Appendix H
Marin Islands National Wildlife Refuge
Environmental Assessment

Tables

Figures

Chapter 1. Purpose and Need for Action

Introduction

This environmental assessment (EA) evaluates the environmental effects of three alternatives for managing the Marin Islands National Wildlife Refuge and State Ecological Reserve (Refuge or NWR) as presented in the preceeding draft Comprehensive Conservation Plan (CCP). The National Wildlife Refuge System Improvement Act of 1997 directed that all National Wildlife Refuges develop CCPs by 2012. The purpose of a CCP is to provide a management plan for the Marin Islands National Wildlife Refuge and long-term guidance in relation to management decisions. Both direction and guidance are described in detail through a set of goals, objectives, and strategies in the CCP for Marin Islands National Wildlife Refuge.

Proposed Action

The Service proposes implementing Alternative C, as described in this EA and the CCP for managing the Refuge.

NEPA and this Document

The National Environmental Protection Act (NEPA) requires Federal agencies to consider the environmental effects of all actions[1] they undertake. This is the primary purpose of this EA. The U.S. Fish and Wildlife Service (Service) will also use this EA process to solicit public involvement in the refuge planning process and determine whether the CCP will have a significant effect on the quality of the natural and human environment, as well. Federal agencies must consider the environmental effects of all reasonable and feasible alternatives to a proposed action and make public the environmental effects of the proposed action and possible alternatives. If adverse environmental effects cannot be entirely avoided, NEPA requires an agency to show evidence of its efforts to reduce these adverse effects, and restore and enhance environmental quality as much as possible. An EA documents that an agency has considered and addressed all of these issues.

This EA discusses the need and purpose for the Marin Islands NWR Comprehensive Conservation Plan; it also provides an analysis of the impacts that could be expected from each of the management proposals outlined in the plan. This analysis will help the Service determine if it will need to prepare an Environmental Impact Statement or a Finding of No Significant Impact regarding the proposed actions for the Refuge.

[1] Under NEPA and implementing regulations, *action* refers to a policy, plan, program, or project that is implemented, funded, permitted or controlled by a Federal agency or agencies.

Decisions to be Made

The Service will select an alternative to implement the CCP for Marin Islands National Wildlife Refuge based on the assessment described in this document. If the selected alternative has significant impacts to the quality of the environment, the Service is required to prepare an Environmental Impact Statement, which includes a prescribed review process. If no significant impacts are found, the Service will prepare a Finding of No Significant Impact (FONSI). After the public review of the FONSI, implementation of the plan will begin. The plan will be monitored annually and revised when necessary.

Plan Area

The Refuge is located in San Pablo Bay in Marin County, California, near the city of San Rafael, the closest mainland location. The Refuge is made up of two islands of approximately 13 acres and approximately 340 acres of surrounding tidelands. The area surrounding the Refuge is heavily urbanized, flanked by several marinas and residential areas. Also, recreational and commercial boaters must pass near the islands to get to the Loch Lomond marina.

Comprehensive Conservation Planning Process

The Service developed this plan using a systematic decision-making approach that encouraged public involvement in management decisions throughout the planning process. A planning team was assembled (see Chapter 5), made up of Service employees from the San Francisco Bay National Wildlife Refuge Complex, the California/Nevada Refuge Planning Office, the California Department of Fish and Game, and the California State Lands Commission. The Service contacted a wide array of people to participate, including representatives from federal agencies, Congress, state officials, state conservation agencies, tribal and local governments, conservation organizations, local interest groups and other members of the public. These interested participants and local residents received announcements regarding the location, date, and time for the initial scoping meeting. At the scoping meeting the staff explained the Refuge's purpose, history, and laws and regulations governing management, as well as purpose and need for the CCP, management activities and issues.

The planning team developed a list of issues and concerns that included comments generated from the scoping meeting, written comments, and verbal comments from discussions with various parties. The planning team reviewed the current Refuge management actions and ultimately presented three alternatives for future Refuge management during the planning process.

This EA describes the existing natural resources on the Refuge and the projected environmental effects of the three management alternatives on those resources. Two of the three alternatives presented in this EA are "action alternatives" that would involve a change in the current management of the Refuge. The remaining alternative is the "no action" alternative, under which the current management of the Refuge would continue. A final CCP would be prepared no matter which alternative is selected.

The policies of the Service, the National Wildlife Refuge System Improvement Act of 1997, and NEPA require the Service to actively seek public involvement in the preparation of environmental documents. NEPA also requires the Service to give serious consideration to all reasonable alternatives for managing refuges, including the "no action" alternative representing continuation of current conditions and management practices. Alternative management scenarios were developed as part of the planning process described in this EA.

Key steps in the Service's comprehensive conservation planning process include:

1. Preplanning
2. Identifying issues and developing a vision statement
3. Gathering information
4. Analyzing resource relationships
5. Developing alternatives and assessing environmental effects
6. Identifying a preferred alternative
7. Publishing the draft plan and NEPA document
8. Addressing public comments on the draft plan
9. Preparing the final plan
10. Securing approval of the Regional Director
11. Implementing the plan

Issues Identification

The Service followed NEPA guidelines and identified issues, concerns, and opportunities through early planning discussions and the public scoping process, which began with the first planning update in September 2004. The planning team identified a range of reasonable alternatives, evaluated the consequences of each alternative, and selected the best approach to guide the Refuge's future direction. This planning effort and the Refuge team's ongoing dialogue with various federal, state and county agencies, interest groups and individuals provided important direction in synthesizing the proposed goals, objectives, and strategies found in the Draft CCP. It will be necessary to further coordinate and cooperate with these entities to implement the plan.

Public Involvement

Public involvement is an essential component of the comprehensive conservation planning process. The Service announced the beginning of this planning effort for the Marin Islands National Wildlife Refuge through a Federal Register Notice of Intent on September 22, 2004. The Service sent individual letters announcing commencement of the planning process to several local organizations, congressional members, state officials, state agencies, interested parties and conservation organizations. Since September 2004, the Service has sent four planning updates to a mailing list of more than 120 individuals. It also held a public scoping meeting on October 19, 2004.

Written public input received during the process is incorporated into the CCP and EA, and a summary of the comments is contained in the CCP. The original comments are being maintained in planning team files at the San Francisco Bay National Wildlife Refuge Complex headquarters in Fremont, California, and are available for review.

U.S. Fish and Wildlife Refuge Service and National Wildlife Refuge System

The mission of the Service is to conserve, protect, and enhance the nation's fish and wildlife and their habitats for the continuing benefit of the American people. The Service is the primary Federal agency responsible for migratory birds, endangered plants and animals, certain marine mammals, and anadromous fish. This responsibility to conserve our nation's fish and wildlife resources is shared with other Federal agencies and State and Tribal governments.

As part of this responsibility, the Service manages the National Wildlife Refuge System (Refuge System). The Refuge System is the only nationwide system of Federal lands managed and protected for wildlife and their habitats. The mission of the Refuge System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife and plant resources and their habitats within the United States for the benefit of present and future generations of Americans. The Refuge is managed as part of the Refuge System in accordance with the National Wildlife Refuge System Administration Act of 1966 as amended, and other relevant legislation, executive orders, regulations, and policies.

Purpose of the Marin Islands National Wildlife Refuge System

The Refuge was established in 1992:

"...for the development, advancement, management, conservation, and protection of fish and wildlife resources..." 16 USC 742f (a) (4) and "...for the benefit of the United States Fish and Wildlife Service, in performing its activities and services. Such acceptance may be subject to the terms of any restrictive or affirmative covenant, or condition of servitude..." 16 USC 742f (b) (1) (Fish and Wildlife Act of 1956).

"…for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 USC 715d (Migratory Bird Conservation Act).

As written in the environmental assessment establishing the Refuge, the Refuge's designated purpose is to protect an important existing egret and heron colony on West Marin Island and to increase colonial nesting bird use on East Marin Island (USFWS 1992).

Vision of the Refuge

Vision Statement

The Marin Islands National Wildlife Refuge will provide one of the few protected sanctuaries of native San Francisco Bay habitat to local and migratory birds in the heavily urbanized San Francisco Bay area. West Marin Island will provide nesting habitat for great egrets, black-crowned night herons, snowy egrets, great blue herons, black oystercatchers, and other colonial nesting waterbirds free from human disturbance. East Marin Island will, over time, be reverted to native coastal scrub and oak woodland habitat that may be colonized by the herons and egrets.

Visitors and the community will develop an understanding of the importance of migratory bird habitat and cultural history in the San Francisco Bay area. A public use program will provide the local community and visitors with opportunities to experience the unique resources of the Refuge. The Refuge will be a classroom where visitors will learn about the wildlife, habitat, and cultural history of San Francisco Bay through compatible wildlife-dependent recreation delivered by high quality interpretive materials, staff-led tours, and partnerships. Lastly, the Refuge will have an active and diverse volunteer group to support the purpose and continued preservation of the Marin Islands.

Goals of the Refuge

Refuge goals were developed based on four principles: wildlife management, habitat management, cultural resources and public access and education.

Goal 1: Maintain and restore, where possible, wildlife communities and coastal scrub and oak woodland plant communities native to San Francisco Bay, including biological and physical features that provide optimal habitat for the heron and egret colonies as well as other coastal wildlife.

Goal 2: Provide visitors with compatible wildlife-dependent recreational and educational opportunities to foster an understanding and appreciation of the San Francisco Bay native wildlife and plant communities.

Goal 3: Provide interpretation to instill public appreciation within the community and visitors for the cultural resources and history of the Refuge.

Chapter 2. Alternatives, including the Proposed Action

Current Management

The Refuge currently has no integrated plan to guide the management of all of its resources and uses. Current management efforts on the Refuge focus on the protection of

sensitive species, enhancement of their habitats and protection of existing physical structures on the Refuge. A major emphasis of current management is prohibiting public access to provide protected habitat for migratory birds, especially on West Marin Island where heron and egret nesting occurs. Signage prohibiting public access is evident on the dock, as well as on physical structures on the Refuge. Refuge law enforcement officers provide some patrols of the area, but are not able to patrol daily. San Rafael Police provides surveillance of the islands to prevent trespassing.

A non-profit research organization has conducted annual heron and egret monitoring surveys on West Marin Island since 1979 under special use permits. A number of visits are made each year to East Marin Island where there are view points of West Marin Island. Surveys of West Marin Island are also conducted by boat, at a distance that limits disturbance. The research organization is careful to avoid disturbing the wildlife while conducting surveys. Non-profit organizations have also provided support for invasive plant removal and native plant restoration.

Wildlife and habitat protection are fundamental priorities for the Refuge because of the Refuge System's conservation responsibility. Unlimited or uncontrolled public use is not compatible with this mission or with the purpose for which the Refuge was created. No public recreation opportunities are currently available on the islands due to the sensitivity of the wildlife habitat.

Alternatives Development Process

Three alternatives were developed to manage the Marin Islands Refuge. The alternatives are: Alternative A, Current Management (no action); Alternative B, prohibit public use and improve and expand resource management (to pre-industrial conditions); and Alternative C, expand and improve public use and resource management. These alternatives are summarized in Table 1 at the end of this chapter. All alternatives considered in this CCP were developed with the mission of the Refuge System and the purposes of the Refuge as guiding principles. The Service's proposed action is Alternative C.

The alternatives development process was an evolving process that began after the planning team developed the Refuge vision statement and revised the Refuge's goals. The first step in this process was to identify all of the important issues related to refuge management. The list of issues was generated collaboratively by the core planning team, Service staff and refuge stakeholders. The public also helped to identify important management issues through the scoping process.

Once the list of important management issues was generated, the planning team described Alternative A (no action). It was important to describe this alternative accurately because the no action alternative serves as the baseline to which all other alternatives are compared.

Next, the planning team listed a wide range of management actions that would address the issues identified and would achieve one or more of the goals of the Refuge. These actions were refined during several meetings and planning team reviews. The planning team then clustered these actions into logical groupings to form the action alternatives. Many actions are common to more than one alternative, but the actions within each alternative reflect a common management approach, as described in detail below. The staff then assessed physical, biological, economic and social aspects affecting the Refuge to select the proposed action.

Description of Management Alternatives

All alternatives prohibit unsupervised public access to the Refuge, due to the sensitivity of the nesting habitat and cultural elements on the Refuge. Access to West Marin Island will be denied for any purpose during breeding season (March through August) with the exception of emergency situations. A summary of the alternatives is provided below.

Alternative A: No Action

Under Alternative A, the Service would continue to manage the Refuge as it has in the recent past. The focus of the Refuge would remain the same, to provide wintering habitat for migratory birds and protect the colonial nesting birds. West Marin Island would continue to be closed to public access for any purpose during the breeding season (March through August), with the exception of emergency situations. Current staffing and funding needs would continue to be shared with the San Pablo Bay National Wildlife Refuge.

Habitat Management

Under Alternative A, the Service would not plant any new native vegetation. However, non-profit organizations would be allowed to continue monthly plant restoration and removal of non-native vegetation on East Marin Island through special use permits. Removal and planting would be conducted manually and with power tools. Seedlings from the Service's nursery will replace non-native vegetation.

Migratory Birds

Under Alternative A, the Service would continue to keep the Refuge closed to the public to provide sanctuary for nesting migratory birds, particularly the egret and heron colony. The Service would continue to allow research organizations to conduct annual egret and heron abundance estimates through special use permits. The Service would also continue to allow boating and fishing from boats to occur in the tidal areas in the Refuge's boundary.

Threatened and Endangered Species

There are no special management considerations for threatened and endangered species on the Refuge. Federally-listed California brown pelicans were observed roosting in 2005 on West Marin Island. Peregrine falcons (previously listed) have also been observed on the Refuge. However, neither species nests on the Refuge.

Public Access and Education
The Refuge is closed to the public because staff is not based on the islands and the nesting migratory birds are sensitive to disturbance; however, permitted research and restoration activities are allowed. Access to West Marin Island will continue to be denied for any purpose during the breeding season (March through August) with the exception of emergency situations.

Cultural Resources
The Refuge contains several cultural features. Under Alternative A, the Refuge would continue limited monitoring of existing structures and archaeological sites on the Refuge.

Alternative B: Improve and expand Resource Management and prohibit Public Use (pre-industrial conditions)

Habitat Management
Under Alternative B, the Service would expand non-native plant removal through mechanical and chemical methods on East Marin Island. Trespassing and vandalism intermittently occurs in the physical structures on the Refuge. Moreover, birds have become trapped in these buildings. All non-significant physical structures would be removed in order to provide more area for native plants. Stone foundations would remain for historical value.

The Service would also expand native plant restoration, which would involve native plants suitable for nesting waterbirds and other migratory birds on East Marin Island, including California buckeye, coast live oak, and scrub oak. Native plant restoration on East Marin Island by non-profit organizations could continue through special use permits. Restoration would be conducted on an annual basis to restore native vegetation to 75 percent of the land area on East Marin Island. Seeds would be collected from the Refuge and other locations to be propagated in a refuge nursery. The seedlings would then be transplanted on-site. More detail on the vegetation management can be found in Appendix L and K of the CCP. Due to the inaccessibility of West Marin Island, the island has had relatively little human intrusion resulting in unspoiled native vegetation. Under this alternative, native plants on West Marin Island would be monitored and maintained during the non-nesting season.

Under this alternative, the Service will also explore needs for managing sub-tidal areas of the Refuge. No data has been collected on these areas and no management activities are currently in place. The Service will coordinate with other agencies on regional activities for managing sub-tidal areas.

Migratory Birds
West Marin Island would continue to be closed to public access due to the sensitivity of the egret and heron colony. Currently, egrets and herons do not nest on East Marin

Island. The Service seeks to increase available nesting habitat on the Refuge for egrets and herons by restoring appropriate nesting habitat on East Marin Island. East Marin Island would have limited public access through staff-led tours in order to restrict disturbance. The extent of human disturbance (fishing and boating) to the egret and heron colony is not known. The Service would encourage and develop studies to assess colony disturbance.

In recent years, predation of the heron and egret population by resident ravens was detected. The Service has partnered with a research organization to study egret and heron nesting mortality by resident ravens. The Service would continue to allow research organizations to conduct annual egret and heron abundance estimates to determine if the predation is impacting productivity of the colonies.

Threatened and Endangered Species
There are no special management considerations for threatened and endangered species on the Refuge. Federally-listed California brown pelicans were observed in 2005 roosting on West Marin Island. Peregrine falcons (previously listed) have also been observed on the Refuge. However, neither species nests on the Refuge. There are no specific management activities directed at threatened and endangered species under Alternative B. Continued closure of West Marin Island will provide roosting sites for these species.

Public Access and Education
The Refuge is one of the largest egret and heron nesting colonies in northern California and is highly sensitive to external disturbance. The Refuge is closed to the public because staff is not based on the islands and the nesting egrets and herons are sensitive to disturbance; however, controlled research and restoration activities are allowed. It is also located in a heavily urban area exposed to considerable human activity. Prior to the Refuge's establishment, fishing occurred in and around the islands and continues today. Fishing will continue to be permitted by boat. It should be reiterated that access will be prohibited to West Marin Island during the breeding season (March through August) with the exception of emergency situations. Under Alternative B, the Service plans to install additional signage prohibiting landing on both islands without authorization.

Cultural Resources
Under Alternative B, any cultural features will be documented and recorded. All archaeological resource site locations are kept confidential and will be monitored on a regular basis.

Alternative C: Improve and Expand Resource Management and Public Use (proposed action)

Habitat Management
Conduct habitat management activities as described in Alternative B.

Migratory Birds
Conduct migratory bird activities as described in Alternative B.

Threatened and Endangered Species
As in Alternative B, there are no prescribed actions under this alternative for threatened and endangered species.

Public Access and Education
Under Alternative C, public access and education activities would be the same as those described in Alternative B. However, Alternative C would provide staff-led tours to East Marin Island when requested by groups or groups of individuals, at no more than six times per year. Tour sizes will be limited to a minimum of five persons and a maximum of 15 persons. Tour participants must provide their own transportation to East Marin Island. An interpretive panel will be designed and posted to facilitate these tours. Also, under Alternative C, an internet-linked camera would be installed on the west side of East Marin Island to view West Marin Island during the water bird breeding season. Educational materials will be developed and disseminated to businesses, community organizations and the public for outreach and educational purposes. Public groups and schools would also have the opportunity to participate in restoration projects or biological monitoring of the Refuge. Kayaking (non-landing) and private kayak tours around the islands would also be permitted. Fishing would be allowed in the waters around the islands and a fishing brochure will be disseminated to provide this information.

Cultural Resources
Cultural resource activities would be conducted as described in Alternative B. Cultural resources on the Refuge would be monitored for vandalism and deterioration. In addition, interpretation would be provided in the form of staff-led tours to educate the public about the history of the buildings and use of the islands by Native Americans. The Service would also develop Marin Islands NWR brochure to educate the public about the historic human and wildlife use. Affiliated Native American Tribe(s) would be allowed to conduct traditional rites or educational tours with coordination from refuge management.

Table 1. Summary of Alternatives.

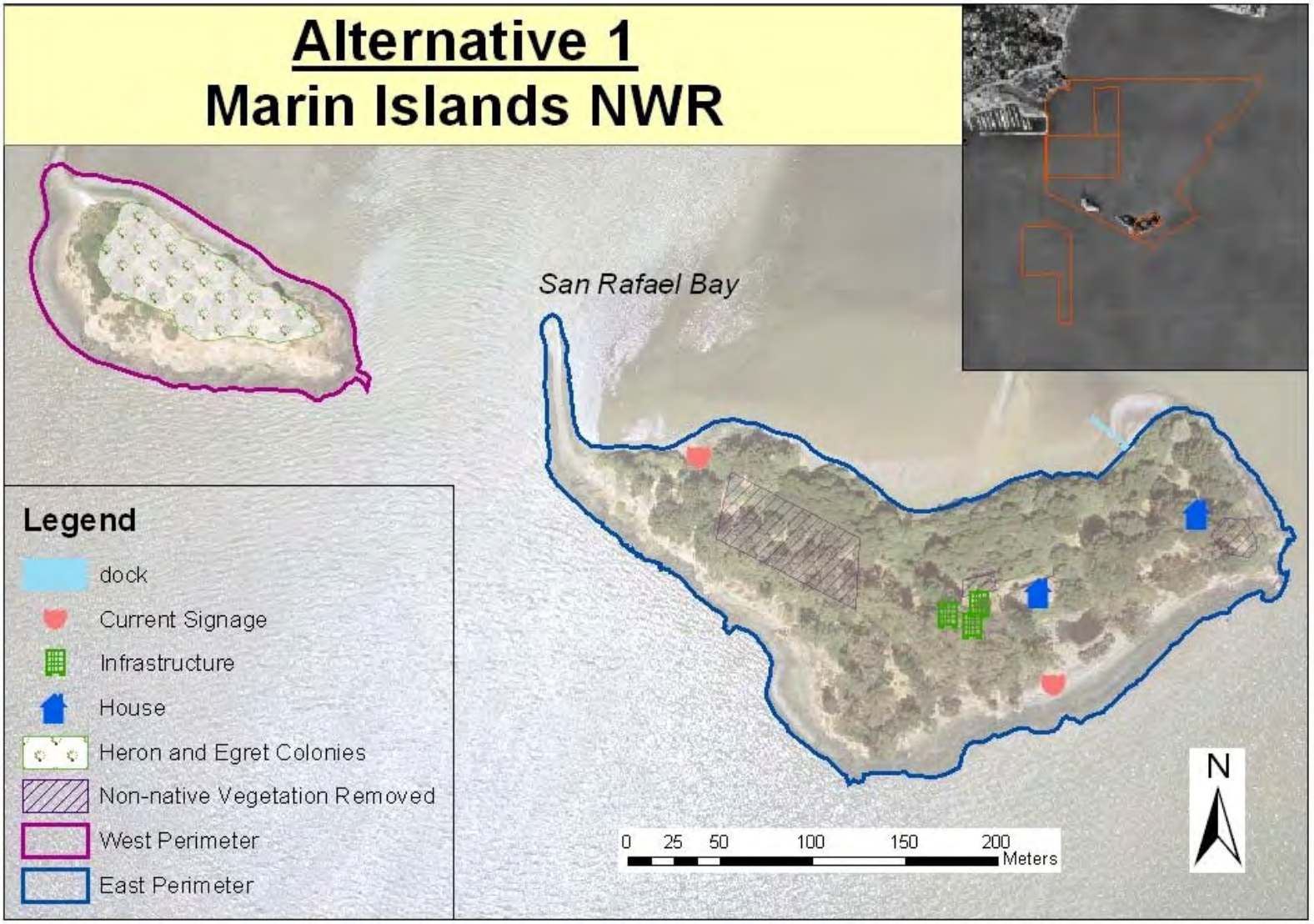
	Alternative A: Continue Current Management	Alternative B: Improve and expand Resource Management and prohibit Public Use (pre-industrial conditions)	Alternative C: Improve and expand Resource Management and Public Use (proposed action)
Goal 1: Maintain and restore, where possible, wildlife communities and coastal scrub and oak woodland plant communities native to San Francisco Bay on the Refuge, including biological and physical features that provide optimal habitat for the heron and egret colony as well as other coastal wildlife.	Current management would coordinate with local non-profit groups to continue regular plant restoration and removal of non-native vegetation on East Marin Island. Continue monitoring of heron and egret colony through Audubon Canyon Ranch.	***Objective 1.1:*** Over the long-term (15 to 30 years), restore native coastal scrub and oak woodland plant communities to 75 percent of the area land cover on East Marin Island (totaling approximately 10 acres) to enhance existing nesting habitat for herons, egrets, and other migratory birds. *Strategies:* • Use the Weed Information Management System (WIMS) or Refuge Lands GIS (Geographic Information System) to annually inventory and map data on invasive and native plant colonies including priority species, size of colony, and exact location. • Control/eradicate invasive plant species utilizing appropriate integrated pest management strategies including mechanical and chemical methods. (See Appendix J and K for detailed table of species, extent of infestations on the Refuge, timeframe and instruction on removal.) • Restore and maintain native plants appropriate for nesting habitat and materials for local birds. (See Appendix J and L for detailed table of species, location of colony, timeframe and instruction on restoration.) • Contract removal of non-significant buildings.	Same as Alternative B
		Objective 1.2: Over the life of the Plan, maintain 95 percent of the existing native coastal scrub and oak woodland plant communities on West Marin Island for heron, egret, and other migratory bird nesting habitat.	Same as Alternative B

		Strategies: • Map native plants and prioritize threats on the entire West Marin Island. • Conduct annual surveys to monitor management changes in native and invasive vegetation through the Refuge Lands GIS or WIMS databases, and adapt management accordingly.	
		Objective 1.3: Within two years of the Plan's approval, reduce unauthorized trespassing on the Refuge by 50 percent to minimize vandalism, wildlife disturbance, spread of disease, and habitat destruction/degradation. *Strategies:* • Install signage prohibiting public access to the Refuge's islands. • Develop brochures/signs to display in the local community (e.g., community centers, marina businesses, libraries). • Increase law enforcement patrols and organize community-based monitoring to minimize unauthorized use of the Refuge. • Conduct a study of the egret and heron colony to determine impact of human disturbance, including fishing and boating activities; acquire funding to conduct the study.	Same as Alternative B
		Objective 1.4: Within five years of the Plan's approval, determine the effect of raven predation on the heron and egret colony and develop methods to evaluate predation effects on heron and egret populations. *Strategies:* • Continue monitoring the heron and egret colony annually through a partnership with Audubon Canyon Ranch. Support research for contaminant threats to the colony by partnering with research	Same as Alternative B

		organizations and universities. • Develop methods to better estimate black-crowned night heron and snowy egret productivity to determine effects of raven predation on productivity. • Conduct predator surveys with a focus on ravens. • Continue study of techniques to reduce raven productivity and its effect on heron and egret productivity. • Evaluate the need for future raven control measures based on site-specific and regional trends in heron and egret colony to determine when predator control is warranted.	
		Objective 1.5: Over the life of the Plan, develop a needs assessment for management and restoration of sub-tidal areas of the Refuge. *Strategies:* • Research available data on the sub-tidal areas. • Coordinate with other agencies in sub-tidal monitoring, restoration or preservation. • Inventory biological resources in the sub-tidal areas. • Prioritize management and restoration needs.	Same as Alternative B
GOAL 2: Provide visitors with compatible wildlife-dependent recreational and educational opportunities to foster an understanding and appreciation of San Francisco Bay native wildlife and plant communities.	Current management does not provide recreational opportunities and is closed to the public. Non-profit organizations currently conduct plant restoration opportunities to their members, with approval from refuge management.	No public access and outreach opportunities are prescribed under this alternative.	Same as Alternative B
			Objective 2.2: Within five to ten years of the Plan's approval, more than 50 percent of residents within the shoreline communities of the San Rafael will be familiar with the Refuge's existence and purpose.

			Strategies: • Develop and disseminate educational materials to local boating organizations, businesses, Friends groups, schools, and recreation centers. • Install a Web Cam during breeding season. • Arrange public groups, schools, etc. to participate in revegetation projects or biological monitoring on East Marin Island. • Provide presentations to local businesses, community organizations, and the public. • Conduct a mail survey after 10 years of the CCP's implementation to determine if objective is successful.
GOAL 3: Provide interpretation to instill appreciation within the community and visitors of the cultural resources and history on the Refuge.	Current management has not conducted any cultural outreach or cultural resource inventory.	No cultural outreach or cultural resource inventory is prescribed under this alternative.	***Objective 3.1:*** Within two to three years of the Plan's approval, the Refuge's cultural resources will be better protected through increasing law enforcement and other refuge staff surveillance to at least bi-weekly visits. *Strategies:* • Prohibit public access to the islands, except for volunteer restoration programs and staff-led tours on East Marin Island. • Provide signage on and off-site noting access to the islands is prohibited. • Increase law enforcement patrols with the addition of a refuge officer and organize community-based monitoring. • Monitor potential erosion areas. If necessary, install equipment to reduce erosion. • Safeguard archaeological objects from damage during refuge management activities such as building demolition and plant restoration activities by avoidance or relocation prior to the activities. Coordinate with affiliated Native

			American Tribal representatives.
			Objective 3.2: Within five years of the Plan's approval, the Refuge's cultural resources and history will be assessed for the purpose of developing a report, outreach materials and complying with regulatory requirements. *Strategies:* • Photograph, research and document cultural resources on the Refuge in coordination with a Service, or other qualified archaeologist. Identify any potential sites where historical objects may be sensitive to refuge management activities such as building demolition or plant restoration activities. Contract for the preservation or mitigation of significant historic structures. • In conjunction with wildlife tours, provide cultural resource interpretation. • Develop interpretive materials to be displayed on and off the Refuge.


Alternative 1
Marin Islands NWR
San Rafael Bay
Legend
dock
Current Signage
Infrastructure
House
Heron and Egret Colonies
Non-native Vegetation Removed
West Perimeter
East Perimeter
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Meters
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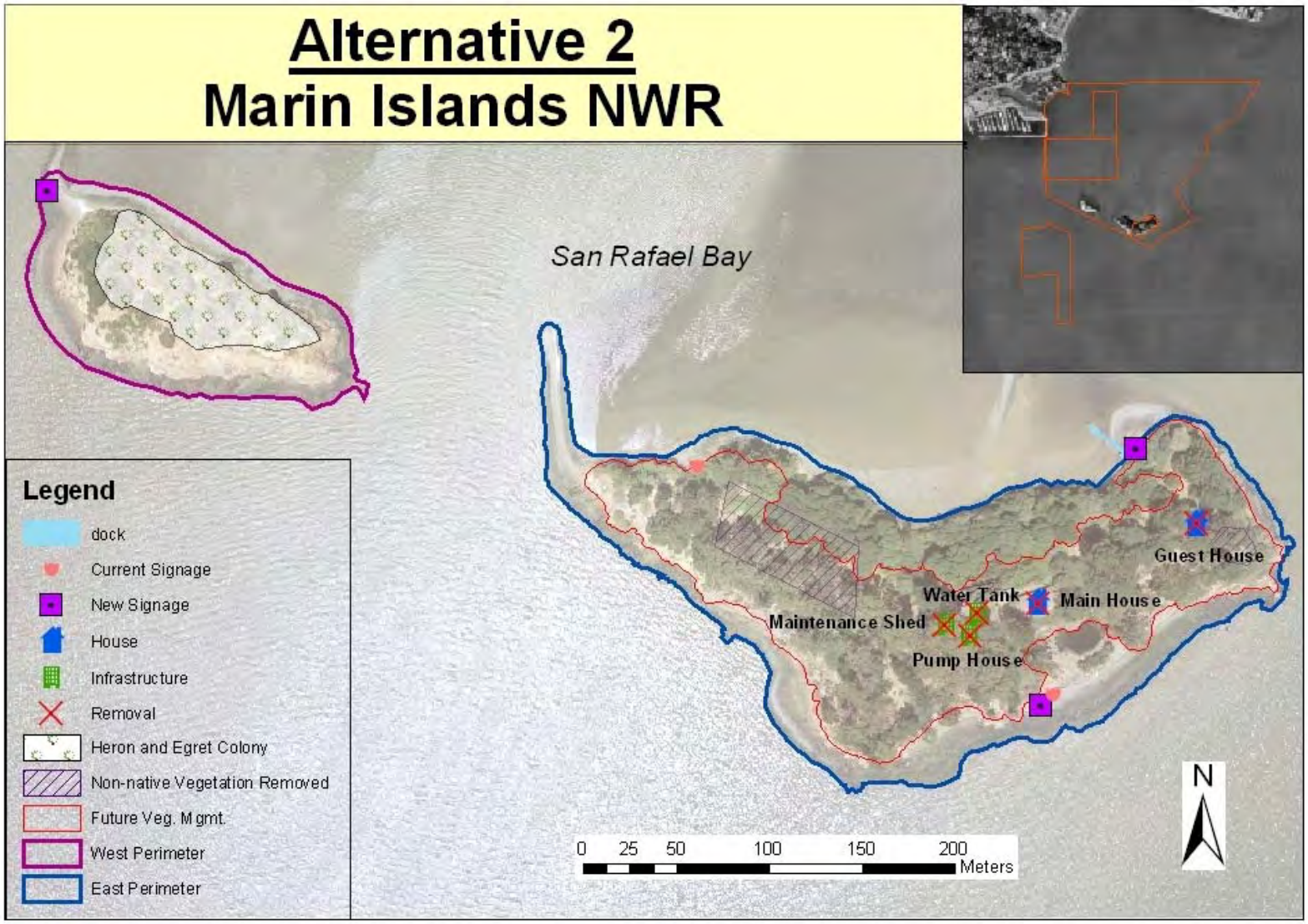
Alternative 2
Marin Islands NWR
San Rafael Bay
Legend
dock
Current Signage
New Signage
House
Infrastructure
Removal
Heron and Egret Colony
Non-native Vegetation Removed
Future Veg. Mgmt.
West Perimeter
East Perimeter
Guest House
Water Tank
Main House
Maintenance Shed
Pump House
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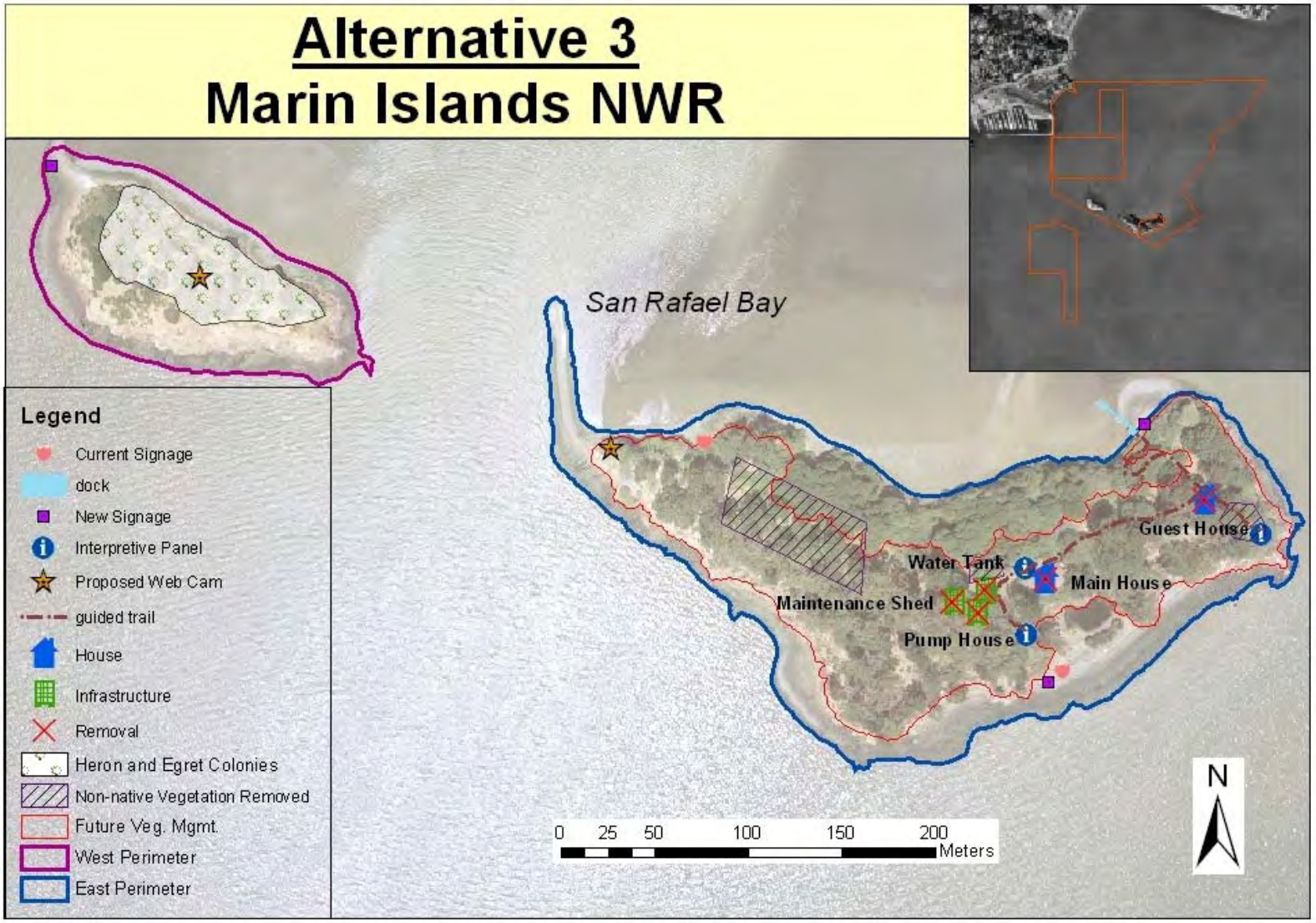

Alternative 3
Marin Islands NWR
San Rafael Bay
Legend
Current Signage
dock
New Signage
Interpretive Panel
Proposed Web Cam
guided trail
House
Infrastructure
Removal
Heron and Egret Colonies
Non-native Vegetation Removed
Future Veg. Mgmt.
West Perimeter
East Perimeter
Guest House
Water Tank
Main House
Maintenance Shed
Pump House
0 25 50 100 150 200
Meters
N

Features Common to All Alternatives
All the alternatives share two features: none of the alternatives provides unsupervised public access due to the sensitive nature of the migratory bird nesting habitat and safety concerns, and each alternative recommends continued support of native plant restoration and removal of invasive vegetation by non-profit organizations.

Features Common to Action Alternatives (B and C)

There are a number of features common to both action alternatives (B and C). The Service plans to initiate a more accelerated invasive plant removal and native plant restoration in coordination with non-profit organizations in both action alternatives. Removal of physical structures is prescribed for both alternatives as a means to deter trespassing and provide additional wildlife habitat. Both alternatives also recommend developing a needs assessment for managing the sub-tidal areas. These action alternatives also prescribe study of raven predation impacts to the heron and egret colony. Nesting habitat will be protected by signage deterring access to both islands, as noted in both action alternatives. Both alternatives also plan to document cultural resources and human history on the islands.

Alternatives Considered but Eliminated from Detailed Analysis

Open access to the Refuge was considered. Access was restricted to staff-led tours because resources on the Refuge are sensitive to disturbance.

Chapter 3. Affected Environment

This chapter is intended to outline the physical resources, biological resources, cultural resources and social and economic environment that would most likely be affected by the alternatives. Chapter 3 of the CCP provides a detailed description of each of these components. Specific resources and activities, including agriculture and local economy will not be addressed because they are not considered relevant, do not exist on the Refuge, or are not expected to be affected by the management alternatives.

Chapter 4. Environmental Consequences

Chapter 4 analyzes the environmental impacts expected to occur from the implementation of the alternatives as described in Chapter 4 of the CCP. Direct, indirect, and cumulative impacts are described where applicable for each alternative. Alternative A (no action) is a continuation of management practices that are in place today and serves as a baseline against which Alternatives B and C are compared.

NEPA requires mitigation measures when federal activities result in significant impacts to habitats, wildlife, or the human environment. None of the activities proposed under the three alternatives are expected or intended to result in significant levels of environmental impacts that would require mitigation measures. However, the CCP contains measures that would prevent the occurrence of significant environmental impacts.

Physical Resources

Hydrology

Continual wind and wave action have slowly altered the surface and boundaries of East and West Marin Islands. A rise in the sea-level has also slowly changed the land portion of the Refuge. None of the management alternatives will mitigate for these natural erosion effects unless they threaten cultural resources or wildlife on the Refuge. Given the slow timescale of natural erosion, mitigation for these threats will not be developed in this CCP, but should be re-evaluated when the CCP is revised. Activities associated with all of the alternatives are not expected to cause increase surface flow, which would impact the surrounding San Pablo Bay. Water from a water tank on East Marin Island may be used to temporarily support seedlings during their initial plantings, but it is not anticipated that the watering will cause increased surface flow. Moreover, once empty, the water tank will not be replenished and there are no plans to use external water sources.

Under Alternatives B and C, the conversion of mature, non-native vegetation to young, native coastal scrub vegetation may change the short-term hydrologic flow of the island, but is not likely to result in long-term hydrological changes. Restoration activities will be done intermittently throughout the year by small groups of people using manual methods to limit immediate large-scale changes to the islands. No other activities in the alternatives are expected to require water sources that may impact hydrology.

Any soil erosion resulting from restoration would be short-term and minimal. Most of the restoration would occur well inland of the East Marin Island, and is unlikely to cause debris to flow into San Pablo Bay. Any uprooted vegetation will be removed from the island by vessel in order to reduce fire potential on the East Marin Island. Areas where vegetation has been removed will be quickly replaced with native vegetation to reduce erosion potential. Like the other alternatives, restoration activities for Alternative A will be conducted on a small scale, using manual methods that are not intended to result in significant levels of environmental impacts requiring mitigation. However, these restoration activities will be slower since they lack the additional support recommended in the other alternatives.

Water Quality and Contaminants

Water was once piped from the mainland, but the pipe is now broken and out of service. There are no water sources on the Refuge other than the remaining supply in the water storage tank on East Marin Island. San Pablo Bay waters are the only surrounding water sources that would be affected by the alternatives. Under all alternatives, non-native vegetation would be removed from the Refuge through a combination of manual and chemical means. No specific water quality issues are expected for any of the alternatives. Herbicides will be used on a limited basis in invasive plant removal activities and are not expected to negatively impact the water

quality of San Pablo Bay. Herbicides will be applied by hand to target vegetation. There could be adverse impacts to non-target vegetation from pesticide drift, but these effects are expected to be minimal due to the small quantities used and precautionary measures taken. Once non-invasive plant presence is reduced on East Marin Island, herbicide application will likely be further reduced. Service-approved herbicides would be used with all action alternatives. The use of herbicides is highly regulated through the Service's Pesticide Use Proposal (PUP) process. This approach notes environmental hazards, efficacy and costs.

Gas-powered machinery is expected to include chainsaws for vegetation removal only on East Marin Island. Travel to and from the Refuge will also be conducted by gas-powered motorboats or other related vessels. These vessels would be used to facilitate refuge management, restoration and public education activities. The use of gas-powered vessels would have the potential to introduce various contaminants to the surface waters, including fuel oils, grease and other petroleum products. Contaminants would be similar to those used by surrounding vessels and may have an adverse effect on marine habitat. Best management practices would be used to reduce the potential for spill occurrences and proper vessel maintenance would reduce the likelihood that excess fuels and other contaminants would impact water quality in the Bay.

Geology and Soils

Soil erosion naturally occurs at the Refuge due to strong to moderate winds representative of the San Francisco Bay area. Erosion is also considered an effect of climate change as a result of rising temperature and sea level. Soil erosion is not anticipated to result from activities occurring in Alternative A (no action). Under the action alternatives, restoration activities may result in minimal soil erosion. Large, non-native tree stumps may remain to reduce erosion potential. However, replacement of native vegetation species will likely mitigate any soil erosion resulting from invasive plan removal.

Air Quality and Climate

Under Alternative A (no action), no considerable air quality or climate disturbances are expected. The Service has not engaged in any activities that would permanently affect the surrounding air quality or climate. Under both action alternatives, the removal of the buildings may temporarily increase harmful and benign air particulates within the Refuge. However, the action alternatives, including the proposed action, are not expected to impact air quality.

Gas-powered machinery will be limited to chainsaws for vegetation removal on East Marin Island. Gas-powered vessels would be used to travel to and from the islands. The use of vessels respectively increases under Alternatives A, B and C. Under Alternative A, boat usage would be limited primarily to refuge management purposes. Alternative B would include refuge management purposes and providing

transportation to groups and individuals involved in the native plant restoration process. Alternative C would include vessel uses under Alternatives A and B, as well as using vessels to conduct staff-led tours. The use of this equipment will result in increased air particulates in the immediate area. However, these particulates should dissipate given the windy condition on the Bay. Vessel emissions under the alternatives would have a long-term minor increase in the area because refuge activities requiring gas-powered machinery would only occur on an intermittent (not daily) basis.

Hazardous Materials and Safety Issues

Two hazardous materials are present on the Refuge. In addition, the natural and man-made landscapes of East Marin Island pose safety concerns. The transformers currently housed in the structures are leaking PCBs and the mastic in the building material of the housing structure contains asbestos. These physical structures on the Refuge are in poor condition and may pose safety concerns for those entering the buildings. Fire is a potential threat to the housing structures from trespassers. Under Alternative A (no action), these structures and hazardous materials would remain on the Refuge and continue to attract trespassers. Action alternatives (B and C) prescribe elimination of building structures and asbestos materials through certified experts to ensure proper removal and disposal. Also, since the buildings may be above or near undiscovered cultural resources, additional expertise in cultural resource preservation may be required. Any archaeological objects potentially affected by refuge activities will be carefully handled in accordance with Native American Graves Protection and Repatriation Act (NAGPRA) and in consultation with the affiliated Native American tribe.

