources issues, application of herbicides to the cut stumps is avoided to avoid spread of the systemic treatment through the roots to the trees that were not to be treated with herbicide. In that case, a thick layer of chips could suppress some proportion of the regrowth, or nailing heavy roofing paper to the stump or applying landscape fabric onto the cut stump could serve to depress resprouting.

The most commonly used herbicide for FMP actions in GGNRA is Roundup Pro, a low-toxicity, general use herbicide. The U.S. Environmental Protection Agency (EPA) has rated it as a Class 3, Caution-labeled herbicide; the EPA registration number is 524-475. Roundup Pro has also been approved and registered for use in California by the California Department of Pesticide Regulation. The active ingredient in Roundup Pro is glyphosate. Glyphosate, when applied to foliage, is absorbed by leaves and stems and rapidly moves through the plant. Glyphosate is a translocating herbicide that moves from the area where it was applied down to the roots of the plant via the active tissue – the cambium. It remains in

the roots. Glyphosate is applied by painting it on the tree stump immediately after the tree is cut. If the trees are in a riparian area, no foliar spraying may occur, especially if the habitat supports anadromous fish. During the dry season (July 1 to November 15), cut stumps of nonnative trees and shrubs may be treated with herbicide.

Foliar herbicide applications beyond the riparian corridor are not approved where saturated soils are present, at wind speeds over 5 miles per hour, or when weather conditions facilitate herbicide movement toward drainages.

If glyphosate is inadvertently dripped or sprayed onto soil, the product will bind with the soil. When used in accordance with label directions, when the product is bound it is no longer available for plant uptake and will not harm offsite vegetation if roots grow into the treatment area or if the soil is transported offsite. The strong affinity of this product to soil particles prevents the product from leaching out of the soil profile and entering groundwater. The affinity between this product and soil particles remain until this product is degraded, involving primarily a biological degradation process carried out under both aerobic and anaerobic conditions by soil microflora. When sprayed on leaves, the half-life for glyphosate is 1.6 to 26.6 days. In water, the half-life is 3.5 to 70 days, In soil, the half-life is 2.8 to 60 days (Badzik 2004).

The surfactant in Roundup has a soil half-half life of less than one week, thus the potential for leaching of the herbicide is low. According to U.S. Forest Service research (Glyphosate fact sheet), the major products from burning vegetation treated with glyphosate are phosphorus pentoxide, acetonitrile, carbon dioxide and water. Phosphorus pentoxide forms phosphoric acid in the presence of water. None of these compounds are known to be a health threat to firefighters or the public at the levels which would be found in a vegetation fire.

All herbicide use is administered through each park's integrated pest management coordinator. All herbicides must be applied by a state-licensed pesticide applicator. The pesticides used on GGNRA lands are registered with EPA and the California Department of Pesticide Regulation and used according to the label directions and federal and state pesticide laws. All use is reported monthly to the coordinator, the county, and the State of California. A review of the current status of all herbicides considered for use is conducted prior to each application season.

Visitor Experience and Visitor Use

GGNRA is unique not only in its diversity and quantity of natural and cultural features, but also in its proximity to a major urban population that also has worldwide status as a tourist destination. This juxtaposition makes GGNRA's resources and recreational opportunities readily accessible to a large number of people, and enhances the importance of the special qualities for which it was set aside. Park visitors can be local residents who have the park as part of their "backyard" as well as visitors from all over the world who have come to San Francisco to see many different attractions as part of their visit. GGNRA is visited by over 16 million people annually (NPS 2003d). Broken down into the three park units (see Chapter 1, Section 1.3, Planning Area), visitation for 2003 was as follows: Golden Gate National Recreation Area – 13.85 million, Muir Woods National Monument – 719,350, and Fort Point National Historic Site – 1.56 million.

The park exposes visitors to many of the resource values that exemplify America's national park system. Within the park, visitors can touch upon millions of years of natural history and thousands of years of human presence. This landscape evolved from a rugged coastal ecosystem – its sheltered estuaries teeming with waterfowl, bears, bobcats, salmon, and whales – and was the setting for American Indian villages, Spanish missions, Mexican ranches, Gold Rush cities, Civil War to Cold War forts, and today's metropolitan complex. The park contains the largest assemblage of historic buildings and the most complete collection of military resources of any single unit of the national park system.

Equally significant is the park's role in preserving an extraordinary convergence of land and water, city and nature, wildlife and people. The continental and ocean plates of the Earth's crust collide along its miles of ocean coastline, spawning the geological formations of the San Andreas Fault, which runs 40 miles through the park. Rivers flowing from the Sierra Nevada join the sea at the Golden Gate; marine, estuarine, and terrestrial ecosystems overlap; migratory birds and butterflies converge and plants respond to changing seasons.

