

## 2. FIRE MANAGEMENT STRATEGIES

### 2.1 FIRE MANAGEMENT GOALS

As part of the NEPA process for the FMP, GGNRA staff developed goals for the overall fire management program based on guidance from Federal Wildland Fire Management Policy, NPS Management Policies, Director's Order #18, and other fire-related guidance documents, in conjunction with public input from meetings and workshops. In the listing below, elements of the adopted FMP alternative are paired with the seven FMP goals to demonstrate how the selected alternative will help the park achieve the goals of the FMP.

*Goal 1. Ensure that firefighter and public safety is the highest priority for all fire management activities.*

Objectives:

- √ In cooperation with Bay Area Network Parks, provide the fire management workforce with the training, equipment, operating procedures, safety measures, and information needed to manage risks and carry out their activities safely.
- √ Ensure that all fire management employees meet the Interagency Qualification Standards for their positions and those held while assigned to an incident.
- √ Identify, inform, and protect visitors, communities, park partners, and other groups and individuals that potentially would be affected by fire management activities.
- √ Comply with the National Wildfire Coordinating Group and agency medical standards and fitness requirements for staff and make sure staff has personal protective equipment appropriate to the job or assignment.
- √ Follow all aviation policies and practices during fire management activities. The fire management officer or designee will stay abreast of aviation policy changes by maintaining periodic contact with the regional aviation manager and the designated park Aviation Officer.

*Goal 2. Reduce wildland fire risk to private and public property.*

Objectives:

- √ Annually analyze fire hazards, fire values, and risks to inform project priority selection for fire management units (FMUs).
- √ Support the development of evacuation plans for wildland urban interface communities, where such plans do not exist.
- √ Develop prevention plans to reduce the number of human-caused ignitions.

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*Goal 3. Protect natural resources from adverse effects of fire and fire management activities, and use fire management wherever appropriate to sustain and restore natural resources.*

Objectives:

- √ Manage ecosystems within the natural range of variability for plant community structure and fuel loads.
- √ Reduce potential spread of nonnative plant species to adjacent natural areas and ensure any fire activities include follow-up actions (planting, seeding, etc.) to meet overall vegetation goals. Ensure that any fill used and/or maintenance activities do not introduce weeds.
- √ Reduce nonnative trees and shrubs (Monterey pine, Monterey cypress, acacia, eucalyptus, etc.) to the greatest extent possible consistent with vegetation management objectives and to the extent that hazardous fuels are reduced.
- √ Protect and restore rare and endangered species and sensitive habitat through fire management activities and project implementation.
- √ Reduce erosion from fire roads and reduce sediment transport through ongoing maintenance of roads and the removal and site restoration of unnecessary fire roads.
- √ Develop standards for the use of water and retardants in fire management activities, such as minimization of the use of saltwater and brackish water, and avoidance of use of nearby water sources with rare species, for the protection of water quality and aquatic habitat characteristics.
- √ Identify and protect natural soundscapes through the course of mechanical treatment activities involving the extended use of power equipment.

*Goal 4. Preserve historic structures, landscapes, and archeological resources from adverse effects of fire and fire management activities, and use fire management wherever appropriate to rehabilitate or restore these cultural resources.*

Objectives:

- √ Survey for and identify historic resources within a project area in the earliest possible stage of planning fire management activity.
- √ Conduct surveys for areas of potential archeological resources (based on sensitivity modeling or prediction) prior to project implementation. Avoid ground disturbance prior to survey of sensitive areas for archeological resources. Protect archeological resources (known, predicted historical, or discovered sites).
- √ Develop standard procedures for projects calling for the use of fire and other treatments in order to maintain the setting of historic sites and to maintain the integrity of cultural resources.
- √ Regularly monitor fire management activities to assess their effects on cultural resources.
- √ Protect historic structures and landscape features through the course of fire management project implementation.

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- √ Use fire management activities to preserve and in some cases to perpetuate historic vegetation patterns.
- √ Rehabilitate pastoral landscapes where fire danger would be lessened by the establishment of a lower fuel-loading plant community.

*Goal 5. Refine management practices by improving knowledge and understanding of fire through research and monitoring.*

Objectives:

- √ Monitor and evaluate the effects of fire and fuels management activities on park resources. Evaluate monitoring information to refine fire management actions and project objectives.
- √ Identify issues or missing information important to developing effective implementation of the park's fire and fuels management program.
- √ Continue ongoing inventory and baseline data collection to enhance existing resource information systems. Use vegetation maps, fire history maps, and other tools to develop risk assessments that will be used to identify and set priorities for appropriate treatments.
- √ Conduct research that will help park managers to understand fire regimes, refine prescriptions, provide data for fire behavior models, and effectively implement the fire management program.
- √ Research the role of fire in old-growth redwood forests.
- √ Conduct research into issues of Sudden Oak Death, and the potential of fire as a management tool.
- √ Determine how fire can be used to target nonnative plant species for eradication.
- √ Research the effects of fire exclusion.
- √ Determine how current fire frequency affects ecosystems with respect to the historic fire regime.
- √ Determine how post-fire recovery patterns may be used in restoration projects.

*Goal 6. Develop and maintain staff expertise in all aspects of fire management.*

Objectives:

- √ Implement annual program reviews for fire management office and personnel.
- √ Implement training plans for each employee to reach target qualifications for the positions in the fire management organization. Conduct annual training appropriate to instructor qualifications.
- √ Keep abreast of the latest developments and technology applicable to fire management.
- √ Establish and promote measurable qualifications and staff experience to accomplish fire management program objectives in a safe manner.
- √ Follow all safety standards and guidelines identified within the Interagency Incident Business Management Handbook.

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*Goal 7. Effectively integrate the fire management program into park and park partner activities.*

Objectives:

- √ Develop a fire management program that is consistent with, and meets the goals of, the park's General Management Plan (GMP) and resource management plans.
- √ Encourage interdisciplinary pre-project planning for fire management activities.
- √ Plan for and conduct fire management activities in an integrated manner with respect for overall resource goals and in an effort not to exacerbate existing problems.
- √ Conduct educational outreach programs on the park's fire management activities and fire safety for park partners, including tenants in park structures within project areas.

*Goal 8. Foster informed public participation in fire management activities.*

Objectives:

- √ Continue and enhance communication and education programs to broaden an understanding of the NPS fire management mission, for both internal and external audiences.
- √ Maintain and expand the current park website to provide information about fire management activities in the park as well as fire safety.
- √ Support an increase in fire ecology and safety programs in schools.
- √ Increase public meetings and homeowners group presentations.
- √ Provide more interpretive programs on fire safety and ecology.
- √ Provide trailhead messages on fire safety.

*Goal 9. Foster and maintain interagency fire management partnerships and contribute to the firefighting effort at the local, state, and national level.*

Objectives:

- √ Maintain cooperative fire management agreements with county and city fire departments.
- √ Continue interagency coordination and cooperation with federal land management agencies and other related agencies supporting or participating as full partners in wildland fire management activities and programs.
- √ Attend interagency planning meetings prior to each fire season to enhance coordination and cooperation to maximize efficiency to manage wildland fire incidents.
- √ Continue participation in regular fire management coordination meetings to share information and discuss related issues with organizations such as FIRESafe Marin and Fire Safe San Mateo.

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*Goal 10. Minimize smoke generation during prescribed burning through the use of a smoke management plan (SMP) that details best management practices or non-burning alternatives where these options would meet resource management and fuel reduction objectives and also achieve emissions reduction.*

**Objectives:**

- √ Confer regularly with Air Resources staff at the NPS Pacific West Regional Office, other parks, fire agencies, and the Bay Area Air Quality Management District (BAAQMD) to keep current on best management practices and non-burning alternatives.
- √ Maintain current information on smoke-related health issues affecting firefighters such as exposure limits, exposure monitoring, risk minimization, and respiration technology.

**2.2 GENERAL MANAGEMENT CONSIDERATIONS****2.2.1 Legal Considerations**

The NPS is constrained from implementing fire management actions that do not comply with relevant federal laws, regulations, or policies. The most widely applied federal laws include the NPS Organic Act, the enabling legislation establishing GGNRA, NEPA, NHPA, the ESA, the Clean Water Act (CWA) and the Clean Air Act (CAA). NPS regulations and policies are developed on a national level in NPS Management Policies (2006) and the NPS Director's Orders addressing specific topics for example Director's Order 12 (Environmental Impact Analysis), Director's Order 18 (Wildland Fire Management), Director's Order 28 (Cultural Resource Management – *currently under revision*), and Director's Order 77 (Natural Resource Management - *currently under revision*). The Pacific West Regional Office generates policy guidance that applies to all national parks in the region. GGNRA issues policy guidance through "standard operating procedures" (SOPs) that only apply to the park and GGNRA staff.

**2.2.1.1 Enabling Legislation**

Congress established GGNRA by Public Law 92-589 "in order to preserve for public use and enjoyment certain areas of Marin and San Francisco Counties, California (San Mateo County added by P.L. #96-607)." In addition to providing for recreation and educational opportunities consistent with sound principles of land use planning and management, the NPS was also instructed to "preserve the recreation area, as far as possible, in its natural setting, and protect it from development and uses which would destroy the scenic beauty and natural character of the area."

**2.2.1.2 Endangered Species Act**

The Endangered Species Act (ESA), as amended, (PL 93-205, 87 Stat. 884, 16 USC §1531 et seq.) protects threatened and endangered species from unauthorized take and directs federal agencies to ensure that their actions do not jeopardize the continued existence of such species. There are approximately 1,300 species that found entirely or in part in the USA and its water that are listed or proposed for listing as threatened or

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endangered under the ESA. Currently, 9 animal and 3 plant species as threatened or endangered under the ESA that occur on lands directly managed by GGNRA that could be affected by FMP projects. Further information on each of these species can be found in the GGNRA FMP Final EIS on pages 205 – 211.

Two federal agencies share responsibility for implementing the ESA -- generally, the USFWS manages land and freshwater species, while the NMFS manages marine and "anadromous<sup>2</sup>" fish species. As part of the NEPA process for the GGNRA FMP Final EIS, the NPS completed formal consultations with the USFWS and NMFS as required by Section 7 of the ESA. In signing the Record of Decision, the NPS adopted all the protective measures recommended by the NMFS and FWS to ensure that adverse effects to the listed plants and animals would be avoided. It is the responsibility of NPS staff to ensure these measures are followed as FMP projects are implemented.



California red-legged frog  
by Marc Jennings

### 2.2.1.3 Clean Air Act

All GGNRA prescribed burns must be submitted to the Bay Area Air Quality Management District (BAAQMD) with a Smoke Management Plan for approval. The BAAQMD grants approval to the NPS to conduct burns based on air basin air quality and competing requests to burn submitted by other entities. Due to these extenuating circumstances, plans for burning may not always be approved for implementation if air basin conditions are poor or there are too many competing requests for approval to burn.

### 2.2.1.4 National Historic Preservation Act

The National Historic Preservation Act (1966), as amended, requires agencies to take into account the effects of their actions on properties listed in or eligible for listing in the National Register of Historic Places. The Advisory Council on Historic Preservation has developed implementing regulations (36 CFR 800) that allow agencies to develop agreements for consideration of these historic properties. The NPS, in consultation with the California State Historic Preservation Officer (SHPO), developed a detailed Programmatic Agreement for implementing FMP projects based upon an existing draft Department of the Interior Fire Management Plan Programmatic Agreement. The Programmatic



Murray Circle, East Fort Baker

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<sup>2</sup> Anadromous fish are born in fresh water, migrate to the ocean to grow into adults, and then return to fresh water to spawn. In the FMP planning area, anadromous fish listed under the ESA are coho salmon and steelhead.

Agreement for the GGNRA FMP provides a process for NHPA compliance through stipulations for identification, evaluation, treatment, and mitigation of adverse effects of FMP actions which could affect historic properties. The requirements in the Programmatic Agreement are incorporated into the mitigation measures developed and adopted specifically for implementing FMP projects.

## **2.2.2 Jurisdictional Considerations**

### *2.2.2.1 Direct Protection Areas (DPA)*

The NPS has wildland fire protection responsibility for all federally owned lands inside the boundary of GGNRA. This makes federally-managed lands within the congressionally designated GGNRA boundary the Federal Responsibility Area or NPS - Direct Protection Area (DPA). The Northern Lands of GGNRA on Bolinas Ridge, managed under an agreement with Point Reyes NS are in the DPA of Point Reyes. The NPS has the financial responsibility, and the fire protection force to accomplish this. However due to the limited capacity of its protection force, Marin County Fire Department, San Francisco Fire Department, California Department of Forestry and Fire Protection, and other nearby fire agencies in Marin and San Mateo counties provide strong backup and reinforcement to any fire in or near lands directly managed by GGNRA.

## **2.2.3 TECHNICAL OR LOGISTIC CONSIDERATIONS**

### *2.2.3.1 Limited Season for Effective Use of Prescribed Burning.*

The normal weather window for prescribed burning at Golden Gate is from mid-April to November. Burning in grasslands should be conducted after the grasses have cured, which can be as late as early July. Summer and fall burns must be scheduled to take place between the dissipation of the morning coastal fog and the onset of strong afternoon sea breezes. Often the fog persists all day keeping much of GGNRA too wet for prescribed burning. The later months of the prescribed burning period, from late September until the first couple of rains in November, can be relatively fog free. Difficulties in scheduling prescribed burns still can occur because red flag conditions can develop quickly if the fuels moistures are already very low.

### *2.2.3.2 Risk-related Considerations*

GGNRA has adopted a full suppression policy for all wildland fires, even those started naturally by lightning, due to high values at risk in the wildland urban interface. Consequently, there is no wildland fire use within GGNRA. Prescribed fires cannot burn overnight in GGNRA limiting the size of each prescribed burn unit to a size that can be successfully controlled within the normal burn window of a typical day. This precludes fire management strategies involving large-scale landscape fire restoration within the park.

### *2.2.3.3 Park Resources or Values Considerations*

GGNRA has unique cultural and natural resources which affect the timing, location and layout of fire management projects. Recurring special events and the constraints of high year-round visitation by local visitors and tourists also require careful advance

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planning. Some projects are modified from an optimal layout from the perspective of operational defensibility in order to avoid adverse impacts to viewsheds or privacy afforded by vegetation, especially on the park boundary.

Where sensitive resources are present within or near a project perimeter, GGNRA may be required to obtain additional permits from regulatory agencies, hold public meetings with homeowners associations, add staffing for prescribed burns, reduce smoke generation, or plan smaller burn units that incorporate buffers around sensitive resources.

#### 2.2.3.4 Staffing Considerations

The NPS and interagency guidelines for prescribed burning require that all NPS prescribed burns have a Contingency Plan identifying “contingency resources” (such as fire trucks on stand-by) that must be available based on the prediction of a worst-case scenario (NPS 2006b, Chapter 10; USDA 2006). Resources may be requested from competing projects especially in the peak of the national fire season in the summer months when resources needed for prescribed burns are also needed for emergency fire suppression. According to the Interagency Prescribed Fire Planning and Implementation Procedures Reference Guide, when specific contingency resources are identified for more than one prescribed fire, the local fire management organization(s) must evaluate and document the adequacy of all contingency resources within the area. The evaluation must consider: 1) Local, current, and predicted fire danger and 2) Local and regional wildland fire activities. Once a contingency resource is committed to a specific wildland fire action, it can no longer be considered a contingency resource for another prescribed fire project and a suitable replacement contingency resource must be identified or the ignition halted.

#### 2.2.3.5 Funding Considerations

There are eight communities bordering GGNRA that are listed as federal “communities at risk from wildfire” under the National Fire Plan (Stinson Beach, Sausalito, Tamalpais & Homestead Valleys and Marin City in Marin County, the City of San Francisco, and the cities of Woodside, Daly City and Pacifica in San Mateo County). Communities are listed as “at risk” if they are within the wildland urban interface with federally managed lands. Each state, in cooperation with five federal land management agencies, originally submitted towns to be listed as communities at risk which were published in the Federal Register in 2001.

Currently, in California, the responsibility of adding or removing communities from the “at risk” list has been assigned to the California Fire Alliance by the Director of Cal Fire. Each September, the California Fire Alliance Board reviews application forms from individual communities requesting that they either be added or removed from the “at risk” list. The current communities at risk list for California, as well as the application form requesting a change in status, can be found on the California Fire Alliance website [http://www.cafirealliance.org/communities\\_at\\_risk](http://www.cafirealliance.org/communities_at_risk).