The cliff areas surrounding the islands pose another safety threat. Wind and wave action has slowly altered the topography of the island's shoreline and soil erosion is a natural occurrence. Trespassers and visitors can be injured along these steep cliff areas. Under all the alternatives, signs will be posted to detract trespassers and staff-led tours or restoration projects will be closely supervised to prevent any dangers during visits to the Refuge.

Biological Resources

Vegetation

No endangered plants occur on the Refuge. Rare plants will be clearly noted and protected from foot traffic. In each of the alternatives, non-native vegetation will be removed from East Marin Island by manual and chemical methods. These activities will not occur as rapidly in Alternative A (no action) as they would in Alternatives B and C. Use of herbicides would result in reduced non-native vegetation and allow for expansion of native vegetation. The area will be restored to native plants and trees, which would also be suitable for egret and heron nesting. Under Alternative A, non-profit organizations will continue to conduct invasive plant removal and native plant

restoration. Under Alternatives B and C, buildings and associated structures would be removed from East Marin Island to reduce attracting unauthorized visitation and fire potential. The remaining area would be restored to native vegetation, thus supporting native plant restoration activities.

Under Alternative C, staff-led tours would increase foot traffic on the Refuge and may increase the potential to trample native and rare vegetation. However, a designated foot trail and close supervision would confine visitor traffic to limit the possibility of harming native vegetation. Under either of the two action alternatives, the abundance of native vegetation is expected to expand on the Refuge. Habitat restoration fulfills the Service's congressional mandate to preserve, restore and enhance riparian habitat for threatened and endangered species, songbirds, waterfowl, other migratory birds, anadromous fish, resident riparian wildlife and plants. Overall, plant restoration activities are expected to result in a significant increase in the Refuge's native habitat under any of the alternatives.

Wildlife

Birds are the primary wildlife on the Refuge and include waterbirds, shorebirds, and seabirds. Black oystercatchers, Canada geese, herons and egret are known to nest on the Refuge. Seabirds and shorebirds may occasionally roost on the Islands or wade offshore of them. Endangered California brown pelicans were observed roosting in 2005 at West Marin Island during low tide. Peregrine falcons (previously listed) occasionally roost or perch at the Refuge. The heron and egret populations at each bay area site fluctuate annually based upon habitat and feeding conditions. Therefore, it is important to maintain habitat for nesting as the environmental conditions in the surrounding Bay area change. There is no recorded information of mammal presence on the Refuge. Overall, refuge management activities would be limited to non-breeding periods to reduce wildlife interaction. Under any of the alternatives, wildlife disturbance may continue because the Refuge is not supervised daily and trespassing occurs. Such illegal trespassing may result in disturbance of individuals or the nesting colony on West Marin Island.

Under Alternative A (no action), no major wildlife impacts are expected. Alternative A will include some restoration efforts by community groups, but refuge management would not include an extensive restoration effort in order to enhance wildlife habitat. Also under this alternative, the Refuge would continue to be intermittently monitored for wildlife disturbance by the Refuge and local law enforcement.

Non-native plant removal and native planting in Alternatives B and C will meet the purposes of protecting wildlife on the Refuge by potentially providing additional nesting habitat for the heron and egret colony, and other migratory birds. Native vegetation to be planted on East Marin Island include buckeyes, coast lives oaks and other trees that are appropriate for heron and egret nesting. However, many non-native trees including Monterey pine, acacia and eucalyptus, occur on East Marin

Island. The colony has not successfully nested in these species of trees on East Marin Island. Their removal and replanting of native vegetation may encourage herons, egrets, and other migratory birds to begin nesting on East Marin Island.

Alternatives B and C also contain actions including public education, trails, signage, and law enforcement which could increase or decrease wildlife disturbance by educating the local community and visitors. The expanded restoration activities in Alternatives B and C will be limited to the interior of East Marin Island; these activities are some distance from West Marin Island, helping to reduce the noise disturbance potential to nesting birds. The removal of building structures will not occur during the breeding season in order to limit wildlife disturbance. A study will be initiated to learn about the effects of raven predation on the heron and egret colony. The results will determine whether measures need to be considered to reduce predation. None of the alternatives prescribe hunting. Waterfowl populations are not found in concentrations sufficient to warrant staff time and effort for a worthwhile hunt program.

Alternative C would increase public access to the Refuge and may result in disturbance to the wildlife. Even when provided with boating instructions to reduce wildlife disturbance, tour participants may still potentially disturb wildlife when traveling (by boat) to East Marin Island. However, staff-led tours would be provided only on East Marin Island, where the colony currently does not nest. In addition, since tours would not be offered during the nesting season, tours would not disturb birds with young. If herons, egrets or other migratory birds begin to nest on East Marin Island, staff-led tours would be further limited on that island. Under the action alternatives, there should not be a substantial increase in boat traffic would increase based on the popularity of the tours. However, these tours would not occur on a regular basis and would be limited to six tours per year. Tour participants will be given boating guidelines to reduce human disturbance to non-breeding wildlife.

Under the action alternatives, enforcement patrols and community monitoring will reduce wildlife disturbances by trespassers. Reducing disturbance may improve heron, egret and other migratory bird nesting success and possibly encourage harbor seals to haul out at the Refuge. Harbor seals have been observed hauling out at the majority of surrounding bay area islands, but they have not been observed on the Refuge (Green and Grigg 2004). Fishing is not expected to increase under Alternatives B and C. Fishing occurring in refuge waters is expected to abide by state regulations that protect endangered fish species.

Cultural Resources

Under Alternative A (no action), limited effort will be made to document and actively preserve the cultural resources on the Refuge. Under Alternatives B and C, all structures will be evaluated under the National Historic Preservation Act for significance. Steps will be taken to preserve significant structures or mitigate for their removal. Environmental education brochures for visitors and local residents will include a discussion of any historic structures.

Restoration of vegetation under any of the alternatives can potentially disturb sub-surface cultural resources. Digging may be one potential method for vegetation removal. This method will be carefully monitored due to its potential impact to cultural resources and soil erosion. Cutting, girdling and herbicides will be the prominent methods for vegetation removal. These activities are not expected to negatively impact cultural resource areas. During vegetation restoration, cultural sites will be avoided when possible to preserve their unique value. In areas where there is a conflict between cultural sites and vegetation restoration opportunities, mitigation will occur or less intrusive methods will be used. Alternative C shares the same features as Alternative B, but also includes developing education opportunities regarding cultural resources. Under both alternatives, natural erosion will continue to occur, which may expose or lead to deterioration of the cultural sites. The refuge staff will determine what measures to take as the erosion effects become more evident.

Social and Economic Environment

None of the alternatives are expected to impact the social and economic environment of the surrounding county. Because it protects islands, the Refuge does not border any communities to provide immediate recreation and agricultural opportunities. The Refuge does not currently provide any direct tourism and therefore, would not add any tourism dollars or employment opportunities to the local area under the no action alternative. Tours to the Refuge as proposed in Alternative C require tour participants to provide their own boat transportation to East Marin Island. Participants may potentially charter or rent watercraft from local businesses or supply their own watercraft to the Refuge.

Recreation

Alternative A (no action) does not provide recreational opportunities on the Refuge. However, fishing and boating has occurred in the area prior to the Refuge's establishment and continues today. Alternative B would continue to allow wildlife-viewing, boating and fishing around the two islands. Fishing brochures and information would be created to communicate appropriate wildlife-compatible public recreation at the Refuge. Alternative C (the proposed action) would include the same recreational opportunities described in Alternative B; additionally, it would expand recreational opportunities on the Refuge by providing staff-led tours upon request during suitable times of the year. Due to the wildlife sensitivity of the Refuge and safety concerns, there will be no recreational opportunities on East Marin Island other than staff-led tours under the selected proposed action.

Employment

Under the no action alternative, the Refuge is not expected to create any significant number of employment opportunities for the surrounding community. Alternative B will create a law enforcement position that could be sought from the surrounding community. Alternative C would create a law enforcement position and outdoor recreation planner position. However, there is no guarantee that these positions will be filled by local residents.

Unavoidable Adverse Impacts

None of the alternatives considered would be expected to result in significant impacts that would degrade habitats, water, or air quality in the community. Where the potential for such effects has been identified, appropriate mitigation measures have been incorporated into the project scope to reduce the effects to below a level of significance. The refuge staff will monitor any incremental or unforeseen adverse impacts to the Refuge and mitigate impacts accordingly.

Irreversible and Irretrievable Commitments of Resources

None of the proposed alternatives would result in an irreversible or irretrievable commitment of resources.

Short-Term Uses vs. Long-Term Productivity

An important goal of the National Wildlife Refuge System is to maintain the long-term ecological productivity and integrity of the biological resources on NWRs. This system-wide goal is the foundation for the goals presented in this CCP. The local short-term uses of the proposed alternative would include increased management of wildlife habitats and limited development of public use activities. The resulting long-term productivity would include increased protection and survival of migratory bird species, local waterbirds and native plants of the San Francisco Bay area. With the preservation of the local plant and animal species, the public would gain long-term opportunities for wildlife-dependent recreational activities in an increasingly urban environment.

Cumulative Impact

Cumulative effects (or impacts) are those effects on the environment resulting from incremental consequences of the Service's proposed actions when added to other past, present and reasonably foreseeable future actions, regardless of who undertakes those actions. Cumulative effects can be the result of individually minor impacts which can become significant when added over a period of time. It is difficult to accurately summarize cumulative effects because one action may increase or improve a resource in one area while other unrelated actions may decrease or degrade that resource in another area.

Under any of the alternatives, major economic benefits are not expected to be lost or gained. Staff-led tours may provide some economic benefit to the community, but it would

be negligible because they would not occur on a regular basis or require the participation of private businesses. The Refuge does not provide any commercial benefits (e.g., farming or fishing) that would be altered under the alternatives. Therefore, job losses or additions would not be an effect caused by one of the alternatives. All alternatives would have long-term benefits for native wildlife species and habitats within the area. The protection of wildlife habitats within the Refuge would represent a benefit to the long-term conservation of migratory birds and other native wildlife species. Alternative A, while beneficial to habitat restoration, may not provide noticeable changes as quickly as the other alternatives because present management activities would not change. Plant restoration activities prescribed in all the alternatives may help slow the natural erosion effects of the islands caused by the harsh marine environment. Overall, the proposed action would integrate wildlife conservation activities with compatible recreation opportunities that would represent a cumulative benefit for local wildlife, native plant communities and human communities.

Table 2. Summary Impacts of Alternatives

Resource	Alternative A **No Action**	Alternative B **Prohibit Public Use and Improve and Expand Resource Management**	Alternative C **Expand and Improve Public Use and Resource Management**
PHYSICAL ENVIRONMENT			
Hydrology	No significant impact	No significant impact	No significant impact
Water Quality/ Contaminants	No significant impact	No significant impact	No significant impact
Geology	No significant impact	No significant impact	No significant impact
Air Quality/Climate	No significant impact	No significant impact	No significant impact
Hazardous Materials/ Safety	PCB and asbestos in structures on Refuge is an attractive nuisance.	Removal of PCB and asbestos.	Same as Alt. B
BIOLOGICAL ENVIRONMENT			
Vegetation	No active non-native management plan in place; native plant restoration	Implementation of a vegetation management plan; removal of structures to increase native	Staff-led tours will increase foot and boat traffic with the potential to impact native vegetation and non-breeding

		vegetation area.	wildlife; implementation of a vegetation management plan; removal of structures to increase native vegetation area.
Wildlife	Native plant restoration will expand wildlife habitat; continued unbuffered area may result in wildlife disturbance.	Native plant restoration will expand wildlife habitat; signage prohibiting island access may provide more disturbance protection.	Same as Alt. B; staff-led tours may result in disturbance of non-nesting wildlife.
SOCIAL AND ECONOMIC ENVIRONMENT			
Recreation	No significant impact	No recreational activities are provided	Staff-led tours provided
Employment		Potential law enforcement position	Potential law enforcement and outdoor recreation planner positions
Cultural Resources	No significant impact	No significant impact	Increased documentation and education of the cultural uses on the islands

Chapter 5. List of Planning Team Members and Persons Responsible for Preparing this Document

Giselle Block	U.S. Fish and Wildlife Service
Winnie Chan	U.S. Fish and Wildlife Service
Christy Smith	U.S. Fish and Wildlife Service
John Krause	California Department of Fish and Game

Chapter 6. Coordination, Consultation, and Compliance

Agency Coordination and Public Involvement

The CCP and EA were prepared with the involvement of technical experts, community groups and private citizens. The Service has invited and continues to encourage public participation through planning updates and public comment periods.

Notice of Intent

A Notice of Intent was published in the Federal Register on September 22, 2004.

Environmental Review and Consultation

As a federal agency, the Service must comply with provisions of NEPA. An EA was developed to evaluate reasonable alternatives that would meet stated objectives and assess the possible environmental, social and economic impacts to the human environment. This EA serves as the basis for determining whether implementation of the proposed action would result in a federal action significantly affecting the quality of the environment. The environmental assessment also acts as a vehicle for consultation with other government agencies and interface with the public in the decision making process.

Other Federal Laws, Regulations, and Executive Orders

In undertaking the proposed action, the Service would comply with the following Federal laws, Executive Orders (EO), and legislative acts: Archaeological Resources Protection Act of 1979; as amended, Fish and Wildlife Act of 1956; Fish and Wildlife Conservation Act of 1980 (16 USC 661-667e); Fish and Wildlife Improvement Act of 1978; Endangered Species Act of 1973 (16 USC 1531 et seq.); National Environmental Policy Act of 1969; Federal Noxious Weed Act of 1990; National Historic Preservation Act of 1966, as amended; National Wildlife Refuge System Improvement Act of 1997; Native American Graves Protection and Repatriation Act of 1990; Antiquities Act of 1906; Protection and Enhancement of the Cultural Environment (EO 11593); American Indian Religious Freedom Act 1978 (PL 95-341; 92 STAT 469; 42 USC 1996); Archaeological and Historic Preservation Act of 1974 (PL 93-291; 88 STAT 174; 16 USC 469); Environmental Justice (EO 12898); Management and General Public Use of the National Wildlife Refuge System (EO 12996); The Refuge Recreation Act of 1962, as amended; Indian Sacred Sites (EO 13007); Consultation and Coordination with Indian Tribal Governments (EO 13175); Invasive Species (EO 13112); and Responsibilities of Federal Agencies to Protect Migratory Birds (EO 13186).

Distribution and Availability

The draft CCP and EA has been sent to various agencies, organizations, community groups and individuals for review and comment. Copies of this environmental assessment will be available from the San Francisco Bay National Wildlife Refuge Complex, 1 Marshlands Road, Newark, California, 94536 (510/792 0222).

References

Green, Deborah E., E. Grigg, S. Allen and H. Markowitz. 2004. Monitoring the Potential Impact of the Seismic Retrofit Construction Activities at the Richmond San Rafael Bridge on Harbor Seals (*Phoca vitulina*) May 1, 1998-March 14, 2004.

U.S. Fish and Wildlife Service. 2006. Marin Islands National Wildlife Refuge and State of California Ecological Reserve Draft Comprehensive Conservation Plan.

U.S. Fish and Wildlife Service. 1992. Environmental Assessment for the Proposed Marin Islands National Wildlife Refuge.

Table 3. Comparison of Alternatives

ISSUE AREAS	Alternative A Current Management (No Action)	Alternative B Prohibit Public Use and Improve and Expand Resource Management	Alternative C Expand and Improve Public Use and Resource Management
Wildlife	Protection from disturbance with signage and law enforcement monitoring; closed for public use	Improved signage; map native and non-native vegetation to develop and implement plant restoration plan; conduct annual vegetation surveys to monitor progress; study human disturbance impacts to wildlife; study raven predation impacts on heron and egret colony	Same as B
Coastal Scrub and Oak Woodland Vegetation	Minimal restoration through staffing and current volunteer base	Map native and non-native vegetation to develop and implement plant restoration plan; conduct annual vegetation surveys to monitor progress	Same as B
Sub-tidal Areas	No current activities	Develop a needs assessment for management and restoration	Same as B
Fire Management	Fire management plan finalized in 2004; fire suppression activities limited to brush clearing	Same as A	Same as A
Wildlife Viewing and Photography	Allowed by boat; no access to the islands	Same as A	Similar to A, except staff-led tours will be offered on East Marin Island
Environmental Education	Volunteer plant restoration program provides some environmental education	Same as A	Program will be developed for local schools, organizations, and businesses; updated website with web camera access
Hunting	None	None	None
Fishing	Fishing by boat allowed in refuge boundaries, must comply with local, state and federal regulations	Same as A	Similar to A, provide fishing brochure with guidelines
Boating	Unrestricted boating allowed, must comply with local, state and federal regulations	Same as A	Similar to A, provide boating brochure with guidelines
Access	None, except under	Same as A	Similar to A, provide

	supervised volunteer opportunities		staff-led tours (no more than six per year) during the non-breeding season
Resource Protection	Refuge brochures are available as an outreach tool; law enforcement patrols	Develop additional brochures and materials with guidelines; increase frequency of law enforcement patrols; develop community-based monitoring	Same as B
Cultural Resources	Compliance with current cultural resource regulations	Same as A	Document cultural resources; develop outreach materials; mitigate for sensitive cultural resources; increase law enforcement monitoring; limit tours to non-sensitive areas; coordinate with Native American tribes

Appendix I. Recreational Sport Fishing Plan for the Marin Islands NWR

RECREATIONAL SPORT FISHING PLAN
For
MARIN ISLANDS NATIONAL WILDLIFE REFUGE
And
STATE ECOLOGICAL RESERVE

I. INTRODUCTION

Marin Islands National Wildlife Refuge and State Ecological Reserve (NWR/SER) consists of 326 acres of open bay waters and 13 acres of upland (2 islands) in San Pablo Bay; north of San Francisco Bay. Approximately 191 acres of the open bay waters are leased from the California State Land Commission (SLC). Under the existing lease with SLC, the Service is encouraged to permit sport fishing unless it is determined after consultation with the State of California Department of Fish and Game (CDFG) that the area should be closed because of public safety, waterfowl resource protection, or administrative purposes. The original lease language is based upon the historic "Public Trust" doctrine, which requires State-owned tidelands remain open to "commerce, navigation and fisheries." The existing lease requirement with SLC is consistent with the National Wildlife Refuge System Improvement Act of 1997, which encourages consideration of fishing as "priority public uses" when found compatible with the purposes for which that Refuge was established.

II. CONFORMANCE WITH STATUTORY AUTHORITIES

The Marin Islands NWR/SER is managed as part of the San Pablo Bay NWR that was established (1) "... for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 U.S.C. 715d (Migratory Bird Conservation Act), (2) "... particular value in carrying out the national migratory bird management program." 16 U.S.C. 667b (An Act Authorizing the Transfer of Certain Real Property for Wildlife, or other purposes), (3) "... to conserve (A) fish or wildlife which are listed as endangered species or threatened species... or (B) plants..." 16 U.S.C. 1534 (Endangered Species Act of 1973).

Other priority wildlife-dependent uses are hunting, wildlife observation, photography, environmental education, and environmental interpretation. As expressed priorities of the

National Wildlife Refuge System, these uses take precedence over other potential uses to be considered during refuge planning and management. The Service strives to provide for the six priority public uses when they are compatible with the purpose(s) of the refuge.

Sport fishing from a boat on the open waters of the Refuge surrounding the Marin Islands will be permitted in accordance with applicable State and Federal regulations and seasons to ensure that it will not interfere with the conservation of wildlife and their habitat. Landing on or fishing from shorelines of the Refuge's islands (East and West Marin Islands) will not be permitted. Fishing will be permitted during daylight hours only.

III. STATEMENT OF OBJECTIVES

A goal of the National Wildlife Refuge System is: To provide an understanding and appreciation of fish and wildlife ecology and man's role in his environment and to provide refuge visitors with high quality, safe, wholesome and enjoyable recreational experiences oriented toward wildlife to the extent these activities are compatible with the purposes for which the refuge was established. Sport fishing has been identified as a priority public use for the National Wildlife Refuge System and will be encouraged on the Marin Islands NWR/SER.

IV. ASSESSMENT OF RESOURCE

The Refuge provides opportunities for several wildlife-dependent recreational activities including fishing. It is located in an area well known for its striped bass and white sturgeon populations (USFWS 1995). The San Pablo Bay also provides habitat for topsmelt, jacksmelt, surfperch, bullheads, anchovies, and leopard sharks.

Two of three sensitive fish species that occur within the San Pablo Bay include the Sacramento splittail minnow (*Pogonichthys macrolepidotus*) and the green sturgeon (*Acipenser medirostris*). Because the splittail is primarily freshwater fish, it is largely confined to the Delta, Suisun Bay, Suisun Marsh, and the Napa and Petaluma rivers (USFWS 1995). Although much less abundant than white sturgeon, the green sturgeon may occasionally be caught by anglers fishing for white sturgeon; however, the greatest number of tagged individuals from the San Francisco Bay system

have been returned from outside the estuary (USFWS 1995). The splittail has been de-listed and the green sturgeon has never been listed.

The third sensitive species, Delta smelt (*Hypomesus transpacificus*), may occur in the Bay during large freshwater outflows from the Sacramento Delta. However, this smelt does not establish permanent populations in San Pablo Bay and its small size (3 inches) prevents it from being caught by anglers (USFWS 1995).

V. DESCRIPTION OF FISHING PROGRAM

A. Areas of Refuge Supporting Target Species

San Francisco and San Pablo Bays have potential to provide habitat for harvestable fish such as white sturgeon, striped bass, and starry flounder. Other harvestable species may be available depending on season and tides.

B. Areas Opened

Fishing would be permitted in the 324 acres of open waters surrounding the Marin Islands on the Refuge. Landing on or fishing from shorelines will not be permitted to protect the heron and egret colonies from harassment or disturbance. Recreational fishing will be permitted during daylight hours only. No commercial fishing will be allowed.

C. Regulations

The open bay waters are open year round in compliance with the current State of California Lands Commission lease with the U.S. Fish and Wildlife Service and all applicable State and Federal regulations will be enforced.

D. Procedures for Coordination with State

Fishing will be permitted within the framework of applicable State and Federal regulations. A joint meeting of the CDFG and refuge staff will occur annually to review these regulations. The CDFG will be consulted if any changes are planned in the Refuge's fishing program.

E. Methods of Enforcement

The Refuge will maintain an active law enforcement presence by San Francisco Bay NWR Complex officers and through an agreement with CDFG to ensure public compliance with fishing regulations. In addition, the San Rafael Police Department also patrols the area around the Marin Islands NWR/SER and reports violations to the Refuge. The Refuge will

increase law enforcement patrols using its own staff or partner agencies during known migrations and movements of harvestable fish species and egret breeding seasons.

F. Funding and Staff Requirements

Approximately 12 staff days will be required to monitor and administer the fishing program at Marin Islands NWR/SER and San Pablo Bay NWR. A staff day is the total time over a period of many days or months that constitute an eight hour day. If a Law Enforcement Officer patrols the Marin Islands NWR for a period of one hour each week, it would take eight weeks to constitute one staff day.

The fishing program will be implemented through the Refuge law enforcement program with patrols during the entire year. Patrols are already conducted on the San Pablo Bay NWR and conducting patrols on Marin Islands NWR will not increase the law enforcement program significantly. The total cost of the fishing program is expected to be approximately $5,000 per year.

VI. MEASURES TAKEN TO AVOID CONFLICTS WITH OTHER OBJECTIVES

A. Biological Conflicts

An Environmental Assessment, FONSI, and Compatibility Determination were prepared, and a Section 7 Consultation was conducted in conjunction with this plan. Fishing will be permitted on the Refuge in accordance with State regulations to ensure the conservation of the fishery resource. No shoreline fishing from the Refuge's islands will be permitted.

B. Public Use Conflicts

Public use conflicts are expected to be minimal with the implementation of this sport fishing plan. Anglers will only be allowed to fish on the Refuge's waters from a boat. As tides go out, mudflats are exposed luring shorebirds to the edges of the Marin Islands. Shallow waters will prevent boat access near the mudflats during low tides that precludes disturbance to migratory birds (especially the heron and egret colonies on West Marin Island).

C. Administrative Conflicts

Potential conflicts could arise from anglers not familiar with regulations. Regulatory information will be available at the Loch Lomond Marina in San Rafael for the public. Fishing information and applicable regulations will be provided to the public as a simple one-

page fishing flyer. Law enforcement officers may need to spend additional time explaining regulations to the public.

VII. CONDUCT OF FISHING

A. Federal Register Special Regulations

The following special regulations are proposed to the Code of Federal Regulations (CFR).

50 CFR 32.24 California (Refuge-specific regulations; Sport Fishing).
Marin Islands National Wildlife Refuge and State Ecological Reserve
D. Sport Fishing. We allow fishing on open water areas surrounding the Marin Islands National Wildlife Refuge and State Ecological Reserve in accordance with State regulations subject to the following stipulations:

1. We allow fishing by boat only in the open waters surrounding East and West Marin Islands.
2. We prohibit landing on or fishing from shore of either island.

B. Anticipated Public Reaction

Very little reaction by the angling public may be expected regarding the prohibition of landing on or fishing from shore of either island. The islands are currently closed to entry and the public is aware of the restriction. In addition, Refuge and State law enforcement officers, refuge personnel, the news media, and other public information systems will be used to convey the reasons for these restrictions related to the opening of fishing on the surrounding waters.

C. Angler Requirements

Anglers must comply with all applicable State and Federal regulations while fishing. Anglers are required to fish from a boat on the open waters surrounding the Marin Islands on the Refuge. No shoreline fishing on the Refuge's islands will be permitted.

LITERATURE CITED

U.S. Fish and Wildlife Service. 1995 Sacramento-San Joaquin Delta Native Fishes Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon.

Appendix J. Marin Islands NWR Wildland Fire Management Plan

WILDLAND FIRE MANAGEMENT PLAN

MARIN ISLANDS NATIONAL WILDLIFE REFUGE

San Rafael, California

2006

2006 WILDLAND FIRE MANAGEMENT PLAN

MARIN ISLANDS NATIONALWILDLIFE REFUGE

Prepared: _____ _____

Christy Smith, Refuge Manager — Date
Marin Islands National Wildlife Refuge

Concurred: _____ _____

Peter Kelly, Fire Management Officer — Date
San Luis National Wildlife Refuge Complex

Concurred: _____ _____

G. Mendel Stewart, Project Leader — Date
San Francisco Bay National Wildlife Refuge Complex

Concurred: _____ _____

Pamela Ensley, Regional Fire Management Coordinator — Date
Pacific Region, U.S. Fish and Wildlife Service

Approved: _____ _____

Steve Thompson, Manager — Date
California/Nevada Operations Office
Pacific Region, U.S. Fish and Wildlife Service

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

This document will serve as the Wildland Fire Management Plan for Marin Islands National Wildlife Refuge. The plan is written to provide guidelines for appropriate wildland fire suppression at the Refuge. A prescribed fire program will not be used to accomplish management objectives on the Refuge due to the archaeological cultural resources on the island and the soils that are highly susceptible to erosion. Suppression activities will include normal maintenance already conducted on the Refuge, which includes mowing, eventual removal of structures and removal of non-native trees. This plan will be incorporated into the Comprehensive Conservation Plan.

Major components include:

- Updated policy for fire suppression at Marin Islands NWR.
- Compliance with the National Environmental Policy Act (NEPA), Section 7 of the Endangered Species Act (ESA), and the National Historic Preservation Act (NHPA).
- Format changes under the direction of Fire Management Handbook.

INTRODUCTION

This document will establish a Fire Management Plan (FMP) for Marin Islands National Wildlife Refuge. This plan is written as an operational guide for managing the Refuge's wildland fire suppression program. It defines levels of protection needed to ensure safety, protect facilities and resources. It is written to comply with a service-wide requirement that Refuges with burnable vegetation develop a fire management plan (620 DM 1).

This FMP outlines a program of full suppression of all wildland fires. There will be no prescribed fires or pile burning on the Refuge. This plan will further the mission of the Refuge by outlining steps to be taken in the event a natural or accidental fire is started on the Refuge.

Fire suppression actions are categorically excluded from the NEPA compliance process. An Environmental Action Statement (Appendix D) was prepared to document the Categorical Exclusion. A "no effect" statement (Appendix E) was made to document compliance with section 7 of the ESA. Compliance with NHPA will be completed at the project level through submission of a Request for Cultural Resource Compliance form (Appendix E) to the Regional Archaeologist.

The San Pablo Bay NWR does not have a dedicated fire management organization. The Refuge Manager is responsible for planning and implementing the fire suppression management program on the Marin Islands NWR. The Zone Fire Management Officer (FMO), located at San Luis NWRC in Los Banos, is responsible for fire management program oversight.

An interagency agreement will be prepared in cooperation with the City of San Rafael Fire Department to assist the Refuge in the event of a wildland fire to protect visitors and facilities of the Refuge.

COMPLIANCE WITH USFWS POLICY

The Marin Islands National Wildlife Refuge (Refuge) was established under the authority of the Fish and Wildlife Act for the development, advancement, management, conservation and protection of fish and wildlife resources. The primary purpose of the Refuge is "to protect an important existing egret and heron rookery on West Marin Island and to increase colonial nesting bird use on East Marin Islands" as described in the 1992 Environmental Assessment prepared for the creation of the Refuge.

Fire will not be used as a management tool to alter landscapes or habitat forms.

Fire suppression actions are categorically excluded from the NEPA compliance process. An Environmental Action Statement (Appendix D) was prepared to document the Categorical Exclusion. A "no effect" statement (Appendix E) was made to document compliance with Section 7 of the ESA. Compliance with NHPA will be completed at the project level through submission of a Request for Cultural Resource Compliance form (Appendix E) to the Regional Archaeologist.

This plan will be included in the Marin Islands National Wildlife Refuge Comprehensive Conservation Plan. The Refuge is managed from the San Pablo Bay NWR.

Authority and guidance for implementing this plan are found in:

- Protection Act of September 20, 1922 (42 Stat. 857; 16 U.S.C.594): authorizes the Secretary of the Interior to protect from fire, lands under the jurisdiction of the Department directly or in cooperation with other Federal agencies, states, or owners of timber.
- Economy Act of June 30, 1932: authorizes contracts for services with other Federal agencies.
- Reciprocal Fire Protection Act of May 27, 1955 (69 Stat. 66, 67; 42 U.S.C. 1856, 1856a and b): authorizes reciprocal fire protection agreements with any fire organization for mutual aid with or without reimbursement and allows for emergency assistance in the vicinity of agency lands in suppressing fires when no agreement exists.
- Disaster Relief Act of May 22, 1974 (88 Stat. 143; 42 U.S.C. 5121): authorizes Federal agencies to assist state and local governments during emergency or major disaster by direction of the President.
- National Wildlife Refuge System Administrative Act of 1966 as amended by the National Wildlife Refuge System Improvement Act of 1997, 16 U.S.C. 668dd et seq.: defines the National Wildlife Refuge System as including wildlife refuges, areas for the protection and conservation of fish and wildlife which are threatened with extinction, wildlife ranges, game ranges, wildlife management areas and waterfowl production areas. It also establishes a conservation mission for the Refuge System that defines guiding principles and directs the Secretary of the Interior to ensure that biological integrity and environmental health of the system are maintained and that growth of the System supports the mission.
- Federal Fire Prevention and Control Act of October 29, 1974 (88 Stat. 1535; 15 U.S.C.2201): provides for reimbursement to state or local fire services for costs of firefighting on federal property.
- Wildfire Suppression Assistance Act of 1989. (Pub.L. 100-428, as amended by Pub.L 101- 11, April 7, 1989).
- Departmental Manual (Interior), Part 620 DM, Chapter 1, Wildland Fire Management: General Policy and Procedures (April 10, 1998): defines Department of Interior fire management policies.
- Service Manual, Part 621, Fire Management (February 7, 2000): defines U.S. Fish and Wildlife Service fire management policies.

- National Environmental Policy Act of 1969: regulations implementing the National Environmental Policy Act (NEPA) encourages the combination of environmental comments with other agency documents to reduce duplication and paperwork (40 CFR 1500.4(o) and 1506.4).
- Clean Air Act (42 United State Code (USO) 7401 et seq.): requires states to attain and maintain the national ambient air quality standards adopted to protect health and welfare. This encourages states to implement smoke management programs to mitigate the public health and welfare impacts of wildland and prescribed fires managed for resource benefit.
- Endangered Species Act of 1973.
- U.S. Fish & Wildlife Service Fire Management Handbook.

The authority for funding (normal fire year programming) and all emergency fire accounts is found in the following authorities:

- Section 102 of the General Provisions of the Department of the Interior's annual Appropriations Bill provides the authority under which appropriated monies can be expended or transferred to fund expenditures arising from the emergency prevention and suppression of wildland fire.
- P.L. 101-121, Department of the Interior and Related Agencies Appropriation Act of 1990, established the funding mechanism for normal year expenditures of funds for fire management purposes.
- 31 US Code 665(E)(1)(B) provides the authority to exceed appropriations due to wildland fire management activities involving the safety of human life and protection of property.

Authorities for procurement and administrative activities necessary to support wildland fire suppression missions are contained in the Interagency Fire Business Management Handbook.

FIRE MANAGEMENT OBJECTIVES

The overall objective for fire suppression management is to promote a program to provide for firefighter and public safety, reduce human-caused fires, and ensure appropriate suppression response capability to meet expected wildland fire complexity. Specific fire management objectives are:

- Promote a fire suppression management program and control all wildland fires.
- Protect life, property, and resources from wildland fires at costs commensurate with resource values at risk.
- Use appropriate suppression tactics and strategies that minimize long-term impacts of suppression actions.
- Rehabilitate and restore lands damaged by fire and fire suppression activities.

DESCRIPTION OF REFUGE

GENERAL DESCRIPTION

The Marin Islands National Wildlife Refuge (Refuge) was established under the authority of the Fish and Wildlife Act for the development, advancement, management, conservation and protection of fish and wildlife resources. The primary purpose of the Refuge is "to protect an important existing egret and heron rookery on West Marin Island and to increase colonial nesting bird use on East Marin Islands" as described in the 1992 Environmental Assessment prepared for the creation of the Refuge.

The Refuge was established in 1992 and consists of two islands that total less than 13 acres in San Pablo Bay near San Rafael, California. Habitat types include uplands, estuarine open waters and estuarine mudflats. The Refuge contains one of the largest heron and egret rookeries in the San Francisco Bay. The Refuge is jointly owned by the U.S. Fish and Wildlife Service, California State Lands Commission and California Department of Fish and Game. However, it is managed by the USFWS, San Pablo Bay NWR, as part of the National Wildlife Refuge System.

REFUGE MANAGEMENT UNITS

West Marin Island

West Marin Island is a steep 2-acre island that is difficult to access. The vegetation consists primarily of native shrubs, forbs and grasses. No cultural sites are known to exist on this island. This island provides nesting habitat for the largest heron and egret rookery in the San Francisco Bay.

East Marin Island

East Marin Island is a steep 10-acre island that is accessed via a trail that begins at the boat dock located on the north side of the Island. Beaching a vessel on the south side of the island next to the quarry pond area and ascending a steep trail can also gain access. Both trails are not maintained regularly and are trip hazards at best. Approximately 5 acres of this island, the top surface, is relatively flat and currently has 2 small houses, 2 sheds and a water tank on it.

CLIMATE

The climate of the San Francisco Bay area consists of mild, wet winters (November through April) and warm, dry summers (May through October) (Nichols and Pamatmat 1988). The annual average maximum temperature is 70°F and the annual average minimum temperature is 45°F. Average annual precipitation is 25 inches in the form of rainfall.

VEGETATION

Marin Islands NWR is in a coastal ecosystem. While the vegetation of the two islands is distinctly different due to human influence on the east island, both islands include mixed evergreen forest, coastal prairie, and northern coastal scrub.

Open Water and Mudflats

Open water and mudflats do not support emergent vegetation. This habitat occurs in the open water area of San Pablo Bay and the Refuge manages 324 acres of this habitat within the Marin Islands NWR.

Uplands

Uplands are areas that occur above the high tide line and support mixed evergreen forest, coastal prairie and northern coastal scrub. The Refuge manages approximately 12 acres of upland habitat on the two islands.

The West Island is dominated by native shrub and tree species such as coast live oak (*Quercus agrifolia*), California buckeye (*Aesculus californica*), Toyon (*Heteromeles arbutifolia*), California sagebrush

(*Artemisia californica*), coyote bush (*Baccharis pilularis*) and wood rose (*Rosa gymnocarpa*) with an understory of annual introduced grasses (Orduff and Vasey 1995).

The East Island is dominated by several introduced trees including *Eucalyptus* spp., olive (*Olea europea*) several pine species including Monterey pine (*Pinus radiate*), digger pine (*P. sambiniana*) and Douglas fir (*Pseudotsuga menziesii*) (Orduff and Vasey 1995). Other introduced trees include edible fig (*Ficus carica*), apple (*Malus sylvestris*), cherry-plum (*Prunus cerasifera*) domestic plum/apricot (*Prunus* spp.). Native trees and shrubs listed for the West Island are also found on the East Island on steep slopes. The dominant understory consists of non-native grasses and periwinkle (*Vinca major*). Prickly pear cactus (*Opuntia* spp.) has populated the southern cliffs of the East Island as well.

FISH AND WILDLIFE

Open Water and Mudflats

The open waters of San Pablo Bay serve as the home or migratory corridor for many species of fish and aquatic invertebrates including herring, anchovy (*Engraulis* sp.), salmon (*Oncorhynchus* spp.), and steelhead (*Oncorhynchus mykiss*). Open waters also provide important resting and feeding habitat for millions of migratory birds each year.

Mudflats and inter-tidal areas are inundated twice daily by tides, and support an extensive community of diatoms, amphipods, worms, and shellfish. At high tide, fish feed on the worms, snails, and crabs that live in the mud. At low tide, shorebirds and waterbirds forage in the mud for their daily meal.

The San Pablo Bay provides habitat for half the diving duck population on the Pacific Flyway, primarily scaup (*Aythya* spp.) and canvasbacks (*Aythya valisineria*), as well as many migratory shorebird species such as dunlin (*Calidris alpine*), stilts (*Himantopus mexicanus*), avocets (*Recurvirostra americana*), dowitchers (*Limnodromus* spp.), willits (*Catoptrophorus semipalmatus*), sandpipers (*Calidris* spp.), curlews (*Numenius americanus*), and other probing waterbirds.

Upland Habitats

Upland habitats support nesting species such as great blue herons (*Ardea herodias*), black crowned night herons (*Nycticorax nycticorax*), great egrets (*Casmerodius albus*) and snowy egrets (*Egretta thula*). Other birds include house wren (*Troglodytes aedon*), spotted towhee (*Pipilo maculates*), western meadowlarks (*Sturnella neglecta*), ravens (*Corvus corax*) and golden-crowned sparrows (*Zonotrichia* albicollis). No mammals have been found on either island.

THREATENED AND ENDANGERED SPECIES

Steelhead (*Oncorhynchus mykiss*) and Chinook salmon (*O. tshawytscha*) may possibly be found in the surrounding waters.

CULTURAL RESOURCES

Native American sites are known to exist on the Refuge.

PHYSICAL RESOURCES

The East Island is approximately 10 acres and the West Island is approximately 2 acres. Three hundred twenty four acres of the Refuge consists of open bay waters and mudflats. To the east are the San Pablo Bay and the Suisun Bay/Delta, which receives water from the Sacramento River and interior watershed drainages. To the west is the Golden Gate opening to the Pacific Ocean.

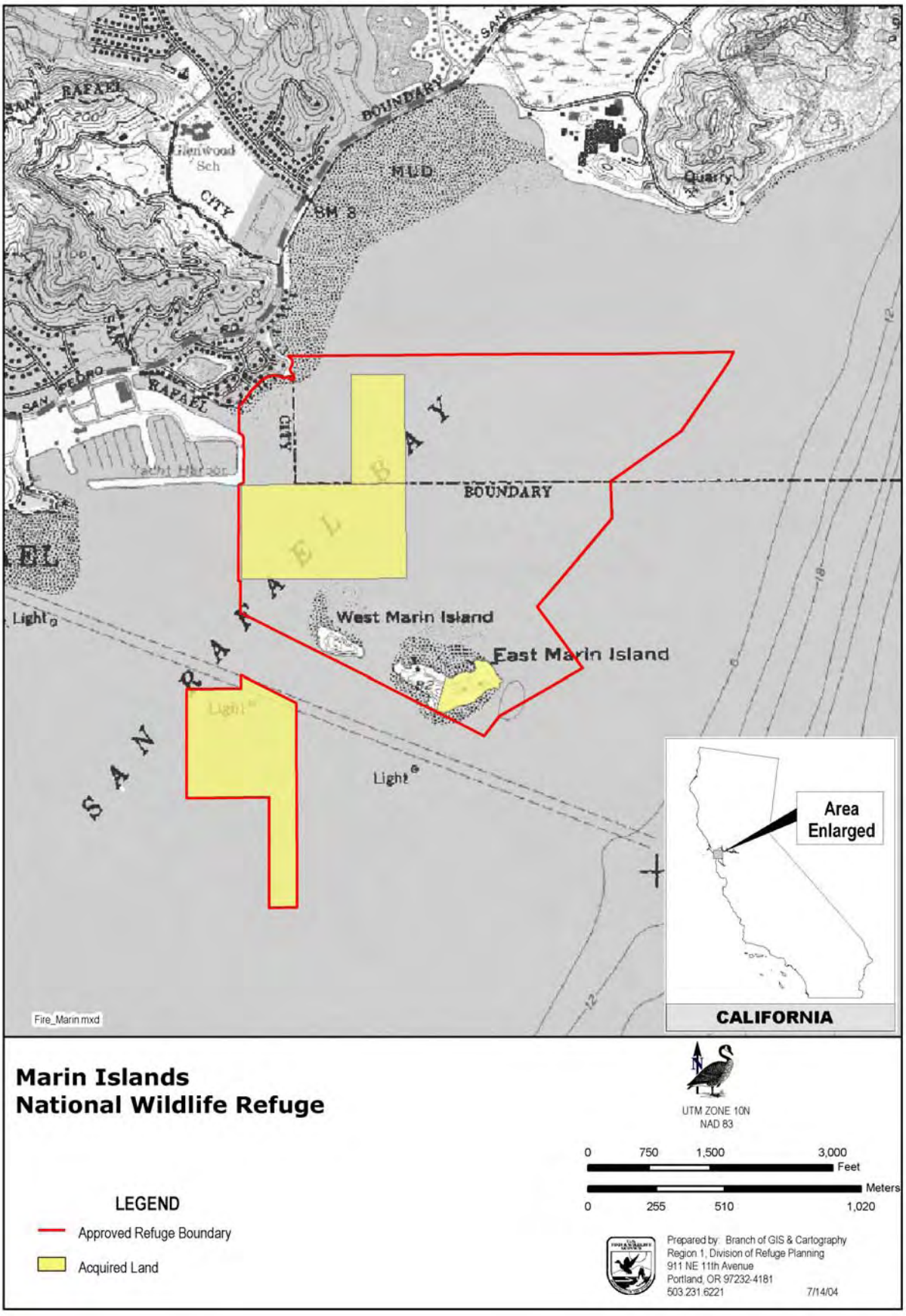
STRUCTURES AND FACILITIES

Structures and facilities on the East Island include 2 small houses, 2 storage sheds, 1 water tank, 1 septic system, 1 pump station and 1 electric transformer shed. Future plans include removal of all but 1 storage shed.

PUBLIC ACCESS

No public access is permitted on the islands except for limited stewardship activities and guided tours.

Figure 1. Marin Islands National Wildlife Refuge



WILDLAND FIRE MANAGEMENT SITUATION

HISTORIC ROLE OF FIRE

Pre-settlement Fires

The history of fire in the vicinity of the Refuge is not documented or well known. Prior to European colonization, Native Americans lived along the Bay shoreline for over 3,000 years. They periodically burned the mainland in order to increase the abundance of edible plant species as well as to provide habitat for large game animals. Lightning was another source of fire in pre-European California but is not common today. The frequency of lightning fires on the Refuge is not known. The fire frequency for pre-European grasslands has been estimated between 1 and 15 years for the grasslands of California's central coast (Greenlee and Langenheim 1990).