These special geologic and climatic factors have created 19 distinct ecosystems that sustain nearly 2,500 species of plants and animals. The fragile and fragmented habitats protected by the park constitute a refuge for almost 100 rare, threatened, and endangered species, among them the northern spotted owl, coho salmon, and mission blue butterfly. The natural diversity of the California Biogeographical Province preserved within and near the greater Bay Area's major cities offers stupendous opportunities for learning about and practicing sustainability and stewardship. It was this rich biodiversity that led to the park's inclusion in the Central California Coast International Biosphere Reserve, designated by the United Nations in 1989.

The area supports miles of hiking trails, five campgrounds, hundreds of historic sites/structures and numerous beaches. There are five visitor centers in the park and more than 10 retail facilities run by park concessionaries or the park association. Overnight stays are available at four walk-in campsites in the Marin Headlands, two hostels (one at Fort Mason and another in the Marin Headlands), and local hotels and inns in areas outside the park boundaries. Activities include hiking, water sports, horseback riding, fishing, bike riding, camping, wildlife viewing, dog walking, sun bathing, and interpretive and educational opportunities. Visitors to the park come as individuals, as families, and as part of private and commercial tour groups including – thanks to a very active educational focus in the park – educational groups (schools, summer programs, youth groups, after school programs, etc.). They come to recreate, to learn, and to attend special events.

The park preserves not only natural systems and historic settings, but also a culturally vibrant and recreationally dynamic center consistent with its urban and Pacific Rim context. The miles of coastal and forested trails, ocean and bay beaches, and scenic vistas afford an array of activities, from traditional ranger-led walks, camping, and hiking to boardsailing, hang-gliding, biking, and jogging. Special events range from museum exhibitions and theater to art, music, and cultural heritage festivals.

As a nationally recognized model of park partnerships and public involvement, the park affords opportunities for thousands of people to participate in site stewardship, habitat restoration, and

interpretive activities. The parks continue to expand this interaction through cultural, environmental, and educational programs offered at a variety of sites.

An important benefit of GGNRA is its contribution to Bay Area open space. With over five million inhabitants, each area of open space in the nine Bay Area counties provides opportunities for respite, relaxation, contemplation, and passive recreation for the millions of Bay Area inhabitants. An important function of open space is its soundscape, which is often remote from the noisy influences of urban experience. In place of the high ambient levels of background traffic noise or the irregular and discordant industrial or heavy equipment noise, the sounds in parts of GGNRA are often those that are lost in a city – bird noise, rustling leaves, distant waves, or barking sea lions. While people often need to block out urban sounds to better communicate or concentrate, natural sounds are sought out for their beauty and restorative qualities.

Though much of GGNRA is undeveloped and far from heavily traveled roadways, portions of the park are within line of sight of portions of multilane freeways, including Highway 101 east of the Marin Headlands and Alta Ridge in southern Marin County, Highway 1 west of Milagra and Sweeney Ridges and Cattle Hill and east of Mori Point and Pedro Point, and Interstate 280 east of the Phleger Estate. A community noise map included in the San Mateo County General Plan (1986) indicated that noise levels would exceed 60 dBA CNEL[5] by 1995 within 2,000 feet of Interstate 280. However, only the very eastern edge of Phleger Estate is within 2,000 feet of the interstate and noise levels decrease from the noise source at 6 dB for distance doubled. Noise levels of 75 dBA L_{eq}[6] at 250 feet from the freeway would be attenuated to 69 dBA L_{eq} at 500 feet and 63 dBA L_{eq} at 1,000 feet. At 4,000 feet, within the more interior portion of the Phleger Estate, that noise source would be attenuated to 51 dBA L_{eq} and even further reduced by intervening topography and/or screening vegetation. Since the majority of the Phleger Estate is beyond 4,000 feet of the interstate, traffic noise would therefore have little influence on the interior noise levels of the park. Similar to much of GGNRA, the most prominent sources of noise would be aircraft and jet overflights; other high levels of sound (rather than noise) are generated by the wind and rustling of vegetation.