In 2003, the Healthy Forests Restoration Act (HFRA) provided communities with the opportunity to partner with federal agencies in planning and implementing fuel reduction



projects within the wildland urban interface with federal lands through the cooperative preparation of a Community Wildfire Protection Plan (CWPP). A CWPP identifies and prioritizes areas for hazardous fuel reduction treatments near federal lands and recommend the types and methods of treatment that will protect one or more at-risk communities and its essential infrastructure. The at-risk communities are so designated due to their proximity to undeveloped federal lands and the assumed high fire hazard these lands represent. A group of geographically-linked communities at risk may join together with adjacent federal land managers and local fire agencies to develop a strategy for hazard reduction through a CWPP. Communities with CWPPs in place are often given priority for funding of hazardous fuels reduction projects carried out under the HFRA and the National Fire Plan.

The 2007 Healthy Forests Report indicates that 46 states have identified and documented over 44,000 communities-at risk. Further, approximately 1100 CWPPs have been completed covering nearly 3000 communities; 450 additional CWPPs are being developed (USFS 2007).

### **2.3 WILDLAND FIRE MANAGEMENT OPTIONS**

To accomplish FMP goals, wildland fires will be suppressed and prescribed fire will be introduced where appropriate for hazard fuel reduction and/or resource benefit. GGNRA, in accordance with NPS policy, uses Minimum Impact Suppression Tactics (MIST<sup>3</sup>) in all fire management activities. Mechanical fuel reduction projects will focus on Wildland Urban Interface areas and protection of park visitors, staff and sensitive natural and cultural resources. Mitigation measures addressing potential environmental impacts will be incorporated into site specific projects as assigned through interdisciplinary project review as required by the NEPA process completed for the FMP. Fire managers, in consultation with resource advisors, will balance the potential resource impacts of wildland fire with the potential impacts of fire suppression activities in choosing the appropriate management response to wildland fire and appropriate MIST techniques to apply.

GGNRA contains significant natural and cultural resource values. Values to be protected and their susceptibility to damage or loss by fire are discussed in more depth by Fire Management Unit (FMU), in Section 2.4 of this FMP and in Chapter 3, Affected Environment of the GGNRA FMP Final EIS. Resource management objectives drive strategies with the objectives of restoring and maintaining the naturally functioning ecosystems, restoring cultural landscapes and protecting sensitive resources.

Wildland fires at GGNRA are managed with supporting cooperation of local fire departments, state wildland firefighting organizations and federal land management agencies. This approach to wildland fire management involves partnership, cooperation and collaboration and is defined by the California Fire Protection Agreement and the

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<sup>3</sup> MIST is defined as the application of techniques that effectively accomplish wildland fire management objectives while minimizing the impacts to cultural and natural resources commensurate with ensuring public and firefighter safety and effective wildland fire control. Further information is provided in Section 3.2 and the MIST Guidelines are in Appendix E, Section 9.

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California Fire Assistance Agreement. Cooperating fire departments include the Marin County Fire Department (MCFD), Southern Marin Fire Protection District, California Department of Forestry and Fire Protection (Cal Fire) and the North County Fire Authority (Northern San Mateo County). Cooperation with volunteer fire districts (Muir Beach and Stinson Beach) and homeowners associations is also critical and should be defined by locally developed agreements as well as the State Mutual Aid Agreement.

Along with other Bay Area Network Parks staff, the GGNRA Division of Fire Management provides technical assistance on fire management matters to two national park units in Contra Costa County on the east side of San Francisco Bay -- Eugene O'Neill National Historic Site and John Muir National Historic Site in Danville and Martinez, respectively. This relationship should be formalized by an inter-park agreement in the future. The network prescribed fire specialist is responsible for providing fuels management program advice to these parks.

## 2.4 ENVIRONMENTAL FACTORS INFLUENCING FIRE MANAGEMENT

### 2.4.1 Fire Regime and Fire History

#### 2.4.1.1 San Francisco Bay Area Fire Regime

Five successive fire regimes have been identified for the Pleistocene era in the central California coast. The “management practices” or human influence on the landscape during last the last four eras have dramatically influenced the disturbance regime for this landscape, though to a lesser degree than change in climate.

Table 2 shows the changes in Bay Area climate over the last 128,000 years and summarizes the changes in the dominant vegetation. For central and northern California, pine is generally an indicator of cooler or glacial conditions, and oak is an indicator of warm conditions. Redwood is an indicator of increased moisture and moderated summer coastal temperature related to coastal fog, also related to coastal upwelling (Heusser 1998).

**Table 2 -- San Francisco Bay Area Climatic Changes**

Time Period	Climatic Characteristics	Dominant Plant Communities
128,000 – 28,000 BP	Much cooler than present	Conifers predominate
28,000 – 13,000 BP	Cold and dry	NA
13,000 – 7,500 BP	Warm and wet	Oaks begin to increase
7,500 – 2,900 BP	Warm and dry	Oak woodland, prairies, coastal scrub dominate until modern era
2,900 – 900 BP	Cooler	NA
900 – 625 BP	Warm and dry at end	Medieval Warm Period
625 – 500 BP	Current climate	NA
500 – 300 BP	Wetter and cooler	Little Ice Age
300 BP – present	Current climate	Nonnative plants introduced

Source: NPS, Pacific West Regional Office, 2004.

Note: BP = before present. NA = not applicable

Additional information on GGNRA Fire Regimes, Fire History, Climate and Fire Weather can be found in the GGNRA FMP Final EIS, pages 135 to 151 (November 2005).

#### Natural Fire Occurrence (128,000 to About 10,000 Years BP)

During the last 20,000 years, the Earth's climate underwent a dramatic transition from glacial to interglacial conditions, a change as large as any change during the past three million years. These climatic variations resulted in large biotic responses, including migrations of individual species and rearrangements of vegetation associations.

Prior to human settlement of central California, natural ignition sources for wildfire would be lightning or spontaneous combustion. Recent records of lightning strikes in the Bay Area show that fires could occur along the Marin coastline throughout much of the year, regardless of the high probability of dense fog. Without human intervention, it is thought that fire could linger in tree trunks for weeks, and reemerge under drier conditions; thus a fire could burn through the summer and fall until the rainy season began (Stuart 1987).

#### Native American Period (≈10,000 BP – 1775 AD)

There is increasing evidence that Native American land management practices, including the use of fire, caused cumulative and permanent effects in plant communities and species composition for many Bay Area vegetation types. Although information on their burning practices is scant, both the Coast Miwok and Ohlone peoples are known to have regularly burned extensive areas of coastal prairie, coastal scrub, marshlands, and oak woodland (Collier and Thalman 1996, Duncan 1992, Kelly 1978, Levy 1978).

Fire is thought to have been used as a tool for communication, driving game, security from human enemies and predators, improving the flow of springs, increasing productivity for grazing, increasing yield of food sources (acorns, grasses, forbs, tubers, bulbs, fruits, grains), controlling plant pests and diseases and removing competing conifers from oak woodland.

Fire management was more common in grassland, oak savannas, and ecotones of grassland and chaparral than in shrublands and forests (the latter two communities burning between 10 and 28 years on average). Sapsis and Martin (1994) estimated that fire burned from one half million to over 19 million acres of California's total area each year. The exact spatial extent of the influence of burning on the landscape is not known and has been debated. Still, the level of fire use necessary to maintain specific resources in conditions required by the various cultures suggests that extensive and very intensive burning would have been common in important vegetation types (Anderson and Moratto 1996).

#### Spanish-Mexican Influences (1769-1848)

Spanish and later Mexican settlement introduced year-long cattle and sheep grazing, burning, and cultivation that led to the extirpation of many native animal species and the further spread of nonnative plants. The rapid, extensive conversion of the landscape to nonnative annual vegetation was so complete that the original extent and species

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composition of most native perennial grasslands are largely unknown (Burcham 1957, Holland and Keil 1995).

The move toward fire exclusion began early in California. The first law against starting fires was issued under Spanish rule in 1793 (Barrett 1935, Gordon 1977). It was aimed at halting Indian burning of grasslands that reduced the amount of forage available to Spanish horses and livestock. Ranchero owners burned coastal scrub, chaparral, and oak woodland to expand pastures. The rancho period, primarily under Mexican rule, was relatively short-lived (1822-1846), but it exerted such a strong influence on the landscape that the fence lines, roads, and vegetation pattern are still visible today. Within GGNRA, there were three ranchos in San Mateo County (Buri Buri, Corral de Tierra, and San Pedro), two in San Francisco (Laguna de la Merced and Cañada de Guadalupe, although the majority of the latter was in San Mateo County, and three in Marin County (Saucelito, Tomales y Baulines, and Las Baulines).

#### American Influences (1848-1945)

In this period, the large ranchos were subdivided into smaller farms, ranches, dairies and timber operations and a 1900-acre parcel in the Marin Headlands was sold to the Army. Beginning in the 1850's, fences went up, fertile marine terraces were tilled, and redwood and Douglas fir forests in Marin and San Mateo County were logged quickly and on a large scale. The entire Phleger property was logged and milled onsite 1852 to 1855. After redwood was removed, loggers focused on cordwood (oak, bishop pine, madrone, etc.). In some areas after the trees were cut, workers skimmed the soil for clay to make bricks (Fairley 1987).

Agriculture, farming, erosion control, landscaping and trade spread fire-adapted nonnative species changing the landscape and altering the fire regime. Eucalyptus was first planted in San Francisco Bay Area in 1856 (McClatchie 1902). Extolled for its qualities as a fast-growing timber species, eucalyptus became a widely planted for ornamental use, timber, and windbreaks. French broom (*Genista monspessulana*), Portuguese broom (*Cytisus striatus*), Scotch broom (*Cytisus scoparius*), and Spanish broom (*Spartium junceum*) all were introduced into California in the mid-1800s for landscaping and to control roadside erosion control. The ability of these plants to fix nitrogen, to produce copious amounts of long-lived seed, and to tolerate almost any soil condition allowed these species to grow rapidly and form dense stands, making regeneration of most native species difficult or impossible.

Wildland fires were frequent and large in the late 1800s and early 1900s (Perry 1984) preventing some grasslands from being invaded by brush. The Forest Reserve Act of 1891 introduced programs to control fire and grazing. By the 1880's, the State Board of Forestry was urging the public to support fire exclusion in forests to increase future wood production.

#### Modern Influences (1945-present)

Grazing by domesticated livestock and clearing of pastureland continued to be practiced until the 1960s (Burcham 1957). These practices had resulted in lighter fuel loading, especially near residential areas, markedly lowering the fire danger for the area. By

1990, explosive growth had filled in the central flats of the San Francisco Bay Area and agriculture had moved beyond the suburbs.

In general, disturbances by fire have gone from long intervals in the pre-human period to shorter intervals in the late Native American and Spanish-Mexican periods, moderate intervals in the early Anglo era, back to long intervals in the modern era. The altered fire regime has led to an increase in crown and surface fuels, increased tree density bringing high-intensity fires and higher fire frequency in some areas (which continued until 1940s), conversion of oak woodland to grassland, and the invasion of understory woody vegetation.

If current management strategies are continued indefinitely, it is difficult to predict where this change in fire regimes will ultimately lead, especially with the potential of future warmer and drier climate patterns resulting from global climate change. However, if warm, dry years become more common, as some suggest is likely (Fried et al. 2003, Union of Concerned Scientists 2002), the recent paradigm of large, severe fires would be expected to continue.

#### *2.4.1.2 San Francisco Bay Area Fire Regime Research*

Fire history can be reconstructed from a variety of data sources: tree-ring analysis (dendrochronology), cultural and historical accounts, written records, and the analysis of charcoal in sediment cores. Each of these data sources has its limitations in regards to spatial and temporal detail and accuracy.

Sunget and Martin (1984) studied the occurrence of lightning in the Marin coastal area and the potential for a fire start. Storms with lightning occurred 1.9 times per year at Mount Tamalpais in the years 1901 and 1908-1926. The weather station at this site indicates that 18 percent of these storms occurred in September coinciding with high fire hazard conditions.

Many researcher have studied the fire history in redwood and Douglas fir/hardwood forests in the Bay Area. A recently published analysis of tree ring fire scars in coast redwood forests in Point Reyes, Jackson State Forest (Mendocino area) and Redwood National Park finds that pre-20<sup>th</sup> century fire intervals ranged from seven to 20 years. It is thought that these forests experienced frequent, recurrent surface fires likely set by Native Americans (Brown, 2007). A recently published study of fire regimes of redwood forests in northern San Mateo County found an average fire return interval of 13 and 16 years for two sample sites in Huddart County Park, directly adjacent to GGNRA's Phleger Estate (Stephens and Fry, 2007).

Additional studies have been completed within the San Francisco Bay Area and are discussed in the GGNRA FMP Final EIS, November 2005, pages 147-150.

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## 2.4.1.3 Recent Fire History in Marin and San Mateo Counties

Table 3 lists fires by date for the two counties, and Figures 3 and 4 show wildfire locations. Months are given when known. Table 4 presents a summary of GGNRA wildfire occurrences over the last two decades.

**Table 3 -- Wildfire History of Coastal Marin and San Mateo Counties**

<b>Date</b>	<b>Description</b>
1859 Sept.	Wildland fire, Mount Tamalpais, burned for three months.
1865	Woods of Marin along the shore of Bolinas Bay burned for two weeks.
1877	Area west of San Andreas Lake burned over large territory for more than three weeks.
1878	1,200-1,500 acres of chaparral, grass, and timber burned near Nicasio.
1880	Campers caused fires, burned 5-mile by 10-mile area in San Mateo County.
1881 Sept.	65,000-acre wildland fire burned for seven days, one fatality. Started near Blithedale Canyon, Mill Valley, by a man who set fire to a pile of brush.
1887	Fire spread from below San Andreas Lake to San Mateo Creek, burning 2,500 acres of second growth bay, oak, and madrone.
1889	On the ridge between San Andreas Lake and Crystal Springs Lake and two ridges west of San Andreas Lake. "For miles the hills are black and bare, the fire burned for at least 4 days spreading at least 1 ½ square miles a day."
1890 Oct.	More than 8,000 acres burned between San Rafael and Bolinas.
1891 June	12,000 acres of Mount Tamalpais burned; fire started in Bill Williams Gulch near Ross.
1892 Aug.	Fire started on Bolinas Road by two men cooking breakfast, spread over several hundred acres.
1893 Aug.	Fire thought to have been started by campers burned over 3,000 acres of Mount Tamalpais and Mill Valley.
1894 Sept.	Mill Valley fire originated from a campfire left by hunters started in redwood forest and "burned over a large stretch of country."
1904 Sept.	15,000-20,000 acres of grass and timber burned on the west side of Bolinas Ridge.
1913 July	On Mount Tamalpais, between 1,600 and 2,000 acres burned, from Rock Springs to Larkspur, including summit of mountain, Blithedale and Cascade Canyons, most of Fern Canyon, and spot fires beyond Muir Woods National Monument on the Dipsea Trail. Started west of West Point Inn at 10 A.M. probably by railroad sparks.
1919 Sept.	Fire started near Pipeline Reservoir, burned 40 houses on the ridge and stopped within 100 yards of Muir Woods.
1919	Fire swept from the hills above Sausalito, burned a hall, 5 stores, and 12 homes.
1923	Fire burned from Bolinas Ridge to within four miles of Fairfax, with a total size of 30-50 square miles.
1928	200 acres of brush burned around Fort Barry.
1929 July	"Great Mt. Tamalpais Fire," involving 2,500 acres of brush, forest, and grassland. Fire burned into Mill Valley from Fern and Cascade Canyons; 117 homes burned.
1929	A week-long fire around the town of Montara; completely burned down the town.
1931 Dec.	Illegal campfire in large group of charred redwoods in Cathedral Grove, Muir Woods.
1932 Nov.	Thanksgiving Eve Fire. Started at 10:25 P.M. in heavy grass 50 feet west of Panoramic Highway near Alpine Club. North winds spread it toward Muir Woods and Tourist Club. Sixty acres burned, including two acres of chaparral inside Muir Woods' boundaries.

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Date	Description
1933 Dec.	Fires prohibited in Muir Woods; all fireplaces eliminated.
1945 Sept.	18,000-acre fire that began at the entrance to Carson Canyon (Kent Lake).
1946	Large intense fires in northern San Francisco watershed.
1959 July	2:53 A.M. fire report in Kent Canyon near logging operations on Brazil Ranch. No wind; burned 50 acres before being controlled by 75 men.
1965 Oct.	150 acre fire ¼ mile from Muir Woods, near southeast boundary.
1995 Oct. 3-7,	12,354 acres at Mount Vision in Point Reyes NS comprised of 11,598 acres NPS, 386 acres State Park lands and 370 acres private. Forty-eight structures destroyed; 1,200 firefighters participated, took 4 days to contain and 9 days to control fire.