Post-settlement Fire History

The San Pablo Bay area has been settled by Europeans since the 1850's. As the area's population grew, the need to suppress natural and human-caused fires increased. Aggressive fire suppression in the surrounding hills altered the natural role of fire in the area. The normal fire season typically runs from May through September. Depending on the specific weather of any particular year the seasons may be shorter or longer and, therefore, may start earlier or last longer.

Prescribed Fire History

No prescribed burns have been conducted on Marin Islands NWR. None are planned in the immediate future due to cultural resources and soil conditions on the island as well as local air quality restrictions.

RESPONSIBILITIES

The Marin Islands NWR does not have a dedicated fire management organization. The Refuge Manager is responsible for planning and implementing the fire suppression management program on the Marin Islands NWR. The Zone Fire Management Officer (FMO), located at San Luis NWRC in Los Banos, is responsible for fire management program oversight. Preparedness planning and work is accomplished by Refuge staff in accordance with national and regional fire management direction under guidance from the Zone FMO. Emergency fire management actions will be handled by Refuge staff according to training and incident qualifications. The Zone FMO will be immediately notified of all emergency actions. Additional information and direction is included in the Fire Dispatch Plan (Appendix C).

Project Leader

- Is responsible for implementation of all fire suppression management activities within the Complex and will ensure compliance with Department and Service policies.
- Selects the appropriate suppression management responses to wildland fire.

Deputy Project Leader

- Coordinates Complex programs to ensure personnel and equipment are made available and utilized for fire management activities including fire suppression and preparedness projects
- Ensures that the fire suppression management program has access to Refuge and Complex resources when needed.
- Ensures that the Refuge Manager and Complex staff will consider the fire management suppression program during Refuge related planning and project implementation.

Refuge Manager

- Identifies and plans preparedness projects and biological objectives to Zone FMO, notifies Zone FMO of project constraints, and ensures that Refuge resources are available to accomplish preparedness projects.

- Acts as the primary Resource Advisor during fire suppression management planning and operations.
- Drafts wildland fire Burned Area Emergency Stabilization and Rehabilitation Plans for the Deputy Project Leader.
- Posts and enforces fire restriction regulations.

Biologist

- Coordinates through the Refuge Manager and Deputy Project Leader to provide biological input for the fire program with the Zone FMO.
- Acts as secondary Resource Advisor during fire suppression management planning and operations.
- Participates, as requested, in preparedness projects, fire suppression, and rehabilitation according to level of training.

Zone Fire Management Officer

- Responsible for all fire-related planning and implementation for the Complex.
- Integrates biological objectives into all fire management planning and implementation.
- Solicits program input from the Project Leader, Refuge Manager, and Biologist.
- Supervises preparedness project planning.
- Coordinates fire related training.
- Coordinates with cooperators to ensure adequate resources are available for fire operational needs.
- Is responsible for implementation of this Plan.
- Is responsible for preparation of fire reports following the suppression of wildland fires and for preparedness projects requiring such.
- Prepares an annual report detailing fire occurrences and pre-suppression activities undertaken in each calendar year. This report will serve as a post-year's fire management activities review, as well as provide documentation for development of a comprehensive fire history record for the Complex.
- Submits budget requests and monitors FIREBASE funds.
- Maintains records for all personnel involved in suppression and preparedness activities, detailing each individual's qualifications and certifications for such activities.
- Updates all fire qualifications for entry into the Fire Management Information System.
- Nominates personnel to receive fire-related training, as appropriate.

Incident Commander

Incident Commanders (ICs) of any level use strategies and tactics as directed by the Project Leader and Wildland Fire Situation Analysis (WFSA) where applicable to implement selected objectives on a particular incident. A specific Limited Delegation of Authority (Appendix I) will be provided to each Incident Commander prior to assuming responsibility for an incident. Major duties of the Incident Commander are given in the National Wildfire Coordinating Group (NWCG) Fire line Handbook, including:

- Brief subordinates, direct their actions, and provide work tools.
- Ensure that safety standards identified in the Fire Orders, the Watch Out Situations, and agency policies are followed at all times.
- Personally scout and communicate with others to be knowledgeable of fire conditions, fire weather, tactical progress, safety concerns and hazards, condition of personnel, and needs for additional resources.
- Order resources to implement the management objectives for the fire.

- Inform appropriate dispatch of current situation and expected needs.
- Coordinate mobilization and demobilization with dispatch and the Collateral FMO.
- Perform administrative duties, i.e., approving work hours, completing fire reports for command period, maintaining property accountability, providing or obtaining medical treatment, and evaluating performance of subordinates.
- Assure aviation safety is maintained to the highest standards.

Resource Advisor

The Resource Advisor (RA) is a technical specialist appointed by the Agency Administrator and reports to the IC or designee and provides guidance for natural and cultural resource protection from suppression operations. The RA provides input to the IC in the development of fire suppression strategies and tactics to minimize or mitigate the expected impacts of fire and fire suppression actions upon natural and cultural resources. The RA also provides input required for the development of rehabilitation plans. Resource Advisor responsibilities include (NWCG 1996):

- Provides analysis, information, and advice to fire managers for areas of concern, including:
  - Critical watersheds, riparian areas, fisheries, and water sources
  - Threatened or Endangered species
  - Prehistoric and historic archaeological sites and cultural landscapes
  - Fuel breaks – locations and specifications
  - Urban interface impact – structures and improvements
  - Hazardous materials
- Assists the planning function in developing fire maps and identifying areas of concern
- Determines environmental restrictions commensurate with FMP resource protection in the fire area
- Provides recommendations to fire management personnel and agency administrators for fire suppression rehabilitation needs
- Documents potential and actual suppression/fire-related resource impacts and the rationale for protection of priority areas
- Provides resource information to local initial attack ICs, dispatchers, or other fire personnel during pre-season training and planning meetings.

INTERAGENCY OPERATIONS

Cooperative agreements with various federal, state and local agencies generally provide that resources of each agency are available to assist in initial attack efforts. An agreement will be prepared in cooperation with the City of San Rafael Fire Department to assist the Refuge in the event of a wildland or structural fire, and to protect visitors and facilities of the Refuge. When completed, the agreement will be added to Appendix G.

Marin Islands NWR will use the Incident Command System (ICS) as a guide for fire line organization. Qualifications for individuals are per DOI Wildland Fire Qualifications and Certification System, part of NIIMS and the National Wildland Fire Coordination Group (NWCG) Prescribed Fire Qualification Guide. Depending on fire complexity, some positions may be filled by the same person.

PROTECTION OF SENSITIVE RESOURCES

Natural Resources

Wildland fire suppression guidelines and restrictions have been developed to minimize impacts on sensitive species and their habitats. These guidelines and restrictions can be found in the "Suppression Conditions" section, and are also summarized in Table 1. Minimum Impact Suppression Tactics (MIST) will be used to the greatest extent possible.

Cultural Resources

The Regional Archaeologist will work with fire staff, Project Leaders, and Incident Commanders to ensure that cultural resources are protected from fire and fire management activities. The "Request For Cultural Resource Compliance" (RCRC) form (Appendix F) will be used to inform the Regional Archaeologist of impending activities, thereby meeting the regulations and directions governing the protection of cultural resources as outlined in Departmental Manual Part 519, National Historic Preservation Act (NHPA) of 1966, Code of Federal Regulations (36CFR800), the Archaeological Resources Protection Act of 1979, as amended, and the Archaeological and Historic Preservation Act of 1974. The NHPA Section 106 clearance will be followed for any fire management activity that may affect historic properties (cultural resources listed or eligible for listing on the National Register of Historic Places).

Impacts to archaeological resources by fire resources vary. The four basic sources of damage are (1) fire intensity, (2) duration of heat, (3) heat penetration into soil, and (4) suppression actions. Of the four, the most significant threat is from equipment during line construction for wildfire holding actions.

The following actions will be taken to protect archaeological and cultural resources during wildland fire incidents:

- Minimum impact fire suppression tactics will be used to the fullest extent possible.
- Resource Advisors will inform fire suppression personnel of any areas with cultural resources.
- Mechanized equipment should not be used in areas of known cultural significance.
- The location of any sites discovered as the result of fire management activities will be reported to the Regional Archaeologist.
- Rehabilitation plans will address cultural resources impacts and will be submitted to the Regional Archaeologist using the RCRC (Appendix F).

WILDLAND FIRE SUPPRESSION ACTIVITIES

Fire program management describes the operational procedures necessary to implement fire management at Marin Islands NWR. Program management includes fire prevention, preparedness, fire detection, minimum impact suppression, fire rehabilitation, and documentation.

All fires will be appropriately suppressed. The City of San Rafael Fire Department will have initial attack responsibility for fires on the Refuge.

FIRE MANAGEMENT STRATEGIES

Suppression strategies should be applied so that the equipment and tools used to meet the desired objectives are those that inflict the least impacts upon the natural and cultural resources. Minimum Impact Suppression Tactics (MIST) will be employed to protect all resources. Natural and artificial barriers will be used as much as possible for containment. When necessary, fire line construction will be conducted in such a way as to minimize long-term impacts to resources. Sites impacted by fire suppression activities or by the fire will be rehabilitated as necessary, based on an approved course of action for each incident.

Specific fire management strategies for the San Pablo Bay NWR are:

- All wildland fires will be controlled using the appropriate suppression strategy which considers safety, property, natural resources, and economics.
- Mechanical treatment will be used to reduce hazardous fuels around structures and improvements annually.
- Known cultural resource areas will be excluded from all fire management activities and adverse fire effects.

Historical Weather Analysis

The normal fire season typically runs from May through September. Depending on the specific weather of any particular year the seasons may be shorter or longer and, therefore, may start earlier or last longer.

The Refuge currently has no means of analyzing historic weather trends. General fire weather information can be obtained through the National Oceanic and Atmospheric Administration (NOAA) at fire.boi.noaa.gov. Marin Islands NWR is located in the area serviced by the National Weather Service (NWS) office in Monterey, CA. The Monterey NWS website, http://www.wrh.noaa.gov/Monterey/fireweather.html, contains zone maps and fire weather forecasts, Remote Automated Weather Station (RAWS) locations, and a request form for spot weather forecasts. The Refuge falls within Fire Weather Zone 205 (Sonoma RU, Marin County). The California Fire Weather Annual Operating Plan contains contact phone numbers and procedures for obtaining fire weather and spot weather forecasts. This plan can be found online at http://www.wrh.noaa.gov/Sacramento/html/Final2006AOP.pdf.

Fire Prevention

An active fire prevention program may be conducted, as needed, in conjunction with other agencies to protect human life and property, and prevent damage to cultural resources or physical facilities.

Hazard Reduction for Structure Protection

Hazard reduction is conducted to prevent wildland fires from spreading onto structures owned by the FWS. Vegetation around the buildings is mowed to a distance of approximately 25 feet, however, large trees are located within close proximity to the structures. The structures are actually nestled under them. Mulch created from mowing is left where it falls. Shrubs and other weeds that are pulled or cut are

placed into piles to be removed from the island later by boat during refuge clean ups. Clean ups occur twice each year depending on the need. As funding is made available, all but one small structure will be removed.

Training
Departmental policy requires that all personnel engaged in suppression and prescribed fire duties meet the standards set by the National Wildfire Coordinating Group (NWCG). Marin Islands NWR will conform strictly to the requirements of the wildland fire management qualification and certification system and USFWS guidelines. Staff will not attempt to fight structural or wildland fires. The City of San Rafael Fire Department will be called and will perform firefighting duties.

Employees participating in any wildland fire activities on Fish and Wildlife Service or cooperators' lands will meet fitness requirements established in PMS 310-1, except where Service-specific fitness requirements apply.

Supplies and Equipment
No fire cache will be maintained at Marin Islands NWR. If needed, supplies can be obtained through the interagency cache system.

DETECTION
Fires would be reported by boaters or residents who live along the shore line of San Rafael to the City of San Rafael Fire Department through 911. Currently when trespass or other problems are found on the Islands, the San Rafael Police Department notifies the Refuge of the problem. When this plan is complete, a Memorandum of Understanding will be developed with San Rafael Fire Department and will outline notification procedures. If Refuge staff detects a fire, they will call 911 to notify the San Rafael Fire Department. The Fire Management Plan does not discriminate between human- and lightning-caused fires. All wildland fires will be suppressed using appropriate suppression strategies and tactics. A determination of fire cause will be conducted by City of San Rafael Fire Department.

COMMUNICATIONS
Staff at Marin Islands/San Pablo Bay NWR communicate via cell phones that are equipped with a group and unit to unit walkie-talkie feature. No radio system exists.

PRE-ATTACK PLAN
Upon discovery of a fire, all subsequent actions will be based on the following:

- The Incident Commander (IC) will locate, size-up, and coordinate suppression actions.
- Provide for public safety.
- Considering the current and predicted fire conditions, the Incident Commander will assess the need for additional suppression resources and estimate the final size of the fire. The potential for spread outside of the Refuge should be predicted, as well as the total suppression force required to initiate effective containment action at the beginning of each burning period.
- The Incident Commander will assess the need for law enforcement personnel for traffic control, investigations, evacuations, etc., and make the request to the Zone FMO.
- Document decisions and complete the fire report (DI-1202).
- Should a wildland fire move into an extended attack a Delegation of Authority (Appendix I) will be invoked. Once a Delegation of Authority has been authorized the Incident Commander will make the final decisions pertaining to the fire.

FIRE MANAGEMENT UNITS

Fire Management Units (FMUs) are areas on a Refuge which have common wildland fire management objectives and strategies, are manageable units from a wildland fire standpoint, and can be based on natural or manmade fuel breaks. Marin Islands NWR has been divided into two FMUs, East Island and West Island. Areas of open water and mudflats are unburnable and are not addressed further.

Due to staff limitations, relatively small land management parcels, long response times, cultural resources, soil conditions and air quality, this plan does not authorize managing wildland fire for resource benefit. Wildland fires will be suppressed using the appropriate suppression response.

East Island Fire Management Unit. All land supporting burnable vegetation associated with East Island. This FMU is 10 acres in size.

West Island Fire Management Unit. All land supporting burnable vegetation associated with West Island. This FMU is 2 acres in size.

FUEL TYPES AND FIRE BEHAVIOR

Fuel types on the Refuge are associated with the 12 acres of upland habitats on the two islands. These habitats will sustain fire, especially during periods of drought. Upland habitats on West Island are dominated mainly by native shrubs, trees and annual non-native grasses. Upland habitats on East Island are dominated by a mixture of non native and native trees, shrubs, grasses and non-native ornamental plants. These fuels are highly flammable and may result in a high rate of fire spread. These fuels most closely resemble Anderson's (1982) Fire Behavior Fuel Models 1 and 4.

Anderson (1982) provides the following descriptions of the fuel models and expected fire behavior of each. Depending on wind and fuel moisture conditions, actual fire behavior may be more or less intense than described.

Fuel Model 1 – Short Grass. Fire spread is governed by the fine, very porous, and continuous herbaceous fueld that have cured or are nearly cured. Fires are surface fires that move rapidly through the cured grass and associated material. Very little shrub or timber is present, generally less than one-third of the area. With a windspeed of 5 miles per hour and a moisture content of 8%, flame length is about 4 feet, and rate of spread is about 78 chains per hour. As windspeed increases, this fuel model will quickly develop faster rates of spread.

Fuel Model 4 – Chaparral. Fire intensity and fast-spreading fires involve the foliage and live and dead fine woody material in the crowns of a nearly continuous secondary overstory. Besides flammable foliage, dead woody material in the stands contributes to the fire intensity. With a wind of 5 miles per hour, dead fuel moisture content of 8%, and live fuel moisture content of 100%, flame length is about 19 feet, and rate of spread is about 75 chains per hour.

FIRE EFFECTS

Uplands on both islands are prone to exotic plant invasions and if a fire occurs within these areas, resource planning should be initiated to seed or treat the areas during recovery. Fires occurring during the breeding season on West Island are not likely to sustain themselves due to the large amounts of guano and lack of leaf material on the trees. Fires that occur prior to the breeding season on West Island will burn readily due to the fuel types that include scrub oak and dry cool season grasses. Fires that occur on the East Island where scrub oak and buckeye are mixed with pines and Eucalyptus with an understory of dried cool season grasses will burn readily. Periwinkle and other evergreen ground cover located away from the structures may restrict ground fire to the area immediately around the structures.

SUPPRESSION TACTICS

Suppression involves a wide range of possible tactics from the initial attack to final control. To this end, all wildland fires will be suppressed in a safe, aggressive, and cost-effective manner to produce efficient action with minimal resource damage and limit smoke impacts to local communities.

Staff will not attempt to conduct initial attacks on any type of fire unless they are still very small, can be stopped immediately with a fire extinguisher or hand tool, and no safety concerns exist. Upon arrival of qualified suppression personnel, all unqualified staff must immediately cease initial attack action. All fires will be assessed by the first on-scene incident commander and attacked using minimum impact fire suppression tactics for the Refuge.

A Resource Advisor should be assigned to the incident from the beginning to consult with the Refuge Manager or Project Leader, assist with on-the-ground tactical decisions, and document rehabilitation needs. There will be only one Incident Commander responsible through the FMO to the Refuge Manager/Project Leader. The Incident Commander will designate all overhead positions on fires requiring extended attack.

Suppression Conditions

A full suppression alternative was selected for this Refuge, which requires containment and control of all wildland fires. Certain guidelines have been developed to assist with this strategy to protect the Refuge from unnecessary damage. These guidelines and restrictions will be provided to all entities that may perform initial attack on the Refuge. These guidelines should be reviewed annually, and changes and areas of concern should be documented.

West Island FMU: Contains native vegetation that is used by herons and egrets for nesting. Vegetation prior to breeding season will contain leafy materials and grasses may be dry during parts of the year and therefore may support fire. Spread potential is high for all areas of the FMU. The use of heavy equipment and off-road driving are not applicable to this FMU, as there is no direct access from the mainland. Fire suppression foams and retardants are prohibited on entire FMU. Hand line, and water drops must be approved by the Resource Advisor during the breeding season that spans from March through the end of July. Fire suppression may involve a confinement strategy (monitoring) to minimize impacts if resources are not at risk OR aggressive control and extinguishment.

East Island FMU: Contains a mix of non-native and native vegetation that have high burn potential. In addition several structures on the island could burn as well. Spread potential is high for all areas of the FMU. The use of heavy equipment and off-road driving are not applicable to this FMU, as there is no direct access from the mainland. Fire suppression foams and retardants are prohibited on entire FMU. Hand line, hose lays, and water drops can be approved by the Incident Commander

Table 1. Marin Islands NWR Wildland Fire Suppression Guidelines

Marin Islands National Wildlife Refuge – Wildland Fire Suppression Guidelines		
NOTE: If human life is threatened, the Incident Commander has the authority to order any suppression strategy or tactic available to mitigate the threat, regardless of the FMU.		
	FIRE MANAGEMENT UNITS	
	WEST ISLAND	**EAST ISLAND**
FMU Description	All land of the West Island	All land of the East Island
Special Considerations	• Smoke/fire may cause a health hazard to San Rafael or other areas. • Important heron and egret rookeries present.	• Smoke/fire may cause a health hazard to San Rafael or other areas. • Cultural resources present. • Structures present.
Preferred Suppression Strategies	Aggressively suppress fire from the open water	Aggressively suppress fire from the open water.
Hand line	Resource Advisor	Incident Commander
Foam/Retardant	Prohibited	Prohibited
Water drops	Resource Advisor (March – July)	Incident Commander
Hose lays	Resource Advisor (March – July)	Incident Commander
Off-road travel	N/A	N/A
Heavy Equipment	N/A	N/A
Safety Considerations	Access difficult – by boat only Steep/unstable terrain	Access difficult – by boat only Steep/unstable terrain

Wildland Fire Situation Analysis

For fires that cannot be contained in one burning period, a Wildland Fire Situation Analysis (WFSA) must be prepared. In the case of a wildland fire, the Project Leader or Refuge Manager, in conjunction with the Zone FMO, will prepare the WFSA. Approval of the WFSA resides with the Project Leader.

The purpose of the WFSA is to allow for a consideration of alternatives by which a fire may be controlled. Damages from the fire, suppression costs, safety, and the probable character of suppression actions are all important considerations.

Public safety will require coordination between all Refuge staff and the Incident Commander. Notices should be posted to warn customers at Loch Lomond Marina and traffic control will be necessary where smoke crosses roads, etc. Every attempt will be made to utilize natural and constructed barriers, including changing fuel complexes, in the control of wildland fire. Rehabilitation efforts will concentrate on the damages done by suppression activities rather than on the burned area itself.

Aircraft Operations

Aircraft may be used in all phases of fire management operations. All aircraft must be Office of Aircraft Services (OAS) or Forest Service approved. An OAS Aviation Policy Department Manual will be provided by OAS.

Helicopters may be used for reconnaissance and bucket drops. As in all fire management activities, safety is a primary consideration. Qualified aviation personnel will be assigned to all flight operations.

BURNED AREA EMERGENCY STABILIZATION AND REHABILITATION

There are three methods of repairing damage caused by wildland fires and wildland fire suppression activities – emergency stabilization, rehabilitation, and fire suppression activity damage repair.

Departmental policy for emergency stabilization and rehabilitation (ESR) on Service lands following wildland fire, including objectives, implementation, plan submittal, monitoring, and funding, is found in the Department Manual (620 DM 3). Service ESR supplemental policy can be found in the Service Manual (095 FW 3.9), with policy implementation guidance provided in Chapter 5 of the FWS Fire Management Handbook. More detailed guidance can be found in the Interagency Burned Area Emergency Stabilization and Rehabilitation Handbook (2002) and Technical Reference (2002). The Service maintains an internet web site (http://fire.fws.gov/ifcc/rehab/) that provides access to these and several other guidance documents.

Any treatment or activity will have an approved plan developed prior to implementation. Monitoring specifications will be included in the plan for each treatment or activity. Emergency stabilization and rehabilitation treatments and activities will be written in separate plans. The Project Leader, Biologist, and Zone FMO will review all plans. The final plans will be submitted to the Region for review prior to submission to the Washington Office.

Implementation activities will be conducted in a manner that is compatible with long-term goals and approved land management plans (e.g., Comprehensive Conservation Plan, Habitat Management Plan, Fire Management Plan), in compliance with applicable law and policy, including the National Environmental Policy Act, Endangered Species Act, Clean Water Act, and National Historic Preservation Act.

REQUIRED REPORTING

The Incident Commander will be responsible for documenting decisions and completing the fire report (e.g., ICS-214, DI-1202). The Zone FMO will be responsible for any additional required reports.

FIRE INVESTIGATION

Fire management personnel will attempt to locate and protect the probable point of origin and record pertinent information required to determine fire cause. They will be alert for possible evidence, protect the scene and report findings to the fire line supervisor.

Prompt and efficient investigation of all suspicious fires will be carried out. However, fire management personnel should not question suspects or pursue the fire investigation unless they are currently law enforcement commission qualified.

Personnel and services of other agencies may be utilized to investigate wildland fire arson or fire incidents involving structures. All fire investigations should follow the guidelines outlined in 4.1-2 of the Fire Management Handbook (2000).

PUBLIC SAFETY

Marin Islands NWR is dedicated to providing for the safety of each visitor and to all residents and property adjacent to the Refuge's boundary. Fires on either island will have no effect on public use. A first aid kit is on the Refuge boat and will be on-site for wildland fires. The local police, fire, and emergency medical services will be notified of any wildland fires.

FIRE CRITIQUES AND ANNUAL PLAN REVIEW

FIRE CRITIQUES

Fire reviews will be documented and filed with the final fire report. The Zone FMO will retain a copy for the Refuge files.

ANNUAL FIRE SUMMARY REPORT

The Zone FMO will be responsible for completing an annual fire summary report. The report will contain the number of accidental fires by type; acres burned by fuel type, cost summary, personnel utilized, and fire effects.

ANNUAL FIRE MANAGEMENT PLAN REVIEW

The Fire Management Plan will be reviewed annually. Necessary updates or changes will be accomplished prior to the next fire season. Any additions, deletions, or changes will be reviewed by the Project Leader to determine if such alterations warrant a re-approval of the plan.

CONSULTATION AND COORDINATION

The following agencies, organizations and/or individuals were consulted in preparing this plan.

Peter Kelly, Fire Management Officer, San Luis NWRC, USFWS, Los Banos, CA.

Bob Parris, Deputy Project Leader, San Luis NWRC, USFWS, Los Banos, CA.

R. Brian Paul, Prescribed Fire Specialist, San Luis NWRC, USFWS, Los Banos, CA.

James Roberts, Fire Planner, Pacific Region, USFWS, Portland, OR.

APPENDICES

APPENDIX A: REFERENCES CITED

Anderson, H.E. 1982. Aids to determining fuel models for estimating fire behavior. USDA For. Serv.Gen. Tech. Rep. INT-122, 22p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

Greenlee, J. M., and J. H. Langenheim. 1990. Historic fire regimes and their relation to vegetation patterns in the Monterey Bay area of California. American Midland Naturalist 124:239-253.

National Wildfire Coordinating Group. 1996. Resource advisor's guide for wildland fire. PMS 313/ NFES 1831.

Nichols, F.H., and M.M. Pamatmat. 1988. The Ecology of the Soft-Bottom Benthos of San Francisco Bay: A Community Profile. Biological Report 85 (7.19). U.S. Fish and Wildlife Service. 71pp.

Orndoff, R., and M.C. Vasey. 1995. The Vegetation and Flora of the Marin Islands, California. Madrono 42:358-365.

APPENDIX B: DEFINITIONS

Agency Administrator. The appropriate level manager having organizational responsibility for management of an administrative unit. May include Director, State Director, District Manager or Field Manager (BLM); Director, Regional Director, Complex Manager or Project Leader (FWS); Director, Regional Director, Park Superintendent, or Unit Manager (NPS), or Director, Office of Trust Responsibility, Area Director, or Superintendent (BIA).

Appropriate Management Action. Specific actions taken to implement a management strategy.

Appropriate Management Response. Specific actions taken in response to a wildland fire to implement protection and fire use objectives.

Appropriate Management Strategy. A plan or direction selected by an agency administrator which guides wildland fire management actions intended to meet protection and fire use objectives.

Appropriate Suppression. Selecting and implementing a prudent suppression option to avoid unacceptable impacts and provide for cost-effective action.

Bureau. Bureaus, offices or services of the Department.

Class of Fire (as to size of wildland fires).
Class A - 3 acre or less.
Class B - more than 3 but less than 10 acres.
Class C - 10 acres to 100 acres.
Class D - 100 to 300 acres.
Class E - 300 to 1,000 acres.
Class F - 1,000 to 5,000 acres.
Class G - 5,000 acres or more.

Emergency Fire Rehabilitation/Burned Area Emergency Rehabilitation (EFR/BAER). Emergency actions taken during or after wildland fire to stabilize and prevent unacceptable resource degradation or to minimize threats to life or property resulting from the fire. The scope of EFR/BAER projects are unplanned and unpredictable requiring funding on short notice.

Energy Release Component (ERC). A number related to the available energy (BTU) per unit area (square foot) within the flaming front at the head of a fire. It is generated by the National Fire Danger Rating System, a computer model of fire weather and its effect on fuels. The ERC incorporates thousand hour dead fuel moistures and live fuel moistures; day to day variations are caused by changes in the moisture content of the various fuel classes. The ERC is derived from predictions of (1) the rate of heat release per unit area during flaming combustion and (2) the duration of flaming.

Extended Attack. This is a fire on which initial attack forces are reinforced by additional forces.

Fire Suppression Activity Damage. The damage to lands, resources and facilities directly attributable to the fire suppression effort or activities, including: dozer lines, camps and staging areas, facilities (fences, buildings, bridges, etc.), hand lines, and roads.

Fire Effects. These are any consequences to the vegetation or the environment resulting from fire, whether neutral, detrimental, or beneficial.

Fire Intensity. This is the amount of heat produced by a fire and is usually compared by reference to the length of the flames.

Fire Management. All activities related to the prudent management of people and equipment to prevent or suppress wildland fire and to use fire under prescribed conditions to achieve land and resource management objectives.

Fire Management Plan. This is a strategic plan that defines a program to manage wildland and prescribed fires and documents the Fire Management Program in the approved land use plan. The plan is supplemented by operational procedures such as preparedness plans, preplanned dispatch plans, prescribed fire plans and prevention plans.

Fire Prescription. A written direction for the use of fire to treat a specific piece of land, including limits and conditions of temperature, humidity, wind direction and speed, fuel moisture, soil moisture, etc., under which a fire will be allowed to burn, generally expressed as acceptable range of the various fire-related indices, and the limit of the area to be burned.

Fuels. Materials that are burned in a fire; primarily grass, surface litter, duff, logs, stumps, brush, foliage, and live trees.

Fuel Loadings. Amount of burnable fuel on a site, usually given as tons/acre.

Hazard Fuels. Those vegetative fuels which, when ignited, threaten public safety, structures and facilities, cultural resources, natural resources, natural processes, or to permit the spread of wildland fires across administrative boundaries except as authorized by agreement.

Initial Attack. This is an aggressive suppression action consistent with firefighter and public safety and values to be protected.

Maintenance Burn. A fire set by agency personnel to remove debris; i.e., leaves from drainage ditches or cuttings from tree pruning. Such a fire does not have a resource management objective.

Natural Fire. This is a fire of natural origin that is caused by lightning or volcanic activity.

NFDRS Fuel Model. This is one of 20 mathematical models used by the National Fire Danger Rating System to predict fire danger. The models were developed by the U.S. Forest Service and are general in nature rather than site-specific.

NFFL Fuel Model. This is one of 13 mathematical models used to predict fire behavior within the conditions of their validity. The models were developed by US Forest Service personnel at the Northern Forest Fire Laboratory, Missoula, Montana.

Prescription. All measurable criteria that guide selection of appropriate management response and actions. Prescription criteria may include safety, public health, environmental, geographic, administrative, social, or legal considerations.

Prescribed Fire. A fire ignited by agency personnel in accord with an approved plan and under prescribed conditions, designed to achieve measurable resource management objectives. Such a fire is designed to produce the intensities and rates of spread needed to achieve one or more planned benefits to

natural resources as defined in objectives. Its purpose is to employ fire scientifically to realize maximum net benefits at minimum impact and acceptable cost. A written, approved prescribed fire plan must exist and NEPA requirements must be met prior to ignition. NEPA requirements can be met at the land use or fire management planning level.

Preparedness. Actions taken seasonally in preparation to suppress wildland fires, consisting of hiring and training personnel, making ready vehicles, equipment, and facilities, acquiring supplies, and updating agreements and contracts.

Prevention. Activities directed at reducing the number or the intensity of fires that occur, primarily by reducing the risk of human-caused fires.

Rehabilitation. Actions to (1) limit the adverse effects of suppression on soils, watershed, or other values, or (2) to mitigate adverse effects of a wildland fire on the vegetation-soil complex, watershed, and other damages.

Suppression. A management action intended to protect identified values from a fire, extinguish a fire, or alter a fire's direction of spread.

Unplanned Ignition. A natural fire that is permitted to burn under specific conditions, in certain locations, to achieve defined resource objectives.

Wildfire. An unwanted wildland fire.

Wildland Fire. Any non-structure fire, other than prescribed fire, that occurs in the wildland.

Wildland Fire Situation Analysis (WFSA). A decision-making process that evaluates alternative management strategies against selected safety, environmental, social, economical, political, and resource management objectives as selection criteria.

Wildland/Urban Interface Fire. A wildland fire that threatens or involves structures.

2006 Fire Prevention and Dispatch Plan
Marin Islands National Wildlife Refuge

FIRE SIZE-UP

Use the following or the card, pocket guide, fire line handbook or red book guides.

Reporting party's name and phone number:_____

Time discovered:_____

Location of smoke or fire (plot on map; legal description):_____

_____

Fire Behavior: ___Smoldering ___Creeping ___Running ___Crowning
Spotting

Estimated size (acres): ___Spot ___1/4-1/2 ___1/2-3/4 ___1 ___1-5 ___5+

Wind (mid-flame speed & direction):_____

Dry Bulb Temperature (°F):_____ Relative Humidity (%):_____

Fuel Type: ___Grass ___Brush ___Timber ___Slash

Adjacent Fuels: ___Grass ___Brush ___Timber ___Slash

Aspect:_____ Percent Slope:_____

Additional Resources Needed:_____

Special Considerations:_____

_____

NOTIFICATION

Upon report of a wildland fire, contact staff in the following order:

1. **CALL 911** – request response by fire department, ambulance if necessary, traffic control

   In any serious threat situation, where there is immediate danger to persons and/or property, dial 911. If you dial 911 from a cell phone, you may get the Highway Patrol which could delay response time. Program local police numbers into your cell phone memory.

City of San Rafael Police Department	(415) 485-3000
City of San Rafael Fire Department	(415) 485-3300
City of San Rafael Fire Prevention	(415) 485-3308

2. Christy Smith – Refuge Manager/Resource Advisor
   Work: (707) 769-4200
   Cell: (707) 975-5521
   Home: (707) 747-9654

3. Giselle Block – Wildlife Refuge Biologist/Resource Advisor
   Work: (707) 769-4200
   Cell: (707) 975-5523
   Home: (415) 479-8254

4. ***Contact one of the following Regional FWS Fire Duty Officers:***

   Pam Ensley – Regional Fire Management Coordinator
   Work: (503) 231-6174
   Cell: (503) 781-7978
   Home: (360) 835-7004

   Robert Spaulding – Regional Fire Management Officer
   Work: (503) 231-6175
   Cell: (503) 816-7054
   Home:

   (Vacant) – Regional Prescribed Fire Specialist
   Work: (503) 231-2075
   Cell:
   Home:

   Bruce Babb – Fire Specialist / Regional WUI Coordinator
   Work: (503) 231-6234
   Cell: (503) 703-5823

5. Refuge Law Enforcement Officers (LE) protect Refuge natural resources, staff, public, interns, volunteers, property and facilities. Please call these officers in this order:

1.	Sean Reier, LE	(510) 557-1109
2.	Carmen Leong-Minch, LE	(510) 377-9229
3.	Clyde Morris	(510) 494-1098
4.	Christy Smith	(707) 769-4200
5.	Giselle Block	(707) 769-4200
6.	G. Mendel Stewart	(510) 792-0222

WILDLAND FIRE SUPPRESSION GUIDELINES

Marin Islands National Wildlife Refuge – Wildland Fire Suppression Guidelines		
NOTE: If human life is threatened, the Incident Commander has the authority to order any suppression strategy or tactic available to mitigate the threat, regardless of the FMU.		
	FIRE MANAGEMENT UNITS	
	WEST ISLAND	**EAST ISLAND**
FMU Description	All land of the West Island	All land of the East Island
Special Considerations	• Smoke/fire may cause a health hazard to San Rafael or other areas. • Important heron and egret rookeries present.	• Smoke/fire may cause a health hazard to San Rafael or other areas. • Cultural resources present. • Structures present.
Preferred Suppression Strategies	Aggressively suppress fire from the open water	Aggressively suppress fire from the open water.
Hand line	Resource Advisor	Incident Commander
Foam/Retardant	Prohibited	Prohibited
Water drops	Resource Advisor (March – July)	Incident Commander
Hose lays	Resource Advisor (March – July)	Incident Commander
Off-road travel	N/A	N/A
Heavy Equipment	N/A	N/A
Safety Considerations	Access difficult – by boat only Steep/unstable terrain	Access difficult – by boat only Steep/unstable terrain

SUPPRESSION TACTICS

Suppression involves a wide range of possible tactics from the initial attack to final control. To this end, all wildland fires will be suppressed in a safe, aggressive, and cost-effective manner to produce efficient action with minimal resource damage and limit smoke impacts to local communities.

Staff will not attempt to conduct initial attacks on any type of fire unless they are still very small, can be stopped immediately with a fire extinguisher or hand tool, and no safety concerns exist. Upon arrival of qualified suppression personnel, all unqualified staff must immediately cease initial attack action. All fires will be assessed by the first on-scene incident commander and attacked using minimum impact fire suppression tactics for the Refuge.

A Resource Advisor should be assigned to the incident from the beginning to consult with the Refuge Manager or Project Leader, assist with on-the-ground tactical decisions, and document rehabilitation needs. There will be only one Incident Commander responsible through the FMO to the Refuge Manager/Project Leader. The Incident Commander will designate all overhead positions on fires requiring extended attack.

Suppression Conditions

A full suppression alternative was selected for this Refuge, which requires containment and control of all wildland fires. Certain guidelines have been developed to assist with this strategy to protect the Refuge from unnecessary damage. These guidelines and restrictions will be provided to all entities that may perform initial attack on the Refuge. These guidelines should be reviewed annually, and changes and areas of concern should be documented.

West Island FMU: Contains native vegetation that is used by herons and egrets for nesting. Vegetation prior to breeding season will contain leafy materials and grasses may be dry during parts of the year and therefore may support fire. Spread potential is high for all areas of the FMU. The use of heavy equipment and off-road driving are not applicable to this FMU, as there is no direct access from the mainland. Fire suppression foams and retardants are prohibited on entire FMU. Hand line, and water drops must be approved by the Resource Advisor during the breeding season that spans from March through the end of July. Fire suppression may involve a confinement strategy (monitoring) to minimize impacts if resources are not at risk OR aggressive control and extinguishment.

East Island FMU: Contains a mix of non-native and native vegetation that have high burn potential. In addition several structures on the island could burn as well. Spread potential is high for all areas of the FMU. The use of heavy equipment and off-road driving are not applicable to this FMU, as there is no direct access from the mainland. Fire suppression foams and retardants are prohibited on entire FMU. Hand line, hose lays, and water drops can be approved by the Incident Commander

CONTACT LIST

Table 2. Contact List for San Pablo Bay NWR and Emergency Services

U.S. Fish and Wildlife Service Contacts		
San Francisco Bay NWRC G. Mendel Stewart, Project Leader	#1 Marshlands Road P.O. Box 524 Newark, CA 94536	Work: (510) 792-0222 Cell: (510) 377-9450 Fax: (510) 792-5828
San Pablo Bay NWR	7715 Lakeville Highway Petaluma, CA 94954	Phone: (707) 769-4200 Fax: (707) 769-8106
Christy Smith, Refuge Manager San Pablo Bay NWR	Petaluma, CA	Work: (707) 769-4200 Cell: (707) 975-5521 Home: (707) 747-9654
Giselle Block, Wildlife Refuge Biologist San Pablo Bay NWR	Petaluma, CA	Work (707) 769-4200 Cell: (707) 975-5523 Home: (415) 479-8254
Region 1 Office	Fire Management 911 NE 11th Avenue Portland, OR 97232-4181	Phone: (503) 736-4750 Phone: (503) 231-6170 Fax: (503) 231-2364
Pam Ensley, Regional Fire Management Coordinator	Portland, OR	Work: (503) 231-6174 Cell: (503) 738-7978 Home: (360) 835-7004
Roger Spaulding, Regional Fire Management Officer	Portland, OR	Work: (503) 231-6175 Cell: (503) 816-7054 Home:
(Vacant), Regional Prescribed Fire Specialist	Portland, OR	Work: (503) 231-2075 Cell:
Bruce Babb Regional WUI Coordinator	Portland, OR	Work: (503) 231-6234 Cell: (503) 703-5823

Law Enforcement, Fire, and Emergency Services		
City of San Rafael Fire Department		911
City of San Rafael Police Department		911
Hospitals/Ambulances		911

UNITED STATES FISH AND WILDLIFE SERVICE

ENVIRONMENTAL ACTION STATEMENT FOR CATEGORICAL EXCLUSION

Within the spirit and intent of the Council on Environmental Quality's regulations for implementing the National Environmental Policy Act (NEPA), and other statutes, orders, and policies that protect fish and wildlife resources, I have established the following administrative record and determined that the following proposed action is categorically excluded from NEPA documentation requirements consistent with the 40 CFR 1508.4 and 516 DM 2.3A.

PROPOSED ACTION

The Proposed Action is to implement the 2006 Wildland Fire Management Plan for Marin Islands National Wildlife Refuge (NWR), which outlines a program of full wildland fire suppression and hazard fuel reduction associated with maintenance of structures. No prescribed burning of any kind will occur.

CATEGORICAL EXCLUSION(S)

- Fire management activities, including prevention and restoration measures, when conducted in accordance with departmental and Service procedures (516 DM 6, Appendix 1.4, B (5)).

PERMITS/APPROVALS

No prescribed burning will occur; therefore, no permits are required.

INTERAGENCY COOPERATION

City of San Rafael Fire Department will respond to wildland and structural fires on the Refuge (agreement in development stage).

SUPPORTING DOCUMENTS

- (620 DM 1). Refuges with burnable vegetation must develop a Fire Management Plan.
- Department of Interior Environmental Assessment for the proposed establishment of the Marin Islands National Wildlife Refuge (1992).
- ESA Section 7 Statement of "No Effect" (Appendix E of the Fire Management Plan).

_____ _____

G. Mendel Stewart, Project Leader Date
San Francisco Bay National Wildlife Refuge Complex

APPENDIX E: ESA SECTION 7 COMPLIANCE

Section 7 of the Endangered Species Act of 1973, as amended, outlines procedures to conserve federally-listed species and designated critical habitats. Internal Fish and Wildlife Service actions involving listed, proposed, and candidate species will promote the conservation of those species to the greatest extent practical under Federal law.

Proposed Action: Implementation of the 2006 Wildland Fire Management Plan (FMP) for Marin Islands National Wildlife Refuge (NWR), of the San Francisco Bay National Wildlife Refuge Complex. The FMP contains operational guidance for wildland fire suppression and hazard fuel reduction as a maintenance activity around structures. No prescribed burning of any type will occur.

Listed Species: Threatened, Endangered, Candidate, and Proposed species and critical habitat found on Marin Islands NWR are listed in the table below. These species may be found in the waters that surround the two islands where fire suppression would take place.

Scientific Name	Common Name	Federal Status
Oncorhynchus mykiss	Steelhead	Threatened
Oncorhynchus tshawytscha	Chinook Salmon	Endangered

Effects Determination: The Project Leader at San Francisco Bay National Wildlife Refuge Complex, in consultation with the Wildlife Biologist, has determined that the actions of full wildland fire suppression and hazard fuel reduction at Marin Islands NWR will have "**no effect**," either directly or indirectly, on federally endangered, threatened, candidate, or proposed species or their habitats and will not destroy or adversely modify designated or proposed critical habitat. Formal consultation with and concurrence from the Endangered Species Office is therefore not required, and no further section 7 compliance documentation will be made unless proposed fire management actions fall out of the range of those described in the Fire Management Plan, if unexpected effects result from any fire management activity, if species and/or habitats found on the Refuge become listed, or if species and/or habitats that are currently listed are discovered.

Justification: The listed species found on the Refuge are limited to marine habitats. The only fire suppression tactic that could potentially affect these species is the use of foams or retardants. The use of foams and retardants are prohibited on the Refuge in normal suppression responses. Due to the isolation of the Refuge from the mainland, it is unlikely that any situation would arise that threatens human life or property of significant value; therefore, the use of foams and retardants are not expected.

G. Mendel Stewart, Project Leader — Date
San Francisco Bay National Wildlife Refuge Complex

REQUEST FOR CULTURAL RESOURCE COMPLIANCE

Project Name: _____

USFWS Unit: _____

Org Code: _____

Ecoregion: _____
(By ARD; CBE, IPE, KCE, NCE)

Program: _____
(Partners, WSECP, Refuges, Hatcheries, Jobs, Federal Aid, Other)

NHPA COMPLIANCE

❑ Appendix _____ Item _____
of the Programmatic Agreement applies.

❑ 36CFR800.4 to 800.6 applies.

_____ _____
Cultural Resources Team Date

Location: _____ **County:** _____ **State:** _____
(nearest town)

Township(s): _____ **Range(s):** _____ **Section(s):** _____ **Meridian:** _____

7.5' USGS Quad(s): _____
(Name, Date)

Project acres or linear meters/feet: _____

Date you want to start the project: _____ **Date of this request:** _____

USFWS Contact: _____ **Phone:** _____

Address: _____ **Fax:** _____

Directions to project (if not obvious):

Attach to this form:

- A **project (sketch) map** showing the Area of Potential Effect with locations of specific ground altering activities *(required)*.
- A **photocopy** of the **USGS quad** clearly marking the project area *(required)*.
- A **photocopy** of an **air photo** showing the project may be attached *(if available)*.