Noise monitoring to support the Draft Marin Countywide Plan (2004) finds that noise generated by traffic, the primary noise source in the county, has remained relatively stable over the past two decades but that higher noise levels are being generated earlier in the morning, indicating a lengthening commute period. Topographic barriers, as well as ocean and wind sounds, protect much of the GGNRA parklands in southern Marin County from vehicle noise from Highway 101. Alta Ridge, with a clear line of sight to Highway 101, experiences higher noise levels on its east-facing slope. Smaller yet busy roadways within Marin County, such as Panoramic Highway, have lower traffic-generated noise levels. County monitoring for the Countywide Plan update recorded noise levels throughout the county for 24 hours on a summer Sunday in 2001. A monitoring station on Highway 1 north of Stinson Beach recorded elevated noise levels within one or two decibels of 60 dBA L_{eq} from approximately 8 A.M. through 7 P.M. The noise

[5] CNEL, community noise equivalent level, is a noise descriptor used in land use planning that presents a time-weighted average of noise energy over a 24-hour period with 5- and 10-decibel penalties applied to evening and nighttime noise to account for people's sensitivity to higher noise levels in the evening.

[6] L_{eq}, or equivalent noise level, represents the level of steady state noise having the same energy as the time-varying noise measured. $L_{eq\,(h)}$ represents the time-weighted average for a 60-minute (hourly) period.

level meter sited at the Marin City shopping center, adjacent to Highway 101, recorded nearly continual noise levels of 65 dBA L_{eq} during the same period time period. The absence of vehicle traffic at 2 A.M. resulted in readings of 45 dBA L_{eq} and below at both locations. Overflights by jets from both Oakland and San Francisco International Airports have increased in Marin County, producing short-term noise levels of up to 70 dBA.

Without the influence of aircraft and jet overflight, noise levels in the interior of GGNRA would be similar to noise levels recorded in San Mateo open space for the recent annexation study by Midpeninsula Regional Open Space District (2004). That study found that noise levels, without the influence of aircraft and jet overflights, would generally range from 40 to 50 dBA $L_{eq(h)}$ depending on wind, with waves and bird noise as the most prominent natural sound sources. Depending on wind patterns and visibility, jets departing from San Francisco International Airport may be shifted to a pattern near the airspace above Milagra Ridge, dramatically increasing noise. Noise level monitoring conducted for a development project in Pacifica in 1997 demonstrates noise levels readings influenced by both vehicle and jet traffic. CNEL readings are high – higher than recommended for residential areas without special noise dampening insulation and windows. The two stations, approximately 1.5 and 2.0 miles north of Milagra Ridge, recorded 66.7 dBA CNEL and 64.4 dBA CNEL, respectively. Since these readings were recorded, noise levels generated by jet overflights have been dropping as more and more aircraft comply with higher levels of noise reduction standards.

FMP-generated noise would be added to these relatively low noise levels in Marin County and higher noise levels at the Pacifica parks. The decibel levels of common noise environments and noise-generating equipment are as follows (League for the Hard of Hearing 2004).

- 40 – quiet office, library
- 65–95 – power lawn mower
- 74 – front loader
- 85 – hand saw
- 90 – tractor
- 95 – electric drill
- 100 – skidder
- 110 – power saw
- 110 – leaf blower
- 120 – jet plane (at ramp)
- 125 – chain saw
- 130 – jackhammer, power drill
- 130 – percussion section at symphony
- 140 – airplane taking off
- 150 – jet engine taking off
- 150 – artillery fire at 500 feet

During project implementation, FMP actions may involve the use of chain saws, brushcutters, weedships, haul trucks, front loaders, skidders, and chippers. Noise would be heard by visitors to the park and could alter the visitor experience.

Park Operations

GGNRA currently has about 230 full-time employees (FTEs) and an operating budget of approximately $21.4 million, consisting of $20.1 million in base funding as well as $1.3 million in other funding from locally generated reimbursements, lease revenue, permit fees, and cost-recovery programs. In fiscal year 2003, the park also received $10 million in nonrecurring project funding from a variety of sources (fee demonstration, leasing and concession revenues, NPS servicewide special funding), and had over $35 million of multiyear capital improvement projects underway, funded through congressional appropriations.

Visitation to the three national parks in the planning area exceeded 16 million visitors in 2003. In addition to unscheduled daily visitation, the Office of Special Park Uses issued 750 permits in fiscal year 2003 for events ranging from the Dipsea race (Mill Valley to Stinson Beach) to the Alcatraz triathlon. Over 190,000 people per year participate in permitted events in GGNRA.

Muir Woods National Monument, an old-growth redwood forest with unique values, high visitation, and high ignition potential, is located within and managed operationally as a part of the park. Provision of emergency vehicle access and egress routes for evacuation is a primary concern.