Source: NPS, Pacific West Region, 2004.

**Table 4 – GGNRA Recent Wildfire History**

Area	Past Two Decades (1987-2006)		Past Decade (1997-2006)	
	Human-caused Fires (average per year)	Lightning Fires (Average per year)	Human-caused Fires (average per year)	Lightning Fires (Average per year)
All GGNRA Lands	7.5	0.15	8.5	0.2
GGNRA Marin County	4.15	0.05	4.8	0.1
GGNRA – San Francisco County	3.1	0.1	3.6	0.1
GGNRA – San Mateo County	0.25	0	0.1	0

Source: PWR GIS, 2007

## 2.4.2 CLIMATIC AND TOPOGRAPHIC INFLUENCES

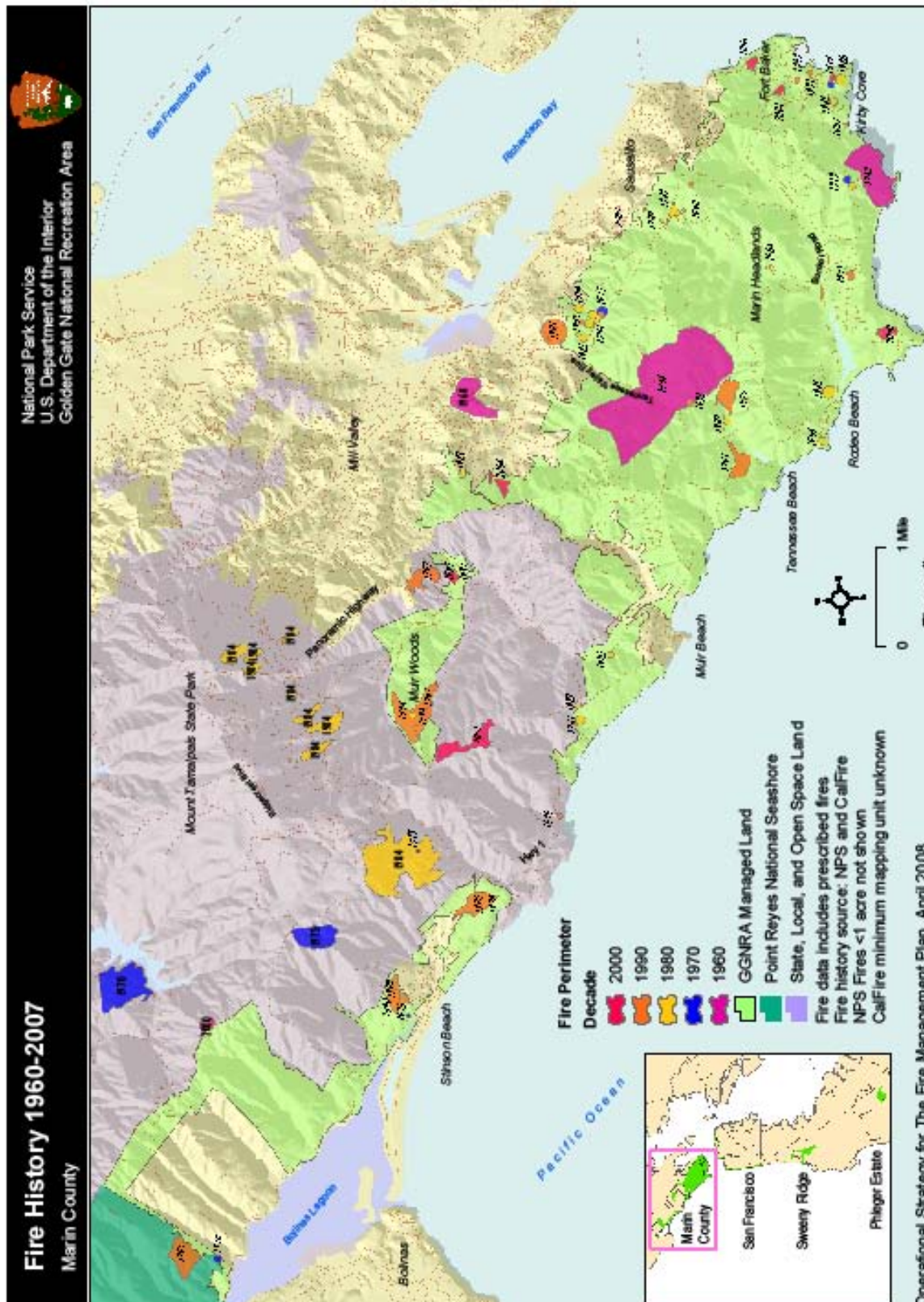
### 2.4.2.1 *Relative Humidity*

The average relative humidity of coastal California is high because of the frequent ocean winds and fogs. Dry northeasterly winds from the interior of the state bring fire weather to the Bay Area periodically during the fall, sending the humidity down to 20 percent.

In general, relative humidity is moderate to high along the coast throughout the year. Inland humidity is high during the winter and low during the summer. Since the ocean is the source of the cool, humid, maritime air of summer, it follows that relative humidity tends to decrease with increasing distance from the ocean. Where mountain barriers prevent the free flow of marine air inland, humidity decreases more rapidly. Where openings in these barriers permit a significant influx of cool, moist air it mixes with the drier inland air, resulting in a more gradual decrease of moisture. This pattern is characteristic of most coastal valleys (Golden Gate Weather Services 2002).

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Figure 3 – Locations of Historic Wildfires in Marin County





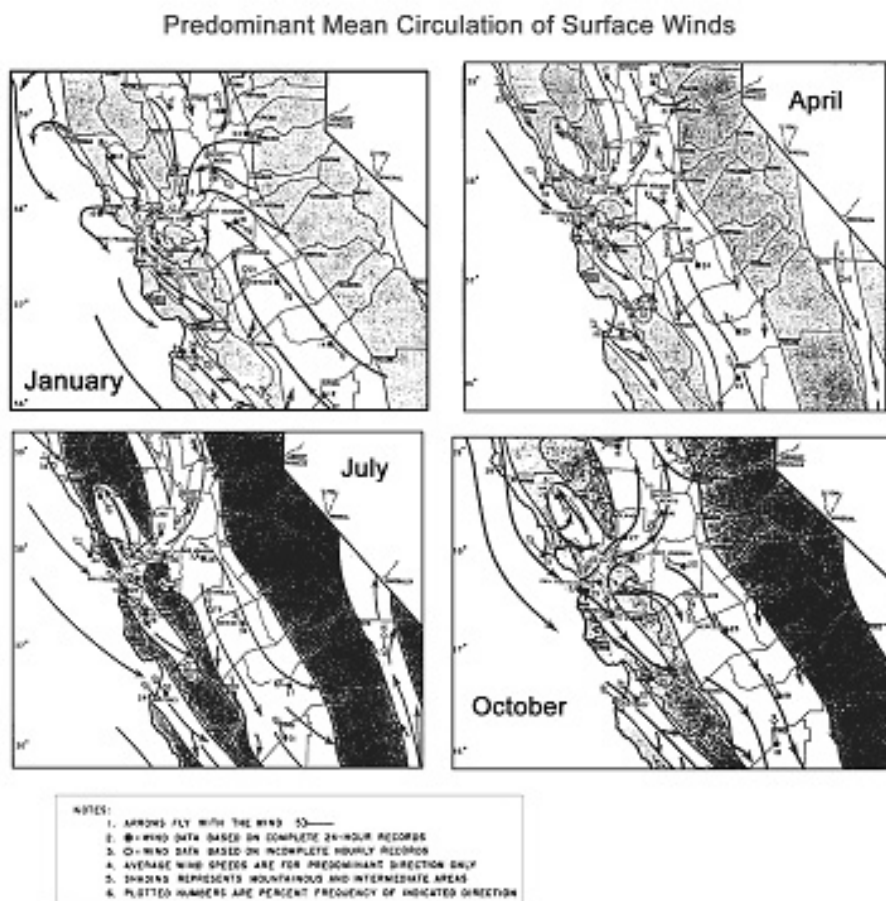


## CHAPTER 2 – FIRE MANAGEMENT STRATEGIES

## 2.4.2.2 Wind Patterns

California lies within the zone of prevailing westerlies and on the east side of the semi-permanent high-pressure area of the northeast Pacific Ocean. The basic flow in the free air above GGNRA is therefore from the west or northwest during most of the year. A local characteristic of the northwest wind alongshore is the creation of a jet effect around some of the more prominent headlands. Eddies form near the Golden Gate and just south of Point Reyes. Wind speeds in the immediate vicinity of these major headlands can be two or three times as great as the wind flow at nearby points (Golden Gate Weather Services 2002).

**Figure 5 – Predominant Wind Patterns in Central California**



Source: Bell 1958

The typical northwest summer wind is reinforced by the dynamics of the thermal low-pressure area located over the Central Valley and the southeastern desert area. In the San Francisco Bay Area, there is a marked diurnal pattern in the strength of the wind even though an onshore circulation tends to continue throughout the 24-hour period.

This helps to carry locally produced smoke away from the Bay Area, but creates problems for the regions immediately south and east of the source area.

When wind patterns shift from the prevailing pattern in the summer, winds can flow out of the Great Basin into the Central Valley, the Southeastern Desert Basin, and the South Coast. The result is high pressure over Nevada and lower pressure along the central California coast. The lower coastal pressure causes the hot interior air to be rapidly drawn to the west from the hot, dry interior. The winds are dry, strong, and gusty, sometimes exceeding 100 miles per hour, particularly near the mouths of canyons oriented along the direction of airflow. These interior winds are known as Diablo winds in the Bay Area, “northers” in the Sacramento and San Joaquin valleys, and Santa Ana winds in southern California (Golden Gate Weather Services 2002).

Figure 5 illustrates the predominant wind patterns in central California (Bell 1958). In the winter, the regional surface winds blow from the north-northeast. During spring and summer, stronger north-northwest winds dominate. These northwesterly winds are primarily caused and/or strengthened by the combination of high pressure offshore and the warmer air inland. During the fall transition, when warm easterly winds break through to the coast while inland conditions remain hot and dry, the coastal region faces its most significant fire threat.

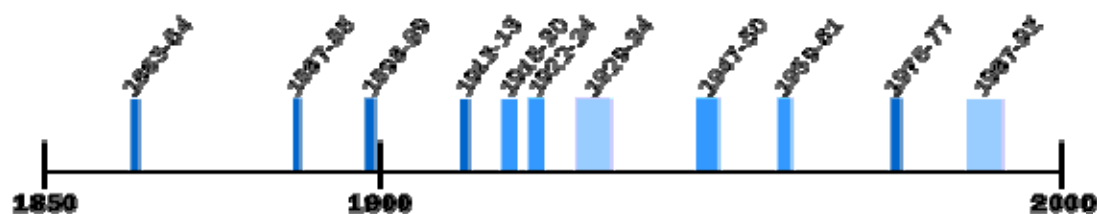
#### 2.4.2.3 *Recurrent Drought*

One dry year does not normally constitute a drought in California. Droughts occur slowly, over a multiyear period. There is no universal definition of when a drought begins or ends. Areas most reliant on annual rainfall typically feel impacts of drought first.

Droughts exceeding three years are relatively rare in northern California, the area which is the source of much of the state’s developed water supply. The 1929-1934 drought years established the criteria commonly used in designing storage capacity and yield of large northern California reservoirs. Figure 6 compares the 1929-1934 droughts in the Sacramento and San Joaquin valleys to the 1976-1977 and 1987-1992 droughts. The driest single year of California’s measured hydrologic record was 1977. California’s most recent multiyear drought was 1987-1992.

Measured hydrologic data for droughts prior to 1900 are minimal. Multiyear dry periods in the second half of the 19th century can be qualitatively identified from the limited records available combined with historical accounts, as illustrated in Figure 6, but the severity of the dry periods cannot be directly quantified.

California sustained two epic drought periods, extending over centuries. The first epic drought lasted more than two centuries before the year 1112; the second drought lasted more than 140 years before 1350. Studies of epic droughts evaluated drowned tree stumps rooted in Mono Lake, Tenaya Lake, West Walker River, and Osgood Swamp in the central Sierra Nevada. These investigations indicate that California has been subject to droughts more severe and more prolonged than those evidenced by the brief historical record.

**Figure 6 – California’s Historical Dry Periods, 1850-Present**

Notes:

Dry periods prior to 1900 estimated from limited data.

Covers dry periods of statewide or major regional extent.

#### 2.4.2.4 *El Niño and La Niña*

Under “normal” circumstances over the Pacific Ocean, trade winds rush toward the equator to replace rising sun-heated air and cause an upwelling of air off Peru. These winds are pushed farther west by a high-pressure zone over Tahiti and attracted by a low-pressure zone over northern Australia. During an El Niño episode, the situation is reversed, with a low over Tahiti and a high over Australia. The trade winds die, the upwelling stops, and the ocean surface warms up in the eastern Pacific. The jet stream over the North Pacific, which normally brings storms to Oregon, Washington, and British Columbia, moves south, picking up warmth from the warm-water bulge below, and drenches California (Gilliam 2002).

During severe El Niño episodes like 1982-1983 and 1997-1998, the Bay Area received more than twice its “normal” rainfall. Houses were destroyed by mudslides, bridges were washed out, and highways were blocked. Although El Niño events occur every four to seven years, they vary greatly in timing and strength. A mild El Niño will scarcely have any important effect, but a strong one can bring disaster. The outlook for El Niño episodes in the 21st century is uncertain. As global warming continues, increasing temperatures of both the air and the water, El Niño events may increase in frequency and intensity (Gilliam 2002).

The opposite of El Niño is the less well-known La Niña. La Niña occurs when trade winds are stronger than usual over the Pacific Ocean, pushing more sun-warmed surface waters westward, causing more upwelling off Peru, and further intensifying the oceanic currents of the northern Pacific Ocean (Gilliam 2002). The wintertime effect of La Niña in the Bay Area is likely to be colder, windier weather and perhaps abnormal rainfall in either direction, too much or too little (and sometimes neither), depending on the erratic location of the jet stream. If La Niña persists into the summer, stronger upwelling off the California coast brings more fog to the area (Gilliam 2002).

#### 2.4.2.5 *Climate Change*

Surface temperature measurements recorded daily at hundreds of locations for more than 100 years indicate that the Earth’s surface has warmed by about 1 degree Fahrenheit in the past century. This warming has been particularly strong during the last 20 years, and has been accompanied by retreating glaciers, thinning arctic ice, rising

sea levels, lengthening of growing seasons for some, and earlier arrival of migratory birds (Union of Concerned Scientists 2004).

GGNRA winters will quite probably become warmer, windier and wetter during the next century (Fried et al. 2003, Union of Concerned Scientists 2004). Summers may well become warmer, though winter will become proportionally even warmer. El Niños may increase in intensity and/or frequency.

Changes in the timing or amount of precipitation over the next century are likely to have a greater impact than changes in temperature (Union of Concerned Scientists 2004). For example, increases in the amount of winter rains could change the extent and mix of plant communities, expanding grasslands will likely encroach on the foothill shrublands of the coastal ranges. In many cases, however, plant and animal species will not be able to shift northward or upslope because the potential habitat has been claimed by development or nonnative species, or contains unsuitable soils or other physical limitations.

The frequency and/or magnitude of wildfires, floods, and disease and pest outbreaks will likely change in coming decades. Fried et al. (2003) predict that these conditions will produce more intense, faster-spreading fires in most locations. Their model shows that, despite any enhancement of fire suppression efforts, the number of escaped fires (those exceeding initial containment limits) increased 51% in the San Francisco Bay Area. Area burned by contained fires could increase by 41%. Furthermore, Fried et al. (2003) predicted that fire return intervals in grass and brush vegetation types would be cut in half on average. Their reported estimates represent a minimum expected change, or best-case forecast. In addition to the increased suppression costs and economic damages, changes in fire severity of this magnitude would have widespread impacts on vegetation distribution, ecological condition, and carbon storage, and would greatly increase the risk to property, natural resources, and human life.