Return form and direct questions to:

USFWS Region 1 Cultural Resources Team
c/o Tualatin River NWR
20555 SW Gerda Lane
Sherwood, OR 97140

Phone: (503) 625-4377
Fax: (503) 625-4887

The Undertaking: *Describe the proposed project and means to facilitate it (e.g., provide funds to revegetate 1 mile of riparian habitat, restore 250 acres of seasonal wetlands, and construct a 5-acre permanent pond). How is the project designed (e.g., install 2 miles of fence and create approximately 25 feet of 3 foot high check dam)?*

Area of Potential Effect: *Describe where disturbance of the ground will occur. What are the dimensions of the area to be disturbed? How deep will you excavate? How long is the ditch, fence, etc? Where will fill be obtained? Where will spoil be dumped? What tools or equipment will be used? Are you replacing or repairing a structure? Are you moving dirt in a relatively undisturbed area? Will the project reach below or beyond the limits of prior land disturbance? Differentiate between areas slated for earth movement versus areas to be inundated only. Is the area to be inundated different from the area inundated today, in the recent past, or under natural conditions? Provide acres and/or linear meters or feet for all elements of the undertaking.*

Environmental Setting: *Describe the environmental setting of the Area of Potential Effect. A) What was the natural habitat prior to modifications, reclamation, agriculture, settlement? B) What is the land-use history? When was it first settled, modified? How deep has it been cultivated? Grazed? etc. C) What is the land-use and habitat today? What natural agents (e.g., sedimentation, or vegetation) or cultural agents (e.g., cultivation) might affect the ability to discover cultural resources? D) Do you (or does anybody else) know of cultural resources in or near the project area?*

APPENDIX G: INTERAGENCY AGREEMENTS

No cooperative agreements or MOUs related to fire management and suppression are currently in place. A formal agreement with the City of San Rafael Fire Department will be developed for wildland and structural fire responsibility on Marin Islands NWR when this fire plan is completed.

APPENDIX H: REFUGE MAPS

When completed, a map of the Refuge's Fire Management Units will be inserted here.

DELEGATION OF AUTHORITY

Region 1, U.S. Fish and Wildlife Service

Marin Islands National Wildlife Refuge

_____, you are assigned as Incident Commander of the _____ Incident on the Marin Islands National Wildlife Refuge. You have full authority and responsibility for managing the fire suppression operation on this incident within the framework of legal statute, current policy, broad direction, and the Wildland Fire Situation Analysis (WFSA). Your primary responsibility is to achieve complete control of the fire by organizing and directing the fire suppression organization in an effective, efficient, economical and most importantly, safe manner.

You should be guided in your duties by the fire job descriptions relating to Incident Commander, as found in the Fireline Handbook. Strongly consider long-term ecosystem health, and the effects of suppression actions in the development of appropriate suppression responses. These issues are to be addressed and documented in the WFSA.

You are accountable to the Project Leader, _____ of the San Francisco Bay National Wildlife Refuge Complex, who is the Line Officer. _____ may serve as the Line Officer Designee for this incident.

You will immediately notify me in person in the event of:

(1) a serious injury or fatality,
(2) threat to private property,
(3) if the incident exceeds the limits of the selected alternative of the WFSA.

Your job as Incident Commander is critical, as you must minimize damage to habitats, as well as provide for firefighter and public safety. Minimum environmental suppression tactics shall be used, commensurate with forecasted and threatened resource values. Unless there are immediate threats to life and/or property, you must receive approval from the Resource Advisor to use heavy equipment (dozers, tractors, etc.).

You are to be guided by the Wildland Fire Situation Analysis, approved by _____, Project Leader.

The Resource Advisor assigned to your incident will be _____.

_____ _____

G. Mendel Stewart, Project Leader — Date
San Francisco Bay National Wildlife Refuge Complex

WILDLAND FIRE

SITUATION ANALYSIS

Incident Name: _____

Jurisdiction: _____

Date and Time Completed: _____

I. WILDLAND FIRE SITUATION ANALYSIS

A. Jurisdiction(s)	**B. Geographic Area**
C. Unit(s)	**D. WSFA #**
E. Fire Name	**F. Incident #**

G. Accounting Code: _____

H. Date/Time Prepared: _____ @ _____

I. Attachments: _____

Complexity Matrix/Analysis * _____

Risk Assessment/Analysis * _____

Probability of Success * _____

Consequences of Failure * _____

Maps * _____

Decision Tree ** _____

Fire Behavior Projections * _____

Calculations of Resource Requirements * _____

Other (specify) _____

* Required

** Required by FWS

This page is completed by the Agency Administrator(s)

II. OBJECTIVES AND CONSTRAINTS

A. Objectives (must be specific and measurable)

1. Safety

   - Public

   - Firefighter

2. Economic

3. Environmental

4. Social

5. Other

B. Constraints

This page is completed by the Agency Administrator(s)

III.	ALTERNATIVES		
	A	**B**	**C**
A. Wildland Fire Strategy			
B. Narrative			
C. Resources Needed Handcrews Engines Dozers Airtankers Helicopters	 _____ _____ _____ _____ _____	 _____ _____ _____ _____ _____	 _____ _____ _____ _____ _____
D. Final Size			
E. Estimated Contain/ Control Date			
F. Costs			
G. Risk Assessment Probability of Success Consequences of Failure	 _____ _____	 _____ _____	 _____ _____
H. Complexity			
I.	**Attach maps for each alternative**		

This page is completed by the Agency Administrator(s) and FMO/Incident Commander

IV. EVALUATION OF ALTERNATIVES			
A. Evaluation Process	**A**	**B**	**C**
Safety			
Firefighter	_____	_____	_____
Aviation	_____	_____	_____
Public	_____	_____	_____
Sum of Safety Values			
Economic			
Forage	_____	_____	_____
Improvements	_____	_____	_____
Recreation	_____	_____	_____
Timber	_____	_____	_____
Water	_____	_____	_____
Wilderness	_____	_____	_____
Wildlife	_____	_____	_____
Other (specify)	_____	_____	_____
Sum of Economic Values			
Environmental			
Air	_____	_____	_____
Visual	_____	_____	_____
Fuels	_____	_____	_____
T & E Species	_____	_____	_____
Other (specify)	_____	_____	_____
Sum of Environmental Values			
Social			
Employment	_____	_____	_____
Public Concern	_____	_____	_____
Cultural	_____	_____	_____
Other (specify)	_____	_____	_____
Sum of Social Values			
Other			
This page is completed by the Agency Administrator(s) and FMO/Incident Commander			

V. ANALYSIS SUMMARY

Alternatives	A	B	C
A. Compliance with Objectives			
Safety			
Economic			
Environmental			
Social			
Other (specify)			
B. Pertinent Data			
Final Fire Size			
Complexity			
Suppression Cost			
Resource Values			
Probability of Success			
Consequences of Failure			

C. External/Internal Influences

National & Geographic Preparedness Level: _____

Incident Priority: _____

Resource Availability: _____

Weather Forecast (long range): _____

Fire Behavior Projections: _____

This page is completed by the Agency Administrator(s) and FMO/Incident Commander

VI. DECISION

The Selected Alternative is: _____

Rationale: _____

_____ _____

Agency Administrator's Signature **Date/Time**

This page is completed by the Agency Administrator(s) or designate

VII. DAILY REVIEW

To be reviewed daily to determine if still valid until containment or control

Date	Time	By	PREPAREDNESS LEVEL	INCIDENT PRIORITY	RESOURCE AVAILABILITY	WEATHER FORECAST	FIRE BEHAVIOR PROJECTIONS	WFSA VALID

IF WFSA IS NO LONGER VALID, A NEW WFSA WILL BE COMPLETED!

This page is completed by the Agency Administrator(s) or designate

VIII.	FINAL REVIEW	
The elements of the selected alternative were met on:	_____ Date	_____ Time
By: _____ Agency Administrator(s)		

INSTRUCTIONS

Section I. WFSA Information Page

A. Jurisdiction(s): Assign the agency or agencies that have or could have fire protection responsibility, e.g., USFWS, BLM, etc.

B. Geographic Area: Assign the recognized "Geographic Coordination Area" the fire is located in, e.g., Northwest, Northern Rockies, etc.

C. Unit(s): Designate the local administrative unit(s), e.g., Hart Mountain Refuge Area, Flathead Indian Reservation, etc.

D. WFSA #: Identify the number assigned to the most recent WFSA for this fire.

E. Fire Name: Self-explanatory.

F. Incident #: Identify the incident number assigned to the fire.

G. Accounting Code: Insert the local unit's accounting code.

H. Date/Time Prepared: Self-explanatory.

I. Attachments: Check here to designate items used to complete the WFSA. "Other could include data or models used in the development of the WFSA. Briefly describe the "other" items used.

Section II. Objectives and Constraints

A. Objectives: Specify objectives that must be considered in the development of alternatives. Safety objectives for firefighter, aviation, and public must receive the highest priority. Suppression objectives must relate to resource management objectives in the unit resource management plan.

Economic objectives could include closure of all or portions of an area, thus impacting the public, or impacts to transportation, communication, and resource values.

Environmental objectives could include management objectives for airshed, water quality, wildlife, etc.

Social objectives could include any local attitudes toward fire or smoke that might affect decisions on the fire.

Other objectives might include legal or administrative constraints which would have to be considered in the analysis of the fire situation, such as the need to keep the fire off other agency lands, etc.

B. Constraints: List constraints on wildland fire action. These could include constraints to designated wilderness, wilderness study areas, environmentally or culturally sensitive areas, irreparable damage to resources or smoke management/air quality concerns. Economic constraints, such as public and agency cost, could be considered here.

Section III. Alternatives

A. Wildland Fire Management Strategy: Briefly describe the general wildland fire strategies for each alternative. Alternatives must meet resource management plan objectives.

B. Narrative: Briefly describe each alternative with geographic names, locations, etc., that would be used when implementing a wildland fire strategy. For example: "Contain within the Starvation Meadows' watershed by the first burning period."

C. Resources Needed: Resources described must be reasonable to accomplish the tasks described in Section III.B. It is critical to also look at the reality of the availability of these needed resources.

D. Final Fire Size: Estimated final fire size for each alternative at time of containment.

E. Estimated Contain/Control Date: Estimates of each alternative shall be made based on predicted weather, fire behavior, resource availability, and the effects of suppression efforts.

F. Cost: Estimate all incident costs for each alternative. Consider mop-up, rehabilitation, and other costs as necessary.

G. Risk Assessment - Probability of Success/Consequences of Failure: Describe probability as a percentage and list associated consequences for success and failure. Develop this information from models, practical experience, or other acceptable means. Consequences described will include fire size, days to contain, days to control, costs, and other information such as park closures and effect on critical habitat. Include fire behavior and long-term fire weather forecasts to derive this information.

H. Complexity: Assign the complexity rating calculated in "Fire Complexity Analysis" for each alternative, e.g., Type II, Type I.

I. A map for each alternative should be prepared. The map will be based on the "Probability of Success/Consequences of Failure" and include other relative information.

Section IV. Evaluation of Alternatives

A. Evaluation Process: Conduct an analysis for each element of each objective and each alternative. Objectives shall match those identified in Section II.A. Use the best estimates available and quantify whenever possible. Provide ratings for each alternative and corresponding objective element. Fire effects may be negative, cause no change, or may be positive. Examples are: 1) a system which employs a "-" for negative effect, a "0" for no change, and a "+" for positive effect; 2) a system which uses a numeric factor for importance of the consideration (soils, watershed, political, etc.) and assigns values (such as -1 to +1, - 100 to +100, etc.) to each consideration, then arrives at a weighted average. If you have the ability to estimate dollar amounts for natural resource and cultural values, this data is preferred. Use those methods which are most useful to managers and most appropriate for the situation and agency. To be able to evaluate positive fire effects, the area must be included in the resource management plan and consistent with prescriptions and objectives of the Fire Management Plan.

   Sum of Economic Values: Calculate for each element the net effect of the rating system used for each alternative. This could include the balance of pluses (+) and minuses (-), numerical rating (-3 and +3), or natural and cultural resource values in dollar amounts. (Again, resource benefits may be used as part of the analysis process when the wildland fire is within a prescription consistent with approved Fire Management Plans and in support of the unit's Resource Management Plan.)

Section V. Analysis Summary

A. Compliance with Objectives: Prepare narratives that summarize each alternative's effectiveness in meeting each objective. Alternatives that do not comply with objectives are not acceptable. Narrative could be based on effectiveness and efficiency. For example: "most effective and least efficient," "least effective and most efficient," or "effective and efficient." Or answers could be based on a two-tiered rating system such as "complies with objective" and "fully complies with or exceeds objective." Use a system that best fits the manager's needs.

B. Pertinent Data: Data for this Section has already been presented, and is duplicated here to help the Agency Administrator(s) confirm their selection of an alternative. Final Fire Size is displayed in Section III.D. Complexity is calculated in the attachments and displayed in Section III.H. Costs are displayed on page 4. Probability of Success/Consequences of Failure is calculated in the attachments and displayed in Section III.G.

C. External and Internal Influences: Assign information and data occurring at the time the WFSA is signed. Identify the Preparedness Index (1 through 5) for the National and Geographic levels. If available, indicate the Incident Priority assigned by the MAC Group. Designate the Resource Availability status. This information is available at the Geographic Coordination Center, and is needed to select a viable alternative. Designate "yes," indicating an up-to-date weather forecast has been provided to, and used by, the Agency Administrator(s) to evaluate each alternative. Assign information to the "Other" category as needed by the Agency Administrator(s).

Section IV. Decision

Identify the alternative selected. Must have clear and concise rationale for the decision, and a signature with date and time. Agency Administrator(s) is mandatory.

Section VII. Daily Review

The date, time, and signature of reviewing officials are reported in each column for each day of the incident. The status of Preparedness Level, Incident Priority, Resource Availability, Weather Forecast, and WFSA validity is completed for each day reviewed. Ratings for the Preparedness Level, Incident Priority, Resource Availability, Fire Behavior, and Weather Forecast are addressed in Section V.C. Assign a “yes” under "WFSA Valid" to continue use of this WFSA. A "no" indicates this WFSA is no longer valid and another WFSA must be prepared or the original revised.

Section VIII. Final Review

This Section is completed by the Agency Administrator(s). A signature, date, and time are provided once all conditions of the WFSA are met.

A GUIDE FOR ASSESSING FIRE COMPLEXITY

The following questions are presented as a guide to assist the Agency Administrator(s) and staff in analyzing the complexity or predicted complexity of a wildland fire situation. Because of the time required to assemble or move an Incident Management Team to wildland fire, this checklist should be completed when a wildland fire escapes initial attack and be kept as a part of the fire records. This document is prepared concurrently with the preparation of (and attached to) a new or revised Wildland Fire Situation Analysis. It must be emphasized this analysis should, where possible, be based on predictions to allow adequate time for assembling and transporting the ordered resources.

Use of the Guide:

1. Analyze each element and check the response "yes" or "no."

2. If positive responses exceed, or are equal to, negative responses within any primary factor (A through G), the primary factor should be considered as a positive response.

3. If any three of the primary factors (A through G) are positive responses, this indicates the fire situation is, or is predicted to be, Type I.

4. Factor H should be considered after all the above steps. If more than two of these items are answered "yes," and three or more of the other primary factors are positive responses, a Type I team should be considered. If the composites of H are negative, and there are fewer than three positive responses in the primary factors (A-G), a Type II team should be considered. If the answers to all questions in H are negative, it may be advisable to allow the existing overhead to continue action on the fire.

GLOSSARY OF TERMS

Potential for blow-up conditions - Any combination of fuels, weather, and topography excessively endangering personnel.

Rate or endangered species - Threat to habitat of such species or, in the case of flora, threat to the species itself.

Smoke management - Any situation which creates a significant public response, such as smoke in a metropolitan area or visual pollution in high-use scenic areas.

Extended exposure to unusually hazardous line conditions - Extended burnout or backfire situations, rock slide, cliffs, extremely steep terrain, abnormal fuel situation such as frost killed foliage, etc.

Disputed fire management responsibility - Any wildland fire where responsibility for management is not agreed upon due to lack of agreements or different interpretations, etc.

Disputed fire policy - Differing fire policies between suppression agencies when the fire involves multiple ownership is an example.

Pre-existing controversies - These may or may not be fire management related. Any controversy drawing public attention to an area may present unusual problems to the fire overhead and local management.

Have overhead overextended themselves mentally or physically - This is a critical item that requires judgment by the responsible agency. It is difficult to write guidelines for this judgment because of the wide differences between individuals. If, however, the Agency Administrator feels the existing overhead cannot continue to function efficiently and take safe and aggressive action due to mental or physical reasons, assistance is mandatory.

FIRE COMPLEXITY ANALYSIS

A. FIRE BEHAVIOR: Observed or Predicted **YES/NO**

1. Burning Index (from on-site measurement of weather conditions) predicted to be above the 90% level using the major fuel model in which the fire is burning. _____
2. Potential exists for "blowup" conditions (fuel moisture, winds, etc.). _____
3. Crowning, profuse or long-range spotting. _____
4. Weather forecast indicating no significant relief or worsening conditions. _____

Total _____

B. RESOURCES COMMITTED

1. 200 or more personnel assigned. _____
2. Three or more divisions. _____
3. Wide variety of special support personnel. _____
4. Substantial air operation which is not properly staffed. _____
5. Majority of initial attack resources committed. _____

Total _____

C. RESOURCES THREATENED

1. Urban interface. _____
2. Developments and facilities. _____
3. Restricted, threatened, or endangered species habitat. _____
4. Cultural Sites. _____
5. Unique natural resources, special designation zones, or wilderness. _____
6. Other special resources. _____

Total _____

D. SAFETY **YES/NO**

1. Unusually hazardous fire line conditions. _____
2. Serious accidents or fatalities. _____
3. Threat to safety of visitors from fire and related operations. _____
4. Restricted and/or closures in effect or being considered. _____
5. No night operations in place for safety reasons. _____

Total _____

E. OWNERSHIP

1. Fire burning or threatening more than one jurisdiction. _____
2. Potential for claims (damages). _____
3. Conflicting management objectives. _____
4. Disputes over fire management responsibility. _____
5. Potential for unified command. _____

Total _____

F. EXTERNAL INFLUENCES

1. Controversial wildland fire management policy. _____
2. Pre-existing controversies/relationships. _____
3. Sensitive media relationships. _____
4. Smoke management problems. _____
5. Sensitive political interests. _____
6. Other external influences. _____

Total _____

G. CHANGE **YES/NO**

1. Change in strategy to confine/contain to control. _____
2. Large amount of unburned fuel within planned perimeter. _____
3. WFSA invalid or requires updating. _____

Total _____

H. EXISTING OVERHEAD

Worked two operational periods without achieving initial objectives. _____

Existing management organization ineffective. _____

IMT overextended themselves mentally and/or physically. _____

Incident action plans, briefings, etc. missing or poorly prepared. _____

Total _____

I. SIGNATURE

_____ _____

Name and Title **Date and Time**

Appendix K: Marin Islands NWR and SER Vegetation Management Plan

Peter R. Baye, Ph.D.
Coastal Plant Ecologist
33660 Annapolis Road
baye@earthlink.net Annapolis CA 95412 (415) 310-5109

Marin Islands National Wildlife Refuge and State Ecological Reserve Vegetation Management Plan

Prepared by:

Peter R. Baye, Ph.D.
Coastal Plant Ecologist

Prepared for:

San Pablo Bay National Wildlife Refuge
U.S. Fish and Wildlife Service
Mare Island, Vallejo, CA 95492

January 2005

ACKNOWLEDGEMENTS

Jake Schweitzer, (MSc., University of California, Berkeley) GIS specialist, provided all GPS field work and produced GIS maps for this plan, through Wetlands and Water Resources, San Rafael, CA (www.swampthing.org). Jake's tenacity, professionalism, and extreme patience with difficult field conditions (including many repeat visits to East Marin Island, and repeat bee stings!) and technical GPS and GIS challenges are important contributions to this report.

Giselle Downard, San Pablo Bay National Wildlife Refuge biologist, provided deep and rich background history of the island from both documentary sources (notably the unpublished Kroll master's thesis), and her own oral history work with Connie Peabody, the previous landowner. Giselle facilitated the development of this report by carefully reviewing and integrating all past studies of the island, and providing them in support of the vegetation management plan. She also provided much-valued supervision of safety for island visits in unpredictable weather.

Doreen Smith, California Native Plant Society (Marin Chapter) provided an exceedingly valuable (and, as always, perspicacious and accurate) floristic study of the island that greatly facilitated the 2004 surveys and assessments of the island's flora.

1.0 INTRODUCTION

Purpose and Scope of the Vegetation Management Plan

The Marin Islands were added to the San Francisco Bay National Wildlife Refuge Complex to protect nesting waterbirds, increase native habitat for nesting and roosting birds, and to protect surrounding tidal mudflats and shallows from wildlife disturbance due to boaters and windsurfers (U.S. Fish and Wildlife Service 2002). Marin Islands are generally closed to public use, except for authorized stewardship activities, research, and monitoring. Most of East Marin Island's woody vegetation is dominated by planted non-native trees and shrubs that continue to spread over the native vegetation of the island. East Marin Island also supports significant stands of native vegetation that are either remnant from original pre-military settlement conditions, or regenerated in recent historic time. West Marin Island's native buckeye and coast live oak stands have provided a major egret and heron rookery in San Francisco Bay for many years. East Marin Island has the potential to support additional similar native woodland, coastal scrub, and grassland vegetation and habitats. Realization of its native vegetation and habitat potential will require substantial reduction of its non-native tree cover, removal of noxious non-native weeds, and management of remant native vegetation stands to limit impacts of naturalized non-native weeds.

This vegetation management plan describes and analyzes the nature and regional context of East Marin Islands native and non-native flora and vegetation, to provide scientifically sound prescriptions for management and restoration of native vegetation within the constraints if the island's land-use history and current setting. The vegetation management plan evaluates site-specific opportunities and constraints for controlling invasive dominant weeds from the ground layer to the tree canopy, commensurate with the level of threat they pose to regeneration of native plants. It also includes site-specific recommendations for recovering degraded native plant populations and communities, and protecting them from further threats.

2.0 BACKGROUND

2.1. Local Vegetation, Substrate, and Microclimate

Marin Islands are located within San Rafael Bay, an embayment of northeastern San Francisco Bay (Figure 1). They are partially submerged hilltops isolated from the main Marin bayshore by the late Holocene rise in sea level (Atwater *et al.* 1979). The islands are composed of fine-grained fractured graywacke (slightly metamorphosed sandstones), including erosion-resistant bedrock outcrops and relatively weak, decomposed regolith and soils. The soils on Marin Islands belong to the Tocaloma-McMullin complex, which generally include gravelly loams, loams, and inclusions of Saurin clay loams, derived from weathering of graywacke and slope processes (U.S.D.A. 1979). The East Marin Island soils have been modified by historic and prehistoric human activities. A large portion of the island plateau includes an anomalous light-textured loam with high content of fine shell fragments, probably remnants of an extensive midden deposit (Kroll 1991). Naturally weathered and organic-stained mature soil profiles occur beneath the mature oak woodlands

along the north slopes, but large sections have been terraced and planted with ornamental and edible landscaping.

The slopes on Marin Islands are variable, ranging from very steep (over 50% slopes) on the bluffs, cliffs, and landslides, to relatively gentle slopes of the south-facing East Marin Islands plateau. Most of the island edges consist of wave-cut scarps and slope failures in weak, fractured graywacke substrates, but segments of hard, resistant bedrock with near-vertical faces also occur (Figure 2) . Deepest soils are associated with landslide deposits. Landslides are common along the wave-exposed south-facing shorelines, but small slips also occur on the north shores. East Marin Island is 4.2 ha (10.28 acres) in area and has a gently sloping plateau; West Marin Island is 1.1 ha (2.80 acres) in area (U.S. Fish and Wildlife Service 2002), and has relatively more steep topography associated with landslides above scarps .

The Marin Islands are partially sheltered from marine air inflows from the Golden Gate by the Tiburon peninsula, and they are partially isolated from northerly airflow from interior valleys and the Novato bayshore by the topographic barrier of the San Rafael Hills. The microclimate of Marin Islands is intermediate between the strong marine influence at Alcatraz and Angel Islands, and the relatively fog-sheltered northeast-facing shores of China Camp, where arid, warm interior valley microclimates prevail during much of the year. Wave fetch at Marin Islands is greatest to the southeast, and the dominant wave approach is from the south and east, as indicated by the orientation of the small gravel spits at the west ends of both Marin Islands.

The principal native vegetation types of East Marin Island are stands of mature coast live oak woodland with California buckeye, understory shrubs and vines of the oak-buckeye woodland, coastal scrub dominated by California sage, coastal sea-bluff scrub/forb associations, and coastal grassland/forb associations. All of these native vegetation types are heavily invaded or locally dominated by naturalized non-native shrubs and grasses that have spread from past cultivation.

The distribution and structure of the oak-buckeye woodlands are affected by patterns of exposure and shelter to bay winds, old windbreak tree plantings on East Marin Island, and bird nesting. Coastal sage scrub is prevalent on coarse-textured unstable soils of south-facing scarps and landslide slopes exposed to southwest winds and full sun. Sea-bluff scrub/forb vegetation is similarly exposed, but occurs mostly on fractured bedrock (graywacke) with no soil development. Woodland and scrub occur mostly on gently sloping or moist north-aspect slopes, sheltered from drying winds and full sun; native trees are infrequent and relatively dwarfed on exposed southern or southwest slopes. Grasslands of variable composition (bulbs, perennial bunchgrasses and sod-forming grasses, forbs, and annual grasses), occur on the sloping terraces beneath horticultural tree plantings.

The native vegetation of Marin Islands contrasts with corresponding mainland vegetation types in several respects. The dominant mixed evergreen forest types of the San Rafael Hills and China Camp support abundant or subdominant madrone (*Arbutus menziesii*) and bay laurel (*Umbellularia californica*); these trees are scarce, small in stature, and comparatively young on East Marin Island, and apparently absent (or negligible components) on West Marin Island. Deciduous oaks of arid, gravelly soils are abundant in the mainland mixed

evergreen/oak forest and woodland, but the only oak on Marin Islands is the more mesic coast live oak (*Quercus agrifolia*), a species that is abundant to dominant at the more maritime Angel Island. Other maritime bluff plants, such as lizard-tail (*Eriophyllum stoechadifolium*) and coast buckwheat (*Eriogonum latifolium*) are either infrequent and local at Marin Islands, or are replaced by related species typical of more inland climates (*Eriogonum nudum*). Riparian vegetation elements associated with seeps, springs, or ephemeral above-ground streams, are absent on Marin Islands.

2.2 West Marin Island vegetation and flora.

Ornduff and Vasey (1995) described the woodland of West Marin Island as "depauperate", with low, spreading buckeyes dominant, and dwarfed occasional coast live oak. Coastal sage scrub dominates the south-facing slopes, and woodland shrub vegetation dominates north slopes, especially poison-oak (*Toxicondendron diversilobum*). Historically, the human-unoccupied island's trees have supported a major heron and egret rookery, which altered vegetation by selecting for nitrophilous annual non-native grasses under nests, and weakening nest trees (Ornduff and Vasey 1995.). Several plant species present on East Marin Island in the early 1990s were found to be absent on West Marin Island (e.g. *Symphoricarpos albus, Lonicera hispidula*), while some were either unique to West Marin Island, or rare on East Marin Island (*Scrophularia californica, Lathyrus vestitus, Clarkia rubicunda*). Because West Marin Island has no history of human occupation, and has relatively minimal modification of its vegetation by human influence, it is not subject to rigorous evaluation and planning for vegetation management.

2.3 East Marin Island: vegetation and flora

2.3.1. Native Flora of East Marin Island

Regional context of the local flora. The local native terrestrial flora of East Marin Island is a small subsample of the regional bayshore Marin flora, isolated by the late Holocene sea level maximum, approximately 3000 yr B.P. (Atwater *et al.* 1979). It comprises limited sample of mostly common, widespread species of the flora found along northeastern San Francisco Bay. The species composition is typical of coastal grassland, scrub, and elements of mixed evergreen forest, primarily coast live oak woodland (Ornduff and Vasey 1995). The current estimated size of the native flora of Marin Islands is approximately 95 species, with some uncertainty due to taxonomic and identification questions (Table 1; see also Section 2.3.3, below). By comparison, the native flora of Marin County as a whole, including highly varied coastal and interior climates, soils, plant community types, etc. is estimated to contain just over 1000 species (Howell 1970). The small size and limited habitat range of East Marin Islands represents a high inherent long-term risk of local extinction for its smaller plant populations. The isolation of Marin Islands within a transition zone between marine fog and interior bay microclimates, partially sheltered from regular incursions of marine airflow within San Rafael Bay, increases the probability of retaining both interior and maritime elements of the regional flora.

Limited historic floristic data. There are no available direct older historic data on the flora of Marin Islands. Howell (1970) reported no Marin Islands localities, but cited general localities

for his flora of the county, based on his extensive field work in Marin County during the 1930s and 1940s. No Marin Island localities were found in the University of California/Jepson Herbarium electronic database, based on a test sample of widespread and uncommon plant species at Marin Islands. Some of Howell's (1979) standard generalized localities include Angel Island, Tiburon, San Rafael, and the San Rafael Hills. These provide points of comparison with Marin Islands, aligned along the bay gradient of between the marine climate of the Golden Gate and the topographic barrier to marine air inflows from San Rafael Hills to McNears Point.

Comparison with proximate mainland and island flora. I conducted a qualitative floristic "gap analysis" of the Marin Islands flora based on a comprehensive review of historic localities reported by Howell (1949) for all species in the Marin Flora. The purpose of this floristic assessment is to examine the unevenness of Marin Island's representation of the regional flora for the range of habitats and communities present. This assessment does not include empirical species-area relationships for the plant communities, because of a lack of available regional data. By identifying idiosyncratic patterns of variation in local plant communities on Marin Islands, this preliminary floristic comparison may provide preliminary objective guidance for species reintroduction policy in the absence of direct historic records of native flora. Using Howell's (1970) habitat/plant community descriptions fitting Marin Islands (grassland ["prairie"] coastal scrub ["brush"], coastal bluff, shaded oak woodland, etc.) and distribution (species described as common or widespread) criteria, I compiled a list of species with multiple historic localities reported by Howell (1970) along the Angel Island-San Rafael Hills axis. Species meeting criteria for wide distribution and high relative abundance (described as common, widespread, or abundant within habitats) occurring in at least two near-maritime bay localities (Angel Island, Tiburon) and at least two northern/interior bay localities (San Rafael, San Rafael Hills, north to Black Point) were ranked as "expected" for Marin Islands, based on this subjective threshold for ranked probability of occurrence.

The results of this qualitative floristic "gap analysis" screening and ranking of common/widespread elements of the regional flora (Table 3) did predict the majority of the native Marin Island flora recorded by Ornduff and Vasey (1985). It also indicated a number of less common species that are present, and expected widespread species not represented ("gap" species). The chief limitation of this qualitative approach is that most of the geographic localities cited by Howell support more diverse topography, moisture gradients, and soils for a given habitat type than Marin Islands, so botanical judgment must be applied carefully in assessment of "suitable habitat". This exercise also does not account for species-area relationships and the size of the island; no species-area curve data are available for mainland reference sites to compare with Marin Islands. Another source of distortion in comparisons between comparison of mainland and island floras is the variation within species (e.g. intergrades among species, ecotypes or hybrid zones) that may occur in different parts of Marin County (Howell 1970; see also section 2.2.3 below): many of the taxa observed on the island appear to be intermediate in characters between related inland and coastal species or subspecies. To supplement this qualitative approach to floristic gap analysis, recent field surveys from relatively intact vegetation at Angel Island and the China Camp shoreline were also used to identify additional widespread species that may be expected at Marin Islands; these are not cited in Table 3, but are discussed below.

Many observed Marin Islands species, such as *Clarkia rubicunda, Stephanomeria* sp. and *Phacelia distans* (Ornduff and Vasey 1985) and *Erigeron foliosus, Piperia* sp. and *Pellaea andromedifolia* (Smith 2003) were not predicted in by the qualitative floristic analysis, either because they were not described as common and widespread, or did not occur at both Angel Island/Tiburon and San Rafael Hills/China Camp vicinity localities. One of the more significant anomalies in the local Marin Islands flora include the relative scarcity and youth of madrone (*Arbutus menziesii*; Figure 3) and California bay (*Umbellularia californica*), despite their presence (Ornduff and Vasey 1985, Smith 2003). California bay in particular is abundant throughout the woodlands of southeastern Marin County. Other expected widespread species that are apparently absent in suitable or typical habitat of Marin Islands include: *Carex tumulicola, Fragaria virginica, Marah fabaceus, Phacelia californica, Pteridium aquilinum, and Pterostegia drymarioides*.

2.3.2. Trends in native species richness of East Marin Island

1990s surveys. Ornduff and Vasey (1995) visited East Marin Islands on four dates, Oct. 1991, 23 January 1992, March 16, and 2 June 1993. Most of these visits were at the end of a period of harsh conditions for survival and growth of native plants, due to 6 years of sheep grazing combined with several years of drought. The island's vegetation was apparently carefully weeded and landscaped in the decades before the 1990's, with park-like conditions of weeded and trimmed vegetation (photos in Kroll 1991; Giselle Downard, pers. comm. from Constance Peabody, previous landowner). The cumulative surveys of Ornduff and Vasey, even after one growing season of non-drought conditions, revealed a small native flora of 65 species for Marin Islands, with two species restricted to West Marin Island, and 37 restricted to East Marin Island. They reported a non-native flora surveyed by Elizabeth McClintock consisting of 49 species. J. Powell (1995) observed about 40 native species during his 1989 visits, and observed a lack of coyote brush, a very common and sometimes short-lived shrub of coastal scrub. Barbary sheep were introduced to East Marin Island in 1985 for vegetation reduction, and were maintained as a flock of 16 by removal of lambs until summer 1991, where sheep were removed (Lidicker and Lidicker 1992, Ornduff and Vasey 1995). Abundant sign of sheep and "park-like" vegetation physiognomy (widespread low, turf-like ground layer with low biomass, and reduced shrub layer) were still evident in 1991 (Kroll 1991, Lidicker and Lidicker 1992). No surveys of the islands vegetation are available from the late 1990s.

The coincidence of drought and heavy grazing by sheep on East Marin Island probably caused a severe reduction in abundance and seed reproduction of native graminoids, herbs, subshrubs, lianas, and low-growing shrubs. Drought and overgrazing may have caused extirpation of small populations of plants dependent on adult survival and short-lived seed banks for regeneration. Alternatively, combined drought and grazing may have temporarily reduced some species to persistent seed banks or depauperate bud banks that were able to regenerate after physiologic stress and grazing disturbance were eliminated in the mid-1990s. Perennial stress-tolerant species, such as bulbs and corms, and species with persistent seed banks, may have survived this stressful period relatively better than small populations of relict, stress-intolerant species. It is unknown whether actual species extinctions occurred immediately prior to acquisition by the Refuge.

2003 Spring Survey. Doreen Smith of the California Native Plant Society, Marin Chapter, prepared a plant survey of East Marin Island. Smith and Wilma Follette (Marin CNPS) surveyed on one mid-spring date (May 16, 2003), confirming nearly all of Ornduff and Vasey's (1995) native species (Smith 2003). Smith potentially added over 30 native vascular plant taxa to the flora of East Marin Island, a remarkable and floristically significant increase in species richness, even as many as five to eight of these are duplications with different identification. Some taxonomic differences between the two species lists are likely due to differences in identification rather than actual species turnover (Table 1). Among Smith's reported additions to the native flora of East Marin Island were the perennial forbs *Erigeron foliosus* var. *franciscensis* (Franciscan leafy daisy, regionally rare), *Eriophyllum confertiflorum* (golden-yarrow), *Wyethia angustifolia* (mule-ears), *Monardella villosa* var. *villosa* (coyote-mint), *Potentilla glandulosa* ssp. *glandulosa* (sticky cinquefoil), and *Sisyrinchium bellum* (blue-eyed grass); annual herbs *Lotus humistratus, L. micranthus, L. wrangelianus* (Lotus species), and *Plantago erecta* (dwarf plaintain); graminoid species *Carex globosa* (round-fruited sedge), *Bromus carinatus* (California brome), *Melica californica* (California melic-grass), an undetermined *Agrostis* species (a perennial rhizomatous bentgrass in dry soil, identified in this report as the native *A. pallens* [intermediate with *A. hallii*] Figure 4); spring-flowering bulbs *Brodiaea elegans* (harvest Brodiaea, locally abundant on south-facing bluffs), *Tritelia laxa* (Ithuriel's spear, a dominant component of East Marin Island's north-sloping grasslands; Figure 5) and *T. pedunculata* (long-rayed Tritelia;), one shrub, *Rubus ursinus* (California blackberry); one tree, *Arbutus menziesii* (madrone; Figure 3); and an orchid, *Piperia* sp. (rein-orchis, identified in this report as the rare *P. michaelii*; Figure 6).

It is highly unlikely that the majority of the conspicuous taxa added to the flora of East Marin Island by Smith were evident or present during the four Ornduff and Vasey (1995) survey dates between 1991-1993, including one May survey date similar to Smith's. In contrast, the 2001 survey failed to detect some species reported by Ornduff and Vasey in 1991. Among the "missing" taxa detected by Ornduff and Vasey, but *not* Smith, include *Artemisia douglasiana*, *Brodiaea californica, Carex barbarae, Lomatium utriculatum, Luzula comosa, Lupinus nanus*, and *Viola pedunculata*. Of these vegetative *C. barbarae* persists today in abundance at the upper edge of the north shore oak woodland, but without diagnostic flowering parts for identification. Another 2001 "missing" taxon was an undetermined *Amsinckia* species on East Marin Island, possibly *A. menziesii* var. *intermedia*, reported by Howell (1949) from coastal scrub in Tiburon and the San Rafael Hills. Populations of large-seeded annual forbs in this genus are prone to local extirpation, depending on disturbances and vegetation gaps. *Amsinckia* forms persistent seed banks, so its population may be possibly quiescent rather than irreversibly extirpated at East Marin Island. This conspicuous species was not detected in spring 2004, but it may persist in seed banks, and emerge in future years.

In other cases, it is possible that some 2003 species additions that are similar congeners of 1991-1993 survey species may represent differences in identification of marginal specimens (non-flowering, depauperate, drought-damaged or grazed), rather than actual species replacements. These include *Brodiaea californica/B. elegans, Lupinus nanus/L. succulentus*, and *Dudleya cymosa/D. farinosa.*

The remaining "missing" taxa from Orduff and Vasey's 1991-1993 surveys should be the object of focused searches and diagnostic identification in future plant surveys, to determine whether they are extirpated, underdetected, or misidentified. The potential discrepancies between some similar congeners reported by different observers in different decades, using the same standard reference flora, indicates the *need to conserve readily available vouchers* (permanent herbarium collection sheets) for Marin Islands, and arguably for other Refuge units in the region with which they may be compared.

Some widespread species with low probability of long-distance dispersal (e.g. less common source populations on the mainland, no specialized dispersal syndrome) may have emerged from local persistent soil seed banks, or dormant buds or bulbs of long-lived perennials. The apparent CNPS survey additions to the Marin Islands flora, on the whole, are probably indicators of reversal of the late 1980s-early 1990s conditions of grazing and drought, re-emerging during years of grazing exclusion and above-average rainfall in the late 1990s. In some cases, plants with inconspicuous vegetative parts that were weakened and unable to flower in the early 1990s may have escaped detection in earlier surveys.

2004 Surveys. I visited East Marin Island for a reconnaissance survey on 12 November 2003, and for general floristic and vegetation surveys on 24 February, 17 March, 6 May, 1 June, and 17 June, with supplemental visits on 15 July and 5 August 2004. I was unable to locate some taxa previously reported from East Marin Island: *Erigeron foliosus* var. *franciscensis*, *Gnaphalium californica*, *Melica californica, Stephanomeria elata, Sisyrinchium bellum, Viola pedunculata,* and *Wyethia angustifolia.* The *Stephanomeria* site was not resurveyed in the appropriate flowering season because of the presence of active gull nests.

Taxa first reported by Smith (2003) that were confirmed in 2004 surveys include *Arbutus menziesii*, *Aster chilensis*, *Atriplex triangularis*, *Eriophyllum confertiflorum* (Figure 7), *Monardella villosa* var. *villosa, Perideridia kelloggii, Potentilla glandulosa* ssp. *glandulosa*; annual native herbs *Lotus* species), and *Plantago erecta*, *Solidago californica*, ; graminoid species *Carex globosa,* (round-fruited sedge), *Bromus carinatus,* (California brome), and *Elymus glaucus* (in abundance); abundant spring-flowering bulbs *Brodiaea elegans* (harvest Brodiaea, locally abundant on south-facing bluffs), *Tritelia laxa* (Ithuriel's spear, a dominant component of East Marin Island's north-sloping grasslands). The *Piperia* sp. recorded by Smith in May was observed as a large colony in flower by late summer 2004 visits, and was identified as the regionally rare *P. michaelii* (Figure 6). The undetermined *Agrostis* species reported by Ornduff and Vasey and Smith was also observed in flower and fruit, and appears to correspond with Howell's "*A. diegoensis*", now placed in synonymy with the *A. pallens,* though intermediate in key characters with *A. hallii,* and perhaps should be referred to the latter species. *Rubus ursinus* was found to be very common. There appear to be at least two undetermined *Iris* taxa on the island. The *Iris* sp. of Orduff and Vasey appears to be a small, non-flowering colony of *Iris macrosiphon*, based on foliar characters and clonal morphology. The other is a garden hybrid of *Iris germanica.*

2004 surveys added eight vascular plant species to the flora of East Marin Island: six invasive non-natives, and two native. Several are noteworthy, but others are common and likely recent incidental immigrants.

A single clump of the invasive non-native *Spartina densiflora* (Chilean cordgrass; Figure 8) was found on the cobble foreshore and *Cressa* "marsh" of the southwest shore (Figure 9). It probably arrived from Corte Madera, the core San Francisco Bay population. *S. densiflora* was removed immediately after discovery, and so has only ephemeral status in the island's flora. Another non-native salt marsh/shoreline weed, *Salsola soda* (Mediterranean saltwort), an annual succulent forb, was found to be locally abundant in drift-lines of the south shore. It is a minor addition to the local flora, and is now widespread regionally. The noxious coastal terrestrial grass, *Ehrharta erecta* (Poaceae) was detected at numerous locations along the north shore oak woodland and French broom understory. It is easily mistaken for *Melica torreyana* in vegetative state. *Cortaderia jubata* (jubata or "pampas" grass; misnomer) occurs on a stabilized landslide slope on the central north shore, and is visible mainly by boat. No seedlings have been detected elsewhere on the island, but typical apomictic (asexual) seeds appear to be produced.

The native perennial sod-forming grass, *Leymus triticoides* (creeping wildrye) was found in local abundance on shell midden soils at the west end of the island, and in sparse relict colonies on the northwestern scarps. The native perennial forb *Iva axillaris* (poverty-weed), a species of alkaline or slightly saline terrestrial soils, was discovered at one rock crevice location just above tideline at the southwestern shore. Wild beet, *Beta vulgaris*, occurs locally in high tide lines, and may be a temporary addition to the strand flora of the island. A single Australian saltbush (*Atriplex semibaccata*), widespread and common in high tide lines of the Bay, was detected on the southwest shore, but was not removed.

Summary of trends: There is evidence of increasing native plant species richness, and also increasing non-native plant species richness, following cessation of cultivation, grazing, drought. Some native species richness increases may be due to immigration (likely bird dispersed seed: *Arbutus menziesii*, no local mature populations on island), but most is likely due to regeneration from seed banks or remnant populations. Shoreline weeds are also probably spontaneous new immigrants. Long-term native species diversity and richness may be reduced by long-term expansion of invasive nonnative vegetation, unless reversed. Because there were no baseline studies of species diversity from earlier survey dates, no direct data are possible to assess changes in diversity; only past species richness (plant list) data are available. It appears likely, however, that diversity and richness of the plant community increased after extreme drought and grazing pressures declined in the 1990s.

2.3.3. Botanical significance of selected native Marin Islands plant taxa

Although there are no listed rare or endangered species at East Marin Islands, there are plants present with biogeographic and taxonomic importance for conservation of the Marin county and San Francisco Bay floras.