Maintenance of the extensive parklands and widespread facilities in Marin, San Francisco, and San Mateo counties is a major, ongoing task. Structures, historic and non-historic, need basic maintenance and repair; utilities must be kept up; trails, roadways, and parking lots are in need of repair. Landscaping and irrigation, tree pruning, fences, gates, restroom cleaning, and trash pick-up give a basic sense of the scope of work needed to maintain park facilities and resources at an acceptable level. Substantial facilities for the Maintenance Division are located at Stinson Beach, Fort Cronkhite, and Fort Baker in Marin County, and at Crissy Field, Fort Mason, and Fort Miley in San Francisco. The environment within which maintenance operations are performed is most affected, in terms of fire management considerations, by the reduction of hazardous fuel loads, the creation of defensible space around structures (or lack thereof), and the condition of main road and fire road access between the widely separated locations of the park.

Law enforcement, search and rescue, emergency medical response, structural firefighting, and wildland firefighting operations are, naturally, extensive in a park in an urban area with such high visitation, essentially open access, a wide range of resources, and nearly unparalleled recreational opportunities from hiking and biking to sail-boarding and hang-gliding. Major firefighting bases are located at Fort Cronkhite and at the Main Post of the Presidio of San Francisco. Law enforcement operations are based primarily at Fort Winfield Scott and the Cavalry Stables at the Presidio and at Fort Cronkhite in the Marin Headlands. The environment within which law enforcement and firefighting operations are carried out is affected in ways similar to those described in the previous paragraph for maintenance operations.

All park operations, but especially maintenance, law enforcement, and structural and wildland firefighting operations, are affected by the state of the roadways that link the widely separated areas of the park. These roads stretch 40 miles from the neighborhood of the coastal Bolinas Lagoon in the north to the Phleger Estate in the hills of San Mateo County in the south. Park roadways are generally two-lane, winding paved roads, with limited pullouts and shoulders. They are not designed for high-speed travel. Certain choke points, such as Highway 1 at Stinson Beach and at Tam Valley, or Frank Valley Road at Muir Woods, can become very crowded during peak visitation periods. Vegetation and fuel loading adjacent to roadways varies widely from managed landscaping to grassland, coastal scrub, and forest – including areas of dense eucalyptus woods. The primary north-south route through the park is Highway 1, the Pacific Coast Highway or Cabrillo Highway. But many locations within the park are nestled within east-west running valleys, and direct access between adjacent locations is often limited to park vehicles using steep, winding, dirt fire roads.

Natural resource specialists research and monitor ecosystems and the physical environment in order to preserve and restore healthy systems and populations. Cultural resource specialists monitor projects and perform research to ensure the stabilization, preservation, and restoration of historic structures, landscapes, and archeological resources.

GGNRA is an acknowledged leader in enlisting organizations into partnerships that leverage the park's ability to preserve resources, educate the public, and provide recreational opportunity to visitors. Many of these partners occupy and maintain park buildings through cooperative agreements and other legal authorities. Partners range from the Marine Mammal Center at Fort Cronkhite to the Bay Area Discovery Museum at Fort Baker. The creation and maintenance of defensible space around partner-occupied buildings are the primary environmental effects on partner operations. Park operations are substantially supplemented by community volunteerism, especially in the areas of habitat restoration, educational programming, and historic preservation at the Nike site in Fort Barry.

Socioeconomics

Regional Setting

The socioeconomic environment affected by GGNRA fire management operations includes San Francisco, San Mateo and Marin counties, each of which encompass GGNRA lands. Table 3-12 provides a summary of selected demographic data for these counties.

As indicated in Table 3-12, the three counties comprise nearly 650,000 acres of land and contain a combined population of over 1.7 million. Total employment for the area is nearly one million jobs. In addition, the region attracts a significant volume of local and international tourists, with 14 million tourists reported per year in San Francisco County and two million in San Mateo County. Marin County Chamber of Commerce does not provide data on countywide visitation rates, however, given the attraction of GGNRA and Point Reyes National Seashore, the county also is a large draw for tourists and local visitors.

Table 3-12: Selected Regional Economic Characteristics

	San Francisco	San Mateo County	Marin County	Total
Total Size (acres) Source (A)	29,890	287,420	332,670	649,980
Population (2001) Source (A)	793,700	720,100	259,400	1,773,200
Employment (2000) Source (A)	435,200	411,300	139,700	986,200
Annual Visitors Source (B)	14 million	2 million	NA	NA
Visitor Spending ($ millions) (2002) Source (C)	$4,645	$1,925	$502	$7,072
Visitor-Related Jobs (2002) Source (C)	48,830	34,850	6,160	89,840

Sources: (A) California Department of Finance, (B) San Francisco and San Mateo Visitors Bureaus, (C) Dean Runyan Associates and the California Division of Tourism.
Note:
NA = not available

According to a 2002 report published by the California Division of Tourism, visitors to the three counties accounted for over seven billion dollars in spending. Associated visitor-related employment totaled approximately 90,000, or nearly ten percent of the area-wide employment.