In August, 2006, the journal SCIENCE published the results of research conducted by Westerling *et al.* which concludes that global climate change has already increased the duration and intensity of the wildfire season in the western United States. They determined that, since 1970, the length of the wildfire season has increased by 78 days and the average burn duration of large fires has increased from 7.5 to 37.1 days. When examining wildland fires, between 1970 to 1986 versus wildland fires since 1986, Westerling *et al.* found a fourfold increase in major incidents and a six-fold increase in acreage burned. According to Westerling *et al.* four critical factors -- earlier snowmelt, higher summer temperatures, longer fire season, and expanded vulnerable area of high-elevation forests -- are causing the increase. During this period, spring and summer temperatures increased by ~0.9°C and mountain snowpack melted 1- to 4-week earlier. As a result, high altitude forests become combustible earlier in the year and remain in that state over a greater period of time due to sparse summer rainfall and low humidities. Look over the fire record for the recent past, they found that years with an earlier snowmelt (and a longer drier summer) had five times as many wildfires as years in which the snowpack melted later. According to the report in the August issue of SCIENCE:

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The fires in Yellowstone Park in 1988 seemed to inaugurate this new era of major wildfires in the western United States. The fires lasted more than 3 months, burning 600,000 ha [~1.482 million acres] of forest, and -- despite the investment of \$120 million and deployment of 25,000 firefighters -- were only extinguished when snow began to fall in mid-September. The Yellowstone fires exemplify a common statistic of wildfires: Less than 5% of all wildfires account for more than 95% of the area burned. A small fraction of fires get very large and become uncontrollable despite human efforts to suppress them, regardless of money expended. Such efforts can cost more than \$20 million per day, and seasonal expenditures by governmental agencies in recent years have reached \$1.7 billion.”

An introductory article in the August 18, 2007 *SCIENCE* by S. Running, reports the results of seven general circulation models running future climate simulations for several different carbon emissions scenarios in preparation for the upcoming Intergovernmental Panel on Climate Change. The models all predict that June to August temperature would increase 2° to 5°C during the period of 2040 to 2069 in western North America. The models also predict that rainfall would decrease up to 15% during the same time period. If the increase was 3°, roughly between the highest and lowest predictions, the trend would show a spring/summer increase roughly three times the rate Westerling *et al.* determined for current trends. Wildfires in Canada and the western United States could increase by 74 to 118% in the next century.

### 2.4.3 Fire Weather

Post-frontal offshore flow can bring high fire danger to the Pacific Coast from British Columbia to southern California. The bulge of the Pacific High moving inland to the rear of a front produces offshore northeasterly winds (Fischer and Hardy 1976).

The fire season usually starts in June and lasts into October. Several synoptic weather types produce high fire danger. One is the cold-front passage followed by winds from the northeast quadrant. Another is similar to the east-wind type of the Pacific Northwest coast, except that the high is farther south in the Great Basin. This Great Basin High produces the foehn-type Diablo winds in the central Coast Ranges. Peak occurrence of these winds is in November, and there is a secondary peak in March. A third high fire-danger type occurs when a ridge or closed high aloft persists over the western portion of the United States. At the surface, this pattern produces very high temperatures, low humidity, and air mass instability (Fischer and Hardy 1976).

#### **2.4.4 Prescribed Fire Windows**

The approximate weather window for prescribed burns in grassland at GGNRA is from June to November. Burning can begin in some areas after annual grasses have cured, which does not normally occur until mid-June to early July. While areas with annual grasses generally have the most flexible burn windows in GGNRA, burns must still be timed to occur between the dissipation of the coastal fog and the onset of afternoon sea breezes.

In shrublands and forested areas, burning can be extremely difficult due to the narrow burning window from late September to early October when fuels dry out. Northeast wind events during this same timeframe can result in Red-Flag Days on which no prescribed or pile burning is allowed. “Burn days,” or days when burns would be in prescription, often do not coincide with weather conditions appropriate for burning in GGNRA, as on many of these days smoke dispersal would contribute to air quality problems.

### **2.5 GGNRA WILDLAND FIRE RISK/HAZARD VALUE ANALYSIS MODEL**

#### **2.5.1 Objectives**

The GGNRA Risk/Hazard Value Analysis identifies and prioritizes areas of concern in the park due to the threat of wildfire. The products of the analysis are data and maps which will be used for fire management project planning such as prescribed burns and hazard fuel reduction. The analysis helps in prioritizing projects in order to meet objectives laid out in the fire management plan.

#### **2.5.2 Analysis Area**

The analysis area includes NPS lands managed by GGNRA, the Presidio Trust, PRNS and lands that will soon become part of GGNRA (i.e., Cattle Hill and Pedro Point). In addition, some lands outside of NPS jurisdiction were included such as Mount Tamalpais State Park and San Francisco Public Utilities Commission Peninsula Watershed. Lands outside of NPS management were included in the analysis because fuel model and other fire behavior input variables existed for these areas and their addition presents an overall perspective of fire risk, hazard, and values both within and surrounding NPS lands.

#### **2.5.3 Methodology**

A Geographic Information System (GIS) in combination with FlamMap fire and Asset Analyzer was used to analyze four variables consisting of fire risk (potential for ignition), fire hazard (potential fire behavior and crown fire), and values (potential loss due to fire, primarily the wildland urban interface). Asset Analyzer Arcview 3.3 extension was used to combine and weight the variables. Input variables were normalized from 0 to 100 (low priority to high priority) then weighted to define their contribution to the final output. The results were categorized into classes representing low, moderate, high areas of concern for fire management. The analysis does not address the ecological need to restore natural historic fire regimes. Instead, this analysis is intended to help direct fire

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management projects (mechanical thinning, prescribed fire, etc.) for effective and cost efficient protection of highly valued resources.

### 2.5.3.1 Input Variables

#### *Risk – potential for fire ignition*

Fire risk was based on 26 years (1980-2006) of NPS historical fire ignition records. The assumption is that the greatest potential for future fire starts is related to where fires have historically occurred. A point density calculation was performed on the historical ignition locations to create a density of fire frequency throughout the analysis area. The result was a raster dataset consisting of fires/year/acre. The kernel method (radius 2000m) was used to create the density surface. Fire densities were then reclassified into low, moderate, high risk of ignition.

<b>Fire Risk</b>		
<b>Fire Density (fires/year/acre)</b>	<b>Fire potential</b>	<b>Asset Analyzer Value</b>
0 - 0.05	Low	33
0.06 – 0.28	Moderate	66
0.29 – 0.88	High	100

#### *Hazard – potential fire behavior*

Potential crown fire activity and fire line intensity as predicted by FlamMap fire modeling software were used as hazard variables in the analysis. FlamMap computes potential fire behavior based on spatial variables of elevation, slope, aspect, fuel model, canopy cover, tree height, canopy base height, and crown bulk density along with fuel moisture and wind direction variables.

In 2004, Fire ecologists, botanists, GIS specialists and local fire experts from GGNRA, PRNS, and the NPS Fire Program Analysis team convened to translate local vegetation types into fuel mode consistent with the Anderson framework (Anderson 1982). Fuels are any organic material (live and dead vegetation, litter, and duff) that may combust during a fire. Fuel models are a numeric description of the quantity and arrangement of fuels developed to allow easy input of environmental parameters and fuel characteristics into fire behavior prediction models. The fuel models used describe potential fire behavior for a given fuel loading (weight per area) and arrangement (surface versus crown fuels), which generally corresponds to a vegetation type (Rothermel 1972).

Vegetation maps from 1994 aerial photography were assigned fuel models based on the alliance-association vegetation type and field plot information. GGNRA and PRNS field crews measured vegetation and fuels during 2001-2002. Data collected to validate vegetation data was also used for the creation of the fuel model data including percent cover and height of each vegetation stratum ocularly measured at 1690 plots (Noonan 2003).



**Table 5 -- GGNRA Vegetation Types and Fuel Model Types**

<b>Fuel Model Types with Predominant Vegetation Community</b>	<b>Fuel Model Acres</b>	<b>Composition of Vegetation Community by Fuel Model Type</b>	<b>Acres</b>
1-Coastal Dunes	21	<b>Coastal Dunes</b>	<b>183</b>
1-Grassland	1,983	Fuel Model 1	21
2-Coastal Scrub/Chapparal	1,780	Fuel Model 5	8
4-Coastal Scrub/Chapparal	132	Fuel Model 8	154
5-Coastal Dunes	8	<b>Grasslands</b>	<b>1,983</b>
5-Coastal Scrub/Chapparal	623	Fuel Model 1	1,983
6-Coastal Scrub/Chapparal	4,991	<b>Coastal Scrub/Chapparal</b>	<b>7,526</b>
6-Douglas-fir/Coast Redwood	41	Fuel Model 2	1,780
6-Riparian Forest/Shrubland	8	Fuel Model 4	132
8-Coastal Dunes	154	Fuel Model 5	623
8-Douglas-fir/Coast Redwood	350	Fuel Model 6	4,991
8-Herbaceous Wetlands	92	<b>Douglas-fir/Coast Redwood</b>	<b>1,556</b>
8-Unclassifiable Vegetation	8	Fuel Model 6	41
8-Native Hardwood Forest	1,381	Fuel Model 8	350
8-Non-native Evergreen Forest	590	Fuel Model 9	924
8-Riparian Forest/Shrubland	328	Fuel Model 10	241
9-Douglas-fir/Coast Redwood	924	<b>Herbaceous Wetlands</b>	<b>92</b>
10-Douglas-fir/Coast Redwood	241	Fuel Model 8	92
10-Non-nat Evergreen Forest	9	<b>Native Hardwood Forest</b>	<b>1,381</b>
98-Water	45	Fuel Model 8	1,381
99-Built-up Disturbed (unburnable)	717	<b>Nonnative Evergreen Forest</b>	<b>599</b>
99-Unveg Shoreline/Outcrop (unburnable)	469	Fuel Model 8	590
<b>Sum Acres</b>	<b>14,896</b>	Fuel Model 10	9
		<b>Riparian Forest/Shrubland</b>	<b>336</b>
		Fuel Model 6	8
		Fuel Model 8	328
		<b>Unclassifiable Vegetation</b>	<b>8</b>
		Fuel Model 8	8
		<b>Sum Burnable Acres</b>	<b>13,665</b>

Source: NPS, GGNRA Fire GIS, GGNRA Fire Management Office, 2008.

Fire hazard was modeled for extreme conditions (97<sup>th</sup> percentile weather) using data derived from the Barnabe RAWS station. Corky Conover (NPS) analyzed historic data from the Barnabe Remote Automated Weather Station (RAWS) in Fire Family Plus (FF+) software program. The “G” model was used to obtain 97<sup>th</sup> percentile fuel moisture estimates for all fuels size classes. Barnabe RAWS is located in the San Geronimo Valley, east of Olema and may not represent weather conditions in all locations of GGNRA; however it was felt the data from this station is sufficient for fire planning purposes.

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All wind directions were analyzed (1), and then only easterly wind directions (2), and finally all wind directions from the NW-SE in a clock wise manner (3). The lowest fuel moisture values from these three FF+ runs were used to create an initial fuel moisture file (\*.fms) in the FARSITE program to use in the FlamMap model runs. Wind was modeled uphill at 7 miles per hour (mph). 97<sup>th</sup> percentile wind speed per Barnabe weather station is 15mph; however since FlamMap was set model winds uphill it was felt 15mph was too extreme to yield realistic results.

**Initial fuel moisture percentages for all fuel models**

1 Hr.	10 Hr.	100 Hr.	Herbaceous	Woody
2	5	8	30	93

FlamMap modeled output of fireline intensity (BTU/ft/s) was reclassified into rankings of low, moderate, high, and extreme based on the fire suppression guidelines (National Wildfire Coordinating Group 2004). Crown fire was reclassified into three rankings (unburned and surface fire, passive crown, active crown).

**FlamMap potential fireline intensity**

Fireline Intensity	Btu/ft/sec	Asset Analyzer Value
Unburnable	0 - unburnable	0
Low	1 – 100	25
Moderate	101 – 500	50
High	501 – 1000	75
Extreme	> 1000	100

**FlamMap potential crown fire activity**

Crown fire activity	FlamMap results	Asset Analyzer Value
Low	Unburned or surface fire	0
Moderate	Passive crown fire (torching)	50
High	Active crown fire	100

*Values - values at risk from fire*

GGNRA borders residential communities in San Mateo, San Francisco and Marin counties for approximately 40 miles. A wildland fire near this boundary could threaten homes and private property. The Wildland Urban Interface was used to delineate values at risk. Wildland Urban Interface is defined as the intermix of housing or developed lands with undeveloped lands. For the analysis a kernel method (radius 2000m) density calculation of tax parcel locations was reclassified into four categories ranking from low (rural) to high (urban). An attempt was made to eliminate parcels with no structures or housing units from the analysis using digital aerial photography from

## CHAPTER 2 – FIRE MANAGEMENT STRATEGIES

2001 and 2004, however the data was not field verified. It was also assumed for the analysis that a parcel containing a structure represents one housing unit and does not take into account multiple-housing units such as apartment complexes. Developed GGNRA lands such as Capehart housing and Fort Cronkhite in the Marin Headlands were also classified as wildland urban interface.

### Values at Risk (Density of developed lands)

Density description	Density	Asset Analyzer Value
Non-Wildland Urban Interface	Less than 1 unit / 40 acres	25
Rural	(1 unit / 40 acres) to (1 unit / 5 acres)	50
Intermix	(1 unit / 5 acres) to (1 unit / 1 acre)	75
Urban	Greater than 1 unit / 1 acre	100

#### 2.5.3.2 Analysis using Asset Analyzer

Asset Analyzer is an Arcview 3.3 GIS software extension developed by the Southern Sierra Geographic Information Cooperative. Asset Analyzer applies a weighted sum to multiple variables in order to identify areas of high concern or priority. Input variables must be normalized on a scale of 0-100 (lowest priority to highest priority). Weighting the input variables allows a range of scenarios to be developed focusing on specific goals. For example, identifying areas of high fire behavior in relation to WUI or identifying areas prone to fire starts in relation to high fire behavior.

Asset Analyzer was run four times with different weighting schemes that emphasized different inputs. Asset Analyzer does not allow an input variable to be set at 0%; therefore 1% was used when a particular variable not to be considered in the analysis.

#### Input Variable Weighting for Asset Analyzer runs

Analysis Run	Risk of Ignition	Fireline Intensity	Crown Fire Potential	WUI Density	Variable Total
1. Equal Weight	25%	25%	25%	25%	100%
2. Fire Behavior Emphasis	1%	49%	49%	1%	100%
3. WUI/Crown Fire Emphasis	10%	10%	40%	40%	100%
4. Ignition Risk/Fire Behavior Emphasis	33%	33%	33%	1%	100%

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2.5.3.3 *Model Results and Discussion*

Asset Analyzer offers the flexibility of emphasizing one or more of the input variables through the weighting process. Four results were presented to fire management for consideration when setting project priorities:

1. Equal Weighting of Variables – Weighting variables equally gives an overall estimate of ignition risk, fire behavior potential, and potential loss due to fire. It provides a broad picture of fire management areas of concern.
2. Fire Behavior Emphasis – Fireline intensity and crown fire potential give an estimate of fire control difficulty, likelihood of fire escaping initial attack, and fire costs.
3. Wildland Urban Interface and Crown Fire Emphasis – Crown fire in proximity to WUI is important for understanding the potential for extreme fire behavior and threats to human life and property and for estimating costs from a large fire.
4. Ignition Risk and Fire Behavior Emphasis – Likelihood of ignition in relation to potential fire behavior gives an estimate of potential fire frequency and fire control difficulty.

There is not a correct or ultimate input variable weighting combination that will yield a best or desired outcome. All four analyses will be considered when setting fire management priorities. It is important to look at each analysis and the weighting of each variable in order to understand what is driving the model. In order to understand why one area of the park falls into a particular category of “area of concern” versus another you need to look at the input variables – it could be close to WUI, could have high crown fire potential, a combination of variables, etc.

It is not surprising that portions of the park along the boundary rank higher in terms of the hazard model due to their close proximity to development and the fact that many of these areas contain heavy fuels, nonnative forest, and hilly terrain. Maps of the results of the analysis are represented in Figures 7 through 10.