Ecotypic variation, range limits, isolated, or intermediate populations. There are several cases of Marin Island plant populations with taxonomic ambiguity between species pairs with contrasting maritime and interior distributions. Marin Islands occupies a distinctive coastal location, near the Golden Gate's jet of marine air layers, but offset within San Rafael Bay, yet influenced by salt spray of the steep, rocky, wave-influence shoreline. Marin Islands are relatively isolated from maritime populations of the outer coast, and proximate to the San

Rafael Hills. Marin Islands also appears to be the interior distribution limit for at least one maritime species, *Eriophyllum stoechadifolium*. This island location with intermediate coastal/inland environments is a likely environmental setting for isolated ecotypes, or stabilized introgressant (old, multiple-generation backcrossed hybrid) populations between species with maritime and interior distributions.

The duration of the islands' isolation during the Holocene marine transgression implies that species with very low rates of long distance dispersal and gene flow have been separated from ancestral populations as local isolates for approximately three thousand years at least. Marin Islands and south Mare Island (the sandstone bluffs of the historic Island) together may constitute natural island laboratory for studies of regional population differentiation in coastal and interior plant populations. Both islands are large and are separated from nearest mainland communities by long distances for wind-dispersal of terrestrial seed along prevailing (westerly) wind directions, and occur in relatively deep surrounding water (several meters, submerged mid-late Holocene).

The following species from Marin Islands are noteworthy for either their biogeographic, ecological, taxonomic, or other conservation significance.

> ***Adiantum jordanii*** C. Mull. (California maidenhair fern, Pteridaceae). This drought-tolerant fern, though not regionally rare, is often associated with local thick accumulations of organic matter on old undisturbed soils under shrubs, or shaded, seasonally moist rocks. The populations identified by Ornduff and Vasey (1995) and Smith (2003) are presumably old, stable relics.
>
> ***Agrostis pallens* Trin.** Vasey (intermediate with *A. hallii* Vasey). D. Smith (2003) reports an *Agrostis* (Poaceae, bentgrass) species undetermined, for East Marin Island. Ornduff and Vasey reported no *Agrostis* in their 1991 – 1992 survey, conducted after drought, intensive grazing, and without summer sample dates that would be optimum for identification. One perennial *Agrostis* species forms extensive rhizomatous to stoloniferous clonal populations of on the dry, semi-shaded sloping plateaus of East Marin Island, forming a subdominant to locally dominant component of the coastal grassland layer beneath the semi-open canopy of planted non-native evergreen trees (Figure 4). Other than the extensive rhizomatous sods it forms, it otherwise has the aspect of the common non-native colonial bentgrass, *A. capillaris*.
>
> Abundant panicles of the East Marin Island *Agrostis* were evident in June-July 2004. The lack of a palea indicates the rhizomatous *Agrostis* is native, but the 1 mm callus-hairs, less than ½ the length of the lemma, make the specimens intermediate between diagnostic characters of *A. hallii* and *A. pallens* in the current Jepson manual key (Harvey 1993). In Howell's (1949) key to the genus in Marin County, the specimens would fall within *A. pallens* ("hairs at base of lemma 1 mm or less"), and he further noted that this species "In Marin County this species and the preceding (*A. hallii*) are nearly confluent and at times are difficult to distinguish, although *A. diegoensis* [note: placed in synonymy with *A. pallens* Trin.; Harvey 1993] is generally more delicate in foliage and inflorescence". This agrees with the East Marin Island

condition of specimens. The only other perennial rhizomatous/stoloniferous *Agrostis* species in Marin are non-native species of moist or wet, disturbed areas, and all these have paleas.

Howell (1949) lists *Agrostis diegoensis* Vasey (now synonymous with *A. pallens*) as "common and widespread on partially shaded flats and banks in woods, chaparral, and meadows: Rodeo Lagoon, Angel Island; Tiburon...San Rafael Hills, Black Point...). He describes *A. hallii* as "widely distributed but not common, occurring on wooded or brushy slopes usually impartial shade…Rodeo Lagoon, Sausalito, Mount Tamalpais...San Anselmo Canyon, San Rafael Hills, Gallinas Valley, Inverness Ridge, Dillons Beach".

Intact stands of native perennial grassland (particularly non-bunchgrass vegetation) are significant because of their widespread replacement by invasive non-native annual grasses in the Bay Area. The isolation of East Marin Island, despite the brief, recent history of intensive sheep grazing at East Marin Island, have preserved major regenerated stands of this species, with good prospects for conservation.

Arbutus menziesii Pursh. Ornduff and Vasey (1992) doubted that the immature, highly branched *Arbutus* sp. they observed (Figure 3) was the native *A. menziesii*. *A. menziesii* is very common in the more arid mixed evergreen forest of China Camp and Novato hills, but mature trees are absent on the Marin Islands. The East Marin Island plants (few juvenile trees and saplings) are clearly *A. menziesii*, not an introduced horticultural species. They probably established by bird dispersal of seeds, and emerged after drought and grazing waned in the 1990s.

Dudleya farinosa (Lindley) Britton & Rose. The coastal bluff *Dudleya* at Marin Islands (Figure 10) may be another intergrade between interior and coastal species. Ornduff and Vasey (1995) identified the locally common succulent "bluff-lettuce" of crevices in sandstone cliffs of East Marin Island as *D. cymosa* (Lemaire) Britton & Rose ssp. *paniculata* (Jepson) K. Nakai. This taxon has a predominantly interior distribution, with very few records in Marin County. Smith (2003), in contrast, identifies the local Dudleya as *D. farinosa*, a determination I find to be a closer match with most East Marin Island specimens with thick, glaucous succulent leaves. The typical coastal cliff species on the north-central California coast is *D. farinosa*, which may be distinguished from *D. cymosa* ssp. *paniculata* by relatively ambiguous or phenotypically variable vegetative characters such as caudex length and habit, branching, and leaf thickness, in a complex key (Bartel 1993). Howell (1949) also cites San Francisco Bay localities for *D. farinosa* (as *Echeveria caespitosa* (Haw.) DC, noting Abram's synonymy with *D. farinosa*) at Sausalito and Angel Island, and two Tiburon localities appear in UC/Jepson accessions. All UC/Jepson accessions of *D. cymosa* are interior localities except one reported for Stinson Beach. The geographic, ecological, and morphological ambiguities of the Marin Islands *Dudleya* warrant closer taxonomic scrutiny. This location may support an introgressant, intermediate population, congruent with its intermediate maritime/interior setting; or it may simply provide an environment for phenotypes that are ambiguous for taxonomic keys to the genus. Comparison with old *Dudleya* populations of other long-isolated

bluffs and cliffs in San Pablo Bay, such as Mare Island, China Camp, and Red Rock, would be instructive.

Erigeron foliosus **Nutt. var. *franciscensis*** G. Nesom. (Franciscan leafy daisy, Asteraceae). Smith (2003) reports this remarkable locality for a very uncommon or rare subspecies. It was probably treated as var. *hartwegii* (Greene) Jepson by Howell (1949), or overlooked in his field work. He reported Marin localities of *E. foliosus* from grassy or brush slopes at Sausalito, Tiburon, Mt. Tamalpais, San Rafael Hills, and "near Chinese Camp". All UC/Jepson accessions of *E. foliosus* in Marin and the central coast are treated as var. *franciscensis* (Nesom 1993). The isolated Marin Islands locality fits the distribution pattern of this uncommon, predominantly coastal species. It was not relocated during the Jan-July 2004 surveys, earlier than the expected flowering period of this species.

Eriogonum nudum Benth. var***. auriculatum*** (Benth.) Jepson (possible intergrade with *E. latifolium;* coast buckwheat/naked buckwheat intermediate, Polygonaceae). The *Eriogonum* at East Marin Island (Figure 11) appears to be an intermediate population with prevalence of diagnostic characters from the mostly interior species *E. nudum* (naked scapes), but with some individuals exhibiting morphological and ecological traits of the maritime *E. latifolium* (broad wavy leaves with grayish pubescence on upper surfaces, coarse leafy stems, compact branched inflorescences, salt spray zone of sandstone cliffs). Ornduff and Vasey (1995) and Smith (2003) treat it as *E. nudum* var. *nudum*, but all UC/Jepson accessions of *E. nudum* in Marin have been placed in *E. nudum* var. *auriculatum*, with localities given for Tiburon, Muir Woods, Mt. Tamalpais, and Tomales Bay.

The description of var. *auriculatum* (Hickman 1993) approximates Howell's (1949) descriptions of *E. latifolium-nudum* intergrades that obscure demarcation between these species in Marin. The Marin Islands locality may represent the "inland" (eastern) geographic limit of *E. latifolium* where it intergrades with *E. nudum* . The intermediate, mixed coastal/inland environment (salt spray zone of shoreline cliffs, restriction of maritime airflow by San Rafael Hills and Mt. Tamalpais) is consistent with the intermediate phenotypes. The population may represent a stable, isolated introgressant form locally adapted to the intermediate or "hybrid" habitat, or an atypical coastal bluff ecotype of the normally interior *E. nudum* var. *auriculatum*. Its taxonomic status warrants further scrutiny. The distinctive marginal population and locality has potential scientific significance for future genecological studies of the genus, and should be presumed to have conservation significance.

Eriophyllum stoechadifolium Lag. The linear population of *E. stoechadifolium* (*E. staechadifolium* of authors) within 2 meters of Extreme High Water at Marin Islands are apparently the most interior limit of this exclusively maritime species in San Francisco Bay. Howell (1949) cites San Francisco Bay localities at Sausalito and Angel Island, and all UC/Jepson accessions for Marin County are maritime localities. It is either absent or very scarce along the more China Camp shoreline to the north, in the fog-shadow of McNears Point (P. Baye, pers. observ.).

Lomatium sp. (Apiaceae). Ornduff and Vasey identify the sole East Marin Island species of this genus as *L. utriculatum*, punctuated "?". D. Smith (2003) identifies the sole Lomatium as *L. dasycarpum* var. *dasycarpum*. The latter determination is consistent with the specimens observed in 2004.

Piperia michaelii (Greene) Rydb. (rein-orchis, Orchidaceae). Several populations of the undetermined *Piperia* sp. reported by Smith (2003) flowered in May-July 2004 (Figure 6). They exhibited the diagnostic characters of the rare *P. michaelii* (Greene) Rydb. This species is distinguished from two species in which it was formerly included, (*P. elegans* and *P. elongata*) by its all-green flowers, ovate-deltate lip, spreading (not recurved) lower sepals, inflorescences shorter than scapes, and stout, foliose-bracted scapes (Wilken and Jennings 1993, Coleman 1995, Howell 1949). Howell (1949) cites one San Pablo Bay coast locality for *P. michaelii* (Black Point); the UC collections are maritime, all very old Point Reyes localities.

Piperia michaelii occurs in two main colonies in semi-shaded grasslands beneath eucalyptus canopies, and as a few scattered individuals on the southwestern grasslands, all in semi-shaded areas. The largest colony near the old pump house has at least 20 flowering individuals, and the total island population (no census) may approach 50 plants or more. The population should be periodically counted or estimated, and mapped for purposes of conservation and scientific management.

Coleman (1995), reviewing the conservation status of native California orchids, argues that *Piperia michaelii* "must be considered threatened" because it occurs only rarely throughout its range, and may be losing some of its range. He recommends that its status be monitored regularly throughout its range. Because of the size of the population, and its isolation, East Marin Island is likely to be the most significant protected population of the species in the Bay Area outside of Point Reyes National Seashore.

Pellaea andromedifolia (Kaulf.) Fee. (cliff-brake, coffee-fern). Howell (1949) reports this dry-habitat fern as an occasional species on dry rocky slopes under brush, with localities at Tiburon, south slopes of Mt. Tamalapais, Carson country, San Rafael Hills, and Tomales. It is very uncommon around San Pablo Bay shorelines: only one UC accession is reported for Tiburon. It occurs locally on East Marin Island on south-facing bluff edges at least two locations. Populations similarly occur locally on south-facing bluffs in similar habitat at south Mare Island, and potential bayside sandy/gravel slope habitat may occur on the Richmond/Point Pinole peninsula.

Polypodium calirhiza S. Whitmore and A. R. Smith. (Polypody fern, Polypodiaceae). This is another taxonomic ambiguity between two related species with coastal versus interior distributions in Marin County. Ornduff and Vasey (1995) identified the polypody fern of Marin Islands as *P. californica* Kaulf., a species with primarily coastal distribution in UC/Jepson accessions. Smith (2003) identified the polypody fern as P. *calirhiza*, a species with numerous interior localities, including San Rafael, in UC/Jepson accessions. Whitmore (1993) notes that hybrids may

occur in the genus. The geographic, ecological, and morphological ambiguities of the Marin Island *Dudleya* warrant closer taxonomic scrutiny. This location may support an introgressant, intermediate population, congruent with its intermediate maritime/interior setting.

Stephanomeria elata Nutt. *Stephanomeria* (Asteraceae) in Marin County is represented by the annual herbs *S. virgata* and *S. coronaria* (syn *S. exigua* ssp. *coronaria*), and *S. elata* Howell 1979, 1970, Stebbins 1993). Annotated specimens of Howell's collections of *S. coronaria* at the University of California/Jepson herbarium were annotated as *S. elata*, an annual species, by L. Gottlieb (SMASCH 2003). Ornduff and Vasey (1995) reported "the perennial *Stephanomeria elata* was observed as only a few plants growing on rocky slopes at the extreme east end of the island". They acknowledged L. Gottlieb, a leading taxonomic expert on the Asteraceae, for assistance with identification of the fragmentary *Stephanomeria* sample they collected on an unspecified date; they did not collect vouchers (Ornduff and Vasey 1995). Doreen Smith collected late-season specimens of *Stephanomeria* on East Marin Island in 2003, from southwest-facing steep bluff slopes at the southeast end of the island (G. Downard, San Pablo Bay National Wildlife Refuge, pers. comm.). Summer surveys at this locality in 2004 were precluded by active gull nesting.

UC herbarium collections of *Stephanomeria* from southeastern Marin County annotated by Asteraceae expert L. Gottlieb are currently referred to *S. elata*. The character combinations observable in this specimen and reported for the East Marin Island population by Ornduff and Vasey (1995), however, are not entirely consistent with either *S. virgata* or *S. elata* (**Table 4**). Howell (1949) reports *S. virgata* from "open slopes in loose clayey or gravelly soil: Angel Island, Tiburon and Mount Tamalpais...to San Rafael Hills..." (a distribution consistent with Marin Islands locality), and "*S. coronaria*" (misapplied, acc. L. Gottlieb; *S. elata*) as "occasional on open gravelly slopes [Mt. Tamalpais area] to San Rafael Hills" (distribution marginal to Marin Islands). One Marin collection of *S. elata* is from a coastal locality, slopes above the ocean at Pt. Reyes (UC 1394186, collector unknown), comparable to the East Marin Island habitat; the other collections are all interior localities.

Howell (1949) also noted the occurrence of a population with traits intermediate between "*S. coronaria*" (*S. elata*) and *S. virgata* near Bootjack (a serpentine "island" of Mt. Tamalpais), which "seemed more closely related to *S. coronaria*....but they may represent an undescribed entity." It may be significant that several key traits in the Marin Island specimens are either intermediate, or have contrasting affinity with the two Marin County species. The strongly tuberculate to rugose surface of the Marin Island specimen's achenes (P. Baye, pers. observ.) is not described for either of the candidate species. Also anomalous is Ornduff and Vasey's observation of perennation in the Marin Islands *Stephanomeria*: all three candidate species are typically annual (Stebbins 1993).

If the *Stephanomeria* at Marin Islands not typical *S. elata*, the local population may have taxonomic and conservation and significance. If the full character set remains anomalous for the current key to the genus in California (Stebbins 1993), complete

specimens should be provided to taxonomic specialists in the Asteraceae re-evaluate the variations in characters. A new narrow endemic to Marin Islands would be a highly significant consideration for vegetation management objectives and priorities. Further information on all character traits (including early-season basal leaf characters, corolla characters), and comparison with *complete* herbarium specimens of Marin collections, may clarify the traits and affinities of the Marin Island *Stephanomeria*.

No listed rare, threatened, or endangered plants are known to occur at Marin Islands, and none are expected, based on soils, geography, and plant communities present. Unlike Angel Island, Marin Islands lacks serpentine soils or outcrops of serpentinite bedrock, features associated with local centers of serpentine plant endemism, such as at Ring Mountain in Tiburon and the Presidio. No wetlands other than the brackish artificial "lagoon" (impoundment) have been detected at East Marin Island.

2.3.4. Non-native flora and vegetation of East Marin Island

The horticultural legacy of East Marin Island is not a marginal aspect of the island's flora and vegetation. Native components of the island's flora and vegetation have regenerated in a matrix of landscaped island gardens, with literally marginal remnants of native plant communities along bluffs: most of East Marin Island is quite literally a garden gone wild.

Overview of local non-native flora. East Marin Island supports a rich non-native flora (Table 2) of naturalized and well-established old horticultural plantings, a legacy of long-term 19th century military occupation and residential use in the 20th century (Kroll 1991). The most important elements of these are the trees, planted as windbreaks and shelter on the plateau of the island. These are a mixture of dominant blue gum (*Eucalyptus globulus*), and subdominant Monterey pine (*Pinus radiata*), and some Monterey cypress (*Cupressus macrocarpa*). They are comparable to similar aged coastal headland stands in the Presidio of San Francisco. These plantings, and younger "volunteer" recruits, dominate most of the canopy and aspect of East Marin Island vegetation, including much of the south-facing coastal bluffs. Blue gum, pines, and cypress have not significantly invaded the natural coast live oak woodland of the islands north slope. The shelter they provide, however, appears to be responsible in part for the successful establishment of many other exotic plants on the island.

Horticultural history of East Marin Island. The history of horticultural introductions to East Marin Island is only partially known. Kroll (1991) reported that the main windbreak tree plantings, quarry (lagoon), northeast seawall, and shoreline palm trees were established in the early military era, sometime between 1850 (U.S. possession in 1848) and 1867 (declaration of military reservation at East Marin Island). Conflicting reports, however, are given by Constance [Crowley] Peabody (previous owner of the Islands), who recalled her father (T. Crowley) planting trees on relatively barren island (G. Downard, San Pablo Bay National Wildlife Refuge, pers. comm. 2004). Prior to military occupation, the island supported a native American village site covering most of the island, with a midden site covering up to one third of its area. The residential horticultural period began as early as 1926, when the island was decommissioned as a military base and auctioned for $45,000 to the Crowley Launch and Tugboat Co., owned by Thomas Crowley Sr. (Kroll 1991). Crowley reportedly

planted additional windbreak trees (blue gum and Monterey Pine), and introduced French broom, Monterey Cypress, she-oak (*Casuarina* sp. no longer extant), fruit trees, and other ornamental plants (Constance [Crowley] Peabody, pers. comm. to Giselle Downard, 2004). The main stone residence was constructed in 1945-46 (or 1930s, according to Kroll 1991), and the guest house was constructed 20 years later (C. Peabody, pers. comm. to G. Downard 2004). The plantings associated with each building probably accrued within 20-30 years after construction. Only a few extant plantings are suggestive of late 20th century horticultural trade selections (e.g. *Sollya, Ligustrum* , *Hakea* cultivars).

Ornamental plantings and escapes (local spread of "naturalized" introductions). In addition to the dominant overstory plantings of mature blue gum, Monterey pine, and Monterey cypress, there are other significant nonnative trees and large shrubs on the island, with more limited distribution near historic residences. These are in part persistent original windbreak plantings (Kroll 1991), and in part their progeny. The range of horticultural escapes is similar to those of other early 20th century coastal settlements in the Bay. Alcatraz Island has retained a similar rich relict perennial/woody horticultural and weed flora in the absence of any irrigation or maintenance for decades (Hart *et al.* 1996), and similar patterns of persistent garden relics occur at Angel Island and the Presidio (pers. observ.).

At least four *Acacia* species, including the robust blackwood acacia (*A. melanoxylon*) have survived and spread locally near the main residence's "terraced orchard and garden" on the north slope (Kroll 1991). Old fig trees (*Ficus carica*), apple cultivars (*Malus domestica*), plum cultivars (*Prunus domestica*) and olive (*Olea europaea*), and rosemary (*Rosmarinus officinalis*) also persist around the terraced orchard, and near the residence. An unusual linear 19th century planting of Canary Islands palms (*Phoenix canariensis*; Kroll 1991) has persisted on the gravel barrier beach (Figure 12) enclosing the now-brackish rock quarry lagoon. The presence of salt-intolerant palms indicates permanent fresh groundwater lens (or persistent nonsaline soil moisture) under the gravel beach. (Note: narrow bay mud levees surrounded by brackish/saline marsh on both sides also support salt-intolerant species such as coast live oak and Monterey Cypress along Highway 37 and Bahia in Novato). A younger palm occurs at the west end of the terrace near the former plum grove (northeast), and a few palm seedlings occur elsewhere. Presumed bank stabilization plantings of ivy (*Hedera helix,* including both typical and the horticultural form "canariensis") and periwinkle (*Vinca major*) persist and spread at several north shore banks, near the locations of the former "Ark" dock at the northeast shore (Kroll 1991), and near the trail and stairs leading to the boat dock.

Prickly-pear cactus or Opuntia (*Opuntia ficus-carica*) appears to have been planted as an ornamental along several segments of the southern bluff top (Figure 13). The Opuntia plantings have spread by layering, clonal fragmentation (detached, rooted pads) and gravity dispersal over the bluff debris slopes (Figure 14). Opuntia is associated with another garden succulent, *Aeonium arborescens*, which has naturalized on the quarry cliffs and adjacent slopes (Figure 15). The succulent iceplant *Drosanthemum floribundum* occurs on bedrock outcrops on bluffs at multiple locations on the south shore. *Carpobrotus edulis* is usually highly invasive in coastal bluffs, scrub, and grassland, but it has limited spread and vigor at the relatively arid, warm East Marin Island. It is confined to two patches along the southwest shoreline on gravels at the toe of a small landslide (Map 3B). In contrast, Pride-of-Madeira (*Echium candicans*, syn. *E. fastuosum*) is seldom invasive along most of the California coast, but at East

Marin Island, it becomes locally abundant to co-dominant in the coastal bluff scrub of southern and southeastern shores. Mattress-vine (*Muhlenbeckia complexa*) forms smothering canopies locally in the shrub and ground layer near the base of the south shore stairway. It is probably limited to the vicinity of original plantings.

Local escapes of perennial bulbs (*Allium* spp., *Amaryllis belladonna, Chasmanthe floribunda, Narcissus* cvs.), perennials (*Acanthus mollis*) and the subshrub geranium (*Pelargonium hortorum*) also persist near the residences and old gardens, spreading mostly within the boundaries of derelict landscaped areas. *Chasmanthe* is unusually abundant on north slopes. Linear *Amaryllis* plantings are conspicuous features of the loose shell midden soils at the west end. Parsley (*Petroselinum crispum*), an unusual garden escape for the region, has in contrast spread widely and in local abundance around shaded, mesic sites of the island. More recent South African and Australian ornamental introductions to the island include *Hakea* sp., *Ficus ficifolia*, and *Sollya heterophylla*.

The most serious escaped ornamental plant is the invasive French broom (*Genista monspessulana;* see below). Relatively younger plantings of privet (*Ligustrum japonicum*) have persisted, but are not invasive. Of the principal horticultural relics, *Acacia, Hedera*, *Rubus discolor* (Himalayan blackberry) and *Vinca* form large, dominant stands, spreading vegetatively in *Hedera* and *Vinca*, and by seed in *Acacia*. .

Noxious wildland weeds. Many of the established, introduced non-native plants of East Marin Island are either highly invasive noxious weeds in other parts of California, or are potentially or actually invasive (rapidly spreading to dominance, excluding native flora) at East Marin Island. Weeds treated here as noxious are highlighted in bold in Table 2. Their basic life-history and weed control information is summarized in Appendix 2.

French broom (G*enista monspessulana*) is locally a noxious, highly invasive weed with potential to dominate most ground layer and shrub layer vegetation of the island. It may permanently alter seed banks and soils so that recovery of native vegetation is permanently corrupted. It was introduced as an ornamental shrub in the 20th century, and has spread almost throughout terrestrial vegetation of the island. It has become an abundant to dominant component of the oak understory, grassland and bluffs. *Genista* is a highly invasive, persistent nitrogen-fixing shrub. It forms monotypic stands in open vegetation and semi-shaded woodland, and leaves abundant persistent seed banks that can regenerate juvenile populations for many years after the adults are removed. Photos of the island from earlier than 1991 (Kroll 1991) indicate that former low-growing grassland turfs have become profusely invaded by *Genista* all over the island. *Genista* appears abundantly in all terrestrial plant communities of East Marin Island except intertidal cobble beach or brackish marsh; seedlings even occur frequently in drift-lines in spring.

Ehrharta erecta (no common name), a perennial South African grass with tenacious fibrous roots and abundant seed production, was detected during 2004 surveys of East Marin Island Its local distribution is largely limited to small, scattered patches in the shady subcanopy of coast live oak on north-facing slopes of the northeastern island. It has probably been present but undetected, since it resembles a robust form of native *Melica torreyana*. This detection is significant because of the extreme difficulty of controlling the species once a seed bank is

established, and the aggressiveness of its spread in coastal woodlands and scrub understories. It is spreading rapidly along the California coast, forming dense carpets in sandy or rocky coastal scrub soils of San Francisco, Monterey Bay, and even the Farallon Islands (*pers. observ.*), in both dense shade and open sun. At Marin Islands, it may remain limited to relatively moist, shaded habitats of the island. See Appendix 1 for additional information.

Fennel (*Foeniculum vulgare*) is highly invasive on disturbed mineral soils, such as the landslides of the south bluffs. Bermuda-sorrel (also Bermuda-buttercup, oxalis; *Oxalis pes-caprae*) is a fall-emerging, winter-flowering bulb that spreads by viviparous bulbils (clonal bulbs formed instead of fruits) and below-ground fleshy roots with bulbs. It forms dense leafy carpets in coastal grassland during critical seedling life-history stages of native plants. Oxalis is locally dominant on the gravelly terrace next to the quarry pond, and occurs in monotypic clonal patches in the semi-shaded grasslands of the plateau. Himalayan blackberry (*Rubus discolor*) establishes dense thickets in relatively moist sites, but can also invade and dominate drier coastal scrub sites. It occurs abundantly on the north slopes near the old terraced orchard.

Two aster family forbs, Italian thistle (*Carduus pycnocephala*) and Napa starthistle (*Centaurea melitensis*) are aggressive invaders of coastal grasslands. They occur in annual grassland patches of the south shore and central plateau.

Naturalized weedy grasses, forbs. Many other weeds occur in East Marin Island's remnant grassland and coastal scrub. They have significant influence on the local vegetation, but tend not to form extensive dominant or monotypic stands in the prevalent low-nutrient, stressful dry soils. Under favorable conditions (e.g. soil disturbance, elevated soil nutrient levels, etc.), they may, however, become dominant. Annual grasses (*Avena barbata*, *Bromus diandrus*, *B. hordeaceus, Briza* spp., *Hordeum murinum* ssp *leporinum* provide much of the biomass of the grassland remnants, and compete with native grasses and forbs. Grassland and ruderal forbs such as English plantain (*Plantago lanceolata*), Tangier pea (*Lathyrus tingianus*), cranesbills (*Geranium* spp.) and cat's-ear (*Hypochaeris* spp.) are common in the semi-shaded grassland patches, especially at the east end of the island.

"Watch list" weeds for East Marin Island. Some wildland weeds with highly invasive, persistent tendencies in coastal settings of San Francisco Bay have not yet become established at Marin Islands. Jubata grass (*Cortaderia jubata*) is in early stages of colonization, and it is a high priority for early, feasible eradication. Seedling establishment may occur on mesic, eroded coastal bluffs, especially slope failures on the north shore. *Delairea odorata* (syn. *Senecio mikanioides*; Cape or German-ivy), a South African vine, is a widespread weed in both riparian woodland and moist, shaded coast live oak woodland understories. The north shore and slopes are vulnerable to invasion by Cape-ivy. Jubata grass and Cape-ivy both are widespread around the mainland Marin bayshore. They may be slow to colonize the suitable, invasion-prone habitats of islands because of dispersal limitation, as long as the islands remain closed to the public. Poison-hemlock, *Conium maculatum*, is a widespread coarse annual weed that can dominate semi-shaded, moist habitats such as riparian areas. It is common in Marin County, and has potential to establish in the coast live oak woodland of the north shore. As the populations of these weeds spread around San Francisco Bay, and as volunteer stewardship crews increase with vegetation management, the Refuge should

remain vigilant for founder populations of these weeds. Unpredictable long-distance dispersal events may also occur by birds or wind.

2.3.5. Description of major vegetation stands at East Marin Island

The existing vegetation at Marin Islands varies from well-defined units closely associated with substrate and landforms, to intergrading heterogeneous assemblages of native and non-native plant assemblages that appear to relate more to historic land use, landscaping, and disturbance than to the original native vegetation patterns. Most of the island's vegetation appears to be either regenerated native vegetation becoming invaded by escaped exotics, or remnants of old gardens and orchards where natives are re-establishing. Much of the island's vegetation local patterning appears to confuse artifacts of past cultivation or disturbance with natural species patterning, but broad patterns of coastal bluff scrub, grassland, and oak woodland are still evident. At a local scale, however, much of the vegetation is semi-artificial, with the most natural elements found along steep bluffs and cliffs. Plantings and weed invasions also are widespread along bluffs, however.

As such, the semi-natural, historically complex vegetation at Marin Islands, and the small scale of the islands' vegetation, limit compatibility with standardized, statewide vegetation or plant community classification systems, such as the CNPS manual for California vegetation (Sawyer and Keeler-Wolf 1995). The vegetation at Marin Islands can be described (prior to formal classification) in terms of stands, or relatively homogeneous vegetation patches contrasting with adjacent patches, at least at a broad scale. This empirical, "bottom-up" approach is a pragmatic foundation for interpretation, classification, and specific mapping of the island's "hybrid" horticultural and native vegetation. Specific local geographic vegetation mapping units (Appendix 3) can be interpreted in view of the following major descriptions. The largest and most important units are briefly described below. They include many distinct stands and patches, such as Himalayan blackberry patches, prickly-pear stands, ivy mats, acacia thickets, oxalis patches, etc., that occur as smaller inclusions within these.

Mapped vegetation units are based on these basic stand types, with minor variations or major intermediate (transitional) areas distinguished in Map 2. Because *Genista* stands effectively pervade the island's terrestrial vegetation, they are not treated as distinct mapped units, but are included in the descriptions of vegetation units as dominant or abundant. *Genista* seedlings and juveniles are, however, present within all non-wetland stands.

- Mature coast live oak woodland (*Quercus agrifolia*). The north shore bluffs and slopes support relatively mesic, mature coast live oak woodland with well-developed trunks and closed canopy, similar to stands on Angel Island. This vegetation corresponds to Coast live oak series (Sawyer and Keeler-Wolf 1995), but in anomalous association with prominent, old California buckeye (*Aesculus californica*), a tree dominant on adjacent West Marin Island, and on Rat Rock offshore from China Camp (Figure 16). A few very large, mature individuals of California buckeye are interspersed within the live oak woodland (Map 1). A few younger buckeyes occur outside the oak woodland, in sheltered areas of the south-central shoreline west of the quarry lagoon (Map 2) . California bay (*Umbellularia californica*), is very minor component of the oak woodland, occurring in small clusters of relatively small trees at the

northwest and northeast end of the island. The older live oak stands are almost entirely limited to the sheltered, moist, north-facing stable slopes of East Marin Island; young oaks occur locally in the shelter of blue gum or pine above the other shores.

The precise age of the oak stands are uncertain: there are no obvious stumps or resprout patterns suggesting recovery from military-era deforestation, and the well-developed trunks suggest that they may be relict stands antecedent to the military era (mid-19th century). This would be consistent with military priority for cover and windbreak, the ability to import fuel from the mainland. The live oak woodlands are similar in structure and composition to remnant old coast live oak woodlands on sandstone and graywacke hillslopes of south Mare Island and the north/northeast shores of Angel Island. They contrast with the lower, sprawling, "ground-hugging" forms of coast live oaks on West Marin Island.

The live oak woodland is associated with variable native shrub understory components, and are heavily invaded by non-native ornamental shrubs and lianas. Important native understory species include *Rubus ursinus, Toxicondendron diversilobum, Heteromeles arbutifolia, Lonicera hispidula, Claytonia perfoliata, Rosa gymnocarpa.* Abundant non-native understory species include *Hedera helix, Rubus discolor, Chasmanthe floribunda*, and especially *Genista monspessulana,* encroaching from cultivated edges. These shrub layers can be interpreted as independent vegetation stands, but they are associated primarily with the oak understory.

Coast live oak woodland on East Marin Island is minimally invaded by non-native trees (with the significant exception of recent pine sapling invasions), and is actively recruiting oak seedlings and saplings in the absence of browsing animals. There is evidence of live oak spread to some sites along the southern half of the island, where pine and eucalyptus canopies provide some sheltering from winds and sun. There are no obvious animal dispersal mechanisms for acorns other than birds (e.g., jays, crows, ravens).

- Mature non-native blue gum (*Eucalyptus globulus*) and Monterey pine (*Pinus radiata*) plantings. This artificial "forest" has a semi-open canopy that allows for shrub and grassland understory development. The canopy and approximate positions of old, large trees (> 1 foot diameter at breast height) are shown in Map 1. The non-native tree plantings include very few Monterey cypress (*Cupressus macrocarpa*), unlike comparable coastal plantings of similar age at Angel Island and San Francisco. This pine and blue gum unit dominates the plateau of the island, and a younger extension occurs on south-facing landslides of marine bluffs. Canopy height of the pines and blue gums significantly exceeding that of native oak-buckeye stands. These stands support variable understory components, ranging from modified coastal scrub and grassland remnants, to thickets of non-native tree saplings.

  Although there is clear evidence of spread by younger trees from older stands, the age-structure of the pine-blue gum is strongly skewed to mature trees, with locally high density of immature pines at the west end of the island, and only scattered

younger blue gums. This suggests that sapling recruitment of pines and blue gum was suppressed until the island was falling into disuse, and Barbary sheep were removed (Lidicker and Lidicker 1992; see discussion of trends, section 2.3.6).

- Extensive shrub layers dominated by introduced French broom, *Genista monspessulana*. *Genista* is now pervasive on East Marin Island, occurring in all non-saline soils and vegetation types. It also appears to have spread rapidly during the 1990s after the island fell into disuse, and following removal of Barbary sheep. *Genista* stands range from dense flowering stands to diffuse patches of juveniles, and therefore have diffuse boundaries or none. They now occur over most of the island, and are likely to become a continuous population unless checked.

- Shrub to low tree layers dominated by local horticultural escapes of ornamental nonnative plants, including *Acacia* spp., *A. baileyana, A. melanoxylon, A.* spp.) with occasional other horticultural species (figs, *Ficus carica*, geranium, *Pelargonium hortorum*, etc.). These appear to be locally important garden escapes near the residences and terraced orchard.

- Evergreen liana and shrub layers (including ground layer) dominated by introduced ivy, *Hedera helix*, Himalayan blackberry, *Rubus discolor*, and periwinkle, *Vinca major*. These may be remnants of deliberate stabilization plantings along banks of the north shore. They are essentially a variation of oak understory, but have particular significance for management, and are therefore distinguished in some dominant stands or transitions (disturbed areas) in oak woodland understory vegetation.

- Bulb-dominated grassland. Appearing as "non-native annual grassland" in summer, the vernal phase of this vegetation (February-April) is strongly perennial, with abundant to dominant bulbs (*Chlorogalum pomeridianum, Zigadenus fremontii, Tritelia laxa*), moderate abundance of perennial grasses (*Agrostis pallens, Elymus glaucus,* but *Nasella* spp. rare to absent, in contrast with blue wildrye-bulb grassland and south-aspect grasslands), and high abundance of perennial forbs (*Stachys ajugoides, Sanicula crassicaulis*). This grassland type occurs today primarily as understory of Monterey Pine at the east end of the island on slopes with north aspect (Figure 17). It may, however, have regenerated or persisted from a prior native grassland community. *Genista monspessulana* is actively invading this grassland type.

- Mixed non-native annual and perennial grassland. This grassland type has little or localized component of native bulbs, and is prevalent on the south-sloping portions of the plateau. It supports significant cover of perennial native grasses, particularly purple needlegrass (*Nasella pulchra*) and bentgrass, *Agrostis pallens*. The frequency of *Nasella* spp. (bunchgrasses) increases to the south with increasing exposure to sun and wind; large clonal patches of *Agrostis pallens* are more frequent upslope in more sheltered areas. *Elymus glaucus* is infrequent to absent. Annual non-native grasses are prevalent throughout, but oats (*Avena*) are infrequent. *Lomatium dasycarpum* and *Perideridia kelloggii* are associated forbs, in addition to *Stachys ajugoides* and *Sanicula crassicaulis*, which are less abundant than in bulb stands. Scattered coastal sage scrub

elements occur at low density in this grassland type. *Genista monspessulana* is actively invading this grassland type.

- Blue wildrye and bulb grassland. Blue wildrye (*Elymus glaucus*, abundant to dominant) in association with abundant *Tritelia laxa* (Ithuriel's-spear) and frequent *Agrostis pallens* occurs mixed with annual grasses in distinctive stands along the crest of the island with slight north aspect and large overstory canopy openings. Perennial native forbs of bulb-dominated grassland, rein-orchid (*Piperia michaelii*), and infrequent edges (*Carex* spp.) are characteristic of this understory grassland type. It currently occurs mostly beneath or around blue gum, probably despite their litter. Blue wildrye, Ithuriel's-spear, rein-orchid and bentgrass generally occur in semi-shaded brushy or woodland habitats.

- California sage scrub (*Artemisia californica*) is closely associated with unstable, south-facing wave-cut slopes and landslides (Figure 18). It is associated with other native coastal scrub shrub and forb elements (deerweed, *Lotus scoparius*; buckwheat, *Eriogonum nudum* var. *auriculatum.* Sage scrub is co-dominated by non-native invasive *Echium candicans* and *Genista monspessulana*, and these invaders dominate many bluff stands. Opuntia colonies are also locally dominant in sage scrub at the southwest shore. Because of the prevalence to dominance of non-native shrubs, this stand type only loosely corresponds with coastal sage series (Sawyer and Keeler-Wolf 1995).

- Coastal subshrub and succulent forb stands (buckwheat, *Eriogonum nudum* var. *auriculatum;* lizard-tail, *Eriophyllum stoechadifolium*), tufted or matted perennials (bluff-lettuce, *Dudleya farinosa*; sea-spurrey, *Spergularia macrotheca*) with minimal total cover on relatively erosion-resistant or well-consolidated near-vertical marine cliff vegetation, mostly on south and east-facing cliffs. These stands occur within the lower zone (bedrock outcrop, salt spray zone) of coastal bluff vegetation, depending on aspect (northern mesic, southern xeric, eastern intermediate microclimates).

- Non-native succulent cliff vegetation. On quarried slopes above the lagoon, an extensive naturalized horticultural assemblage of *Aeonium, Opuntia, Echium, Pelargonium* occurs as bedrock crevice vegetation, with marginal native scrub elements (Figure 15). Native succulents are absent.

- Mesic coastal bluff scrub stands form a narrow transition zone along the low near-vertical bluffs of the north shore, including understory elements of live oak woodland, and one mesic coastal scrub species excluded from the south shore: *Eriophyllum stoechadifolium*, *Mimulus aurantiacus, Heteromeles arbutifolia*, *Toxicondendron diversilobum* are frequently dominant. These stands often exhibit zonation according to elevation above tide line. These stands are fragmented by *Hedera, Rubus discolor* and *Genista* stands. Where dense shade of buckeye or oak canopies overhang the bluff edge, the north shore bluff scrub stands occurs interspersed or intergrading with oak woodland understory (Figure 20: *Polypodium calirhiza, Claytonia perfoliata, Melica torreyana*).

- Cobble beach *Cressa* stands. This is the dominant "salt marsh" vegetation of the south shore, where rhizomatous colonies of *Cressa truxillensis* dominate the upper foreshore locally (Figure 9). Pickleweed (*Salicornia virginica*) is rare here. It is a regionally unusual ("unique") local vegetation type not represented in regional salt marshes.

- Nontidal brackish high marsh. This is the vegetation of the lagoon edge behind the Canary Island Palm beach. The stand is dominated by salt marsh plants saltgrass (*Distichlis spicata*), jaumea *(Jaumea carnosa),* and *Salicornia virginica.* The lagoon itself is brackish, and supports minor seasonal stands of submerged *Ruppia maritima*.

- Drift-line vegetation. The tidal litter wracks at the high tide line of the south shore support a mix of mostly non-native salt-tolerant vegetation, with abundant *Salsola soda*, and locally abundant *Lepidium latifolium*. *Beta vulgaris* and *Atriplex triangularis* are occasional; *Oxalis pes-caprae* extends to this stand locally. This local flora is highly dynamic.

2.3.6. Vegetation trends at modern East Marin Island

Trends in non-native vegetation.

Nonnative overstory trees. The dominant overstory trees over most of East Marin Island are all large non-native plantings, with limited younger, spontaneous recruits in the subcanopy and beyond boundaries of plantings, such as younger landslides of bluffs. The future trends of the stand may be compared with the Presidio of San Francisco, which supports the same species, and includes similarly mature or overmature, unmanaged stands and younger cohorts. Long-unmanaged coastal California stands of blue gum (*Eucalyptus globulus*) and Monterey Pine (*Pinus radiata*) self-regenerate in their own understories and gaps, resulting in mixed age structured "forest". The East Marin Island stands age structure is strongly skewed to mature trees, with a single major cohort of relatively young (1990s) pines patchily distributed. Only scattered young blue gums occur in relatively remote areas. This strongly suggests that non-native sapling recruitment was suppressed by maintenance and later goat browsing, and recruitment was released from suppression after public acquisition. This pattern appears to be mirrored in the spread of other woody non-native invasive plants.

Blue gum is a very long-lived tree, and the mature planted population shows few signs of degeneration other than usual loss of limbs and branches. The subdominant conifers, Monterey pine and cypress (*Pinus radiata, Cupressus macrocarpa*) are not so long-lived, and are prone to degeneration, disease, and windthrow as they become overmature. Natural senescence of the mature planted conifers may occur over several decades or more, and mass mortality does not appear imminent.

The younger age-classes of pine and blue gum saplings suggest that if the stand remains unmanaged, it would eventually be likely to replicate conditions of historically unmanaged stands in the Presidio, and develop excessively high densities, canopy closure, and dense ground layers of leaf litter and woody debris that exclude most of the ground layer (California blackberry sometimes persists under closed-canopy blue gum). Active

maintenance of the landscape during 20th century residential use presumably prevented this succession and change in age-structure. Canopy closure would be followed by self-thinning (mortality of crowded young understory trees). The current density of mature planted trees is moderate, with gaps in the canopy and a rich shrub and ground layer persisting in the understory. The understory of remnant native coastal grassland and scrub vegetation will very likely decline progressively as the evergreen non-native tree canopy closes, and thickness of the litter/woody debris layer increases.

Coastal scrub and non-native overstory trees. Relatively younger coastal scrub vegetation on the scarps and debris slopes of the south shore of the island are also becoming colonized by non-native trees, particularly blue gum. Some coastal scrub vegetation units are strongly influenced (degraded) by blue gum shelter, leaf litter, and shade, which appear to facilitate invasion and dominance by non-native shrubs. Established trees are likely to expand their canopies, and recruit more seedlings and saplings on these slopes, which would otherwise provided some refuge for native coastal scrub plant populations displaced by non-native trees on the plateau.

Rapid intensive French broom invasion and other non-native shrub invasions. The shrub layer of the island also appears to be highly dynamic and expanding, released from suppression by former weeding and browsing pressures. The lack of a dense shrub understory, and prevalence of maintained park-like conditions are evident in photos of the island's landscape prior to 1991 (Kroll 1991). The large stands of French broom (*Genista monspessulana*) appear to be expanding rapidly into adjacent open habitats, as well as under coast live oak canopies, as indicated by a diffuse gradient of juvenile *G. monspessulana* around mature, seed-producing populations. This process has probably been active since removal of Barbary sheep shortly before public acquisition (Lidicker and Lidicker 1992). The stands of *Acacia* spp. near the former residence also have marginal populations of juveniles, and are clearly producing a seed bank. Stands of these and other woody (nitrogen-fixing) Fabaceous species are likely to cause persistent residual elevated soil nitrogen, favoring weedy vegetation even if the shrubs are removed.