Golden Gate National Recreation Area

GGNRA encompasses nearly 75,000 acres of land in San Francisco, Marin, and San Mateo counties, or nearly 12 percent of the total three-county land area. The park currently employs 230 full-time equivalent staff. The current GGNRA operating budget is $20.1 million in base funding, $1.3 million in other project funding, and $10 million in non-recurring project funding. The Fire Management Office has an annual operating budget of $400,000 and employs seven full-time staff. Compared to total employment levels in the affected area, the fire management payroll has a relatively minor beneficial impact on the local economy.

In 2003, a total of 13,457,900 people visited GGNRA, representing 84 percent of total visitation to San Francisco and San Mateo counties. In part due to its urban environment, GGNRA has achieved one of the highest volumes of annual visitors in the national park system. Visitation averaged about one million people per month from November through February, and averaged approximately 1.2 to 1.3 million monthly visitors during the spring, summer, and fall months.

As shown in Table 3-13, the vast majority of park visitors are day travelers. An estimated 80 percent of visits are from people residing in the area. An additional 15 percent are day visitors from other regions. Lodging guests and camp visitors make up five and less than one percent of total visitors, respectively. The recreational visitors to GGNRA contribute substantially to the local economy. In 2001, visitor groups

spent an average of $42 per day (visitor groups also called “party days” are based on size of party, length of stay and other factors), resulting in a total of $212.8 million in total spending in the area.

Table 3-13: GGNRA Visitation and Spending by Visitor Segments in 2001

Year 2001	Local Day Visitors	Non-Local Day Visitors	Hotel Visitors	Camp Visitors	Total
Recreation Visits	10,700,470	2,006,339	730,102	20,991	13,457,902
Segment Shares in Recreation Visits	80%	15%	6%	1%	100%
Party Days	4,093,163	767,468	244,286	6,770	5,111,687
Average Spending Per Party Day	$30	$45	$225	$87	$42*
Total Spending ($ millions)	$122.79	$34.54	$54.85	$0.59	$212.77

Sources: GGNRA, NPS Park Visitation Report, MGM2

Note:

* Weighted average.

As shown in Table 3-14, of the total dollars expended by visitors ($212.77 million), an estimated 78 percent ($166.40) was retained in the local economy. The remaining 22 percent of spending is associated with goods and services manufactured and imported from out of the area. Local spending also contributed to $63 million in personal income (wages and salaries), $95.18 million in value added (employee compensation, profits, and indirect business taxes) and 3,859 jobs. The largest share of spending occurred in local restaurants and bars, followed by retail expenditures, admission fees, and overnight accommodations.

Table 3-14: Economic Impacts of Visitor Spending by Sectors

Sectors	Sales (millions)	Personal Incomes (millions)	Jobs	Value Added (millions)
Direct Effects				
Motels, Hotels, B&Bs and Cabins	$ 25.90	$ 9.17	481	$ 13.93
Campsites	$ 0.14	$ 0.05	3	$ 0.08
Restaurants and Bars	$ 59.68	$ 21.19	1,613	$ 29.52
Admissions and Fees	$ 27.98	$ 9.89	764	$ 16.18
Retail	$ 33.04	$ 16.85	810	$ 26.32
Others	$ 19.66	$ 5.87	188	$ 9.15
Total	**$ 166.40**	**$ 63.02**	**3,859**	**$ 95.18**
Secondary Effects	$ 88.63	$ 32.31	1,125	$ 55.10
Total Effects	$ 255.03	$ 95.33	4,984	$ 150.28

Sources: GGNRA, NPS Park Visitation Report

As direct spending dollars circulate through the local economy, they result in secondary beneficial economic effects. Secondary effects measure the spin-off impacts of expenditures as money cycles through the regional and local economy. For example, increased spending by visitors at local restaurants may create additional jobs in those businesses. Business owners may also experience an increase in income, which they then spend locally on ordinary consumer goods and services. The secondary impacts associated with visitor spending account for an additional $88.6 million in local sales, $32 million in personal income, 1,125 jobs and $55 million in value added. In summary, visitors to GGNRA spent $212.8 million in sales in 2001, which supported a total of $255 million in local sales revenues, $95 million in personal income, 4,984 jobs, and $150 million in value added.