Figure 7 –Value Model Input Variables: WUI & Fire Density

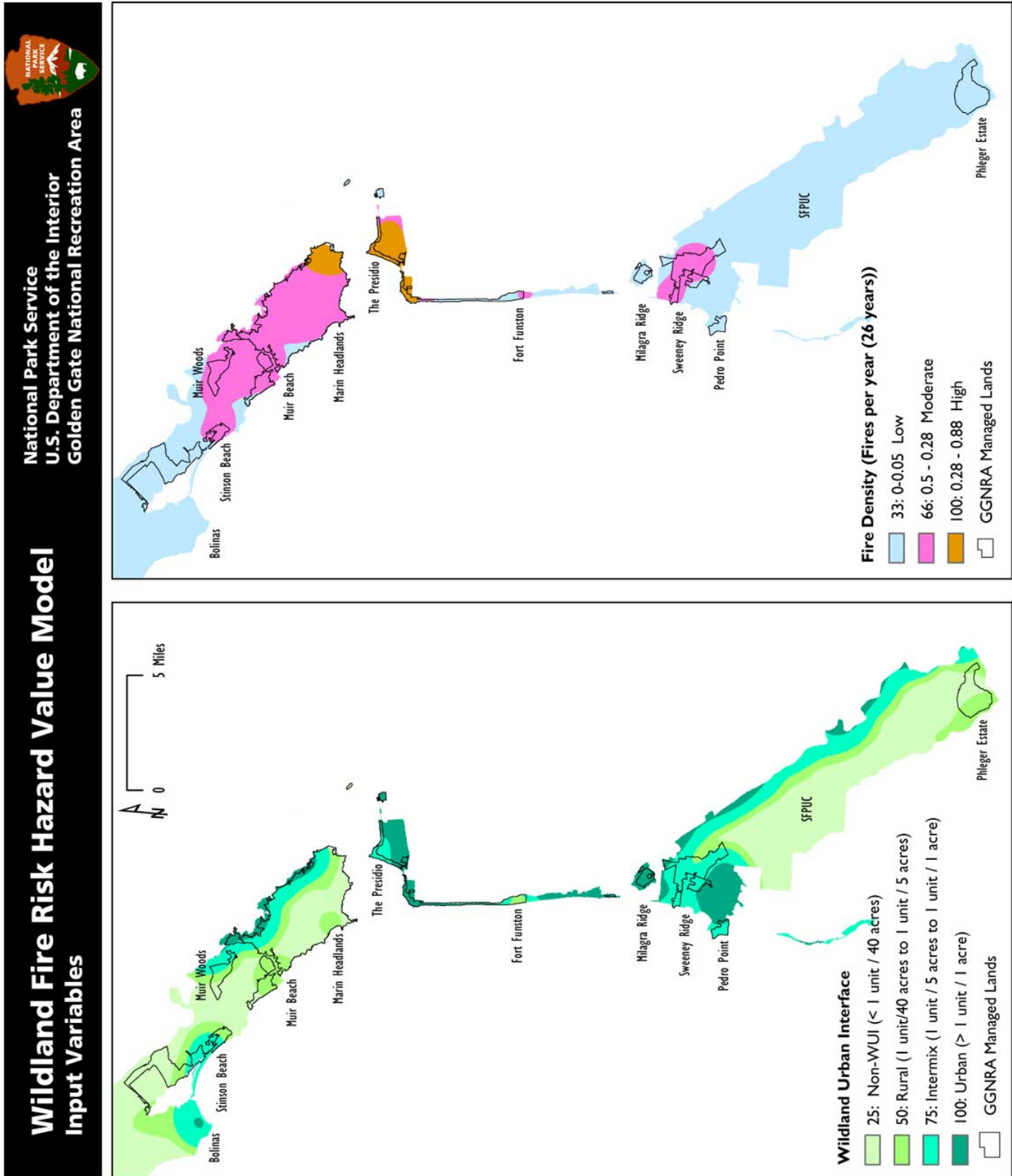
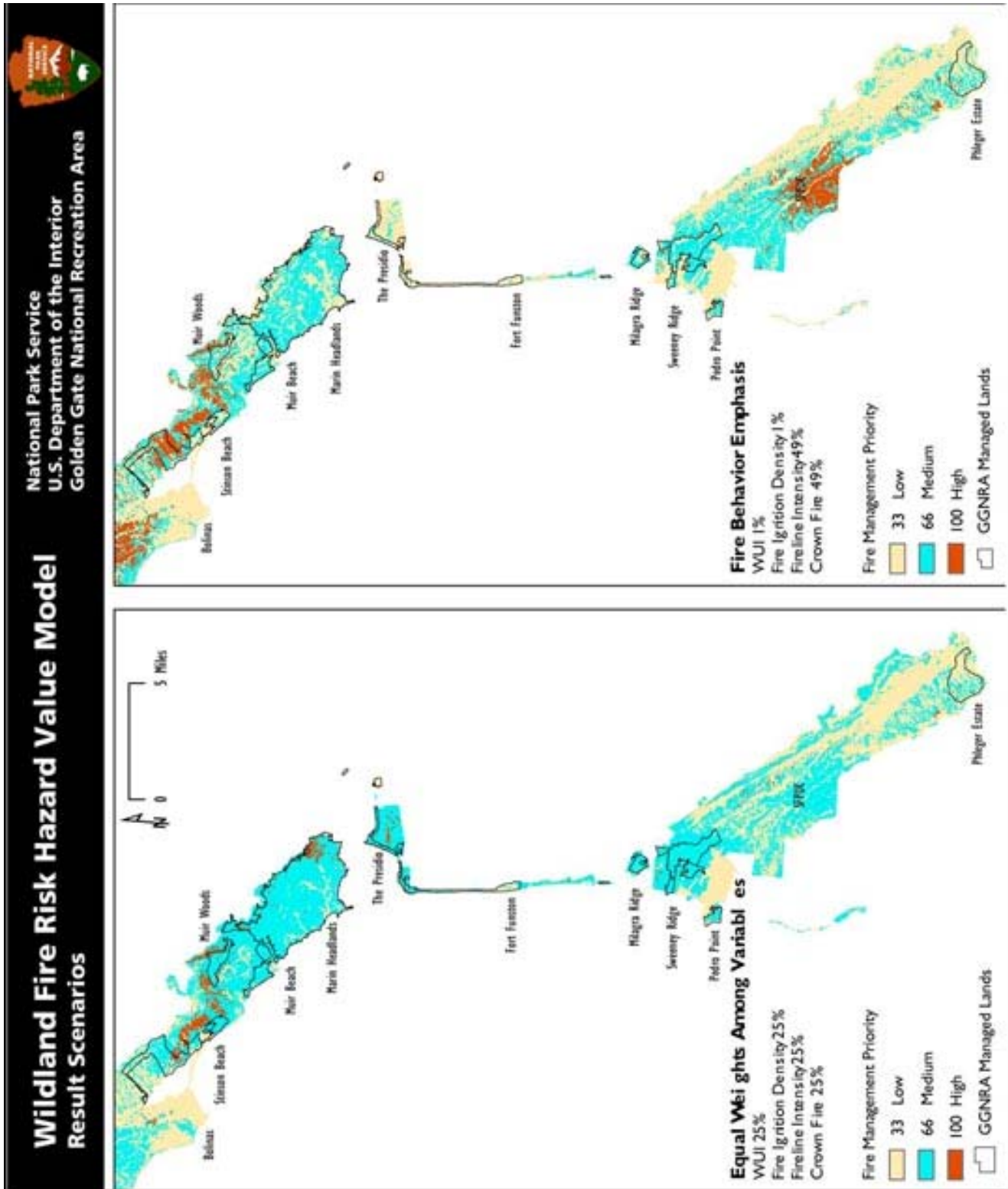


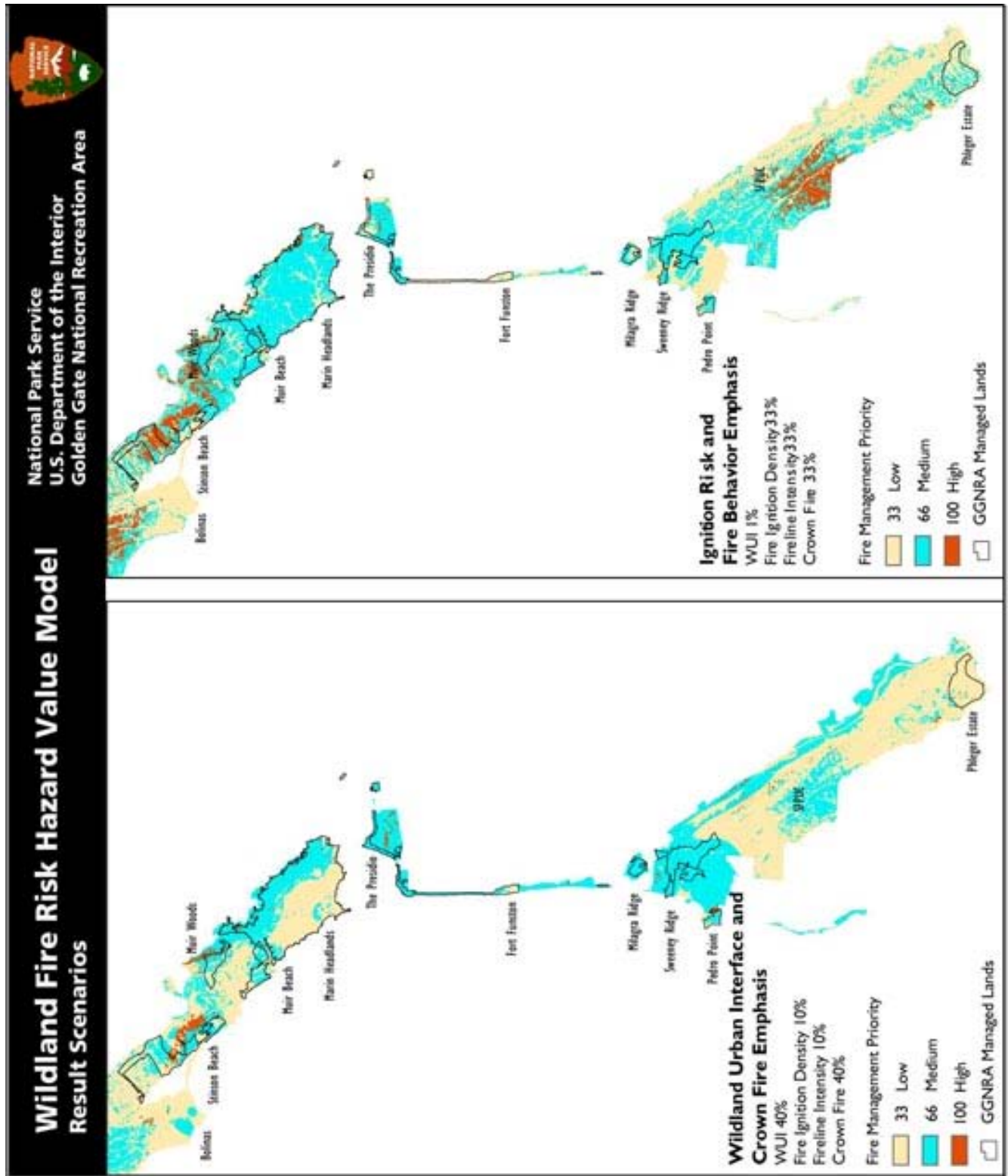


Figure 9 - Model Results: Equal Weight & Fire Behavior Emphasis



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Figure 10 - Model Results: Crown Fire & Ignition Risk Emphasis

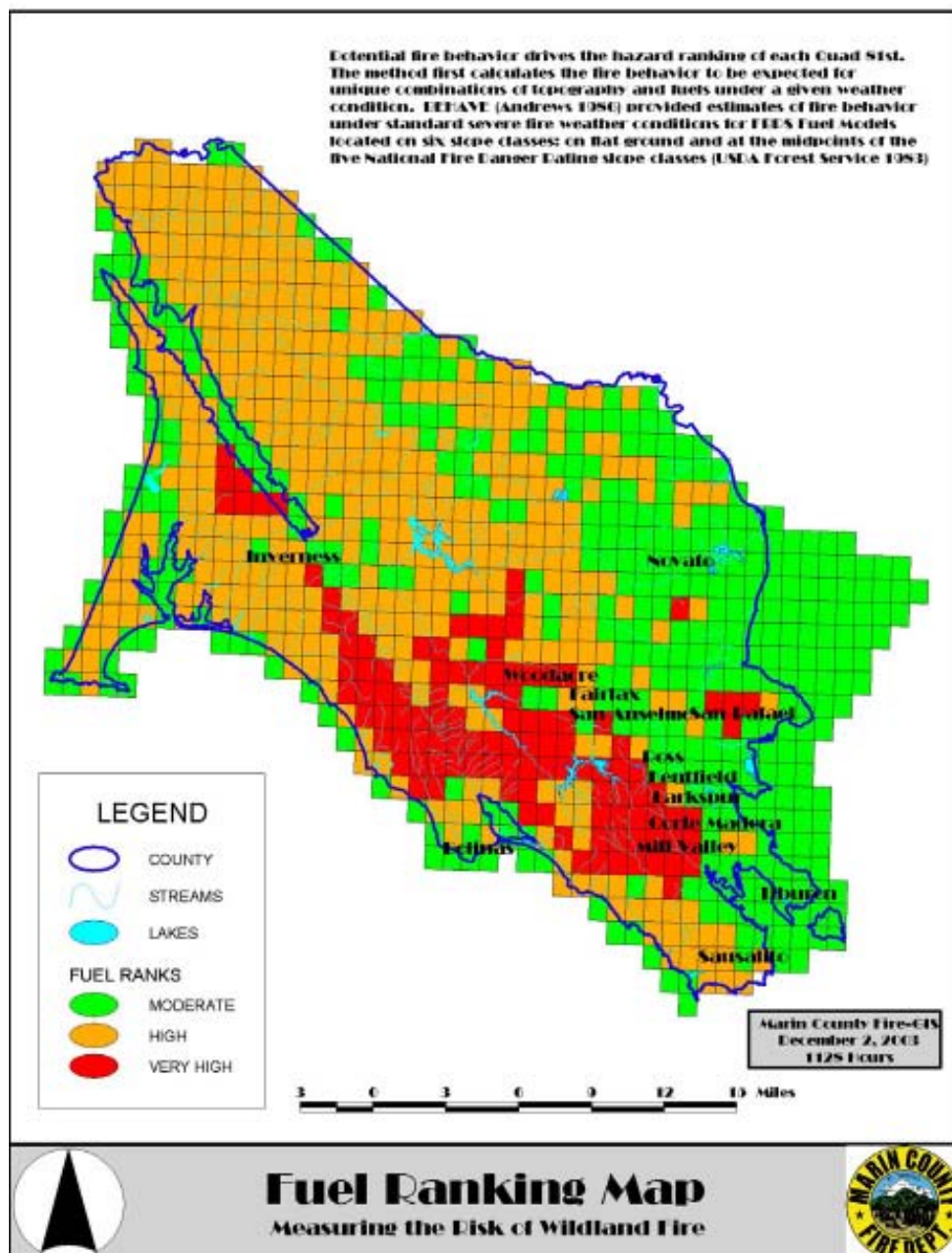




## 2.6 MARIN COUNTY FIRE DEPT HAZARD MODEL

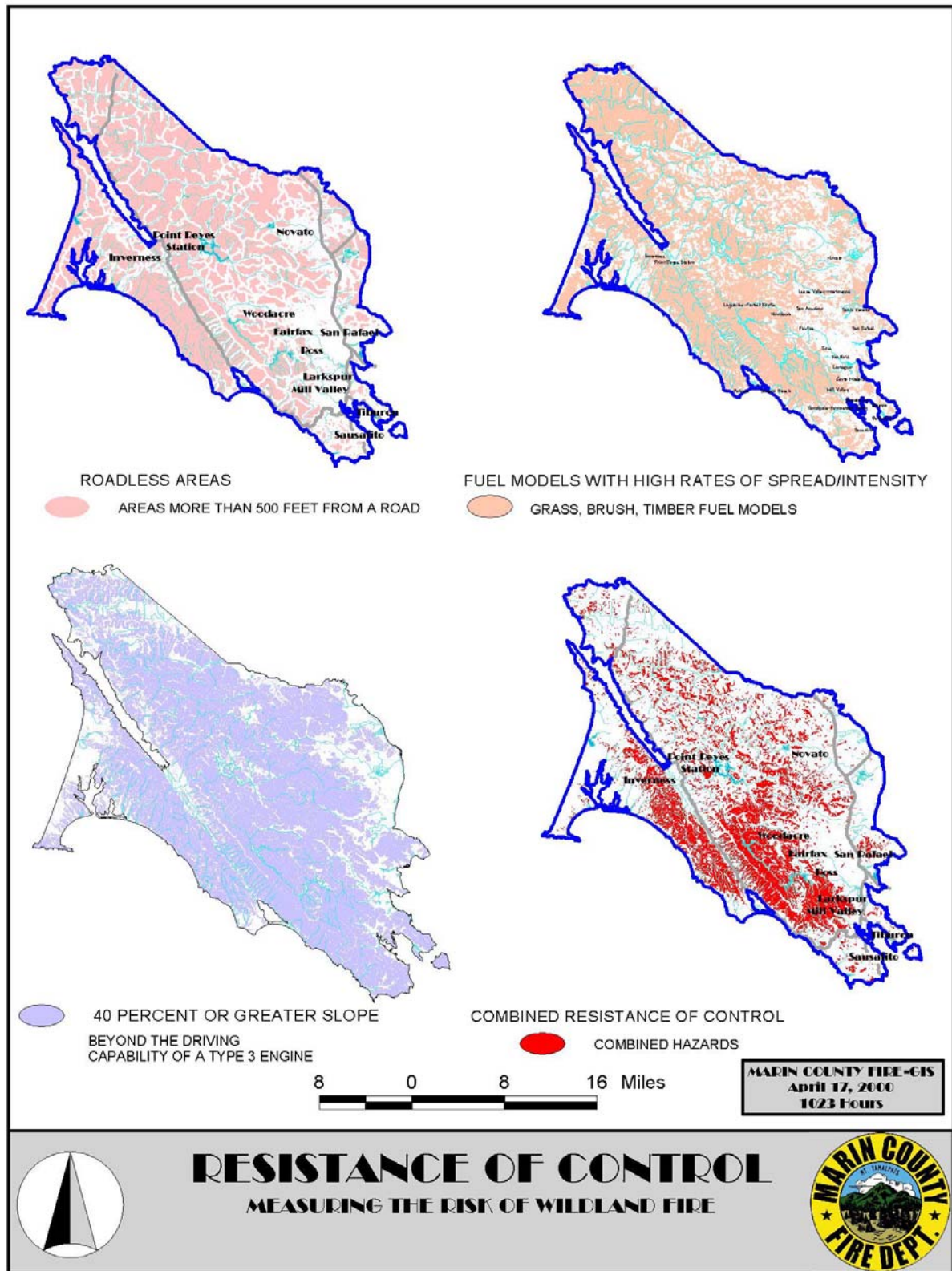
The Marin County Fire Department, using data provided by GGNRA Fire Management and GIS personnel, developed a wildland fire hazard model to identify the highest risk areas in the county. Fire behavior factors such as rate of fire spread and level of fire intensity, fuel type under extreme weather conditions (see Figure 11), was combined with variables such as slope, proximity to roads, etc. to map those areas of the county where it would be more difficult to control a wildland fire, denoting a higher level of risk. The results are shown in Figure 12.