The ground layer composed of old stands of planted ivy (*Hedera helix*), on the north shore slopes near the boat dock, have spread by vegetative growth to the oak woodland understory, excluding all other cover types. There is little evidence of significant seedling recruitment of ivy elsewhere; it appears to expand by gradual, progressive and severe local clonal spread from old plantings.

Stands of prickly-pear cactus (*Opuntia ficus-indica*) occur on the southeastern wave-cut bluffs of East Marin Island. The distribution and local abundance suggests locally intensive, ongoing slow clonal spread by fragmentation and rooting of pads. As portions of the bluff become exposed, they may provide additional habitat for colonization. The stability of this population may depend on maintaining a stable bluff-top source for fragmented pads dispersed by gravity. This may represent a relatively slow but persistent invasion.

The distribution of Bermuda-buttercup (*Oxalis pes-caprae*) is likely to undergo progressive clonal spread by dispersal of bulbils, based on observation of coastal bluff and grassland populations in west Marin, San Francisco, and San Mateo counties. It is already abundant

and widespread on the Island, forming monotypic clonal stands that exclude spring-emerging seedlings of native species. It co-dominates the above-tide gravel beach terrace next to the lagoon, along with the native bulb *Chlorogalum pomeridianum* (Figure 19). In the absence of animal dispersal, its spread here may occur primarily by radial clonal growth.

Some gaps occur in the predominantly native oak-buckeye and coastal scrub cover of the island's north shore, possibly due to former landslides. Some of these gaps are dominated by Himalayan blackberry (*Rubus discolor*), but disturbances favorable for its further opportunistic (gap-colonizing) spread of this relatively shade-intolerant species appear to be minimal on the north shore. Jubata grass (*Cortaderia jubata*) may currently be limited by lack of vegetation gaps for seedling recruitment, but may also spread rapidly following landslides or slumps that expose subsoil. *Ehrharta erecta* is also likely to spread progressively in shaded, mesic oak understories, especially where vegetation gaps occur.

Weakly naturalized or noninvasive nonnative species. Many relict ornamental horticultural plants, in contrast, appear to be persisting but spreading only slightly (often by suckering) from their original locations. (Table 2, Appendix 1). *Acacia longifolia* and *A. melanoxylon* are exceptions: they appear to be spreading at high density by suckers and seedlings, but mostly near the former terrace gardens.

A regularly spaced, linear population of Canary Island date palms (*Phoenix canariensis*) is established on the gravel barrier beach that encloses the brackish lagoon (Figures 12, 19). The population is apparently an old planting (perhaps military era; Kroll 1991), and has persisted despite rising sea level. Seedlings of *P. canariensis* occur on the plateau near the residential site, probably due to bird dispersal of fruits from the beach plantings. Invasion pressure appears to be very minor.

Trends in native vegetation

High densities of coast live oak (*Quercus agrifolia*) "seedlings" (suppressed saplings, probably 2 years old or more) in and around the understory of parent trees and competing French broom (*Genista monspessulana*), provide evidence of successful recruitment in recent years. The high-density seedling stands, however, are probably not viable in the long term because of shading and competition. Oak saplings at low densities in surrounding grassland may expand the oak population at the expense of some of the annual-dominated grassland near the residence. Unusually high seedling recruitment and survival is likely due to lack of herbivory, ample seed production, lack of animal dispersal, and local mesic microclimate of the island's oak woodlands.

No visible evidence of sudden oak death (*Phytopthera ramorum* infection) symptoms, such as rapid dieback of branches or whole crowns, marcescent foliage (withering while attached; lack of abscission after death) was detected at this geographically isolated population in November 2003. No comparable recruitment of California buckeye (*Aesculus californica*) seedlings or saplings is currently evident over most of the island. Past buckeye recruitment has apparently occurred, as indicated by younger shrub-like trees on stabilized landslides of the southeast slopes, and near the mature fig plantings of the derelict terraced orchard.

Native perennial grassland elements, such as bunchgrasses (*Nasella* spp.) blue wildrye (*Elymus glaucus*), creeping wildrye (*Leymus triticoides*) and bentgrass (*Agrostis pallens*), bulbs (*Tritelia, Chlorogalum, Zigadenus*) appear to be either stable or increasing locally in the partially shaded understory grassland of the southern island slopes, beneath mature non-native tree plantings. Turf maintenance (mowing) almost certainly suppressed this vegetation prior to federal acquisition. The extensive clonal populations of *Agrostis pallens* (not recorded by Ornduff and Vasey) also suggest post-drought, post-mowing, post-grazing recovery (Figure 4). Native coastal scrub woody species, in contrast appear to be recruiting only weakly in the partial shade of canopy gaps in grassland. On south-aspect grassland slopes, bunchgrasses (*Nasella* spp.) appear to have increased in abundance. The overall short-term trend of the native grassland relict vegetation during the last decade has been a significant recovery of native species diversity (see Section 2.3.3.), but long-term trend is for reduction of abundance and diversity, based on expected structural trends of the blue gum and pine overstory.

The north shore woodland vegetation of East Marin Island in general is dense, old, and apparently stable in the tree layer: some very large buckeyes, gnarled large trunks of toyon (*Heteromeles arbutifolia*) occur just above the limit of tidal action, above scoured, erosion-resistant low cliffs. Pines, however, are actively spreading into oak woodland at high density above the northeast shore, and these may breach the oak canopy gaps over time. Himalayan blackberry (*Rubus ursinus*) dominance in the oak woodland may correspond with vegetation gap disturbances associated with former landslides.

The trees of West Marin Island appear to be able to survive long-term impacts of heron and egret nesting and roosts. There appears to be little whole-tree mortality at West Marin Island, and there is no evidence of any roosting impacts on trees at East Marin Island. Egret and heron impacts on West Marin Island trees may be due to canopy "pruning" (due to shoot tip breakage from wingbeats during landings/takeoffs, or possibly plucking). The low, wide, smooth crowns of West Marin Island trees may be due in part to wind-flagging on the crest of the island, but on the lee side, roosting and nesting birds may be the strongest influence on tree crown form. Potential for local dieback of tree branches due to ammonia and urea toxicity of guano deposits appears to be confined to West Marin Island. Gulls locally disturb and enrich coastal bluff nest sites on East Marin Island, often in association with sparse or prevalent non-native vegetation. In contrast, long-term occupation of eucalyptus trees by herons, egrets and (later) cormorants at Morro Bay has resulted in significant dieback and mortality of whole roost trees (blue gum) and virtual elimination of understory vegetation. Despite past predictions of tree mortality or signifcant dieback due to rookeries at West Marin Island, none is evident in 2004. Understories, however, do appear to be affected by guano deposition: abundant non-native annual grasses appear to thrive under prevailing levels of guano deposition. Similar effects may be expected at East Marin Island if rookeries establish there in the future.

Coastal scrub of southern and eastern shores of East Marin Island is in jeopardy of general dominance by *Genista monspessulana* within a decade. *Echium candicans* is also recruiting in coastal bluffs at least as well as the native dominant *Artemisia californica.*

3.0 VEGETATION CLASSIFICATION AND MAPPING

3.1. Formal and practical classification of local vegetation stands

Vegetation classification for national or regional inventories or descriptions emphasizes uniform, comprehensive systems to emphasize relationships and contrasts with widely disparate, variable vegetation over wide geographic areas (Sawyer and Keeler-Wolf 1995). Vegetation classification for site-specific management, such as parks, watersheds, refuges, and ecological reserves, however may focus on contrasts and relationships of vegetation internal to the site, with priority assigned to vegetation units of practical significance for management (protection, rehabilitation, restoration, management activities). Local vegetation stands may vary significantly from type descriptions or formulae that are useful for broad geographic treatments. Local jurisdictions, however, may also have interests in relating local vegetation types to broader geographic classsifications and mapping efforts.

The vegetation at East Marin Islands, however, comprises semi-natural derelict landscaping ("gardens gone wild") and disturbed, invaded coastal scrub and oak woodland along the coastal bluffs and steeper slopes. There are many incongruities in applying natural vegetation classifications to this condition. Classification of the highly heterogeneous stands of island by standard, objective, semi-quantitative methods based on natural vegetation would result in a proliferation of inclusions, anomalies, and units with doubtful interpretation and utility. Preliminary site-specific attempts to delineate discrete natural units on the island confirmed this.

To address the complex horticultural history of the island, and the heterogeneous patterns resulting from post-horticultural succession of the mixed native and non-native flora, a management-oriented classification of selected stand types was developed. This classification combined objective classification of discrete stands of species with management significance (invasive non-native stands or priority native populations to conserve), within a broader semi-objective mixed classification of vegetation types based on dominant species, slope, aspect, and physical environmental (habitat) factors. This approach addresses significant seasonal variation within vegetation units, such as seasonal shifts in dominance from native bulbs to non-native grasses within units. Where these units approximately correspond to objective floristic classifications (species dominance only; Sawyer and Keeler-Wolf 1995), the relationship is noted. Given the small scale of the island's vegetation and its prevailing human-influenced composition, this approach is justified. The relationship of this approach to conventional vegetation classifications is discussed below (3.2).

3.2. Interpretation and geographic scale of vegetation: integration with regional vegetation classification systems

The vegetation at East Marin Islands varies significantly it its conformity with the various published vegetation classifications used in California, or in the Bay Area. Part of the non-conformity is due to the *very small scale of the island's vegetation*, smaller than the minimal "grain" size of most regional vegetation maps (Table 5). Individual trees at East Marin Island occupy a significant portion of the total cover of the island, and particularly within distinct

vegetation types. The other major cause of the poor fit with standard California plant community classifications, however, is due to the *local horticultural history and intensive past landscaping*. The island's vegetation on the whole is an idiosyncratic "wild garden", rather than exemplary of standard regional or provincial plant communities. There are significant gaps and anomalies among these vegetation and community classification systems applied to Marin Islands stands. In accordance with the Refuge's stated interest in mapping East Marin Island's vegetation in accordance with standard California vegetation classification systems (in the request for proposals for this plan), standard systems are here reviewed and compared with the observed local vegetation conditions.

The most widely used statewide system of vegetation classification is currently the California Native Plant Society-sponsored "Manual of California Vegetation (Sawyer and Keeler-Wolf 1995). It is essentially a floristic approach to vegetation, with classification emphasis and priority of "series" based solely on dominant vascular plant species, to the exclusion of traditional vegetation factors such as physiognomy, soil, climate topography, ecological dynamics, or geographic factors, reflected in most North American systems (Zedler 1997, Sawyer and Keeler-Wolf 1995, Holland and Keil 1995). The CNPS system adopts the "series" as the basic objective plant community unit, defined by dominant species. Associations defined by sub-dominant species form subordinate classes. This almost exclusively *floristic* approach contrasts with the traditional, subjective, but widely used Munz and Keck typology of vegetation ("plant communities" following the broad concept of Oosting (1948); Munz 1959), which explicitly invests vegetation types with ecologically coherent habitat and geographic relationships. Ornduff (1974) adopted the Munz approach in his broad classification system of California plant communities, and its perspective is reflected in the Holland system of vegetation classification traditionally used in the California Natural Diversity Database. The traditional Munz classification was also the dominant influence on the standard ecological text of California vegetation (Barbour and Major 1977, 1988).

Holland and Keil (1995) modified the Munz and Ornduff approaches to a synthetic, but more detailed and hierarchical, classification of ecologically and geographically coherent vegetation units. Holland and Keil (1995) treated their plant communities as sets of variable ecological entities related to the California landscape, rather than classes or types with essential traits. In contrast, the objective floristic emphasis of series dominants in the Sawyer and Keeler-Wolf system can place vegetation from widely contrasting geographic areas or ecological communties with few or no shared associated species into the same series (Zedler 1997) dominated by one shared dominant species (e.g. tidal salt marsh and nontidal interior saline sink vegetation dominated by saltgrass, *Distichlis spicata*). Howell (1949) presented a non-systematic, subjective classification variously emphasizing species dominants or soil/habitat types in Marin County, with partial correspondence with the Munz and Keck system. Shuford and Timossi (1989) adopted a modified Munz and Keck system for their summary of Marin County plant communities.

The "oak-buckeye forest" plant community of Howell (1970) does not correspond with the coast live oak – buckeye woodland at Marin Islands, contrary to the conclusion of Ornduff and Vasey (1995). Howell's oak-buckeye forest was expressly a dry-deciduous oak, on an arid climate gradient approaching chaparral and grassland (Howell 1970 p. 9); he considered

coast live oak to be a potentially abundant member of the tanbark oak – madrone forest, and did not recognize coast live oak woodland as a distinct community, as Holland and Keil (1995) and Sawyer and Keeler-Wolf (1995) did.

Howell (1970), Munz (1959) and Holland and Keil (1995) all recognize variations of coastal scrub or "coastal brush" as a distinct community, including phases that lack coyote-brush (*Baccharis pilularis*, a post-disturbance indicator species, often abundant after removal of livestock). Sawyer and Keeler-Wolf (1995) recognize "Coyote brush series", which not only fails to distinguish between bluff scrub and general coastal scrub, but defines them in terms of a species that may not be dominant or even present, as in East Marin Island scrub during the early 1990s drought (Powell 1995, Ornduff and Vasey 1995). Sawyer and Keeler-Wolf also recognize "California sagebrush series" as applicable to coastal scrub dominated by *Artemisia californica*, but this series is defined to include chaparral and arid interior habitat vegetation, ecologically unrelated to the south-facing coastal bluffs of the Marin Islands.

If Sawyer/Keeler-Wolf classification were applied to the vegetation of East Marin Island, the tree layer units (series) would include: Monterey Pine series (exotic range, artificial in origin), Eucalyptus series (artificial); and Coast Live Oak series (natural). There is close correspondence between the oak woodland mapped and the Sawyer/Keeler-Wolf series (allowing for the scale of mapping relative to large buckeye trees and gaps), but the blue gums and pines are interplanted and do not form a coherent unit at a consistent mapping scale. The Sawyer/Keeler-Wolf shrub series under "coastal scrubs" that most closely approximates the East Marin Island bluff vegetation is "California sagebrush series", but in fact *Artemisia californica* is not dominant at most locations, and non-native succulents and *Genista* are. Mapping "potential" or ideal vegetation is contrary to the CNPS vegetation classification system, so the Marin Islands bluff scrub would be anomalous to this system. The north slope scrub (a mix of coast live oak understory, horticultural escapes, and coastal bluff elements) is anomalous for the Sawyer/Keeler-Wolf system. The distinct local phases of local native and non-native grasslands would similarly be "lumped" in broad series such as purple needlegrass series and California annual grassland series, but the scale and distribution of these units would be uninformative for management. The Sawyer/Keeler-Wolf grassland series and would fail to distinguish ecologically important variations in native perennial bulb associations in "annual grassland", despite their local dominance. Accordingly, the local vegetation variations with management and ecological significance are distinguished. For purposes of statewide mapping, they can be "tiered up" to the broader series.

3.3. Vegetation mapping of East Marin Island

Vegetation mapping of East Marin Island was based on 2003 aerial photography, multiple field surveys and GPS-based field mapping from November 2003 to August 2004. Significant or discrete stands, including ephemeral dominants (e.g. vernal flora) were flagged cumulatively over the growing season to define approximate boundaries of vegetation units. These boundaries and points were intended to be mapped by GPS techniques, but the island's large blue gum/pine overstory, steep rocky cliffs and bluffs, and seasonal satellite "gaps" combined to severely constrain satellite signals during limited tidal (navigation) access windows, and resulted in highly inconsistent and distorted resolution of GPS data. GPS data along the bluffs (the most "natural" vegetation locations) were particularly affected by signal

distortion from near-vertical cliffs and adjacent water. Point data were offset from less than 1 meter to over 4 meters from true positions, and the shapes of many polygons were either distorted or missed points needed to "close" the polygon. Most point data representing approximate positions of small stands (populations or large individuals) were retained for the final maps, but most of the vegetation units (described at section 2.2.5) were re-delineated with manual field mapping directly on aerial photographs, and transferred to GIS maps manually. The point data provided a complete inventory of mature non-native trees over 1 foot Diameter at Breast Height, with relative positions accurate within 3-4 meters.

Vegetation units were distinguished primarily by dominant species, landform (geomorphic features), slope, aspect, and outstanding artificial modifications such as excavation, fill and planting of cultivated species.

Global Positioning Systems (GPS) data were collected using a "sub-meter accuracy" Trimble GeoXT mobile GPS unit. Within accessibility constrained by tides, surveys were planned according to predicted optimal satellite geometry cataloged in a satellite constellation almanac. However, the accuracy tolerance for data collection had to be lowered due to the impact of working under tree canopy and along cliff the bottoms of edges.

Data from the GPS were then converted into a GIS (ESRI ArcInfo) database, where it was then manually adjusted using with rectified aerial photography where accuracy fell below accuracy standards. The aerial photography provided by the Refuge (which was apparently photographed at a scale of 1:2,000 and scanned at 1,200 dots per inch) was itself rectified using GPS points around the shores of East Marin Island. These "benchmark" GPS points were collected using a higher standard of accuracy (lower positional dilution of precision, or PDOP), but were nonetheless affected by the intrusion of steep cliffs and tree canopy on satellite reception. Along the shores, overall RMS accuracy for the photograph generally falls into the range of 2 meters horizontal to the GPS positions, most of which were nominally within 1 meter of true XY location. This accuracy decreases by 1 to 2 meters toward the center of the island on the photograph as a result of topographic distortion on the photograph (the photo was not orthorectified because topographic data of a sufficient resolution are unavailable for the island). Overall rectification accuracy exceeds that of publicly available USGS Digital Ortho-corrected Quadrangles (at least ~10m for 1:6,000 scale photos).

Reference features, including the built structures and former terraced garden, were digitized from Kroll (1990) figures, which were in turn geo-referenced to and corrected according to the rectified aerial photograph.

Detailed metadata documenting accuracy, provenance, projection and other technical information for the aerial photography as well as all GPS-based and photo-based digitized GIS data is available in HTML text format.

Vegetation maps of the island (Appendix 3) comprise:

(1) Tree overstory canopy map of native coast live oak woodland, and artificial plantations of blue gum, Monterey pine. This comprises the dominant vegetation layer of the island. The

blue gum and Monterey pine map includes (approximately 1 to 3 m error) positions of individual trees greater than 1 ft DBH, for inventory/monitoring of removal or snag conversion.

(2) Sub-canopy maps of contrasting grassland and coastal scrub types, and semi-artificial stands (horticultural relicts, transitions between ornamental, disturbed, and relatively natural ground or shrub layer vegetation).

(3) Maps of native and nonnative discrete plants, populations, and outlier colonies locations that have utility for conservation, management or weed control. These points also have an error of approximately 1 to 3 meters (see metatada).

(4) Management-oriented map to guide reintroduction, restoration, weed control, and tree removal activities, based on significant shrub or ground-layer stands (level at which vegetation management is applied), and major native oak woodland boundaries.

Maps are presented in Appendix 3.

4.0 VEGETATION MANAGEMENT GOALS AND OBJECTIVES

4.1 Goals for native vegetation and flora conservation goals

In the absence of a clear pre-settlement historic record of the vegetation of East Marin Island, reconstruction of a very precise model of its prehistoric vegetation, or natural potential vegetation, is probably not feasible for setting restoration objectives. Precise, narrow restoration and management objectives for the island's native vegetation are also limited by the lack of closely similar reference (surrogate) systems. The adjacent mainland vegetation in closely similar soil and local climate conditions is a suburban landscape, and the closest comparable semi-natural vegetation reserves (Angel Island, China Camp State Park, portions of the Tiburon peninsula) differ in microclimate and soil conditions, land use history, and geographic dispersal barriers. Brooks Island (Richmond) lies close to the mainland, and is separated by shallow water, suggesting only recent submergence and isolation. The small size of the Marin Islands, and their long isolation from mainland vegetation, provides a significant role for chance events (dispersal events, founder populations, local extinctions) to compose the local flora in idiosyncratic, unpredictable ways (see Section 2.3.3 and Table 3).

East Marin Island also represents no unique habitat or natural refuge potential for endangered plant species, and no endangered plants occur on the island. Therefore, as a matter of plant community restoration principle, and pragmatic necessity, the ultimate goal for management of native vegetation of the island should be to *release existing native plant populations from strong interference caused by invasive non-native plants, to the greatest extent feasible.* This goal assumes that reducing the ongoing interference (competition, occupation or pre-emption of space, modification of soil and microclimate) caused by introduced plants will facilitate a significant degree of spontaneous re-assembly of natural, native plant communities, in an unstable, dynamic state (White 1996). This goal also assumes that the re-assembled native plant community will differ from a completely natural one because of some

effectively irreversible historic changes in the island's soil and plant community conditions. It further assumes that reasonable levels of management intervention and maintenance can compensate for the most significant artificial influences of historic settlement on its native vegetation.

An alternate general approach to goal-setting for native vegetation would be to assign somewhat arbitrary standards for vegetation reference conditions, idealized generalized vegetation types, or "enhanced" plant community conditions (e.g. increased species diversity, introduction of rare species, etc.), with target specifications for ranges of native plant species composition and density. Because of the high degree of natural dynamic spatial and temporal variability of coastal scrub and grassland vegetation, and lack of appropriate reference sites, this approach is not ecologically justified for Marin Islands. It would elevate essentially esthetic native plant horticultural preferences and expectations for to the level of restoration ecology.

An appropriate subordinate goal for vegetation management of East Marin Island would be to *avoid local extinctions of native plant populations*, if declines appear to be related to competition or microhabitat change caused by invasive nonnative vegetation, or other artificial influences. Because of inherent uncertainty about whether small native plant population size is natural or not at this point in the island's history, current circumstantial evidence of decline should be sufficient to trigger a presumption against allowing extinction of native plants. The plant species currently in small populations at risk of local extinction include: *Aster chilensis, Camissonia ovata, Cynoglossum grande, Carex globosa, Eriophyllum confertiflorum, Festuca californica, Iris macrosiphon, Iva axillaris, Luzula comosa, Monardella villosa, Piperia michaelii, Phacelia distans, Potentilla glandulosa, Solidago californica, Stephanomeria elata*, *Viola pedunculata,* and *Zigadenus fremontii. See also Appendix 2)* As drought, invasive species, new management activities, and chance events proceed over time, this list should be re-evaluated.

Because East Marin Island is small and has been isolated from continuous distribution of mainland vegetation for millennia, a goal of *protecting potential local genetic differentiation of plant populations against artificial gene flow patterns and rates* is justified. This implies a presumption: any propagation or augmentation of existing native plant populations on the island should rely exclusively on local seed or clonal sources (Millar and Libby 1996).

Similarly, a conservative approach to plant introductions or potential reintroductions is justified by the lack of botanical evidence for artificial extinction of native plant populations, and the inability to discriminate between artificial past extinctions and natural, chance-driven prehistoric gaps in the local flora of the small island. This implies a *presumption against native species introductions from mainland or off-island population sources*, unless justified by overriding conservation objectives (Morse 1996). This presumption should not be absolute.

Finally, as a practical and ecological principle, goal for *minimizing intensive long-term* (10-15 year and beyond) *vegetation management activities* is justified. While idealized 'self-sustaining natural communities' may not be feasible in mixed populations of annual grasses, and with cumulative effects of low-level long-distance weed dispersal from the Bay Area, a regime of initial intensive rehabilitation of native vegetation, and subsequent low-level maintenance, should be at least a goal, if not a reality.

Summary of native vegetation management goals.

- Protect and maintain the natural isolation of island populations of widespread native plant species; avoid homogenization of populations with mainland populations. Do not import "native" plant populations from the mainland to replace or augment natural remnant plant species diversity.
- Avoid introductions of pathogens and additional non-native invasive plants; use phytosanitation techniques for visitors and equipment arriving on the islands.
- Avoid extinctions of small local plant populations of native plants on the islands; intervene by augmenting local populations when necessary.
- Manage for relatively "natural" native vegetation by reducing or eliminating (to the extent feasible) influences of nonnative invasive vegetation on existing native plant populations, rather than re-constructing or converting to theoretical "restored natural" conditions by intensive replanting of native plants. Avoid arbitrary "native landscaping" as a proxy for restoration except where local vegetation is lacking in significant native components. Keep management of vegetation consistent with observed natural local patterns of plant distribution.

4.2. Proximate goals for non-native vegetation management

While eradication of invasive non-native vegetation is desirable, and is particularly feasible on small islands relatively isolated from long-distance dispersal, eradication of all non-native plants is not always necessary or the best investment of limited resources for Refuge management. Small populations of noxious weeds should be eradicated whenever feasible. Extensively naturalized, widespread weeds that seldom become dominant, also do not require or justify eradication. They indicate control by reduction and management of native vegetation to discourage overabundance. The ultimate criterion for weed control on East Marin Island is to reduce weed population pressures, and rates of population change, to levels low enough to enable native vegetation to dominate and persist, and undergo natural dynamics without significant interference. Recovery from drought cycles, recolonization of natural disturbances such as slope failure, and long-term successional trends should not be redirected by non-native vegetation.

Jubata grass (*Cortaderia jubata*) and Napa starthistle (*Centaurea melitensis*) are recommended for *full eradication* on East Marin Island: control alone would not be prudent.
Reproduction of French broom (*Genista monspessulana*) should be eliminated by destroying all adult plants in phased long term removal strategies. Long term *Genista* removal strategy should be based on (1) early removal of seed-bearing outlier colonies and removal of juvenile invasion fronts and outliers before they bear seed; (2) and sequential centripetal (periphery-to-center) reduction of long-established seed-bearing stands. This approaches eradication, but recruitment of seedlings should be expected to occur at low levels for many years.

Monterey pine and cypress should also be *eradicated*, an objective that would be relatively easy to achieve. Pine eradication should begin with prompt removal of juvenile/immature trees, and phased kill (optional removal) of mature trees, with priority given to trees nearest oak woodlands and southern bluff tops. The variation in individual Monterey pine longevity is

significant, even though the species is generally considered to be "short-lived"; trees well over 90 years occur in plantings in Golden Gate Park and the Presidio. Monterey pines on East Marin Island should not be assumed to be self-extinguishing, particularly over a 10-20 year period; most of the trees remain vigorous, and there is significant observed recruitment of saplings.

Eradication of living blue gum is feasible, but killing individual trees will require much effort over at least several years. Blue gums are long-lived, and are very likely to persist unless actively killed or removed. Blue gum removal priorities should be along southern bluffs, with sequential removal northward. Annual grasses should be managed (reduced in abundance relative to native grasses, bulbs, forbs) grassland cultural practices. This also applies to annual Eurasian broadleaf weeds of the grassland.

4.3. Refuge goals for wildlife habitat conservation in vegetation management

Some of the primary wildlife goals for vegetation management on East Marin Island are (1) to minimize pine/blue gum habitat for avian predators of nesting egrets and herons on West Marin Island, particularly ravens; and (2) to facilitate development of potential alternative or additional suitable nesting or roosting sites in oak/buckeye woodland for egrets and herons on East Marin Island, provided that local avian predator habitat is eliminated. These goals assume that raven roost cover and nest sites would be enhanced by live blue gum and Monterey Pine, relative to snags (no cover) or lack of gum-pine forest, with only coast live oak woodland as forested cover.

Potential secondary wildlife goals for vegetation management at East Marin Island are (1) to maintain or enhance roosting or nesting habitat for osprey, provided it is compatible with egret and heron nesting on West Marin Island; (2) to maintain or increase potential woodpecker foraging in large snags, and provide potential tree cavity habitats for bat roosts.

The feasibility of developing osprey nest and roost sites is suggested by the summary of ecological requirements for the species in Marin County (Shuford 1993). Most osprey nest sites in Marin are associated with dead crowns or dead taller trees, often with platform-like broken boles or limbs near the top. Osprey nest locations reflect changing availability of suitable nest sites in Marin, and they readily adapt to new nest sites provided. Inaccessibility is a factor for nest selection.(Shuford 1993).

Over 85 species of North American birds use cavities in dead or deteriorating trees, including woodpeckers and owls. Dead and dying trees, or "topped" trees (crown breakage for platforms) are recommended for management as potential nest sites by osprey. (Schemnitz 1980).

4.4. Ancillary goals for compatible conservation of historic horticultural values

Many of the horticultural plantings (edible and ornamental plants) are historic relics with limited potential for invasion of natural habitats, especially with moderate to minimal removal efforts aimed at spreading seedlings. Only a few of the 20th century introductions, like *Echium* and *Genista*, are locally noxious weeds. To retain some sense of place and

historic cultural values related the military era landscaping and long 20th century residential use of the island, it would be desirable to retain selected *compatible*, non-intrusive horticultural plantings for retention *if they do not conflict with wildlife or vegetation management goals or occupy excessive space*. The residential plantings and some elements of terrace gardens immediately surrounding the residential complex, are one example (e.g. figs plums). Leaving some historic horticultural legacy is also cost-effective: the effort required to restore these historic cultivated areas to native vegetation would be much greater and less productive than managing existing vegetation that is predominantly native.

Later 20th century introductions have little horticultural or historic value in the Refuge. Occasional "waifs" or escapes may be detected and removed with little long-term maintenance effort. Areas of excessively dense growth of nonnative ornamentals should be at least thinned and confined to the edges of residences (if buildings are retained). If seedling recruitment proves to be significant, they may warrant complete removal. Some expanded plantings in natural vegetation, such as the periwinkle (*Vinca*) stands, should be eradicated. *Opuntia* stands in coastal bluff scrub also may be in conflict with native vegetation goals, but conflicts need not be resolved with eradication; selective reduction and retention of historic plantings may be feasible. Fruit trees may be rehabilitated (suckers, dead branches) to a few representative old individuals without compromising native vegetation. The highly unusual gravel beach plantings of Canary Island palms would be difficult to remove and dispose of, and do not actually displace a stable native community; a "laissez faire" approach to their ultimate mortality by shoreline retreat may be prudent, in view of higher priorities for vegetation management.

5.0 VEGETATION MANAGEMENT STRATEGY

5.1. WILDLAND WEED MANAGEMENT AT EAST MARIN ISLAND

5.1.1. Weed management priorities for East Marin Island

Vegetation management at East Marin Island will be constrained by time available to implement management activities (limited by tide, season, and seasonal windows for weed population management), manpower (staff and stewardship volunteers, conservation crews), equipment (lack of dock and road access for large equipment), and resources (funding and materials, including propagules for revegetation of treated sites). Therefore, overall priorities in sequence and importance of weed management activities are necessary.

Containment of rapidly spreading, seed-producing weed stands, particularly those with persistent seed banks, is the most time-sensitive weed control activity. Removal of outlier or "guerilla" juvenile weeds is necessary before they become seed parents of new colonies with persistent seed banks at new locations. French broom is the leading example of this priority. French broom is capable of rapid invasion and dominance in most grassland and scrub, regardless of disturbances from weed removal. Disturbance of soil seed banks and vegetative cover, however, are likely to promote recruitment (increase seedling density) of French broom seedlings, so long-term removal efforts must be sustained once they have begun. Reduction of other noxious weeds to their core locations, eliminating outliers, is urgent for

control of Napa starthistle, Italian starthistle, fennel, and oxalis. Control of high-density core populations (including local eradication) should follow thorough removal of outliers.

The canopy of the dominant blue gum and non-native conifer stands is arguably the primary structural control for persistence of native vegetation relics over most of the plateau of the island. Early initiation of canopy reduction at the leading, windward edge of the windbreak stands, where most sunlight and thermal breeze modification occurs, is the highest priority for "weed" control in this master vegetation layer.

Direct restoration activities for native plants (planting of propagated local populations) are somewhat lower in priority, since their success in most cases will be constrained by tree canopy and shrub layer conditions. Grassland enhancement treatments such as mowing, raking, and supplemental seeding in most cases should follow rather than precede higher priority actions such as canopy reduction. Exceptions to this priority may be for small experimental trials to adjust techniques to site-specific conditions. Another exception may be transplanting small numbers of native trees locally in the shelter of non-native overstory dominants, to benefit from both growing time and "nurse effect" of the temporarily semi-open canopy. This is consistent with the pattern of south/windward to north/downwind pattern for removal priority : oak regeneration would be focused north of the crest of the island (see management unit prescriptions), while open grassland and scrub would dominate south slopes and bluffs. The longer duration of partial shelter at the north end of the gum plantation should facilitate oak establishment, and shorter duration of gum should facilitate scrub and grassland.

5.1.2. Management of non-native trees at East Marin Island

Existing and forecast conditions with no management. Old nonnative tree plantings at East Marin Island are similar to many stands in the Presidio of San Francisco in composition, size, and age. The original plantation appears to consist of widely spaced Monterey pine (*Pinus radiata*), Monterey cypress (*Cupressus macrocarpa*) and blue gum (*Eucalyptus globulus*), all tolerant of coastal winds. Blue gum is massive at maturity, and long-lived; Monterey pine and cypress, though capable of attaining great size in cultivation, are shorter-lived and prone to disease, decay windthrow, and limb breakage at maturity. The existing plantation over time would be expected to increase in density by ongoing recruitment of understory saplings over time, particularly pine and cypress. The dense subcanopy shade and litterfall of closely spaced younger trees (subcanopy close to the shrub and ground layer), would probably cause extirpation of most native coastal scrub species beneath them within several decades of unmanaged growth, other than California blackberry (*Rubus ursinus*) and some sedges that can be quite shade-tolerant. Self-thinning (density-dependent mortality of understory trees) would probably be significant, resulting in high densities of dead standing trees with branches close to the ground, as in many unmanaged areas of the Presidio at the end of its military period. The original plantations would probably degrade over decades, with eucalyptus becoming increasing in relative abundance over decades as conifers die out.

Assumptions for wildlife values. This "cultural forest" at East Marin Island (planted nonnative trees and younger recruits), and potential management or removal activities, should be evaluated in terms of wildlife impacts to the Refuge (e.g. nesting potential for avian

predators such as ravens; alternate roost sites for heron/egret rookeries; raptor roosts; passerine habitat), a task outside the scope of this vegetation management plan. Assuming that direct potential beneficial wildlife values of planted trees are subordinate to the objectives for managing natural vegetation of the island, the plan assumes that significant reduction of planted non-native trees is appropriate to achieve overall vegetation goals.

Early elimination of growth in younger trees. Progeny of the original plantations of pine, cypress and blue gum appear to be in rapid growth phases; mature trees appear to be slower-growing. Younger trees may also have greater proportional impact to native ground layer/shrub layer vegetation because younger trees canopies produce more shade and litterfall close to the ground surface. Early cessation of growth of younger trees would be efficient and advantageous; deferred removal of younger trees may disproportionately increase overall costs and impacts of non-native trees. The young trees on south-facing coastal bluffs are among the highest priorities for prompt removal, before their canopies expand enough to cause significant loss of coastal bluff scrub.

Standing snags, felled trees, and offsite disposal. Conventional timber harvest or tree removal operations may be severely constrained at East Marin Island by its topography, lack of access for heavy equipment and vehicles used in forestry operations, lack of staging areas, and limited capacity for boat landings (limited barge access). Disturbance of recovering native ground layer vegetation may also be a trade-off or constraint for felling and removal of very large blue gum trees, particularly on erosional bluffs with gap-colonizing *Genista* and *Echium*. Costs for removal of massive eucalyptus logs and slash, (even off-island disposal were feasible), may be significantly more expensive than for urban or open space conditions on the mainland – possibly prohibitively so. The high ratio of standing tree biomass to island surface area indicates that on-site disposal (leaving large woody debris) would permanently displace a highly significant proportion of ground surface intended for native plant community restoration, defeating the ultimate purpose of tree removal (see Section 5.2.2.). This leaves two options: (1) killing trees in place to eliminate foliar canopies, leaving slow-decaying standing snags; (2) manual felling with intensive labor for bucking logs and limbs, and offshore disposal. Felling and removal may be relatively feasible if it is subsidized by donated labor and equipment, but commercial contracts for island felling may be cost-prohibitive without ample grant or Refuge budget funds.

Standing snags may be produced by girdling trees (removal of bark and cambium layers in wide strips) wound-treatment with herbicides (exposure of cambium/phloem layers to herbicide solution), or combinations of both. Standing snags are seldom considered for parks or wildland areas with significant fire risks or high visitor frequency and safety hazards. For the isolated Marin Islands Refuge, however, leaving standing snags may be a feasible "non-disposal" alternative for management of non-native trees. Blue gum wood is very slow to decompose, so standing gum snags may be effectively "permanent" (lasting more than 4 decades). Snags may enable disposal logistics and costs to be avoided, and vegetation impacts of massive deposits of large woody debris to be avoided as well. Standing snags would gradually decay, but less biomass would be deposited directly on the ground per decade, and smaller, lighter, rotted and desiccated downed wood would be easier to move and dispose of. Potential incidental habitat benefits of standing snags may include cormorant roosts and bat roost habitat in trunk cavities (cf. Lidicker and Lidicker 1992).

Owl habitat would be unlikely because of the lack of small mammal populations at East Mare Island.

One potential constraint on management of snags is potential use as roosts by ravens. Ravens appear to prefer the cover of blue gum/pine canopy, but they may adapt to their snags, and use them for feeding on eggs from the West Marin Island rookery, or for monitoring egret disturbances. If ravens do use snags as habitat, there would be much stronger justification to commit to the increased cost and disturbance of felling and removal of blue gum and pine.

If offsite disposal of dried, rotted downed wood is necessary to keep coastal grassland and scrub open, disposal methods and routes with minimal impact to vegetation should be planned. It may be possible to drag or roll limbs/bucked trunk sections downslope to southeastern bluff segments dominated by non-native clonal stands of *Opuntia ficus-carica* (prickly-pear cactus). Wood may be rolled down the bluff face over (expendable) non-native bluff vegetation to the shoreline. At the shoreline, crews may carry wood to the intertidal zone at low tide, tie woody debris together with nylon cord into flotillas, where they could be floated off at high tide and retrieved by tugs or barges for disposal on the mainland.

Spatial pattern and sequence of tree removal or snag conversion. As discussed in management of native grassland and scrub vegetation (Section 5.2.2.), the most effective pattern of nonnative tree stand conversion would probably be to generate a progressive wave of skeletal forest, or felled trees, from south (windward in relation to most bay breezes) to north, maximizing exposure of the understory to both sunlight and wind. Young trees on the bluff landslide slopes should be removed or killed in place first. Reducing windbreak effects of the non-native vegetation should increase moisture stress, and favor competition by most native coastal grassland and scrub species. Phasing a wave of skeletal forest may also help mitigate esthetic effects of stand conversion, buffering changes in canopy views among years. Beyond the wave of contiguous tree removal/snag conversion, individual trees shading areas of relatively high native plant species diversity or density may be targeted for canopy reduction, creating larger gaps within the non-native forest.

5.1.3. Management of weed seed banks

Weed seeds at East Marin Island disperse and persist in contrasting modes, requiring multiple strategies for management. Infrequent long-distance dispersal by wind, water, or bird (fecal) transport of seeds cannot be managed directly. Some indirect modification of long-distance dispersal by weed seeds can potentially be effected by reducing habitat quality for birds that prefer artificial ornamental and edible landscaping, such as mockingbirds, starlings, etc. This may be achieved by limiting ornamental non-native fruit trees and shrubs (cherries, plums, Himalayan blackberry) on the island.

Short-lived weed seed banks are relatively manageable. They can be sharply reduced by several consecutive years of reduced seed production (see annual grasses, Appendix 1; also Section 5.1.4.1., below). Long-lived seed banks, in contrast, require either (a) long-term recruitment and elimination of seedlings, with accelerated recruitment or "flushing" by repeated disturbance; or (b) suppression by creating unsuitable cover for recruitment, such

as dense perennial or woody cover, heavy leaf litter deposits. Native "smother crop" vegetation may be semi-artificial in relative abundance and species composition for practical purposes o managing weeds. Potential local native candidate species for this purpose would include competitive clonal or laterally extensive shrubs and perennials with high density or canopy cover, such as *Rubus ursinus, Carex barbarae, Leymus triticoides, Festuca californica, Lonicera hispidula*. The use of these approaches depends on the type of native target vegetation suitable for the site and stage of succession appropriate. For vegetation types that require semi-open conditions (grassland, scrub with vegetation gaps), the flushing/eradication approach is most appropriate, because long-term weed recruitment in restored vegetation causes conflicts with both control and restoration. For potentially closed vegetation types (sod-forming grasses, sedges, dense scrub), rapid revegetation with dense cover may be a feasible control method for persistent seed banks.

5.1.4. Control of wildland weed populations

5.1.4.1. Methods, techniques of weed control suitable for East Marin Island

Prevention. The Refuge has limited control over natural dispersal of additional weed species from suburban landscapes of San Rafael Bay to Marin Islands by wind, water, or bird transport. The Refuge does have some indirect control over local habitat selection for birds that are more likely to forage in native grassland and coastal scrub rather than consume and deposit fruits and seeds from domestic or agricultural landscapes (e.g. mockingbirds, robins). Native plant community restoration, like non-native vegetation, may tend to reinforce itself by attracting dispersers of its own seeds. Most importantly, the Refuge has direct control over policies regarding incidental transport of weed seeds to the island by boots, fabric, equipment, or nursery materials transported by Refuge personnel, contractors, and volunteers. Sanitation practices for Sudden Oak Death prevention (Section 5.2.1) also apply to inadvertent introduction of weeds. The Refuge *should minimize or prohibit importation of soil with potential to transport weeds (seedlings or dormant seeds) from nursery sources*. On-site storage of generally useful, adaptable equipment for weed removal (tile spades, curved-blade folding pruning saws) is recommended.

Winter wet-season transplanting of perennial and woody species can be performed by *bare-root transplants* with high success rates (and usually superior rooting than with rootballs). Bare-root transplants can be grown as container or field-grown plants, dug, and washed free of soil during winter dormancy immediately before transport and transplanting. Prepared bare-root stock is temporarily stored and transported in cool, shaded, moist bags or containers (wet sawdust, peatmoss, vermiculite, or other sanitary media). Compensatory top-pruning (about 1/3 shoot mass removed) increases the survivorship of transplants. Container-grown transplants are necessary only if transplanted during active spring growth, which should be avoided for horticultural reasons in addition to weed control objectives. Any translocated plants should be packed wet and dormant as bare-root transplants. Local populations of native annual plants propagated off-island for seeding should be reintroduced as manually harvested seed from essentially weed-free plots. Any weeding or digging equipment should be washed free of soil before transport to the island. Boots, packs, field books should be cleaned of plant debris prior to arrival at the island.

***Manual removal* (pulling, digging, cutting)** Small shrubs and non-clonal caulescent perennial herbs with taproots (those with above-ground stems, no rhizomes, stolons, or adventitious shoot buds on lateral roots) can often be adequately removed by pulling firmly and slowly from the base of the plant, particularly in moist, sandy or gravelly soil, or in debris slides. If breakage occurs at or slightly below the soil level, where dormant buds may remain on the detached basal shoot section, bud sprouting and shoot regeneration is likely to occur. Breakage versus successful removal often varies with plant size and with soil firmness. Manual pulling of weeds in high density populations may cause substantial concentration of soil disturbance patches, which are often sites for either seedling regeneration of the species being controlled, or establishment sites for other weeds present, but competitively suppressed by the target weed species. Pulling should be avoided where significant soil disturbance is observed, and below-ground cutting (using locking curved-blade pruning saws) should be used instead. Examples of weeds potentially amenable to removal by pulling in suitable soil conditions include French broom, Pride-of-Madeira, and Monterey pine.

Digging (manually grubbing root-crowns, roots, or excavation with spades, shovels) causes more severe soil disturbance (and potential stimulation of non-target weed succession) and should be employed sparingly in weed control of relatively intact coastal scrub or grassland. The same caution against soil disturbance applies to many specialized manual weed removal tools, such as weed wrenches, root jacks, etc.

If soil disturbance occurs from pulling or digging, small-diameter woody or semi-woody erect plants can be manually severed at or slightly below ground level with a sharp, curved pruning saw. Sharp, high quality curved pruning saws can work quickly and efficiently to cut very close to or slightly below the soil surface, with virtually no soil disturbance. The probability of leaving viable buds on the severed shoot increases with height of the cut above the ground surface. Cutting is appropriate only for those erect woody and perennial species that normally do not regenerate from basal buds at or below the ground surface. Pines, cypress, pride-of-Madeira, and (with caution) French broom are potential subjects for cutting. Moderate-sized jubata grass plants (basal diameter less than 6 inches) can also be severed by pruning saws, sometimes with greater ease than other tools like mattocks. Himalayan blackberry, fig, acacia, ivy, and olive can regenerate from buds below ground, and are unsuitable subjects for cutting unless used in combined treatment with either cut-stump herbicide treatment, or post-resprout herbicide treatment. Other tools can also be used to cut rosette-forming or basal crown-forming herbaceous perennials, such as Acanthus, Italian thistle, fennel, sweet-clover, English plantain, radish, and Napa starthistle. Sharp hoes can be used with precision for small forbs, adjusting angle of cuts along the flat blade or its corners. For larger forbs, narrow tile spades are also useful for severing tough root crowns, since they have narrow, curved blade tips and are designed to allow the force of a boot heel to cut. Their blade tips may be sharpened with a file or sharpening stone for precision weed cutting.