**Figure 11 – Marin County Fire Department’s Fuel Ranking Map**



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Figure 12 – Marin County, Inputs Fire Department’s Fuel Ranking Map



## 2.7 CAL FIRE RISK ASSESSMENT FOR SAN MATEO COUNTY

To develop a wildfire risk assessment for San Mateo County, Cal Fire gathered data on vegetation type, fire history, fire weather history, level of service (distance to a fire station), slope, presence of ladder fuel, and crown closure. Much of Sweeney Ridge, Pedro Point and Milagra Ridge are rated as having high fuel loading. In addition, Sweeney Ridge is rated as having a moderate to high level of assets at risk overall combining public and private assets into one value. The Sweeney Ridge rating may stem from its proximity to the San Francisco watershed as the Ridge is given a lower risk rating when only residential structures are considered. An assessment of risk is often prepared to support recommendations for vegetation management projects to reduce the potential for wildland fire to spread. Of the Cal Fire vegetation management proposals, one – the South Firebreak -- is near GGNRA property. The South Firebreak is near the Phleger Estate; extending from Canada Road north of Woodside west along the PG&E right of way, ending at Skyline Boulevard (Highway 35).

## 2.8 STRATEGIC APPROACH OF THE FMP

FMP implementation is based on the following strategies:

- Reduction of hazardous accumulations of vegetation (fuels) in areas where these activities would have the highest likelihood of reducing the potential risk of wildland fire to lives and property;
- Enhancement of the conditions of natural resources (e.g., increasing abundance or distribution of habitat for threatened and endangered species; reducing infestations of nonnative plants; increasing native plant cover); and
- Protection or enhancement of cultural resource elements and values (e.g., burning would be used to reduce vegetation in areas that are identified as important historic viewsapes).
- Annually, a maximum of 275 acres would be subject to mechanical fuel treatments, and a maximum of 320 acres would be subject to prescribed burning. Under maximum annual achievement, acreage treated by county is estimated as shown below in Table 6.

**Table 6 – Annual Maximum Achievement  
Distribution of Acres by County**

Treatment Type	County	Acreage
Mechanical Treatment	Marin	225
	San Francisco	10
	San Mateo	40
	TOTAL	275
Prescribed Burning	Marin	285
	San Francisco	<1
	San Mateo	35
	TOTAL	320

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- Prior to each funding cycle, fire management and resource management personnel would review the past year's accomplishment, modify the coming year's project list as necessary, and develop a new "fifth year" implementation schedule for the five-year plan to maintain its long-range implementation focus. After modification, the annual program will be presented to the park's internal review processes to ensure regulatory compliance and conformance to the GGNRA FMP Record of Decision and Final EIS.
- The FMP will be reviewed annually to determine if course corrections are needed based on the prior year's experience, recent research findings or changes in the environmental, policy or regulatory setting. Changes proposed to the FMP will also be subject to the park's internal review processes.
- Mechanical treatments will be used to reduce hazardous fuel accumulations and to create and maintain defensible space and fuel breaks. Some areas may be mechanically treated prior to burning to increase the efficacy of the burn.
- The focus for prescribed burns will be: 1) enhancing ecosystem health by reducing invasive nonnative plant species; 2) fostering the restoration of native habitat; 3) rehabilitating cultural landscapes; or 4) reducing hazardous fuel accumulations. Prescribed burns would be conducted to approximate natural fire intensity and fire intervals to the extent possible while ensuring the protection of life and property.
- Prescribed burns intended for resource enhancement will initially be small and will be intensively researched during preparation and monitored during implementation. If research results indicated that ecological conditions improved after burning, the size of the burns can be increased. All prescribed burns would be conducted under specific burn plans in accordance with national fire policy requirements. Research topics may include:
  1. The effects of fire on management of nonnative plant species such as eucalyptus, Scotch/French broom, and Harding grass;
  2. The effects of fire on the species composition and fuel load of coastal grassland and scrub communities;
  3. The role of fire in Douglas-fir/coastal redwood communities and the effect of fire on fuel loading in these communities;
  4. The interaction between plant diseases such as sudden oak death (SOD) and fire; and
  5. The effects of prescribed fires and wildfires on plant and/or animal communities, including rare or sensitive species and their habitat.

### 2.8.1 GGNRA Fire Management Units (FMU)

An FMU is any land management area that can be defined by management goals and constraints, topographic features, access corridors, values at risk or values to be protected, political boundaries, fuel types, or major fire regime groups that set it apart from management characteristics of an adjacent unit. FMUs provide the framework for development of a wildland fire program. As directed by NPS Reference Manual #18 (NPS 2006b), each FMU should be unique as evidenced by management strategies, objectives, and attributes; should be consistent with management goals and objectives found in land and resource management planning documents; should avoid redundancy and should be kept to a minimum.

In developing the FMUs for GGNRA, staff referenced the goals of the FMP, area topography and hydrology, adjacent development density, and distribution of park resources and divided the planning area into three FMUs:

- Unit 1. Wildland Urban Interface FMU: areas around the park exterior adjacent to suburban development and developed areas within the park;
- Unit 2. Park Interior FMU: larger, more open and undeveloped tracts of the park relatively distant from built-up areas; and
- Unit 3. Muir Woods FMU: targeting Muir Woods National Monument and its unique natural setting, high visitation levels and its access limitations.

The distribution of the three FMU types across GGNRA-managed lands in the three counties is shown below in Table 7 and depicted in Figures 13 and 14. Nearly sixty-six percent of the area to be treated under the FMP is in Marin County. All of the lands in San Francisco County are in the WUI FMU while San Mateo County lands are split between WUI FMU lands near Pacifica neighborhoods and Park Interior lands primarily at Sweeney Ridge.

**Table 7 -- Distribution of FMU Acreage by County**

FMU	Marin	San Francisco	San Mateo	Total Acres
Wildland Urban Interface	2,524	923	1,479	4,926
Park Interior	7,910	NA	1,765	9,675
Muir Woods	552	NA	NA	552
Total Acres	10,986	923	3,244	15,153

Source: GGNRA Fire Management Office Data 2004.

NA = not applicable

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**2.8.2 Descriptions and Strategies of the FMUs****2.8.2.1 Wildland Urban Interface FMU**

The Wildland Urban Interface (WUI) FMU includes those lands that border developed or “interface” zones and totals 4,926 acres. For the GGNRA FMP, the WUI zone is defined as any land within 1,200 feet of an urban/developed area. Where it made practical sense, the WUI FMU boundary was extended to include fire roads, trails, and jurisdictional boundaries. Many of the lands in the WUI FMU are in close proximity to values at risk (i.e., homes, infrastructure, etc.); have high hazard fuel loading and steep slopes, are exposed to dry, easterly winds during the fire season and have high visitation (and, correspondingly, an increased chance of ignitions).

The primary strategy in the WUI FMU is to reduce hazardous fuel loads through mechanical fuel reduction projects and prescribed burning targeted to complement the mechanical treatments. Prescribed fire would be available as a resource management tool, but restricted in its use and applied to answer specific research questions.

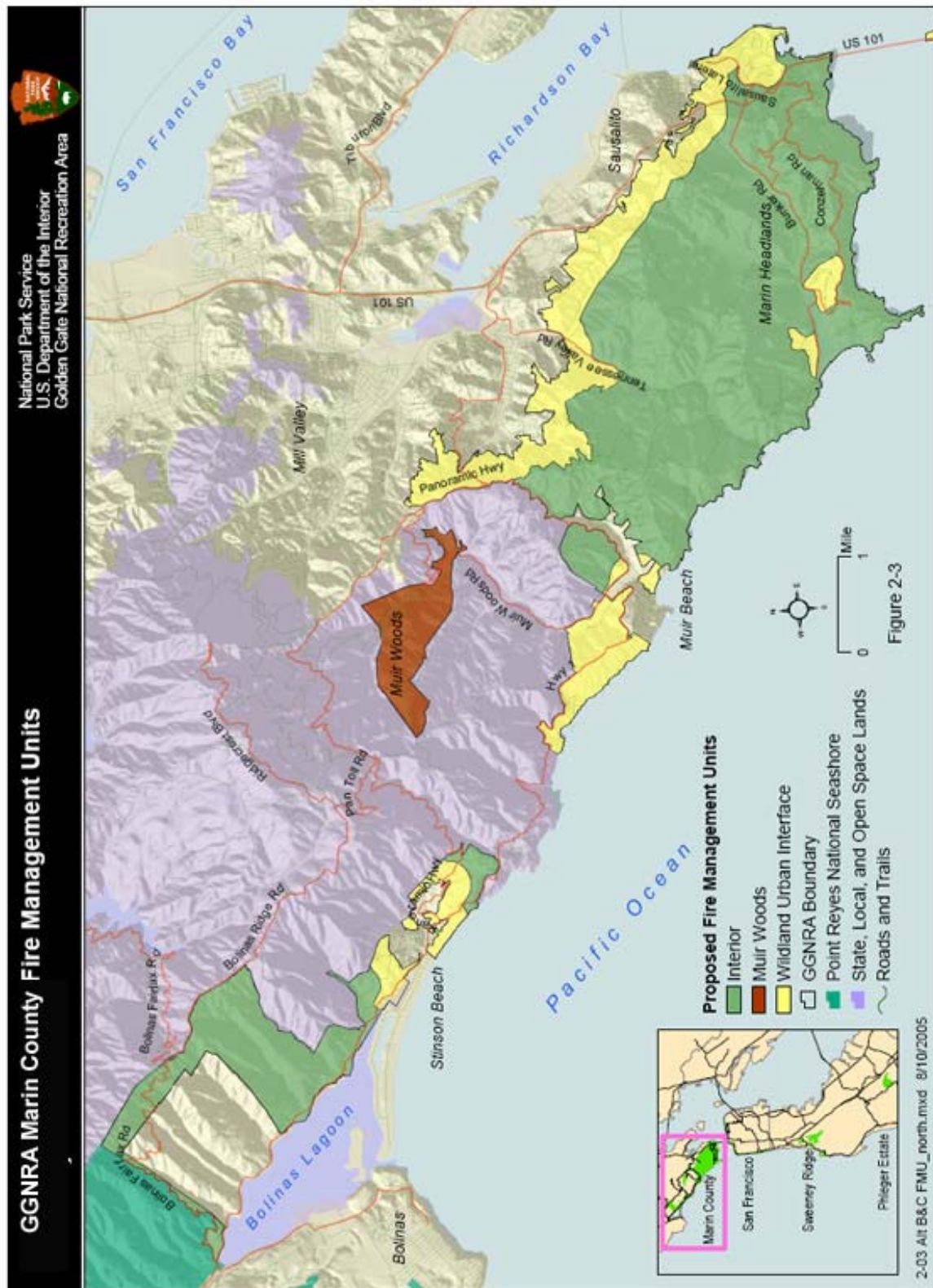
Examples of fire management treatments in this FMU would include:

- Removal of nonnative evergreen trees in most project areas where needed to achieve fire management objectives;
- Removal of nonnative evergreen trees that do not contribute to the historic setting and that are spreading beyond boundaries of the historic Forts Baker and Barry;
- Control and reduction of nonnative plant species in coastal scrub and grassland communities with mechanical treatments in combination with follow-up burning treatments in most project areas, and when possible, restoration and expansion of these native plant communities;
- Research prescribed burns to enhance Mission Blue Butterfly habitat;
- Limited research prescribed burns in the Douglas-fir/redwood community to reduce fuel loading at the Phleger Estate project area; and
- Research into prescribed burning for restoration of grassland communities.
- Reduction of hazardous fuel loading along the GGNRA boundary within close proximity to homes and other improvements which would prevent homeowners from meeting PRC 4291 addressing residential defensible space.

**2.8.2.2 Park Interior FMU**

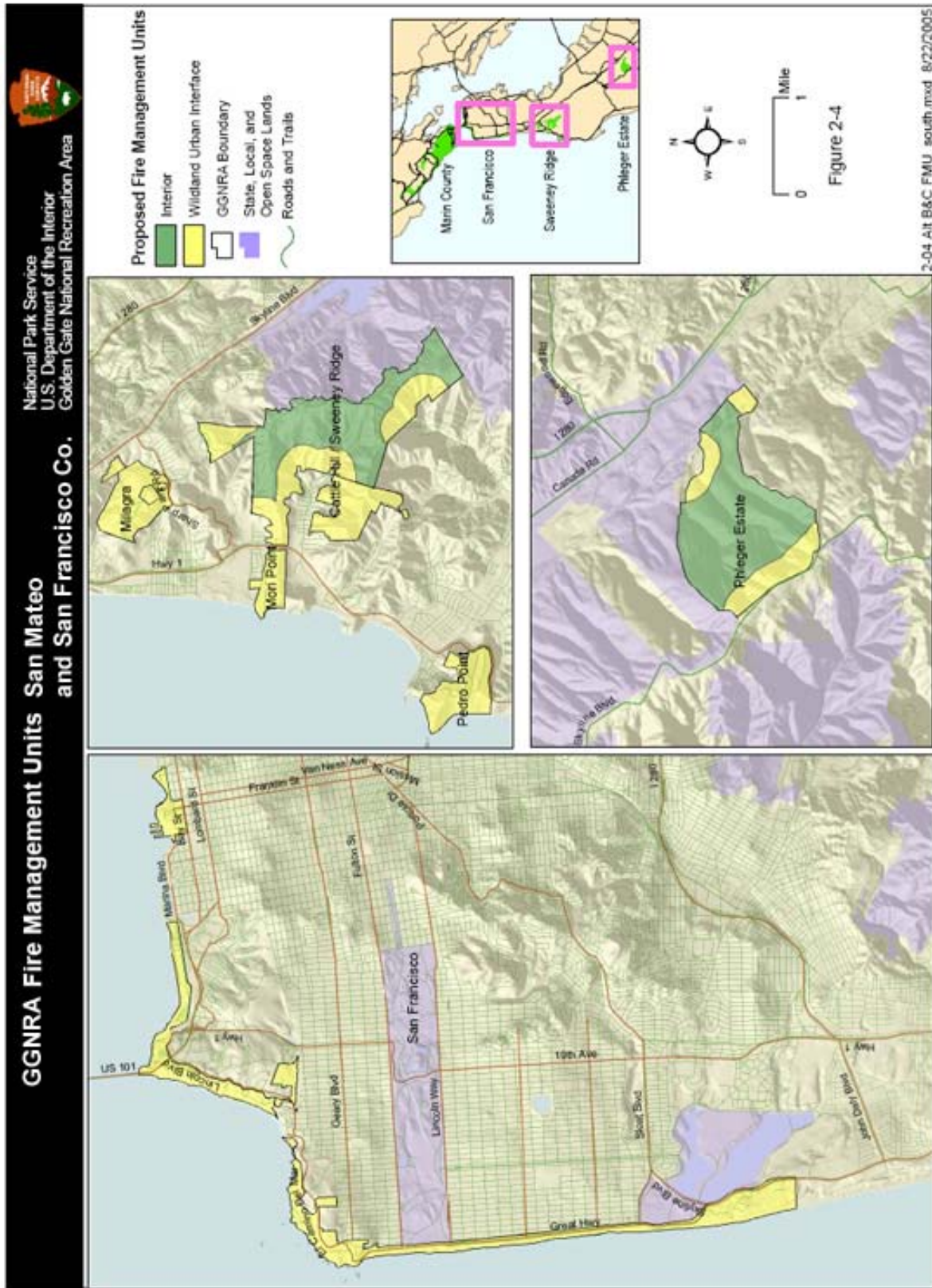
The Park Interior FMU is the largest FMU and is characterized by a lower probability of fire threatening structures and the potential to use prescribed fires to achieve some resource management goals. The park interior lands include larger expanses of natural areas and cultural landscapes, inclusive of ranching and farming lands, and contain relatively intact native plant communities and contiguous areas and corridors of wildlife habitat.

Figure 13 – Fire Management Units, Marin County



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Figure 14 – Fire Management Units, San Francisco & San Mateo Counties





All wildfires occurring in this FMU will receive prompt initial attack and subsequent aggressive suppression action.

Prescribed burns will be used reduce fuel loads and to implement natural and cultural resource management goals. Prescribed burn projects will take into account the vegetation type, restoration goals, and location and will have a strong research and monitoring component. Examples of the types of projects that would occur in this FMU include:

- Prescribed burns, including broadcast burns, to manage nonnative perennial grasses;
- Research burns, and potentially broadcast burns, for management of coastal scrub communities in the Marin Headlands;
- Research into use of fire for managing Sudden Oak Death syndrome in key locations;
- Use of some prescribed fire, including broadcast burns, for management of Harding grass and broom in the coastal scrub and grassland communities in Tennessee Valley.
- Mechanical treatment to reduce fuel loading and resistance to control of wildland fire starts along roads and near sensitive resources and historic properties.

### 2.8.2.3 *Muir Woods FMU*

Muir Woods National Monument is a separate FMU due to the area's unique values at risk (first-growth redwoods), the area's high visitation (and consequent ignition potential), and a successful and ongoing fire management program.

The management priority in the Muir Woods FMU is the protection of the pristine character of the National Monument. Many species contribute to the ecosystem in and around the Monument and this diversity calls for a variety of prescription parameters. The buildup of fuels in close proximity near residential development east of Panoramic Highway in Homestead Valley increases the risk of wildland fire. The exclusion of fire from the Monument over most of past century and a half has perpetuated and increased the likelihood of higher-intensity fires to occur. Prescribed fire will be used in the redwood/Douglas-fir forest to restore the role of fire to this ecosystem. Prescribed fire may also be used for management of nonnative species, such as in the Conlon Avenue area near the maintenance yard.

A fire chronology based on fire scar examination was done for two redwood (*Sequoia sempervirens*) forest sites in Marin County (McBride and Jacobs 1978). Fire frequencies averaged 21.7 and 27.3 years. The difference between the two sites was attributed to the increased influence of fog (Jacobs et al. 1985). The short interval is thought to be an artifact of Native American burning. Natural fires would ignite and burn through sections of the forest, cleaning out undergrowth, dead and down material, and litter on the forest

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floor. The beneficial effects of this process were numerous in that nutrients were released into the soil, forest density was regulated, fire-dependent species were provided with a favorable environment for reproduction, and wildlife was provided with more favorable habitat. Redwoods themselves require bare mineral soil to reproduce successfully from seed after the passing of a fire. Conversely, pests and pathogens find conditions generally less favorable.

The interruption of this ecological cycle through 150 years of fire suppression has produced visible deleterious effects. The buildup of dead and down material on the forest floor and the density of undergrowth create conditions favorable to catastrophic fire. Increased amounts of fuel produce fires that burn faster, hotter, and with greater intensity. Control becomes more difficult and the likelihood of adverse ecological effects such as mortality in mature trees is increased.

The existing fire hazard can be illustrated by the Ben J. Fire of June 13, 2001, which may have been started by an illegal campfire. The fire burned on the slopes west of Redwood Creek and the Hillside Trail and south of the Ben Johnson Trail. NPS staff responded quickly and was able to contain the fire. If this fire had occurred in late summer/early fall, during the height of the fire season, it would have been much hotter and spread faster, posing a significant threat to the first-growth redwood groves.

The NPS reintroduced fire into the ecology of Muir Woods National Monument during the second half of the 1990s under the 1993 FMP. Three burns were conducted in the redwood/Douglas-fir forest. In 1996, the nine-acre Upper Deer Park prescribed burn between Deer Park Fire Road and the Dipsea Trail was conducted to serve as an anchor point for future suppression efforts and as a starting point for future burns. In 1997, the Deer Park 2 prescribed fire (52.5 acres) was completed, and in the following year in 1998, the Johnson prescribed fire (35 acres) was conducted on neighboring forested units. Two prescribed burns in the Conlon Avenue area at the lower end of Camino Del Canyon were completed in 1997 and 1999 (20 acres each) in order to reduce nonnative broom species in these grassland areas. Several other burns were planned but not executed. The California Department of Parks and Recreation conducted several burns around the FMU to create fuel breaks and manage nonnative plant species.

The objectives for the fire management strategy in the Muir Woods FMU are to:

- Restore the role of fire in the relevant vegetation communities;
- Reduce fuel loading and the threat of catastrophic wildfire; and
- Further study fire effects in old-growth coast redwood forest.

Strategies recommended for the Muir Woods FMU include:

- Prescribed burning to reduce fuel loading.
- Prescribed burning to reintroduction fire as a component in the FMU's fire-adapted plant communities.

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- Small-scale mechanical fuel reduction projects, such as construction of shaded fuel breaks and understory thinning, to reduce the risk of a high-intensity fire.
- Mechanical fuel reduction treating roughly 5 acres annually. In woodlands hard hit by sudden oak death (SOD), thinning could be used to reduce standing snags and ladder fuels and to remove smaller-diameter trees.
- Mowing alone or followed by prescribed burning to control nonnative species. Mowed brush would be left to cure in place followed by prescribed fire.
- Prescribed burning to research the relationship between fire and SOD and to limit or control French broom in the Conlon Avenue area.
- Use of established trails, roads, and natural features as much as possible as fire control lines to limit disturbance to soil and subsurface cultural resources.
- Design all burn preparations and operations to minimize impact to FMU resources to the greatest degree possible.
- Post-burn rehabilitation will be planned in advance as part of a prescribed burn.
- Annual acreage of prescribed burning would range from small 0.5-acre research burns up to the annual maximum of 50 acres.
- Annual maximum of mechanical clearance of 5 acres includes clearing defensible space around park structures and treating areas of nonnative plants.
- Expansion of the public education program to support prescribed burn projects. Current interpretive opportunities at Muir Woods include school and public programs on fire ecology, a self-guided walk on fire ecology, a public display on fire ecology and control burning, a fire wayside exhibit, and placement of the fire weather station and interpretive information in an area visible to the public.

## 2.9. GGNRA PROJECT AREAS

The three FMUs are further broken down into a total of 17 project areas, to allow a finer level of understanding of existing resource values, vegetation and fire management conditions, treatment options, and management objectives specific to the referenced park area. It is the project areas that form the framework for planning the five-year implementation program. Project areas are delineated logically by practical and geographical boundaries such as roads and trails, watersheds, park boundary, and buffers from urban development (see Figures 15 and 16). Table 8 shows the park's acreages and vegetation classification by project area. The following descriptions of the 17 project areas are sorted by county.

## CHAPTER 2 – FIRE MANAGEMENT STRATEGIES

**2.9.1. Marin County Project Areas****2.9.1.1 Alta Project Area**

FMU: entirely within the WUI FMU.

Extent: Bordered on the northeast by Marin City and Sausalito, on the southwest by the Alta Trail, and on the southeast by the Wolfback Project Area.

Vegetation: More detailed mapping on this area is needed. Vegetation types include coastal scrub/chaparral, native hardwood forest, and nonnative evergreen forest (primarily eucalyptus).



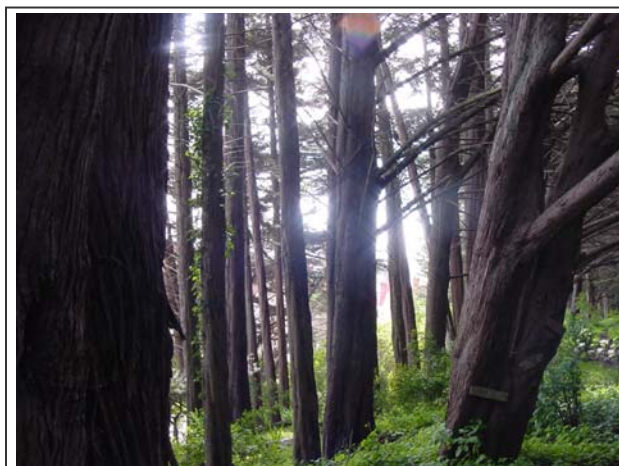
Special Resources: The project area has mission blue butterfly habitat.

Fire Management Issues: 1) large stands of nonnative evergreen forest adjacent to residential areas in Marin City and Tamalpais Valley, and 2) needed fuel reduction on fire roads, eliminating stands of broom and other nonnative vegetation and fostering the conversion to grassland and native scrub.

**2.9.1.2 Fort Baker Project Area**

FMU: entirely within the WUI FMU.

Extent: The project area includes the Fort Baker cantonments, the Bay Area Discovery Museum, the future Fort Baker Retreat and Conference Center, the U.S. Coast Guard station, the north anchorage of the Golden Gate Bridge and the Vista Point viewing area. It is bordered by San Francisco Bay to the east and south, Sausalito to the north, and the Marin Headlands project area to the west. The most developed areas of Fort Baker are those closest to the Bay.



Vegetation: a mix of coastal scrub, grasslands, oak woodland, and nonnative forests.

Special Resources: The project area contains important mission blue butterfly habitat.

Fire Management Issues: (1) dense stands of nonnative trees that have expanded beyond the historic landscaping boundaries are a fire hazard putting nearby historic structures at risk; (2) need to reduce fuel loading in the Highway 101 and Alexander Avenue corridors; and (3) reduction of fuels to improve defensible space around buildings and below the High Vista neighborhood.

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**Table 8 – Acres of Vegetation Type by Project Area**

**Table 3-10: Acres Within Each General Vegetation Class By Project Area**

Project Area	FMU	County	Acres	Developed	Coastal Dunes	Coastal Scrub/Chaparral	Douglas-Fir/Coast Redwood	Grassland	Herbaceous Wetlands	Native Hardwood Forest	Nonnative Evergreen Forest	Riparian Forest/Shrubland	Unvegetated Shoreline/Outcrop
Alta	WUI	Marin	153			55				60	38		
Fort Baker	WUI	Marin	178	75		34		26		12	31		
Homestead Valley	WUI	Marin	166			94		23		44	5		
Marin Headlands	Park Interior	Marin	3,667	202	30	2,230	3	785	53	11	92	116	145
Milagra Ridge	WUI	San Mateo	245	10		204		23			3	5	
Mori Point	WUI	San Mateo	110	3		15		79	3			2	8
Muir Beach/Green Gulch	WUI/Park Interior	Marin	1,202	15		905		208	4	3	11	25	31
Muir Woods National Monument	Muir Woods	Marin	558	6		2	472	2		59	2	15	
Oakwood Valley	WUI/Park Interior	Marin	567	2		310		27		171	45	12	
Phleger Estate	WUI	San Mateo	1,205			82	556	9		558			
San Francisco	WUI	San Francisco	923	347	150	69				8	122	75	152
San Pedro Point	WUI	San Mateo	229	1		142					33		53
Stinson Beach	WUI/Park Interior	Marin	1,683	38		555	561	172	13	265	10	34	35
Sweeney Ridge/Cattle Hill	WUI	San Mateo	1,432	29		1,231		95			64	13	
Tam. Valley	WUI	Marin	495	3		147	1	42		188	109	5	
Tennessee Valley	Park Interior	Marin	1,928	16		1,348		453	19	2	18	30	42
Wolfback/ Sausalito	WUI	Marin	398	14		231		60		49	41	3	
<b>Total</b>			<b>15,139</b>	<b>761</b>	<b>180</b>	<b>7,654</b>	<b>1,593</b>	<b>2,004</b>	<b>92</b>	<b>1,430</b>	<b>624</b>	<b>335</b>	<b>466</b>

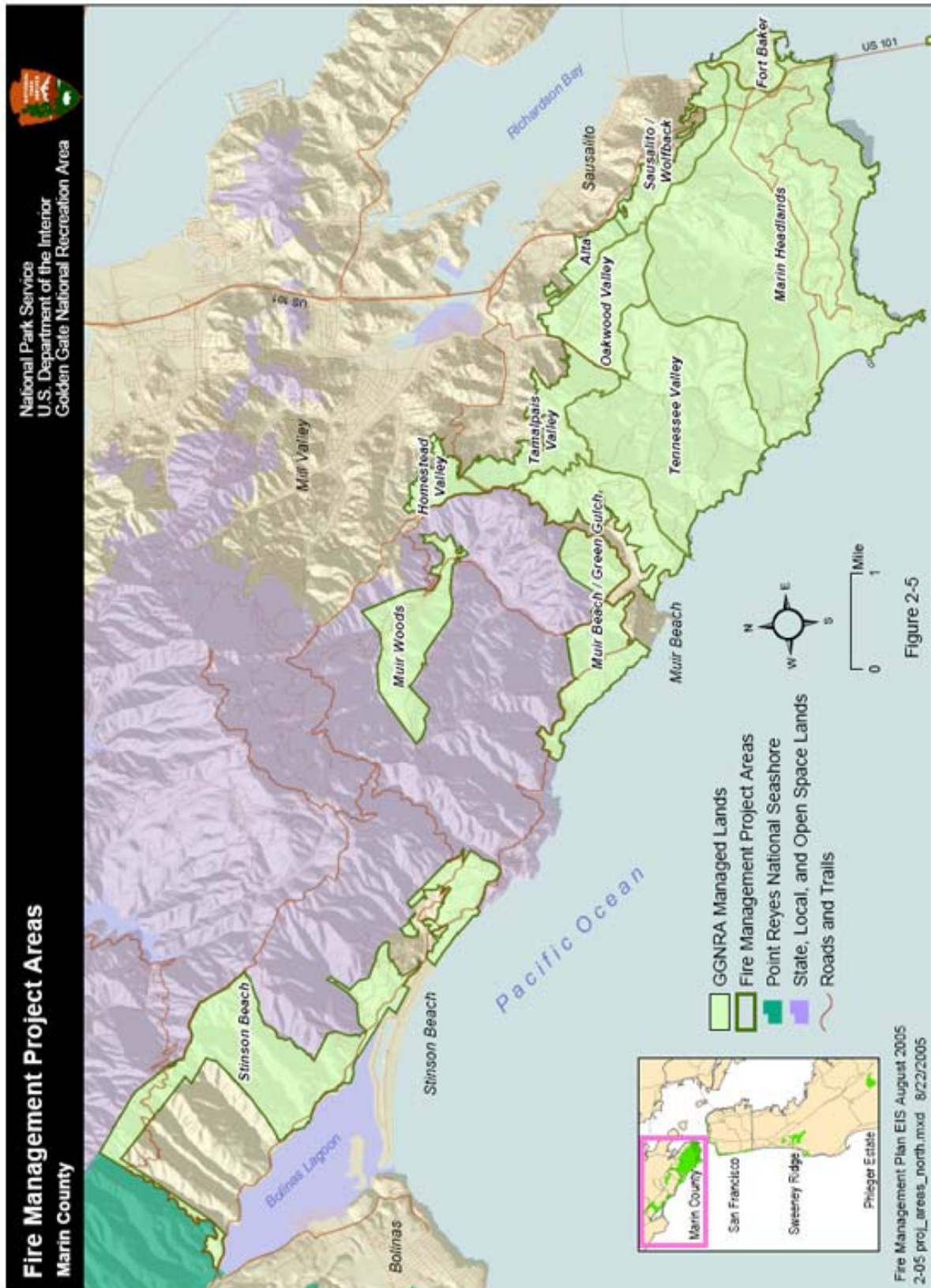
Source: NPS, GGNRA Fire Management Office, 2004.