Girdling. Girdling consists of removing a continuous ring of bark below the cambium layer (meristematic tissue producing wood and bark on opposite sides), with sufficient exposure so that callus wound tissue cannot bridge the girdle cut within a growing season. The girdle cut prevents photosynthate (sugars) from being translocated to roots, causing root death and later shoot death. Trees lacking stump-sprouting ability (especially conifers

such as pines, cypress) can be killed efficiently by girdling alone. Stump-sprouting trees usually respond to girdling by proliferation of juvenile basal shoots, sometimes keeping roots alive long enough for the girdle cut to regenerate by natural bridge grafts. Eucalyptus stump-sprouts readily. Pines are readily killed by girdling within one year. Girdling can be combined with use of systemic herbicides on fresh girdle wound tissues, or directly on dense masses of stump-sprouts. Repeat treatment of multiple stump-sprout generations may be needed for large eucalyptus trees. Successful girdling of large trees produces standing dead snags that gradually shed branches and limbs, and develop cavities. Girdling small trees prior to felling may reduce the mass and density of wood and slash to be disposed, making handling easier.

Girdling is performed in winter-spring months when cambium is active and water potential is high; inner bark easily separates from true wood at this time. A strip of bark at least 3-4 inches wide, exposing bare wood, is removed by hatchet, axe or pruning saw. Fresh cut tissues may be treated (sprayed, painted) with appropriate herbicides such as glyphosate or imazapyr.

Herbicides and application techniques. Prudent, selective use of herbicides with low toxicity to wildlife, low persistence (half-life) is indicated for many wildland weeds that are morphologically unsuited to control by cutting or digging. Geophytes, cryptophytes, and hemicryptophytes (perennials with regenerative buds significantly below the soil surface), clonal perennial plants (those with below-ground rhizomes, bulbs, bulbils, root buds, etc.), lianas (woody vines) capable of layering (stems re-rooting on contact with the ground), and woody plants with strong resprouting from basal buds or root suckers are appropriate subjects for herbicide treatment.

Glyphosate, an isopropylamine salt of a synthetic amino acid derivative (N-(phosphonomethyl)glycine, an exceptional herbicide chemistry), is widely used in forestry and wildland weed control work because of its very low reported mammalian and bird toxicity, and its physiological inactivation caused by adsorption on soils. It is registered for use in California. It has broad-spectrum, nonselective systemic action (translocated to below-ground parts), lethal to broadleaf plants and monocots, and conifers. Its efficacy can be limited by physical resistance to absorption, often caused by thick, water-repellant waxy cuticles on leaves of some species. Its formulations for terrestrial use include surfactants to increase leaf wetting and absorption. (EPA 1993, U.S. Forest Service 1997). Recent commercial retail formulations include mixtures include supplemental herbicides such as diquat for faster visual dieback responses; the following discussion does not refer to such mixed formulations. Glyphosate formulations are now sold under a variety of trade names by multiple manufacturers. Legal use of glyphosate must conform with label requirements.

Glyphosate may be applied as a foliar spray (to point of wetting), or pressurized wick application. Wick applicators minimize non-target plant contact with herbicide from spray drift or drip. Glyphosate can also be applied as a narrow-beam spray on cut or lacerated ("frilled") stumps or bark wounds, with varying efficacy. Generally, wounded tissues exposed to glyphosate do not regenerate. Glyphosate can be applied to bark wounds or

girdled bark ("hack and squirt"; see manual methods, above) to poison large trees, such as eucalyptus, pine, cypress, fig, acacia, plum, and others.

Mature leaves with thick cutinized surfaces (waxy cuticles) resist wetting by glyphosate solutions, even with strong surfactants. Uptake of glyphosate solution can sometimes be augmented by breaking or crushing foliage with weed-whackers, machetes, or steel rakes, or by trampling. Many woody plants are most responsive to glyphosate when producing soft, young herbaceous new growth, either in spring, or following regeneration from pruning or cutting. Ivy (*Hedera helix*) and periwinkle (*Vinca major*) are good examples of recalcitrant glyphosate subjects that should be controlled with seasonal timing or pre-treatment to complement use of glyphosate for control (Appendix 1). For stands of weeds with complex foliar canopies and many non-target plants present, pruning as a pre-treatment to force proliferation of dense, low, compact resprouts may be a means of reducing herbicide use, minimizing non-target contact, and increasing efficiency of application and coverage. Pre-herbicide pruning to generate compact, low new growth may be useful for treating some stands of ivy, French broom (*Genista monspessulana*), fennel (*Foeniculum vulgare*), and Himalayan blackberry (*Rubus discolor*).

Glyphosate can be applied as a spot-spray to kill individual crowns or rosettes of forbs prior to bolting, using backpack sprayers with adjustable nozzles, or even hand-held sprayers. Napa thistle, radish, and italian thistle, for example, are suited to spot-spray treatment by glyphosate. Broadcast sprays are appropriate for monotypic stands of weeds with clonal mats or similar cover, such as iceplants (*Carpobrotus*, *Drosanthemum*), and mattress-vine (*Muehlenbeckia*).

Glyphosate is infeasible for control of most naturalized grassland weeds with diffuse patterns of dispersion, such as annual grasses, storksbills and cranesbills (*Erodium, Geranium* spp.), chickweeds (*Stellaria media*), clambering vetches (*Vicia* spp.) and Tangier peas (*Lathyrus tingianus*), etc.

The use of glyphosate at East Marin Island is particularly well-suited to: control of weed stands on steep slopes where soil disturbance is undesirable or footing is unsafe; monotypic, dense stands of shrubs or mat-forming perennials; localized treatment of cut stumps or girdled trees; and layered lianas or clonal perennials. Use of glyphosate is generally unsuitable for diffuse, mixed stands of weeds in predominantly native vegetation, unless applied directly to cut stumps or reprouting crowns.

Imazapyr (trade names "Arsenal", "Chopper") is also used for forestry and wildland weed control work. It also has very low reported wildlife and human toxicity, but is not inactivated by contact with soil, and is more mobile in groundwater. It has somewhat greater risk of non-target and residual activity. Because there is less information about its use in wildand weed control in California, it is mentioned here only for future reference and inquiry if an alternative to glyphosate is needed.

Burning. Controlled burns are used to manage weedy vegetation (starthistle, annual grasses) in portions of China Camp State Park, where it has enhanced bunchgrasses (*Nasella* spp.). Hatch *et al.* (1999) found that burn management of some coastal grasslands may have

undue artificial selection effects in favor of *Nasella* spp. at the expense of other important native coastal grassland species. The use of controlled grassland burns at East Marin Island is presumably infeasible because of a lack of water supply and access for equipment for controlled burns, and extremely high accumulation of woody fuels from the unmanaged cultural forest. Use of small burn-boxes (metal containers for burning small individual patches at a 1 meter scale) may be feasible for experimental establishment of locally enhanced native seed source populations.

Grazing. The unfortunate results of overstocking and non-selective overgrazing by Barbary sheep in the late 1980s (Lidicker and Lidicker 1992, Powell 1995) suggests great caution is needed in the application of grazing as a grassland and coastal scrub management technique. It may, however, have some short-term utility in removing excessive weed biomass in heavily invaded vegetation.

Marin Islands are probably not naturally grazed coastal grasslands, and may be expected to have distinct vegetation because of its isolation from grazing. The degree of historic modification of Marin Islands grassland vegetation, and the naturalized annual grasses prevalent, indicate that restoration of purely natural grassland conditions may be as infeasible locally as in the rest of California.

For management of native perennial California grasslands, grazing intensity and timing of grazing are important factors for grazing maintenance.. Potential benefits to coastal grasslands from moderate to light grazing by sheep or cattle include reduction of accumulated inhibitory non-native grass leaf litter, reduction of competition by dominant annual grasses, and selection for grazing-tolerant perennials (Hatch *et al.* 1999). Commercial sheep grazing year-round can maintain high native species diversity of forbs in coastal grasslands of west Marin and Sonoma counties, and seasonal, rotational sheep grazing is used with some success to manage degraded native coastal grasslands in northwest Sonoma County at The Sea Ranch (pers. observ.). Dyer (1993) recommended brief, intensive spring grazing by sheep to enhance California *Nasella* bunchgrass communities, based on long-term experimental plot results at Jepson Prairie, Solano County. Prediction of site-specific effects of domestic grazing animals on local grasslands at East Marin Island may be infeasible, and may require adaptive management. Use of grazing animals at East Marin Island would be at least initially incompatible with many plant population enhancement, augmentation, or reintroduction activities. Experimental low-intensity grazing management (less than 1 sheep per acre grassland) may be appropriate for future maintenance of coastal grassland vegetation after more fundamental vegetation management actions, like reduction of non-native forest canopy, and establishment of native woody trees above grazing/browsing height, are successfully completed.

Goat grazing/browsing within confined areas (solar electric fence enclosures with watering stations) can be used to reduce all vegetation in heavily invaded, non-native dominated vegetation, but it is entirely non-selective. Goat grazing would be comparable to the effects of past Barbary sheep on the island that largely denuded above-ground cover. It would be appropriate only for overwhelmingly non-native stands, and only in summer. The overall cost-effectiveness of maintaining fence exclosures, water, and moving grazing animals off and on the island is probably low if commercial goat grazing leases for weed control are

used. Goat browsing may, however, be considered if some weed invasions escape control and other methods fail. Sonoma Land Trust (Nathan Boone, Land Manager, pers. comm. 2004) is developing cost-effective grazing leases for baylands in San Pablo Bay.

Mowing and raking. Mowing and raking are partial surrogates for the effects of grazing and burning on mixed annual and native perennial grasslands. Combined mowing and raking is appropriate for grasslands that have accumulated thick leaf litter (thatch) of dead annual grasses, especially where bulbs or perennial grasses are present but suppressed by thatch.

Mowing can be timed to coincide with the seasonal stages between the annual grass flowering, and early fruit (caryopsis or "seed") set, prior to later stages of fruit maturation when severed fruits may ripen to viable seed. Mowing prior to seed set can significantly reduce annual grass seed production. For annual grasses with short-lived seed banks, two successive years of mowing may cause a substantial decline in seedling recruitment. For a spectrum of non-native annual grasses species with slightly different flowering and fruit set times, mowing times must be set for the earliest-maturing species of the stand treated. In general, annual grass fruit maturation occurs in May-June, but may occur earlier and later, depending on temperature and rainfall patterns. In years prolonged growing seasons for annual grasses (early emergence, warm winters and cool, late-season rainfall conditions), two spring mowings may be necessary to control later-maturing grasses capable of tillering after initial mowing. Mowing is likely to limit seed production of perennial native plants during treatment years, but this is unlikely to cause significant long-term population effects in perennials. Mowing is likely to cause significant local reductions of seed production in late-maturing annual native forbs if they are present in the treated stand.

Mowing at small grassland sites (less than 10 acres) like West Marin Island can be performed mechanically (power mowers) or manually (weed-whackers or cutting tools), depending on availability accessibility of equipment, availability of operators at critical seasons, roughness of microtopography, and area treated. Intensive treatment of discrete patches (minimum size approximately 5 to 10 m diameter) in 2 successive years is recommended over single-year widespread mowing. Hand-pulling of grasses is not recommended because of incidental soil disturbance in the presence of weed seed banks (dislodging stress-tolerant native bulb seedlings, reducing soil bulk density, facilitating weed invasion) and potential loss of native soil seed banks with attached soil. Mowing height should be adjusted to the stand conditions, so that nearly all fruiting structures are cut.

Unlike grazing or burning, mowing alone deposits leaf litter (thatch) and the nutrients it contains. Leaf litter promotes regeneration of annual grasses and many grassland weeds, and suppresses emergence of relatively mesic native coastal grassland species in California (Dyer 1993, Reynolds *et al.* 2001) and other grassland types (Foster and Gross 1998, Besenyei and Trueman 2001). Mowing with redeposition of leaf litter may have limited effectiveness because of high fitness (vigor and seed production) of annual grasses recruited in treatment areas at reduced densities. Residual leaf litter of mowed mixed annual/perennial grassland stands is likely to suppress recruitment of native plant seedlings more than large-seeded weeds and annual grasses. Intensive manual raking of accumulated leaf litter is likely to further reduce numbers of large, light, barbed annual grass fruits within litter layers. Exposure of surface soils should also create favorable microsites for emergence of native

grassland species small or heavy, smooth-seeds, and reduce competition for emerging bulbs and buds of perennials. In this respect, intensive raking without subsurface soil disturbance is similar to biomass-removal aspects of burning (Hatch *et al.* 1999), without including antagonistic effects among native species, nutrient pulses, or fire-dependent germination cues.

Raking thick annual grassland to remove most shoot litter requires two types of rakes, and two phases of raking: initial raking with rigid-tine soil rakes for bulk removal of matted thatch, followed by raking with flexible-tine leaf rakes to scarify the soil surface and efficiently remove finer surface debris. Removal of surface debris with leaf rakes tends to select for small, rounded seed, while barbed seed of annual grasses tend to be enmeshed and removed with litter.

Recurrent raking also removes soil nutrients with biomass, which is expected to favor competition by stress-tolerant native perennial grassland species (Besenyei and Trueman 2001, Foster and Gross 1998). Addition of available soil carbon (sawdust, sugar) to immobilize excess soil nitrogen (a key soil nutrient favoring competition by productive weeds), known informally as "reverse fertilization", may at least temporarily increase relative abundance of native species in some grassland systems (Morgan 1994, Seastedt et al. 1996, Blumenthal 2003). Soil carbon addition should be considered experimental, not a primary management tool for Marin Islands. The sandstone-derived soils of the island probably have low nutrient-holding capacity, so removal of tree and annual grass litter sources of nutrients may sufficiently promote regeneration of native plant community composition. If it does not, other methods such as burning, grazing, or carbon addition may be used experimentally.

Intensive manual raking, a "gardening" technique, is not a method with wide applicability to most large native grassland reserves, but it fits the small scale of East Marin Island well. It is also fitting for the use of volunteer stewardship crews available for brief, intensive, manual labor. Given the constraints of conventional native grassland management methods (grazing, burning) for East Marin Island, it may be relatively feasible to attempt as adaptive management. At East Marin Island, raking may be most effective when above-ground standing litter is deteriorating (readily detached and removed) in late summer or fall. (Author's note: my own experience with intensive raking as a tool for restoration of native grassland bears this out: after two successive years of intensive fall raking after manual cutting of annual *Bromus/Briza/Avena*-dominated grassland plots in the outer Coast Ranges of northwestern Sonoma County, qualitative results included strong shifts in dominance from annual grasses to native bulbs, *Lotus* spp. *Gilia* spp., *Trifolium* spp. in the absence of seeding, with initially low densities of native forbs and bulbs. Native bunchgrasess (*Nasella* spp., *Elymus glaucus*) increased in relative abundance and vigor following intensive raking. Raked grassland plots resembled adjacent fall-burned plots closely.)

Practical, minimal post-treatment monitoring of weed plots. Any successful weed treatment in vegetation with more than one weed species indicates the potential for competitive interactions and invasions to cancel each other's control efforts, and minimize potential benefits for native target beneficiary populations. Intensive, quantitative monitoring of vegetation can be labor-intensive and expensive, and limited labor and funding resources for weed treatment and monitoring may make competing demands

between weed control work and monitoring. To ensure that wildland weed control efforts do not result in serial replacements of one weed species with another, it is important that at least minimal subjective rank estimates of plant cover or other measures of abundance are recorded following weed control work, and at intervals thereafter, for at least several years. Photographic records from fixed-perspective benchmarks are also useful basic tools for assessing long-term effects of weed control in case other monitoring activities are curtailed by changes in budgets or staff.

5.2. MANAGEMENT OF NATIVE VEGETATION AT EAST MARIN ISLAND

The management of native vegetation refers here to general practices aimed directly at modifying or enhancing established, existing native vegetation of East Marin Island. Indirect benefits from species-specific wildland weed control practices are covered in Section 5.1, above. Reintroduction of species not currently established at East Marin Island, and augmentation of existing populations by propagation, are treated as optional components of vegetation management.

5.2.1. Coast Live Oak management and phytosanitation

Sudden Oak Death. The mature stand of coast live oak (*Quercus agrifolia*) dominant along the north shore of East Marin Island exhibited no symptoms of Sudden Oak Death, an often lethal stem blight caused by a parasitic alga ("water-mold") *Phytophthera ramorum*. Sudden Oak Death infection is severe in much of Marin County, and inoculum should be presumed to be abundant from mainland sources. Lack of current infection on East Marin Island may be due in part to the isolation of Marin Islands from mainland sources of infection (rainsplash, transport of soil, wood products, landscaping materials), and the infrequent occupation of the island by visitors during the years Sudden Oak Death spread occurred in the region. The vectors of *Phytophthera ramorum* are not fully known, but basic phytosanitary precautions should be enforced for visitors (especially volunteer stewardship crews, restoration crews routinely handling plant and soil materials), equipment, and materials (especially nursery materials). Nursery-grown plants from Marin County generally should not be brought to East Marin Island. Weeding equipment used in counties with Sudden Oak Death should be washed with detergent or bleach before being transported to the island. Boots and other gear used by stewardship volunteers should also be washed before arrival at the island

Oak seedling/sapling transplanting. Locally abundant "seedling" colonies (dwarfed saplings) of coast live oak occur below mature tree canopies, and under stands of French broom (with nutrient-enriched litter and soil), at several locations near the trail from the boat dock to the residence area. This cohort of small saplings is probably not likely to persist in the long-term because of high density, tree canopy shading, and competition with broom. This sapling population may provide an effective pre-established "nursery" source for appropriate-sized transplants from the local genetic population. The local oak population should be used exclusively for any transplanting work, to avoid risk of Sudden Oak Death infection, and to conserve any potential genetic differentiation of the local island population. The oak stands should be inspected at least annually for symptoms of Sudden Oak Death. If potential symptoms are detected, the Refuge should consult with Marin County Agricultural

Extension Services for diagnosis and recommended treatment. It is likely that infected trees may require rapid removal to avoid spread of infection by rainsplash dispersal. Other than disease inspection and weed control, mature oaks should require no other intervention.

Distribution and microenvironments of oak transplants. The pattern of oak abundance appears to relate to moisture gradients according to slope and aspect: oaks are most abundant on relatively steep, north-facing slopes with greater shade and moisture than gentle south-facing slopes with chronic exposure to desiccating thermal breezes from the Golden Gate. Oaks may be dispersal-limited on East Marin Island in the absence of small mammals that cache acorns. Coastal scrub and grassland were probably naturally dominant on south slopes and exposed plateau areas. Some relatively gentle north-aspect slopes suitable but unoccupied by coast live oak are dominated by exotic shrubs and small trees near the residence site, and some occur under the Monterey Pine overstory. These partially shaded, sheltered sites may provide both suitable initial establishment sites, and natural settings for restored low-density stands of oak within grassland and coastal scrub. Suitable sites for oak transplants would be in cleared patches of *Vinca* and *Hedera* (between residence and boat dock, derelict terrace garden; Map 4).

In natural conditions, the gentler south-aspect slopes with slightly greater exposure to wind and sun may have been relatively harsher sites for seedling establishment of coast live oak, but the wind-sheltering and partial shade of planted blue gum overstory trees and adjacent shrubs may ameliorate moisture stress from wind desiccation and sun, facilitating oak sapling establishment. Callaway and D'Antonio (1991) found higher survivorship of coast live oak under partial shade of "nurse" shrubs than open exposed sites subject to moisture stress. Parikh and Gale (1998) found less clear "nurse shrub" facilitation of coast live oak seedlings, but agreed with earlier authors (Callaway 1990, Matsuda and McBride 1986) that moisture stress (related to slope, aspect, soil, and other factors) is a primary influence on seedling survivorship and distribution. The present non-native tree and shrub cover may facilitate establishment of coast live oak transplants while phased south-north blue gum and pine removal is in progress.

Oak seedling/sapling transplanting techniques specific to East Marin Island. . Transplanting guidelines for coast live oaks should be modified if salvaged wild seedlings are used instead of deep nursery pots for saplings. All transplanting should occur in cool, wet winter months (Dec.-Jan. or early Feb.) to minimize moisture stress during handling and after transplanting. Transplants should be lifted (dug from multiple oblique cuts 1 ft away from seedlings, to a depth of about 1 ft, pushed up as a cone), and soil should be manually loosened to retain as many intact lateral root branches as possible. Lifted root systems should be moistened immediately, covered, and shaded. Small saplings (under 20 cm tall) may be planted bare-root with no soil amendments. Approximately one third to one half of the leaves should be removed from the shoot base towards shoot tips to reduce transpiration, but shoot pruning or disbudding should be avoided. Because no browsers or grazers are present on East Marin Island, no cages are necessary. Disturbed soil at transplant sites should be heavily mulched with leaf litter (other than eucalyptus or pine) to retain near-surface soil moisture, and inhibit weed seed emergence and competition, especially annual grasses. "Cages" of twigs loosely arranged as cones over seedlings may be used to provide temporary partial shading (less than 50%) of seedlings, using local materials.

Similarly, buckeyes (*Aesculus californica*) can be propagated by seed collected from local East Marin Island populations (Section 5.2.3.), and transplanted bare-root into appropriate sites during the winter or late fall. The distribution of deciduous California buckeye on the island, in contrast with oak, may occur naturally on relatively dry, windward slope and plateau sites. Some buckeye recruitment has occurred already on upper slopes of landslides on the south shore. Buckeyes become dwarfed or wind-flagged on exposed, windy, stressful sites, and occur on even extremely small islands (like Rat Rock) at China Camp. Replacement of some gum, pine, and cypress with California buckeye saplings, at low densities (mostly spaced more than 2 mature crown widths apart, roughly 50 to 100 ft spacing) would be an appropriate component of forest stand conversion: standing snags may facilitate establishment of sparse buckeye groves to replace non-native trees. In the long term, mature East Marin Island buckeyes may provide potential alternative rookery sites for herons and egrets.

5.2.2. Grassland and coastal scrub management

The primary limiting factors affecting the quality of coastal grassland and scrub of the plateau and gentle south-facing slopes (above marine cliffs and bluffs) appear to be:

- Shading and litter deposition by planted non-native overstory trees;
- Competition with non-native annual grasses
- Cumulative leaf litter accumulation

Some degradation of coastal grassland and scrub (potential loss of native species richness or abundance) may be residual from historic factors, such as the recent era of combined sheep grazing during a drought.

The most fundamental changes in quality of coastal grassland remnants would be achieved indirectly through management of the nonnative tree canopy and early-stage *Genista* invasions. Reduction of the non-native tree canopy is treated in Section 5.1.5. Even partial removal of the canopy (selective cuts of individual trees or clusters of trees, forming large gaps and gap-edges in the understory), should significantly increase the growth, survival, and recruitment of native grassland and scrub species. Removal of low-density, juvenile-dominated *Genista* stands before they develop dense canopies and leaf litter would help prevent rapid loss of native grassland stands. Trees killed in place, or removed, at the south end of the island would be expected to have the most beneficial impact on physical environmental factors favoring coastal scrub and grassland. Thermal breezes from marine air inflows generally approach from the south and west. Planted trees and non-native shrubs at the southern end of the island act as windbreaks, casting wind-shadows and light-shadows towards the central slopes and plateau of the island that support remnants of coastal grassland and scrub. The reduction of near-surface wind velocities reduce desiccation stresses that shift competition in favor of weeds adapted to more mesic soil and vegetation. Many coastal scrub species are relatively shade-intolerant. If phased removal or killing of planted trees is implemented, early phases should be located at the south end of the island, moving north.

If planted trees are felled, impacts to native understory vegetation can be minimized by conducting felling operations in late summer or fall, but before fall germination. The amount of slash to be handled and disposed, and the weight of bucked trunks and limbs can be minimized by felling trees after they have been killed by girdling or wound-herbicide treatment, and allowed to dry for one season. Felled trunks left on the ground surface as large woody debris (for lack of disposal feasibility) may be expected to occupy space for native vegetation for many decades. Heavy organic residue from rotted logs may permanently establish unsuitable conditions for native coastal scrub and grassland. There is a trade-off between light exposure from felling trees, and ground surface area permanently occupied by large woody debris. Leaving standing snags of girdled/killed trees may be a better long-term compromise for benefits of coastal grassland and scrub management if off-island disposal of felled trees is infeasible. (see Section 5.1.2.).

Locally abundant *Genista, Opuntia* and *Echium* stands on southwest and southeast coastal bluffs would not be substantially affected by tree removal. These would require targeted removal of seed-parents (*Echium, Genista*) and vegetative dispersal sources (*Opuntia*) on bluff faces, particularly near bluff crests.

Other planted tree removal/killing patterns should be located according to the positions of potential canopy gaps and patches of high-diversity native coastal grassland and scrub patches. Estimating the position of potential canopy gap shadows for the mid-spring ground layer (when most native plants are reproducing, and most responsive to competition), individual planted trees can be targeted for early canopy reduction to benefit native understory populations.

The second most important influence on the quality of grassland remnants is the abundance (biomass, cover dominance) of annual non-native grasses, including persistent accumulated leaf litter (dead shoot material, or thatch). Accumulated leaf litter inhibits perennial California bunchgrasses (Dyer 1993, 2003), and many native annual grassland forbs, while favoring regeneration of annual grass species (see Section 5.1.4.1.). Intensive raking of senescent annual grasses in summer to fall can remove annual grass biomass and nutrients, acting as a partial surrogate for grazing and burning. Intensive raking can also remove a substantial amount of annual grass seed. Combined close mowing in late spring (early stages of annual grass seed set) and raking can have a stronger effect on local annual grass seed bank depletion, especially if conducted for two or more consecutive years.

Mowing in late spring, however, may also have an adverse effect on seed reproduction of native species, particularly native annuals. Therefore, spring mowing should be emphasized for areas with large native perennial populations, and few native annuals (this applies to almost all the grasslands). Native perennials can tolerate short-term reduction (2-3 yr) in seed production, because they regenerate primarily by vegetative means, and their increased vigor due to reduction of inhibition by annual grasses should compensate for impacts of mowing. Native perennial grasses and forbs are likely to respond to temporary mowing-induced reductions in seed reproduction by producing larger, *more viable and competitive seeds* in the fallow year following mowing treatment, as native bunchgrasses do following burning treatments (Dyer 2003). Mowing and raking of annual grass-dominated vegetation, however,

are likely to have antagonistic effects on coastal scrub succession on bluffs, where manual pulling or selective herbicide treatment would be more appropriate for annual grass removal.

The natural proportion of coastal grassland vegetation on soils of East Marin Island may be relatively low. Coastal scrub may be the long-term potential dominant vegetation on fractured graywacke-derived soils, especially where local soil clay content is low. Twentieth-century land-use history, such as original clearing of scrub for non-native tree plantings, may have initiated succession with enhanced conditions for native grasses. Following removal of the non-native tree canopy, long-term shifts towards dominance by coastal scrub need not be treated as an unnatural or undesirable trend. Most coastal scrub vegetation on the Marin Coast retains substantial pockets of grassland vegetation more than five decades after removal of livestock. In restoring the quality of native (versus natural) grassland on East Marin Island by biomass-removal methods, gradual reduction in the intensity of grassland management efforts may be appropriate to enable natural succession to coastal scrub to proceed.

Trampling of grassland vegetation by visitors should be restricted to narrow prescribed footpaths (avoiding locally uncommon forbs) during sensitive spring and early summer months. Trampling of coastal bluffs should be restricted to a minimum in all seasons because of soil shear potential.

5.2.3. Optional methods for augmentation of selected plant populations

Need, purpose, and feasibility of selective addition of propagules. Reduction of direct competition by annual grasses and invasive broadleaf weeds, and reduction of non-native tree canopies, should enable most of the larger native grassland plant populations at East Marin Island to recover spontaneously to resilient, natural ranges of local abundance. Some native species' populations, however, may have become reduced to sufficiently low population size to constrain their recovery, or limit their ability to compete with more abundant species. Seabloom *et al.* (2003) found evidence that at least some coastal California grassland sites, seed dispersal limitation and low seed densities themselves may constrain restoration of native grassland communities. Supplemental seeding of seed-limited, subordinate or declining populations may be useful as a method to ensure equitable representation of less common or abundant species in East Marin Island grasslands.

Seeding or transplanting natives may also be used in weed-treated plots where weed seed banks have been exhausted, or where natives may help to competitively suppress re-establishment of weeds. Plantings of competitive native species may also be used as a practical tool to pre-empt or suppress re-invasion by weeds in weed removal/treatment sites, even where they may not necessarily fit the most "natural" expected vegetation pattern. For example, *Rubus ursinus, Festuca californica*, *Carex barbarae* or *C. globosa* may be useful competitive post-weeding species for revegetation of barren semi-shaded grassland or oak woodland transition plots. Closely spaced mixtures of coastal scrub dominants, particularly *Artemisia californica* (open sun, south bluffs) and *Heteromeles arbutifolia* (sun or shade), may be planted to inhibit weed regeneration in weed-cleared coastal bluff sites as they revegetate. For example, *Artemisia californica, Elymus glaucus, Eschscholzia californica* and *Nasella* spp. would be appropriate species to replant and stabilize south shore landslide slopes where blue gum is

removed. *Mimulus aurantiaca, Festuca californica, Rubus ursinus (transplants)* and *Claytonia perfoliata* (seed) would be appropriate to revegetate north shore landslides where non-native invasive species would otherwise be prevalent seed-parents for pioneer vegetation. Refer to Appendix 2 for general practical revegetation species lists for East Marin Island vegetation units.

Where local native plant seed production is abundant, and invasive species are adequately controlled, natural revegetation may be assumed to be sufficient for revegetation of natural disturbances (e.g. landslides, demolition) or artificial disturbances (e.g. logging, weed removal). Where non-native vegetation dominates cleared or disturbed sites for more than one year despite control efforts, however, revegetation with competitive native species may be justified to help occupy or pre-empt available space. Following raking or mowing/raking treatments, and tree canopy reduction, treatment plots should be monitored to provide at least rank abundance/frequency data for native species. Species that disproportionately lag in response to treatments may be selected for seed augmentation or transplanting.

Relatively small populations, or uncommon species, that justify propagation and augmentation include *Amsinckia* sp. (if rediscovered), *Erigeron foliosus* var. *franciscensis*, *Potentilla glandulosa*, and *Stephanomeria elata* (Appendix 2). These species occur in populations small enough to carry a significant risk of local extinction. Propagation of *Piperia* sp., though desirable, may be infeasible. Reintroduction or population augmentation experiments can be worked into annual vegetation management plans, depending on availability of resources and demands of higher priority invasive plant control actions. Augmentation is not suggested as an alternative to protection and management of existing populations.

Revegetation and plant provenance (population origin). Because of the natural geographic isolation of Marin Islands, plant species with limited or localized dispersal ability should be presumed to be reproductively isolated from mainland populations. Importation of native plant seed from commercial or off-island sources to augment natural populations is generally not recommended under any circumstances. Seed sources for augmentation should be custom-propagated by collecting approximately equal amounts of seed from at least 20 distinct genetic individuals sampled from the whole of the parent population (more, if feasible), and propagating seed to mature, reproductive plants at an off-island native plant nursery, but in isolation from populations of the same species. Seed should be harvested from the garden population derived from original Marin Islands stock, and sowed directly to test plots in treatment areas. Local populations of native bulbs (*Tritelia, Brodiaea*), native bunchgrasses (*Nasella* spp,) and most annuals such as miner's-lettuce (*Claytonia perfoliata*), *Crassula connata*, *Lotus* spp., lupine (*Lupinus nanus*), *Stephanomeria*, and phacelia (*Phacelia distans*) are likely to respond to seed augmentation treatments in suitable microhabitats.

Seed and clonal propagation. For many perennial plants, clonal (vegetative) propagation of a diverse sample of existing genotypes (inequitable proportions) is an appropriate technique for population augmentation, as it allows natural selection to operate on the seeds and seedlings of the original genetic sample. Clonal propagation most feasible for species with rhizomes, independently rooted basal shoots, or elongate stems (e.g., *Achillea millefolium*, *Aster chilensis, Calystegia* spp.*, Carex* spp. *Festuca rubra, Luzula comosa, Monardella villosa*). Taprooted perennials with dense crowns may be difficult subjects for clonal propagation (e.g., *Camissonia ovata*, *Cynoglossum grande, Erigeron foliosus, Eriogonum nudum, Potentilla glandulosa,*

Wyethia angustifolia), and may be propagated by seed. Many native shrubs can be propagated easily by cuttings of early spring vegetative growth, treated with rooting hormones, propagated in nursery flats (e.g., *Artemisia californica, Eriophyllum stoechadifolium, Heteromeles arbutifolia*)

5.2.4. Soil scrapes.

An experimental method that may be attempted to recruit patches of native forbs and grasses involves creating small scrapes to expose mineral soil (B horizon) with high bulk density. This is a small-scale enhancement tool that may facilitate local native seed parent colonies to disperse into adjacent grassland. Grassland vegetation on nutrient-poor, thin soils tends to support higher native species diversity (Huenneke *et al.* 1990, Wedin 1992, Weiss 1999). Exposures of nutrient-poor, dense mineral subsoil is likely to favor selective recruitment of native bulbs, grasses, and forbs over annual grasses, especially where local seed banks of annual grasses have been reduced by successive years of mowing and raking treatments (Section 5.2.2., 5.1.4.1.). Deposition of loose, disturbed soil mounds with low bulk density, in contrast, are likely to favor seedling establishment by large-seeded annual grasses with rapid growth (Stromberg and Griffin 1996). Direct seeding of subsoils scrapes with propagated local seed sources may enhance recruitment (Seabloom *et al.* 1993). Shallow scrapes and compressed subsoil mounds in raking-treated grasslands in the outer Coast Ranges of Sonoma County became dominated by bulbs (*Tritelia, Brodiaea* spp.) and small annual herbs within 1 to 2 growing seasons after scraping, and in the absence of direct seeding (pers. observ.).

5.2.5. Reintroduction of selected plant populations

Following conservative principles for reintroduction (Morse 1996; Section 4.1), off-island "reintroductions" of presumed extirpated species are generally not recommended in the absence of historic data, unless compelling, overriding reasons justify reintroduction. Reintroduction in the form of population augmentation (propagation of seed or clones derived from local East Marin Island populations), however, is an appropriate tool to combine with weed removal (like oak and buckeye replacement within snag groves), and to minimize risks of extinction of infrequent or locally rare species.

Native plantings may also be used as a practical tool to pre-empt or suppress re-invasion by some weeds at weed treatment plots, even where they may not be the most "natural" expected vegetation. Development of early rapid local dominance by native plantings of sedges (*Carex barbarae, C. globosa*), blue wildrye (Elymus glaucus), for example, may inhibit weed regeneration and competition. These options should be considered in planning site-specific weed removal activities each year.

Small populations of native species should also be managed to increase the number, size, and distribution of colonies within appropriate vegetation, but using only local populations as stock. See Sections 4.1, 5.2.3, and Appendix 2.

SUMMARY TABLE OF MAJOR VEGETATION MANAGEMENT ACTIVITIES

Activity and priority	YEAR	expected duration	Fall	Winter	Spring	Summer	concurrent or associated activity
Annual site-specific implementation plans (comprehensive)	**all**	**all years**					
French broom seedling removal: GRASSLAND *High priority*	**all**	**10 yr +**	**X**	**X**	**reduce**	**X**	**revegetate disturbed plots with natives as needed**
Echium removal GRASSLAND	**1-2**	**2 yr**	**X**			**X**	**broom removal**
French broom seedling removal: BLUFFS *High priority*	**all**	**10 yr +**	**X**	**reduce effort**	**reduce effort**	**X**	**revegetate disturbed plots with natives as needed**
Echium removal BLUFFS	**1-10**	**10 yr**	**X**			**X**	**broom removal**
***Ehrharta* removal** *High priority*	**all**	**5 yr +**	**X**	**X**	**X**	**X**	
Jubata grass removal *High priority*	**1-2**	**1-2 yr**	**X**	**X**			
juvenile pine removal *High priority*	**1-2**	**2 yr**	**X**			**X**	
***Lepidium latifolium* removal** *Moderate priority*	**1-2**	**2 yr**			**X**	**X**	
Experimental girdling *Moderate priority*	**1-2**	**2 yr**	**X**	**X**	**X**		
South shore blue gum removal/snag conversion *High priority*	**1-5**	**5 yr?**	**X**			**X**	**oak planting beneath northern limit of gums**
South plateau blue gum removal/snag conversion *High sequential priority*	**5-10**	**5 yr?**	**X early**			**X late**	**broom removal**
Monterey Pine (mature tree) removal/snag conversion *High priority*	**1 - 3**	**4-5yr**	**X early**			**X late**	**broom removal**
Opuntia removal – south bluffs *Moderate priority*	**1-5**	**7? yr**	**X early**			**X late**	**broom removal**
North Shore & Old Garden ornamental removal (vinca, ivy, etc.) *Moderate priority*	**1-10**	**10+ yr**	**X early**			**X late**	**broom, ehrharta removal**
Oak seedling/sapling transplants, north slopes *(Delay if drought)* *Low to moderate priority*	**1-2**	**2 yr**		**X**			**broom, ehrharta, old garden ornamental removal**
Native seed collection *Low to moderate priority*	**1-2+**	**2 yr**			**X**	**X**	
Native vegetative propagule collection	**1-2+**	**2 yr**	**X**				
Native plant transplanting	**1-5 +**	**5+**	**X late**	**X**	**NO!**	**NO!**	**north shore and old garden ornamental removal**

SEQUENTIAL OUTLINE OF IMPLEMENTATION SCHEDULE: VEGETATION MANAGEMENT ACTIONS

Year 1 (2005 expected)

Winter

- **Prepare annual site-specific implementation plan**

- **Pilot transplant oak saplings, buckeye saplings. OAK BLUFF TRANSITION, NORTHEAST BLUFF SCRUB, in cleared patches.**
- **Pilot herbicide-treat selected Oxalis patches. SOUTH GRASSLAND, WEST GRASSLAND.**

***Spring*:**

- **Initiate test girdling/wound herbicide treatment of selected blue gum and pine to test blue gum resprout response, pine mortality and dieback rate, and to initiate root weakening. Test locations: windward (south) side of island, edges of oak woodland. SOUTH BLUFF SLOPE EDGES, GRASSLAND SCRUB TRANSITION, ORNAMENTAL/ WOODLAND TRANSITION.**

- **Initiate phtytosanitation practices for sudden oak death. COAST LIVE OAK WOODLAND.**

- **Field-flag and GPS-locate significant native plant populations for subsequent seed collection, propagation, census. ALL VEGETATION UNITS (Map 3A).**

- **Manually pull isolated or low-density juvenile and seedling French broom plants, away from high-density centers of abundance; prevent new reproductive colonies. HIGHEST PRIORITIES: EAST GRASSLAND AND ADJACENT UNITS; SOUTH GRASSLAND; ORNAMENTAL/GRASSLAND TRANSITION, SOUTHWEST AND SOUTHEAST BLUFF SCRUB.**

- **Manually cut or pull juvenile (under 10 ft, pre-reproductive) and seedling pine and cypress, and blue gum. COAST LIVE OAK WOODLAND, ORNAMENTAL/WOODLAND TRANSITION.**

- **Manually pull or cut Napa starthistle colonies within 10 days of initiation of flowering (expected early June). OUTLIER LOCATIONS (Map 3B).**

- **Manually remove all jubata grass (*Cortaderia jubata*) founders. (Map 3B).**

- **Herbicide-treat *Ehrharta, Lepidium* patches (MAP 3B) and search for additional populations.**
- **(Optional) Collect and store seed of *Tritelia laxa* (June), *Cynoglossum grande* (May), other selected locally uncommon species for either field sowing or propagation.**

***Summer*:**

- **Prune or brush-cut patches of ivy, French broom, to force young, soft growth receptive to uptake of glyphosate. Cut from colony edges towards center. OAK BLUFF TRANSITION, NORTH BLUFF SCRUB, Lower priority: Plum Grove ornamentals, ornamental/ruderal.**

- **Prune or brush-cut patches of fennel (*Foeniculum vulgare*) to force young, soft growth in mid-summer. Treat regenerating fennel with glyphosate, or manually remove with mattock and spade. SOUTHEAST BLUFF SCRUB, EAST GRASSLAND, GRASSLAND-SCRUB TRANSITION.**

- **Eradicate outlier populations of noxious non-woody weeds before flowering and seed set (Map 3B)**

- **Begin or continue seed collection for selected uncommon native plants (e.g. *Festuca californica, Elymus glaucus*) for field sowing or propagation (Map 3A).**

Fall

- **Begin vegetative propagation for selected native perennial/woody plant species (population augmentation)**

- **Sow fall seeds for field sowing nursery propagation**

- **Initiate trial plots of mowing/raking or raking-only treatments in remnant grassland patches with minimal tree shading, EAST GRASSLAND, SOUTH GRASSLAND.**

Winter

- **Translocate on-site bare-root oak seedlings/saplings in invasive weed-cleared patches OAK BLUFF TRANSITION, NORTH BLUFF SCRUB**

Year 2 (2005 expected)

- **Prepare annual site-specific implementation plans**

- **Continue non-native tree girdling/wound herbicide treatment, proceeding from southern bluffs to north.**

- **Continue removal of *Ehrharta, Lepidium, Cent*aurea wherever detected.**

- **Begin phased implementation of high-priority woody invasive shrub (*Genista, Echium*) removal; centripetal pattern of removal (edge to center). <u>All grassland units and units peripheral to them; southeast and southwest bluffs.</u>**

- **Extend grassland management/ treatements in any tree canopy gaps that form.**

- **Transplanting of propagated native seed, in available bluff and grassland habitats in tree gaps. Propagate and transplant clonal divisions of *Leymus, Agrostis* in WEST GRASSLAND.**

Years 3 – 5

Continue tree girdling/wound-herbicide treatment. Continue, expand *Genista* and *Echium* removal, as above. As canopy gaps form, apply litter reduction (mow/rake), and follow with selective sowing/transplanting.

As resource and labor availability allows, phase in removal of blue gum and ornamental succulents, invasive shrubs on bluffs west of SOUTHEAST BLUFF SCRUB (MIXED ORNAMENTAL BLUFF SCRUB), east to west.

Years 5+

As resource and labor availability allows, phase in herbicide treatment of non-native ground layer of Plum Grove ornamental unit.

Remove or kill standing (snag-convert) blue gum and pine overstory trees in ALL GRASSLAND UNITS, progressing south to north.

Maintain suppression of seed production in all *Genista*; maintain intensive high priority seedling/juvenile removal program for at least 10 years.

Maintain grassland biomass removal methods.
Table 1. Native vascular flora of Marin Islands. Compiled from Ornduff and Vasey (1995), Smith (2003), and preliminary November 2003 survey by the author. EMI = East Marin Island. WMI = West Marin Island. OV= Ornduff and Vasey (1995). DS = Doreen Smith (Smith 2003). PB = author. Author initials in parentheses indicates probable but not confirmed identification of same taxon.

Table 1. Native vascular flora of Marin Islands.