FMU = Fire Management Unit

WUI = Wildland Urban Interface

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Figure 15 – FMP Project Areas, Marin County



### 2.9.1.3 Homestead Valley Project Area

**FMU:** entirely within the WUI FMU.

**Extent:** bordered by Panoramic Highway to the west, Shoreline Highway to the south, and the Homestead Valley neighborhood to the north and east.

**Vegetation:** coastal scrub, grassland, native hardwood forest, and nonnative evergreen forests (eucalyptus and Monterey cypress).

**Special Resources:** The Douglas fir/redwood forest in the north part of the project area provide habitat for the northern spotted owl.

**Fire Management Issues:** buildup of hazardous fuels in close proximity to residential areas of Homestead Valley and Tamalpais Valley.

### 2.9.1.4 Marin Headlands Project Area

**FMU:** Park Interior FMU except Fort Barry and Fort Cronkhite which are in the WUI FMU.

**Extent:** The Gerbode Valley and Rodeo Valley watersheds bordered by the Fort Baker Project Area and the City of Sausalito to the east, the Tennessee Valley Project Area to the northwest, and the Pacific Ocean to the west and south.



**Vegetation:** dominated by coastal scrub and grasslands, with herbaceous wetlands and riparian scrub in the low-lying areas. Nonnative stands of eucalyptus and Monterey pine are present in some of the developed areas, and native hardwood forest is present in Gerbode Valley. A large portion of the land along the Pacific Ocean is unvegetated rocky slopes.

**Special Resources:** The larger clusters of development from the past military occupation include Fort Barry, Fort Cronkhite, a former Nike missile site, historic coastal fortifications, and the Marine Mammal Center area. The project area supports habitat for several plant and animal species listed under the Endangered Species Act, including the threatened California red-legged frog, the endangered tidewater goby and endangered mission blue butterfly. Two species of bats that are federal species of concern use buildings in this Project Area.

**Fire Management Issues:** buildup of hazardous fuels adjacent to historic structures, nearby residential communities, and the draw of popular visitor destinations within the project area served by roads that could limit access by emergency responders.

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2.9.1.5 *Muir Beach/Green Gulch Project Area*

**FMU:** Park Interior FMU with WUI FMU at the community of Muir Beach, the developed area of Green Gulch Zen Center and along Highway One.

**Extent:** comprised of the land surrounding the Muir Beach community and the Green Gulch Zen Center and the Banducci Ranch. The area is bordered by Tennessee Valley Project Area to the south, the Tamalpais Valley Project Area to the east, Mount Tamalpais State Park to the north, and the Pacific Ocean to the west.

**Vegetation:** Primarily coastal scrub and grassland, with herbaceous wetlands and riparian forests in the drainages as well as stands of native hardwood and Douglas fir/redwood forest and nonnative eucalyptus.

**Special Resources:** Streams providing habitat for coho salmon, steelhead, and the California red-legged frog.

**Fire Management Issues:** 1) eucalyptus stand adjacent to GGNRA could spread into the park at project area; 2) dune scrub on Muir Beach is often ignited by beach fires which could spread into the residential area; and 3) Muir Beach draws high visitation but is served by Highway One and one access road both of which are bordered in part by areas of high fuel loading that could impede access by emergency responders.

2.9.1.6 *Muir Woods Project Area*

**FMU:** entirely within the Muir Woods FMU.

**Extent:** defined by the boundaries of the National Monument. It is west of Mill Valley off Panoramic Highway. Camino Del Canyon, in the eastern section of the Project Area, has several residences, and structures that could have historic significance.

**Vegetation:** predominantly native hardwood and evergreen forests, including Douglas-fir, old-growth and second-growth redwoods, bay, tanoak, and madrone. The Camino Del Canyon portion includes riparian forest, grassland, and a large stand of eucalyptus around the residential area.



**Special Resources:** Habitat for the northern spotted owl, marbled murrelet, salmonids, California red-legged frogs. Ten species of bats, including 4 federal or state species of concern, are found in the Project Area.



Fire Management Issues: an area with very high visitation served by a road that could limit access to emergency responders; fuel reduction needed along ingress/egress routes, isolated Camino del Canyon amidst a large eucalyptus stand and is served by a road that is subject to washouts.

#### 2.9.1.7 *Oakwood Valley Project Area*

FMU: Park Interior FMU and WUI FMU.

Extent: bordered by Alta Fire Road to the northeast, Tennessee Valley Road to the northwest, and the Miwok Trail to the south. The Oakwood Valley and Marinview residential communities are adjacent to this project area.

Vegetation: mainly native hardwood forests (oaks), coastal scrub, and some grassland. Riparian forests, as well as nonnative eucalyptus, are present in the drainages.

Fire Management Issues: maintain low fuel conditions and adequate fire road access/egress particularly along the residential community interface.

#### 2.9.1.8 *Stinson Beach Project Area*

FMU: predominantly within the Park Interior FMU and acreage around the Stinson Beach community within the WUI FMU.

Extent: parklands north of Stinson Beach, south of the Bolinas/Fairfax Road and south of Stinson Beach along Panoramic Highway.

Vegetation: large tracts of coastal scrub, grasslands, Douglas-fir/coast redwood, and native hardwood forest, unvegetated shoreline and smaller areas of herbaceous wetlands, riparian forests, and nonnative evergreen forests.

Special Resources: Spotted owl habitat in Stinson Gulch. Several Bolinas Lagoon tributaries, including Easkoot Creek, support coho salmon and steelhead.

Fire Management Issues: 1) fuel reduction needed on parklands surrounding the residential area; and 2) provision of safe fire road ingress/egress especially on days of very high visitation.

#### 2.9.1.9 *Tamalpais Valley Project Area*

FMU: entirely in the WUI FMU.

Extent: bounded by the Miwok Trail on the south and west, Tennessee Valley Road to the southeast, and the unincorporated community of Tamalpais Valley to the northeast. The Homestead Valley Project Area lies due north, the Tennessee Valley Project Area to the south, Muir Beach Project Area to the west southwest and Oakwood Valley Project Area to the southeast.

Vegetation: primarily coastal scrub, grassland, and native hardwood forest, with some large stands of eucalyptus and a riparian forest corridor along Tennessee Valley Road.

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Special Resources: Tennessee Valley Creek provides habitat for the California red-legged frog. Fire management issues in this area include the need to reduce fuel loads between the park and adjacent communities and to provide for safe fire road access and egress routes.

#### 2.9.1.10 Tennessee Valley Project Area

FMU: entirely within the Park Interior FMU.

Extent: bounded by the Pacific Ocean to the southwest, Coyote Ridge to the northwest, the Miwok Trail to the northeast, and the Hill 88 Ridge to the south.

Vegetation: mainly coastal scrub with roughly a fifth of the acreage in grassland. Herbaceous wetlands, riparian scrub, and nonnative evergreen forests are present in the drainages. Disturbed lands and remnant landscape is found in and around the Miwok riding stables and the old farmhouse. Much of the coastline is unvegetated rock outcrops.

Special Resources: California red-legged frogs.

Fire Management Issues: maintaining adequate fire road access, reducing roadside fuel loading to this area with heavily visited trails.

#### 2.9.1.11 Wolfback Ridge/Sausalito Project Area

FMU: entirely within the WUI FMU.

Extent: Highway 101 and Sausalito to the east, the Marin Headlands Project Area to the west and south, the Oakwood Valley Project Area on the northwest, and the Alta Project Area to the north. Lands lie to the west AND east of the Wolfback Ridge neighborhood.

Vegetation: principally coastal scrub and grassland, native hardwood forest, riparian forest, and nonnative evergreen forest (mostly eucalyptus).

Special Resources: Mission blue butterfly habitat north of Fort Baker.

Fire Management Issues: reducing the density of the eucalyptus forest west and east of the Wolfback Ridge neighborhood.

### 2.9.2 SAN FRANCISCO COUNTY

#### 2.9.2.1 San Francisco Project Area

FMU: entirely within the WUI FMU.

Extent: all NPS lands within San Francisco County including Fort Mason, Alcatraz, Area A of the Presidio, Fort Point National Historic Site, and the coast from Fort Miley to Fort Funston.

Vegetation: Coastal dune communities, with areas of coastal scrub, native hardwood forest, and riparian scrub and large stands of nonnative evergreen forest and landscaping.

Special Resources: Raven’s manzanita, Marin dwarf flax, and the San Francisco lessingia, western snowy plover, the Presidio Historic Landmark District, Fort Mason and other historic coastal military structures, Sutro Heights, Fort Point Historic Site.

Fire Management Issues: maintenance of defensible space around park buildings (working closely with the Presidio Fire Department responsible for structural fire prevention and suppression), reducing fuels at the interface with residences and conducting limited research burns, in conjunction with FWS consultation, to benefit federally listed plant species.

### **2.9.3 San Mateo County**

#### **2.9.3.1 Milagra Ridge Project Area**

FMU: entirely within the WUI FMU.

Extent: In northern Pacifica, the project area borders on Sharp Park Road to the south, Oceana High School to the southwest, a City of San Bruno neighborhood to the southeast, undeveloped , a new Pacifica residential development to the west and the Edgemar area of Pacifica to the northwest.

Special Resources: significant cultural and historical resources, and mission blue butterfly and San Bruno elfin butterfly habitat, California red-legged frog and San Francisco garter snake habitat.

Vegetation: primarily coastal scrub with areas of grassland and riparian forest. Nonnative evergreen forest is also present.

Fire Management Issues: reduction of hazardous fuels adjacent to residential communities.

#### **2.9.3.2 Mori Point**

FMU: entirely within the WUI FMU.

Extent: From the Pacific Ocean on the west to Highway 1 across from Sweeney Ridge on the east, near Sheldance Nursery. The City of San Francisco Sharp Park Golf Course and Natural Area is to the north and the former quarry to the south.

Vegetation: dominated by grassland interspersed with coastal scrub. The low-lying areas contain herbaceous wetlands and riparian scrub.

Special Resources: San Francisco garter snake and the California red-legged frog.

Fire Management Issues: none identified in the FMP.

#### **2.9.3.3 Phleger Estate Project Area**

FMU: primarily in the Park Interior FMU with a strip of WUI FMU along Skyline Boulevard and Woodside’s Raymundo Road.

## CHAPTER 2 – FIRE MANAGEMENT STRATEGIES

Extent: From Huddart County Park and the town of Woodside on the south and southeast, respectively, to Highway 35/Skyline Highway to the west and San Francisco Public Utilities Commission's Peninsula Watershed to the north.

Vegetation: dominated by second-growth Douglas-fir/coast redwood and native hardwood forest with several acres of coastal scrub along the northern boundary and a small area of grassland on the east.

Special Resources: The area is in the West Union/Francisquito Creek watershed, which supports steelhead.

Fire Management Issues: buildup of hazardous fuels with the potential for wildland fire in close proximity to developed areas in Woodside or the Peninsula Watershed.

#### 2.9.3.4 *Pedro Point Project Area*

FMU: entirely within WUI FMU.

Extent: bounded on the east by Highway 1 and to the west by the Pacific coast. The Pedro Park area of Pacifica lies to the north and undeveloped lands to the south.

Vegetation: mostly coastal scrub, with nonnative evergreen forest encroaching from the northern boundary and rocky coastal bluffs to the west.

Fire Management Issues: large, dense stand of eucalyptus forest adjacent to the Highway 1 corridor and the Pedro Point section of Pacifica.

#### 2.9.3.5 *Sweeney Ridge/Cattle Hill Project Area*

FMU: divided equally between the Park Interior FMU and the WUI FMU.

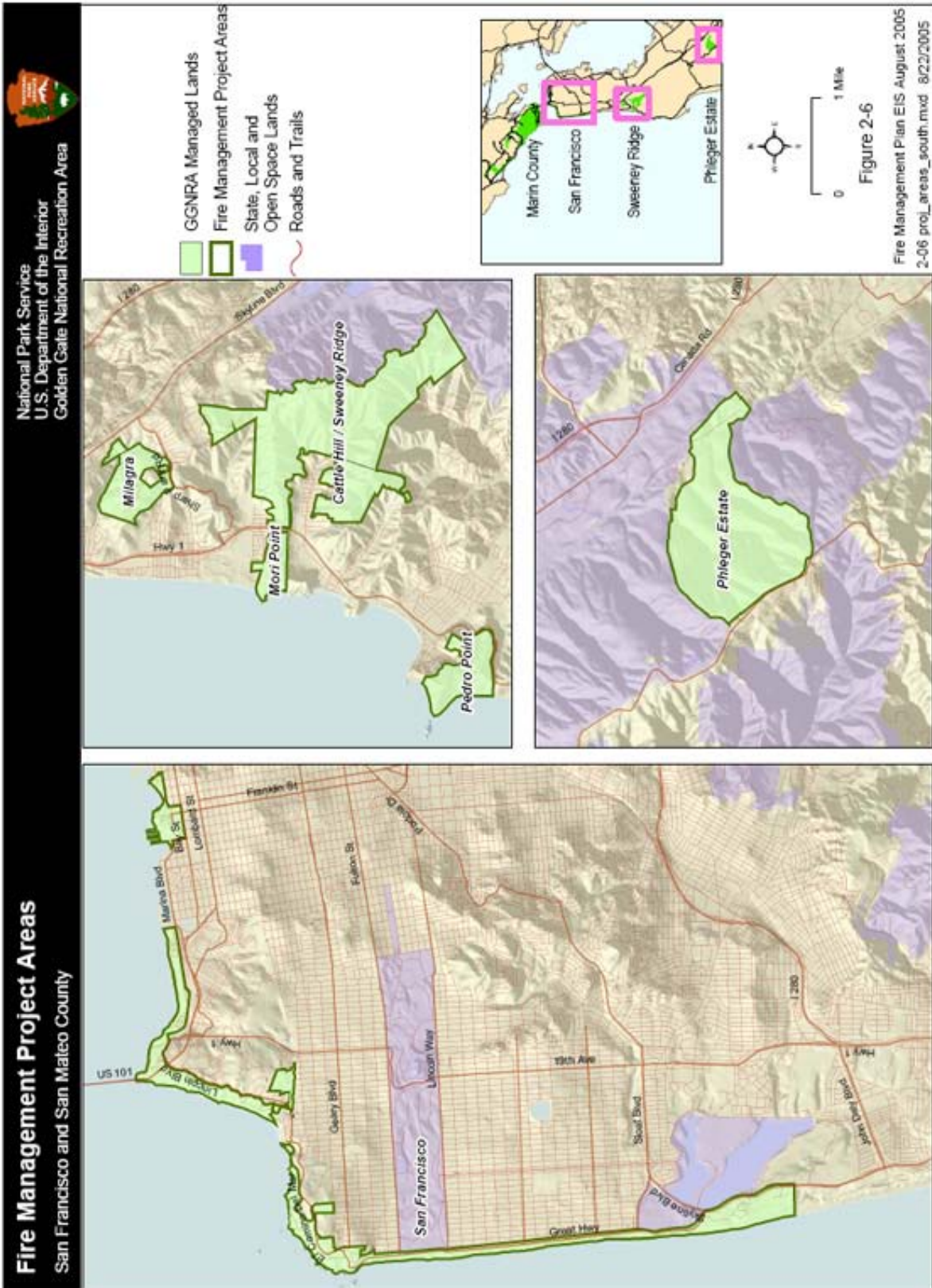
Extent: Lying east of Pacifica, Sweeny Ridge borders the Vallemar neighborhood to the north and east while Cattle Hill forms the southern boundary of this Pacifica neighborhood. Sweeney Ridge is bordered to the south and southeast by San Francisco Public Utility Commission's Peninsula Watershed, the Terra Nova neighborhood of Pacifica on the southwest and Skyline Junior College and residential areas of the City of San Bruno on the north.

Vegetation: primarily coastal scrub, with extensive grasslands in the north and riparian scrub in several of the drainages. Stands of nonnative evergreen forest (mostly eucalyptus) encroach into the project area from outside the park boundary.

Fire Management Issues: reduce fuel loading on the boundary with the Vallemar neighborhood and Skyline Junior College where fuels may pose a threat to structures and urban developments; maintain adequate fire road access for local fire agencies .

CHAPTER 2 – FIRE MANAGEMENT STRATEGIES

Figure 16 – FMP Project Areas, San Francisco & San Mateo Counties



CHAPTER 3 – FIRE MANAGEMENT PROGRAM COMPONENTS