Species	Family	Observer	EMI	WMI
***Achillea millefolium* L.**	Asteraceae	OV, DS	X	
***Adiantum jordanii* C. Mueller**	Pteridaceae	OV, DS	X	
***Aesculus californica* (Spach) Nutt.**	Hippocastanaceae	OV	X	
***Agrostis pallens* Trin. [intermediate with *A. hallii*?]**	Poaceae	[DS, as *Agrostis* undet. sp.], PB	X	
***Amsinckia* sp. (? *A. menziesii* var. *intermedia*)**	Boraginaceae	OV	X	
***Arbutus menziesii* Pursh**	Ericaceae	DS	X	
***Artemisia californica* Less.**	Asteraceae	OV, DS	X	X
***Artemisia douglasiana* Besser**	Asteraceae	OV	X	
***Aster chilensis* Nees**	Asteraceae	DS	X	
***Atriplex triangularis* Willd.**	Chenopodiaceae	DS	X	
***Baccharis pilularis* DC**	Asteraceae	OV, DS	X	X
Brodiaea californica* Lindl. var *californica	Liliaceae	OV	X	
Brodiaea elegans* Hoover ssp. *elegans	Liliaceae	DS	X	
***Bromus carinatus* Hook. & Arn.**	Poaceae	DS	X	
Calystegia purpurata* (E. Greene) Brummit ssp. *purpurata	Convolvulaceae	OV (DS)	X	
***Camissonia ovata* (Torr. & A. Gray) Raven**	Onagraceae	OV, DS	X	
***Carex barbarae* Dewey**	Cyperaceae	OV	X	
***Carex globosa* Boott**	Cyperaceae	DS	X	
Chlorogalum pomeridianum* (DC) Kunth var. *pomeridianum	Liliaceae	OV, DS	X	X
***Clarkia rubicunda* (Lindl.) H. Lewis and M. Lewis**	Onagraceae	OV	X	
***Claytonia perfoliata* Willd. ssp. perfoliata**	Portulacaceae	OV, DS	X	X
***Crassula connata* (Ruiz Lopez & Pavon) A. Berger**	Crassulaceae	DS	X	
***Cressa truxillensis* Kunth**	Convolvulaceae	OV, DS	X	
***Cynoglossum grande* Lehm.**	Boraginaceae	OV, DS	X	
***Dichelostemma capitatum* Alph. Wood ssp. capitatum**	Liliaceae	OV, DS	X	
***Dichondra donelliana* Tharp & M. Johnston**	Convolvulaceae	OV, DS	X	
***Distichlis spicata* (L.) E. Greene**	Poaceae	OV, DS	X	X
***Dryopteris arguta* (Kaulf.) Maxon**	Dryopteraceae	OV, DS	X	X
Dudleya* sp. [*D. cymosa* (Lemaire) Brotton & Rose ssp. *paniculata* (Jeps.) K. Nakai, acc. OV; *D. farinosa	Crassulaceae	OV, DS	X	X

Species	Family	Observer	EMI	WMI
(Lindley) Britton & Rose, acc. DS]				
***Elymus glaucus* Buckley**	Poaceae	DS	X	
***Erigeron foliosus* Nutt. var. *franciscensis* G. Nesom**	Asteraceae	DS	X	
***Eriogonum nudum* Benth. [var. *nudum* acc. OV, DS; likely var. *auriculatum* (Jeps.) Bentham, or intergrade with *E. latifolium*]**	Polygonaceae	OV, DS	X	X
Eriophyllum confertiflorum* (DC.) A. Gray var. *confertiflorum	Asteraceae	DS	X	
***Eriophyllum stoechadifolium* Lagasca** [corrected spelling]	Asteraceae	OV, DS	X	X
***Eschscholzia californica* Cham.**	Papaveraceae	OV, DS	X	X
***Festuca californica* Vasey**	Poaceae	OV, DS	X	X
***Festuca rubra* L.**	Poaceae	DS	X	
***Frankenia salina* (Molina) I.M. Johnston**	Frankeniaceae	OV, DS	X	X
***Galium aparine* L.**	Rubiaceae	DS	X	
***Galium porrigens* Dempster**	Rubiaceae	DS	X	
***Gnaphalium canescens* DC**	Asteraceae	OV	X	
***Gnaphalium californicum* DC**	Asteraceae	DS	X	
***Heteromeles arbutifolia* (Lindley) Roem.**	Rosaceae	OV, DS	X	X
***Holodiscus discolor* (Pursh) Maxim**	Rosaceae	OV, DS	X	X
***Iris macrosiphon* Torrey**	Iridaceae	PB	X	
***Iva axillaris* Pursh ssp. *robustior* (Hook.) Bassett**	Asteraceae	PB	X	
***Jaumea carnosa* (Less.) A. Gray**	Asteraceae	OV, DS	X	
Lathyrus vestitus* Nutt. var. *vestitus	Fabaceae	(OV) DS, PB	X	X
***Leymus triticoides* (Trin.) Pilger**	Poaceae	PB	X	
***Lomatium utriculatum* (Torr. & Gray) J. Coult. & Rose**	Apiaceae	OV	X	
Lomatium dasycarpum* ssp. *dasycarpum	Apiaceae	DS	X	
***Lonicera hispidula* Douglas var. *vacillans* A. Gray**	Caprifoliaceae	OV, DS	X	
***Lotus humistratus* E. Greene**	Fabaceae	DS	X	
***Lotus micranthus* Benth.**	Fabaceae	DS	X	
Lotus scoparius* (Nutt.) Ottley var. *scoparius	Fabaceae	OV, DS	X	X
***Lotus wrangelianus* Fischer & C. Meyer**	Fabaceae	DS	X	
***Lupinus nanus* Benth.**	Fabaceae	OV	X	
***Lupinus succulentus* Koch**	Fabaceae	DS	X	

Species	Family	Observer	EMI	WMI
***Luzula comosa* E. Meyer**	Juncaceae	OV	X	
***Mimulus aurantiacus* Curtis**	Scrophulariaceae	OV, DS	X	X
***Melica californica* Scribner**	Poaceae	DS	X	
***Melica torreyana* Scribner**	Poaceae	OV, DS	X	
Monardella villosa* Benth. var. *villosa	Lamiaceae	DS	X	
***Nasella lepida* (A. Hitch.) Barkworth**	Poaceae	OV, DS	X	
***Nasella pulchra* (A. Hitch.) Barkworth**	Poaceae	OV, DS	X	
Pentagramma triangularis* (Kaulf.) G. Yatschkievych, M.D. Windham & E Woflenweber ssp. *triangularis	Pteridaceae	OV, DS	X	
***Perideridia kelloggii* (A. Gray) Mathias**	Apiaceae	DS	X	
***Phacelia distans* Benth.**	Hydrophyllaceae	OV, DS	X	
***Piperia* sp. (*P. michaelii*)**	Orchidaceae	DS	X	
***Plantago erecta* E. Morris**	Plantaginaceae	DS	X	
***Polycarpon depressum* Nutt.**	Caryophyllaceae	OV	X	
***Polypodium* sp. (*P. californicum* Kaulf. acc. OV; *P. calirhiza* S. Whitmore & A. R. Smith acc. DS for EMI**	Polypodiaceae	OV, DS	X	X
Potentilla glandulosa* Lindley sp. *glandulosa	Rosaceae	DS	X	
***Quercus agrifolia* Nee**	Fagaceae	OV, DS	X	X
***Rumex salicifolius* J.A. Weinm. var. crassus (Rech. f.) J. Howell**	Polygonaceae	OV, DS	X	X
***Rosa gymnocarpa* Nutt.**	Rosaceae	OV, DS	X	X
***Rubus ursinus* Cham. & Schldl.**	Rosaceae	DS, PB	X	
***Ruppia maritima* L.**	Potamogetonaceae	OV, DS	X	
***Salicornia virginica* L**	Chenopodiaceae	OV, DS	X	X
***Sambucus mexicana* C. Presl.**	Caprifoliaceae	OV, DS	X	X
***Sanicula crassicaulis* DC**	Apiaceae	OV, DS	X	
Scrophularia californica* Cham. & Schlecht. spp. *californica	Scrophulariaceae	OV, DS	X	X
***Sisyrinchium bellum* S. Watson**	Iridaceae	DS	X	
***Solidago californica* Nutt.**	Asteraceae	DS	X	
Spergularia macrotheca* (Hornem) Heynh. var. *macrotheca	Caryophyllaceae	OV, DS	X	X
***Stachys ajugoides* Benth. var. *rigida* Jeps. & Hoover**	Lamiaceae	OV, DS	X	X
***Stephanomeria elata* Nutt.**	Asteraceae	OV, DS	X	
Symphoricarpos albus* (L.) S.F. Blake var. *laevigatus	Caprifoliaceae	OV, DS	X	
***Symphoricarpos mollis* Nutt.**	Caprifoliaceae	DS	X	
***Toxicondendron diversilobum* (Torr.**	Anacardaceae	OV, DS	X	X

Species	Family	Observer	EMI	WMI
& A. Gray) E. Greene				
***Triphysaria pusilla* (Benth.) Chuang and Heckard**	Scrophulariaceae	OV, DS	X	
***Tritelia laxa* Benth.**	Liliaceae	DS	X	
***Tritelia peduncularis* Lindley**	Liliaceae	DS	X	
***Umbellularia californica* (Hook. & Arn.) Nutt.**	Lauraceae	OV, DS	X	X
***Wyethia angustifolia* (DC.) Nutt**	Asteraceae	DS	X	
Vicia americana* Willd. var. *americana	Fabaceae	OV, DS	X	
***Viola pedunculata* Torr. & A. Gray**	Violaceae	OV	X	
***Zigadenus fremontii* (Torr.) S. Watson**	Liliaceae	OV, DS	X	X

Table 2. Nonnative flora of East Marin Island

Compiled from Ornduff and Vasey (1995), Smith (2003), and author's observations.
Ranking of invasive status specific to Marin Island habitats, considering species potential for region.
cv. = cultivar; aff. = affinity; undet. = undetermined taxon or cultivar. Nomenclature follows Hickman (1993).

Species	Common Name	Family	Invasive Status	Local Abundance
Acacia baileyana	Bailey acacia	Fabaceae	moderate spread	locally common
Acacia decurrens	green wattle	Fabaceae	invasive	locally common
Acacia melanoxylon	blackwood acacia	Fabaceae	invasive	locally abundant
Acacia retinodes	water wattle	Fabaceae	invasive	locally abundant
Acanthus mollis	Acanthus	Acanthaceae	clonal; slight spread	local
Aeonium arboreum	Aeonium	Crassulaceae	Local, slight spread	high
Allium sp. *aff. A. neopolitanum*	white-flowered onion	Amaryllidaceae	clonal; locally aggressive	locally abundant
Allium triquetrum	european wild onion	Amaryllidaceae	clonal; locally aggressive	locally abundant
Amaryllis belladonna	naked ladies	Amaryllidaceae	non-invasive, persisting from cultivation	local
Anagallis arvensis	scarlet pimpernel	Primulaceae	invasive, mostly disturbed moist soils	occasional, minor
Atriplex semibaccata	Australian saltbush	Chenopodiaceae	High tide line	rare (regionally common)
Avena barbata	bearded oat	Poaceae	invasive	abundant
Briza maxima	rattlesnake grass	Poaceae	invasive	abundant
Briza minor	small rattlesnake grass	Poaceae	invasive	abundant
Bromus diandrus	ripgut brome	Poaceae	invasive	abundant
Bromus hordeaceus	soft brome	Poaceae	invasive	abundant
Cakile maritima	sea-rocket	Brassicaceae	local, shoreline; minor sp.	local, minor [not recorded 2004]
Carduus pycnocephala	Italian thistle	Asteraceae	**highly invasive**	local, disturbed soils
Carpobrotus edulis	iceplant	Aizoaceae	invasive to highly invasive	local, bluff toe
Centaurea melitensis	Napa starthistle	Asteraceae	**highly invasive**	local, disturbed soils
Chasmanthe floribunda	Montebretia	Iridaceae	mostly clonal	locally abundant, north slopes, plantings
Cotula coronopifolia	brass-buttons	Asteraceae	shoreline, pond edge; low potential for spread	local
Cortaderia jubata	jubata grass	Poaceae	**highly invasive,** coastal bluffs	currently local, minor
Cupressus macrocarpa	Monterey cypress	Cupressaceae	normally nvasive, dominant on coast	local, minor, but reproducing
Drosanthemum floribundum	iceplant	Aizoaceae	clonal mat; very local	southern cliff edges
Echium candicans	Pride-of-Madeira	Boraginaceae	infrequently invasive	occasional
Ehrharta erecta	[erect Ehrharta]	Poaceae	**highly invasive in maritime California**	currently local, minor
Eucalyptus ficifolia	scarlet or fig gum	Myrtaceae	non-invasive	persistent planting
Eucalyptus globules	blue gum	Myrtaceae	**highly invasive**, dominant	dominant: canopy
Euphorbia peplus	petty spurge	Euphorbiaceae	invasive, esp.	local

Species	Common Name	Family	Invasive Status	Local Abundance
			disturbed sites	
Ficus carica	fig	Moraceae	local, persisting from cultivation	local, persisting from plantings
Filago gallica	French cudweed	Asteraceae	minor	disturbed soil, bluffs
Foeniculum vulgare	fennel	Apiaceae	**invasive to highly invasive**, bluffs	locally abundant, disturbed bluffs, grassland
Galium aparine	bedstraw	Rubiaceae	slightly invasive, mostly disturbed soils	locally common, woodland understory
Genista monspessulana	French broom	Fabaceae	**highly invasive**	locally dominant, north slopes and plateau
Geranium dissectum	cut-leaved cranesbill	Geraniaceae	invasive, but not dominant	
Geranium molle	soft-leaved cranesbill	Geraniaceae	invasive, but not dominant	occasional to common, grassland
Gladiolus cv.	gladiolus	Iridaceae	local, persisting from cultivation	plantings, persistent
Hedera helix	ivy	Araliaceae	**highly invasive**, dominant	locally dominant, north slopes
Hordeum murinum ssp. *Leporinum*	foxtail barley	Poaceae	invasive	widespread
Hypochaeris glabra	smooth cat's-ear	Asteraceae	invasive	widespread
Hypochaeris radicata	cat's-ear	Asteraceae	invasive	
Iris cv.	bearded iris	Iridaceae	noninvasive; persisting from cultivation	local, minor
Lathyrus tingitanus	Tangier pea	Fabaceae	invasive	widespread
Lepidium latifolium	perennial pepperweed	Brassicaceae	highly invasive only in brackish wetlands	limited
Ligustrum japonicum	wax-leaf privet	Oleaceae	persisting from cultivation	plantings
Lolium multiflorum	italian ryegrass	Poaceae	moderately invasive, mostly disturbed or wet soils	common, grassland
Malus domestica cv. undet.	apple	Rosaceae	noninvasive, persisting from cultivation	local
Medicago polymorpha	bur-clover	Fabaceae	invasive	minor, disturbed soil
Melilotus indica	yellow sweet-clover	Fabaceae	invasive, disturbed sites	minor, disturbed soil
Muhlenbeckia compressa	mattress-vine	Polygonaceae	highly invasive but local	very local, abundant
Narcissus cvs.	narcissus	Amaryllidaceae	clonal, local; persisting from cultivation	local, minor
Olea europaea	olive	Oleaceae	noninvasive; persisting from cultivation	local, minor
Opuntia ficus-carica	prickly-pear cactus	Cactaceae	locally invasive, clonal fragments	locally abundant to dominant, south bluffs only
Oxalis pes-caprae	Bermuda-buttercup	Oxalidaceae	**clonal, highly invasive**	locally abundant
Pelargonium hortorum	geranium	Geraniaceae	noninvasive, persisting from cultivation	occasional, minor
Petroselinum crispum	parsley	Apiaceae	naturalized, noninvasive	widespread, minor

Species	Common Name	Family	Invasive Status	Local Abundance
Phoenix canariensis	Canary Islands date palm	Arecaceae	persisting from plantings; slightly invasive	very localized mature stand; few isolated seedlings
Poa annua	annual bluegrass	Poaceae	moderately invasive, mostly disturbed moist soils	occasional, paths
Poa pratensis	Kentucky bluegrass	Poaceae	moderately invasive, mostly disturbed or moist soils	occasional, grassland
Pinus radiata cv.	Monterey pine	Pinaceae	invasive	dominant: canopy
Plantago lanceolata	English plaintain	Plantaginaceae	invasive	widespread, moderate (grassland)
Polycarpon tetraphyllum		Polygonaceae	invasive, mostly disturbed soils	minor, grassland and bluff
Prunus domestica cv. undet.	plum	Rosaceae	noninvasive, persisting from cultivation	local, minor
Prunus cerasifera cv.	cherry	Rosaceae	noninvasive, persisting from cultivation	local, minor
Raphanus sativa	radish	Brassicaceae	invasive, mostly disturbed soils	rare
Rosmarinus officinalis	rosemary	Lamiaceae	noninvasive, persisting from cultivation	local, minor
Rubus discolor	Himalayan blackberry	Rosaceae	**invasive to highly invasive**	locally dominant
Rumex acetosella	sheep-sorrel	Polygonaceae	invasive but seldom abundant	widespread, minor (grassland)
Salsola soda	saltwort	Chenopodiaceae	local, shoreline; invasive	low, local
Senecio vulgaris	common groundsel	Asteraceae	invasive, mostly disturbed soils	minor
Silene gallica	windmill pink	Caryophyllaceae	invasive, mostly disturbed soils	minor, bluffs
Sisymbrium officinale	hedge mustard	Brassicaceae	invasive, mostly disturbed soils	minor
Spartina densiflora	Chilean cordgrass	Poaceae	invasive, upper intertidal zone	extirpated individual 2004
Spartium junceum	Spanish broom	Fabaceae	invasive, mostly sandy disturbed soils	[not recorded 2004]
Stellaria media	chickweed	Caryophyllaceae	invasive, mostly disturbed soils	locally abundant, north bluffs
Sonchus asper	prickly sow-thistle	Asteraceae	invasive, mostly disturbed soils	minor
Sonchus oleraceus	common sow-thistle	Asteraceae	invasive, mostly disturbed soils	minor
Tetragonia tetragonioides	New Zealand spinach	Aizoaceae	shoreline, bluff only;	local, minor
Tropaeoloum majus	nasturtium	Tropaeolaceae	spreading locally from cultivation, gen. noninvasive	local, minor
Vicia benghalensis	red vetch			local
Vicia sativa	common vetch			local
Vinca major	periwinkle	Plumbaginaceae	invasive, highly persistent	locally abundant

Table 3. Common and widespread vascular plant species "expected" for East Marin Island. Species list meeting habitat, distribution, and locality criteria selected for prediction of likely occurrence at Marin Islands (Section 2.3.4), based on historic qualitative locality, distribution and habitat data (Howell 1970). No quantitative species-area relationships are reflected in this "expected" list for the island. Species with asterisks (*) have been reported as present at Marin Islands by either Ornduff and Vasey (1995) or Smith (2003). (?*) indicates a presumption that the genus previously reported and species currently identified area the same entity.

**Adiantum jordanii*
Acaena pinnatifida
**Achillea millefolium*
**Aesculus californica*
(?)Agrostis pallens*
**Arbutus menziesii*
**Artemisia californica*
Astragalus gambellianus
**Baccharis pilularis*
(?)Calystegia subacaulis*
Carex tumulicola
**Carex barbarae*
Ceanothus thyrsiflorus
**Chlorogalum pomeridianum*
**Claytonia perfoliata*
**Collinsia sparsiflora*
**Cynoglossum grande*
**Dudleya farinosa*
**Eriogonum nudum*
**Festuca californica*
**Festuca rubra*
Festuca idahoensis
**Elymus glaucus*
Eriophyllum lanatum
**Eschscholzia californica*
Fragaria vesca
Galium californicum
**Gnaphalium californicum*
Gnaphalium purpureum
**Heteromeles arbutifolia*
**Holodiscus discolor*
Hordeum brachyantherum
**Lathyrus vestitus*
**Lonicera hispidula*
Lotus purshianus
Lotus subpinnatus
**Lotus micranthus*
Lupinus bicolor
**Lupinus nanus*
Lupinus micranthus
Madia gracilis
Marah fabaceus
**Melica torreyana*
Micropus californicus
**Mimulus aurantiacus*
**Nasella pulchra*
**Nasella lepida*
Navarretia squarrosa
Osmorhiza chilensis
**Pentagramma triangularis*
**Perideridia kelloggii*
Phacelia californica
Phlox gracilis
Polystichum munitum
**Polypodium californicum*
**Potentilla glandulosa*
Pteridium aqualinum
Pterostegia drymarioides
**Quercus agrifolia*
Rhamnus californica
**Rubus ursinus*
**Sanicula crassicaulis*
**Scrophularia californica*
Sidalcea malvaeflora
**Sisyrinchium bellum*
**Spergularia macrotheca*
**Stachys ajugoides ssp. rigida*
**Symphoricarpos rivularis*
**Toxicondentron quercifolium*
Trifolium microdon
**Triphysaria pusilla*
**Umbellularia californica*
**Wyethia angustifolia*
**Zygadenus fremontii*

Table 4. Comparison of characters: East Marin Island *Stephanomeria elata* and native Marin *Stephanomeria* spp. Comparison of taxonomic traits observable on of late-season sample of *Stephanomeria elata* collected at East Marin Island by Doreen Smith (2003), *Stephanomeria* species in the Marin Flora (Howell 1970), and *S. elata* (identification by Ornduff and Vasey (1995)).

Character states and ranges from Stebbins (1993) key and species descriptions unless otherwise indicated. PM: key or species description character from Munz 1970; JTH: key character from synonym in Howell 1949; OV: reported by Ornduff and Vasey (1995).

character	Marin Island *S. elata*	*Stephanomeria virgata* ssp. *virgata*	*Stephanomeria elata (S. coronaria misapplied by JTH)*
outer phyllaries	variably reflexed, straight to appressed	strongly reflexed	gen. reflexed
pappus	100% plumose white	100% plumose white	100% plumose
pappus detachment	fully deciduous (persistent rim)	fully decidious (JTH)	pappus bristles break above base (JTH)
achene surface	strongly tuberculate to rugose, ribs/grooves present but obscured by tubercles dark gray-brown	not grooved not grooved (JTH) ribbed (PM) buff (JTH)	sides of achene with longitudinal groove, 5-angled (JTH), gray-brown (JTH)
achene length mm	+/- 3.0	2.2 – 3.6	2.5 – 5.0
duration	perennial (OV)	annual	annual
(basal leaves)	(no 2003 data)	sinuate, oblong-spatulate,	withered at flowering
(corolla)	(no 2003 data)	white above, purplish-pink below	pink

Table 5. Relation of major Marin Islands vegetation stands to some of the major contemporary and historic classification systems of California vegetation.

Marin Islands stands	*Holland and Keil 1995*	*Howell 1949*	*NDDB/Holland type*	*Munz and Keck 1959/Ornduff 1974 / Barbour and major 1977*	*Sawyer/Keeler-Wolf 1995*
Nasella, annual grasses, *Agrostis, Festuca*	North Coastal Grasslands	Coastal Grassland	Coastal Prairies	Coastal Prairie	California annual grassland series
Nasella, annual grasses,	Native Bunchgrass Grasslands	Hill and Valley Grassland	Valley and Foothill Grasslands	Valley Grassland	Purple Needlegrass series
Artemisia californica, Baccharis pilularis, Eriophyllum stoechadifolium	North Coast Scrub Communities	Coastal Brush	Coastal Scrubs	Northern Coastal Scrub	Coyote Brush series (?), California sagebrush series
Eriogonum nudum, Eriophyllum stoechadifolium, Dudleya	North Coast Sea-bluff Scrub Communities	? phase of Coastal Brush	Coastal Bluff Scrubs	Northern Coastal Scrub	none
Aesculus californica (W. Marin I.)			Broadleaved upland forests: mixed north slope forests (?)	Valley and foothill woodland	California Buckeye series
Quercus agrifolia, Heteromeles arbutifolia, Aesculus californica	Coast Live Oak Woodlands	[abundant element of tanbark oak-madrone, not oak-buckeye]	Broadleaved upland forests: coast live oak woodland	Valley and foothill woodland	Coast Live Oak series
Blue gum, Monterey pine and cypress	Plantations	none	none	none	Eucalyptus series

FIGURES

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PERSONAL COMMUNICATIONS

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GLOSSARY OF SELECTED TERMS

Working definitions of nonstandard technical terms as applied to this document in multiple contexts.

bluff – eroded steep slope associated with scarps or landslides above water bodies or streams.
caulescent – tending towards developing stalks or stems.
depauperate - impoverished development, stunted
diagnostic – definitive, exclusive (traits)
disclimax – older theoretical concept about succession: atypical or artificial disturbance prevents or delays, progressive, trend towards attainment of predictable end-state "climax" vegetation.
floristic – pertaining to a flora, the plant species occupying a given geographic study area.
ecotype, ecotypic – locally adapted populations of plants associated with particular or extreme environmental conditions (wind, salinity, extreme soil conditions, microclimate, etc.)
forb – herbaceous plant (syn. = herb); annuals and perennials.
genecological – population-level genetic aspects of ecology
graminoid – grass-like (plants); sedges, grasses, etc.
introgressant - multiple-generation backcrossed hybrid and parent population.
invasive – having a strong tendency to spread and become dominant or exclusive vegetation; aggressive, rapid, or extensive spread in abundance.
liana – woody "vine", lax elongate shrubs climbing over vegetation.
management – (of vegetation) deliberate modifications that promote vegetation change (trends, dynamics) toward a desired set of conditions.
native – occurring in an ecological community because of long-term past migrations, or persistence over geologic time, unaided by artificial (human-dependent) dispersal in historic times.
nitrophilous – nitrogen-loving (thriving in highly nitrogen-rich soils)
nonnative – occurring in an ecological community because of past dispersal by humans (deliberate or not); introduced by artificial means, dependent on human introduction.
perennation – regenerating from persistent vegetative structures over multiple years.
phenotype: full suite of traits as developed by a plant; contrast with genotype, full suite of genetic (heritable, potential) traits.
physiognomy – the shape or structure of vegetation
plant community – interacting populations of plant species associated within an area.
propagule – any plant structure capable of regenerating a growing physiologically independent individual.
restoration – a type of (vegetation) management that returns vegetation to a prior late Holocene condition (recent historic, or inferred historic, or prehistoric), either by shifts in composition, function, and structure of existing vegetation, or "type conversion" (qualitative replacement of one community type with another).
ruderal – "weedy", of disturbed habitats near human activities in domestic, urban, agricultural settings.
seed bank – populations of dormant seeds associated with substrate of an area.

scarp – eroded steep slope cut in unconsolidated or weakly consolidated sediments.
succession – change in plant communities over time
weed – generally, invasive plants(often but not always nonnative), or those which become excessively abundant relative to local vegetation management objectives.
taxa – (*sing.* = taxon) biological classification units of any rank (variety, subspecies, species, etc.)
taxonomic – pertaining to classification (species relationships)
vascular – plants having specialized tissues that conduct water; "land" plants.
vegetation – the plant cover of land, wetlands, or submerged areas, considered in terms of structure (physiognomy), mass, composition, and plant life-forms and growth habit

Appendix 1

Summary Species Accounts : Selected Wildland Weeds of East Marin Island

Background information on species biology, threats, and general control methods summarized from McMinn and Maino (1935), Hickman (1993), Bossard *et al.* (2000) and author's observations, unless otherwise indicated. Site-specific control recommendations by the author.

Acacia baileyana **Bailey acacia**

Life-form and life-history: small tree, evergreen 15 – 10 ft tall, or shrub-like. . Early spring/winter flowering in coastal California. Reproduces by abundant hard-coated, persistent seed, long dormancy. Stump-sprouts and suckers vigorously after pruning, injury, fire, or felling.

Likely effects on local native plant populations: Slow, long-term invasive small tree, affecting shrub and ground layer. Hard-coated seed may be slow to emerge from seed bank. Produces heavy litter of slow-decomposing sclerophyllous leaves.

Likely effects on local wildlife habitat: Not known.

Level of threat/site-specific priority for control: Low to moderate threat of spread from plantings, but long-term impacts of persistent seed bank are a concern, source of uncertainty.

Population status: Clustered near original planting sites near residence.

Local modes of regeneration and spread: seedlings

Recommended site-specific feasible control techniques: Felling/cutting of specimens outside historic cultivated area, followed by herbicide treatment of stump-sprouts.

Acacia decurrens **Black wattle*, A. melanoxylon*** **Blackwood acacia**

Life-form and life-history: large erect trees, evergreen, maximum height to over 60 ft. Early spring/winter flowering in coastal California. Reproduces by abundant seed, hard-coated, slow germination, persistent seed banks. Also suckers and stump-sprouts after injury, pruning, felling, fire.

Likely effects on local native plant populations: Dense canopy, heavy shade and leaf litter year-round; likely inhibitory to ground layer and shrub layer. Mature trees are large enough to compete with coast live oak and buckeye if uncontrolled for decades.

Likely effects on local wildlife habitat: not known.

Level of threat/site-specific priority for control: Slow to spread from plantings, but long-term impacts of persistent seed bank are a concern, source of uncertainty. Relatively easy to contain spread of mature trees, but seedling/sapling escape would be more difficult to control. Low priority.

Population status (distribution, abundance, age-structure): Primarily occurs near original plantings.

Local modes of regeneration and spread: seed, suckering**.**

Recommended site-specific feasible control techniques: Options are removal (felling) or reducing population to a few individuals, maintained by pruning (canopy thinning).

Annual non-native grasses
(*Aira caryophylla, Briza maxima, Briza minor, Bromus diandrus, Bromus hordeaceus, Hordeum murinum* ssp*. leporinum, Lolium multiflorum, Poa annua*)

Life-form and life-history: annual graminoid, generally erect or ascending.

Likely effects on local native plant populations: Rapid and early competition for near-surface soil moisture in winter-spring, pre-emption of space of native seedlings of annual native forbs, perennial grasses, bulbs and shrubs. Suppresses native grassland, especially in disturbed soils or nutrient-enriched (elevated nitrogen) soils. Leaf litter accumulation promotes self-regeneration, suppresses survivorship of native forbs and bulbs.

Likely effects on local wildlife habitat: May reduce seed availability for passerine birds.

Level of threat/site-specific priority for control: Low level of priority for reduction of distribution, but moderate to high level of priority for reduction of abundance in coastal grassland remnants.

Population status (distribution, abundance, age-structure): Well-established, naturalized; effectively "saturating" communities it may invade.

Local modes of regeneration and spread: Annual age structure; presumed short-lived seed banks in near-surface litter and surface soil cracks. Passive physical seed dispersal and dispersal by humans (fabric, footwear), but in "saturated" habitat.

Recommended site-specific feasible control: Control should be aimed at reduction of seed abundance and accumulated leaf litter, not eradication; purpose to increase relative abundance of native forbs, grasses, bulbs, shrubs. If native annual *Hordeum brachyantherum* is detected, modify control methods to manual local weeding. techniques. Because of location and infrastructure constraints, controlled burns and intermittent grazing are presumed to be infeasible for grassland management at East Marin Island. General treatment: reduce non-native tree canopy shade and tree leaf and bark litter. Mowing option: Treat patches by mechanical mowing or manual cutting of grassland below the height of immature seeds (April or early May), with raking and removal of fresh and old accumulated leaf litter, for two successive years per patch; treat adjacent patches during 3rd year fallow (rest period) of initial treatment patch. Allow recruitment of native seed production, bulbs in fallow year; repeat cycle to select for native perennial species, against short-lived annual grass seed bank. Monitor recruitment of native grassland and scrub seedlings in treated patches; monitor re-invasion of annual grasses. Raking option: Heavily rake treatment patches in late summer/fall annually to remove accumulated dead shoots and seed, exposing soils surface. Apply raking option if abundance of low-growing annual grasses (*Aira* spp, *Vulpia* spp.) increases after mowing treatment. Grass-specific herbicides are not recommended because of incidental damage to native grasses.

***Avena barbata* (wild oat)** see annual grasses

***Briza* spp. (rattlesnake grass)** see annual grasses

***Bromus* spp.** (annual brome species; not including *B. carinatus*, native perennial) see annual grasses

***Carpobrotus edulis*/hybrid Iceplant**

Life-form and life-history: Clonal perennial succulent subshrub, prostrate, mat-like, massive. Produces abundant small seeds in fleshy fruits, dispersed by vertebrates. Capable of clonal fragmentation, dispersal and colonization by fragments.

Likely effects on local native plant populations: Forms monotypic stands in coastal bluffs, coastal grassland, scrub, displacing native coastal grassland and scrub. Persistent leaf and stem litter.

Likely effects on local wildlife habitat: Reduces cover for small mammals; reduces diversity of seed for passerine, mammal foraging.

Level of threat/site-specific priority for control: Very high, especially on coastal bluffs.

Population status (distribution, abundance, age-structure) [survey]

Local modes of regeneration and spread

Recommended site-specific feasible control techniques. Manual removal is labor-intensive. If stands are monotypic, treat with glyphosate (and strongest surfactant consistent with label), and remove dead leaf and stem litter one year later. If stands are mixed with native vegetation, manually remove, cover with black plastic in sun to prevent regeneration. For bluff populations out of reach, use wick applicator to extent feasible.

***Centaurea melitensis* Napa starthistle**

Life-form and life-history: erect taprooted forb, short-lived perennial. Germinates with fall rains from short-lived seed bank; overwinters as vegetative rosette. Bolts in mid-late spring; flowers early summer (usually June) to late fall. Severed immature seedheads may continue development to viability.

Likely effects on local native plant populations: Aggressive invader of grasslands, including undisturbed grasslands; prefers disturbed annual grassland. Very similar to yellow starthistle, with which it is easily confused.

Likely effects on local wildlife habitat: Reduces diversity of grassland plant community, forms monotypic stands. Highly attractive to european honeybees; abundant local nectar source may facilitate competition with native bees.

Level of threat/site-specific priority for control: Highest priority

Population status (distribution, abundance, age-structure) [survey]

Local modes of regeneration and spread: seed, gravity, humans (attachment of spiny seedheads to fabric); possibly wind

Recommended site-specific feasible control techniques: Cutting or mowing plants to ground level during late earliest flowering stages, within 10 days of first flowering. Monitor for resprouts; re-mow to prevent late-season repeat flowering. Manual pulling, digging may be feasible for isolated individuals or clusters. Repeat treatment for several consecutive years in each treated patch to eliminate local seed bank. Glyphosate, Clopyralid herbicides may be effective, but difficult to apply without adversely affecting non-target native vegetation at appropriate treatment times.

Cupressus macrocarpa **Monterey cypress**

Life-form and life-history: coniferous tree, usually <75 ft in cultivation; usually less in native range. Relatively short-lived**.** Reproduces by seed only; no stump-sprouting regeneration.

Likely effects on local native plant populations: Produces dense shade, low-growing branches, very heavy resinous leaf litter, woody debris. Very dense canopy with branching close to ground, used for coastal windbreaks. Maintains low diversity of ground layer vegetation.

Likely effects on local wildlife habitat: Mature trees used by raptors, passerines, small mammals.

Level of threat/site-specific priority for control: slow but progressive invasions are a significant threat to coastal bluff, dune, scrub, and grassland vegetation. High priority for control at East Marin Island.

Population status (distribution, abundance, age-structure): seedlings, saplings, juveniles, young trees, and old parent plantings are present at East Marin Island.

Local modes of regeneration and spread: seed

Recommended site-specific feasible control techniques: seedlings, saplings: manual pulling, cutting (saw). Larger trees: girdling, herbicide/wound treatment recommended for rapid reduction in canopy cover. Felling is an option only if off-island disposal is feasible.

Echium candicans **Pride-of-Madeira**

Life-form and life-history: erect short-lived subshrub or soft-wooded shrub. Reproduces by seed at young age, 3 – 4 years after seedling stage. Frost-sensitive.

Likely effects on local native plant populations. Seldom escaping from cultivation, usually local spread. Almost never develops high-density populations in coastal California.

Likely effects on local wildlife habitat: none known**.** Flowering spikes in April highly attractive to generalist bee pollinators.

Level of threat/site-specific priority for control: Low level of threat, but easily controlled. Low priority for removal.

Population status (distribution, abundance, age-structure) Abundant and actively recruiting juveniles on disturbed coastal bluffs, south shore and southeast; also locally common on south-facing slopes with mixed grassland and scrub. Individual shrubs are probably short-lived because of weak secondary wood; depends on abundant seed production and seedling recruitment in semi-disturbed soils, partial vegetation cover for maintenance of population.

Local modes of regeneration and spread: seedling

Recommended site-specific feasible control techniques: Cut soft-wooded shrubs at base, spray stump with glyphosate solution to prevent regeneration. Where efforts for full removal are constrained, remove fruiting panicles before seed set where seedling habitats are evident.

Ehrharta erecta
[no common name; "tall Ehrharta, tall Veldtgrass" approximate translation of Latin]

Life-form and life-history: Perennial bunchgrass with erect to strongly spreading (decumbent) stems, nearly evergreen in San Francisco Bay; winter growth like annual grasses, with rapid growth in moist months, but persisting green into summer, particularly in shaded or moist areas. Tolerates sandy, dry soils in summer, but ceases growth. *Identification*: in winter, it may resemble *Melica torreyana* vegetatively, but its leaves much broader and usually on elongated culms with swollen nodes, and climbing through or over supporting vegetation if present. Flowering and fruiting culms (spring through fall) with sparse open branches, basal branches reflexed (bent backwards). Produces abundant seeds and seedlings, capable of establishing in deep shade and through heavy leaf litter. Established plants have tough, tenacious fibrous root systems that are difficult to pull manually, and tend to leave rooted fragments with buds that regenerate after pulling. The longevity of the seed bank is not known with precision, but based on horticultural experience in San Francisco, persistent viable seed banks are likely to last at least 2-3 years.

Likely effects on local native plant populations: Potentially severe. Mature populations form mat-like turfs like rhizomatous perennial grasses, even under dense shade of Monterey cypress, pine, native oaks. Potentially replaces native ground layer in coastal habitats; intense competition with native seedlings. Disperses and spreads very rapidly in coastal habitats, including rock crevice habitats.

Likely effects on local wildlife habitat: In the absence of mammals at Marin Islands, impacts may be indirect, altering seed and insect availability for passerine birds. Seed-eating birds do appear to consume the seeds.

Level of threat/site-specific priority for control: HIGH PRIORITY, equal to French broom (*Genista monspessulana*) at East Marin Island. Site stewards should be trained to recognize Ehrharta; voucher specimens and photographs are recommended to be kept on-site for ready access to identification information.

Population status (distribution, abundance, age-structure): *Ehrharta erecta* is currently found primarily on north-aspect bluffs at the northeast end of East Marin Island; status on West Marin Island is unknown. One disjunct colony (mapped) occurs in the central oak woodland below the former terraced orchard. The northeastern (northeast bluff scrub, transition; also under *Genista* stands) populations occur in moderate to deep shade, and co-occur with Melica torreyana in some

locations. The size and extent of the population indicates very likely establishment of a persistent seed bank.

Local modes of regeneration and spread: seedling, perenniation.

Recommended site-specific feasible control techniques: Prompt removal of flowering and fruiting culms by cutting; herbicide treatment (grass-specific herbicide or glyphosate), using either wick or spray application techniques. Manual pulling alone is not recommended because of likely fragmentation and regeneration. Detection (recognition, marking/flagging) is key to control. Control will depend on intervention during early stages of spread.

Eucalyptus globulus **Blue gum**

Life-form and life-history: Massive tree, resinous evergreen leaves, shredding bark, lignotubers with high capacity for very rapid resprouting following fire, injury, felling. May reach 70 to 140 feet tall, with trunks meters wide. Reproduces mostly by seed, with some suckering/resprouting.

Likely effects on local native plant populations: Heavy deposition of resinous, sclerophyllous leaf litter, abundant stem and bark litter, in thick persistent mats, inhibits seedlings of many native species; few tolerate its understory. Also deposits significant amounts of large woody debris (fallen limbs). Shade of semi-open canopy of mature trees can be moderate.

Likely effects on local wildlife habitat: Flower nectar sources are attractive to Anna's hummingbirds in winter. At East Marin Island, lacking small mammal populations, less impact to wildlife than on comparable invasions of mainland coast. Eliminates foraging habitat for passerine birds using coastal scrub/grassland.

Level of threat/site-specific priority for control: This species (along with the conifers of Marin Islands) are the "keystone" invasive non-native species, dominating the environment of East Marin Island. It is the highest priority for control to recover native coastal scrub and grassland vegetation.

Population status (distribution, abundance, age-structure): Dominant vegetation of East Marin Island. Mature trees, young trees, and seedlings indicate ongoing recruitment.

Local modes of regeneration and spread: seedling recruitment appears to be the mode of spread.

Recommended site-specific feasible control techniques: (see text). The most rapid and feasible method for reduction of canopy shade is conversion of live trees to standing snags by girdling and herbicide treatment of wounds ("hack-and-squirt"). Dead standing snags will continue to generate large woody debris for many years, but litterfall and shading should be reduced rapidly, within 2 to 3 years. Felling of massive old trees would be a major expense, disturbance, and waste disposal requirement. Disposal of massive trunks on the ground would displace excessive native vegetation for many decades; decomposition of eucalyptus wood is very slow.

Foeniculum vulgare **Fennel**

Life-form and life-history: Erect, coarse perennial forb with multiple shoot crowns, taprooted, nonclonal. Dissected, compound 'feathery' leaves, thread-like segments. Reproduces by abundant seed, no specialized dispersal syndrome.

Likely effects on local native plant populations: Establishes tall dense stands readily on disturbed open coastal bluffs, landslides, disturbed soils; often invasive dominant, pre-empting space for colonization by coastal bluff, scrub, grassland species. Less invasive in intact soils of grassland and coastal scrub if seed rain from source populations is high. Absence of burrowing animals on East Marin Island may discourage spread away from bluffs. Potential threat for landslides and scarps of West Marin Island.

Likely effects on local wildlife habitat: Seeds are consumed by many small passerine birds. Foliage is habitat for larval stages of native butterfly, anise swallowtail.

Level of threat/site-specific priority for control: High for coastal bluffs, where potentially dominant.

Population status (distribution, abundance, age-structure) [survey]

Local modes of regeneration and spread: Seed dispersal, presumably by gravity and wind, runoff.

Recommended site-specific feasible control techniques: For small populations, manual removal by severing crown from taproot below ground level is likely to kill individuals, but seed banks should be expected to regenerate. Glyphosate herbicide is most effective on young, unelongated shoots or crown-sprouts, not mature stem leaves. Glyphosate herbicide of young foliage (early spring or post-cut basal regrowth) has been reported to achieve up to 80% reduction of cover. Glyphosate treatment of cut crown stumps has been reported to be relatively ineffective.

Hordeum murinum **see annual grasses**

Lepidium latifolium **Perennial pepperweed**

Life-form and life-history: Clonal perennial, adventitious buds on fleshy rhizome-like roots; juvenile rosette first year; bolts to unbranched erect stem with terminal panicle second year. Forms massive monotypic colonies in seasonal subsaline wetlands, brackish emergent marsh.

Likely effects on local native plant populations: Probably limited to small colonies on rocky shoreline or sand/gravel beaches at Marin Islands.

Likely effects on local wildlife habitat: May interfere with gull or shorebird high tide roosts on sand/gravel spits.

Level of threat/site-specific priority for control: For habitats present at Marin Islands, only moderate; focus on beaches.

Population status (distribution, abundance, age-structure) [survey]

Local modes of regeneration and spread: seed, clonal spread from roots.
Recommended site-specific feasible control techniques: Do not pull or grub plants; mechanical removal tends to cause fragmentation of roots and delayed regeneration. Treat cauline (bolted) pre-flowering shoots with glyphosate, wick or spray application, usually April in San Francisco Bay. Repeat treat clonal sectors that escape translocation of glyphosate and resprout by summer.

***Lolium* spp. (ryegrass) see annual grasses**

***Muehlenbeckia complexa* Mattress-vine**

Life-form and life-history: scandent shrub/fine-stemmed liana, evergreen; clonal by layering. Forms dense canopies at ground layer or over shrub layer; hence "mattress vine" common name. Seldom reproduces by seed in California.

Likely effects on local native plant populations: Forms dense local monotypic stands, eliminates ground and shrub layer, but largely confined to shaded, moist habitats (north slope oak woodland and garden relics)

Likely effects on local wildlife habitat: not known.

Level of threat/site-specific priority for control : low level of threat for spread, but high level of threat where established. Should not be retained as historic ornamental plant; difficult to contain.

Population status (distribution, abundance, age-structure) [survey]

Local modes of regeneration and spread: clonal spread by layering.

Recommended site-specific feasible control techniques: Systemic herbicide; labor-intensive manual removal by pruning may be feasible.

***Salsola soda* Mediterannean saltwort, saltwort**

Life-form and life-history: Annual succulent salt-tolerant forb, decumbent to ascending, up to 0.5 m. Produces abundant buoyant fruits, dispersed by currents and waves, deposited near high tide lines of estuaries, in beaches and salt marshes. Widespread, non-local seed sources around San Rafael Bay and San Francisco Bay in general.

Likely effects on local native plant populations: localized distribution along shorelines. May compete with *Atriplex triangularis, Grindelia stricta*, other high-tide line species.

Likely effects on local wildlife habitat: May produce dense annual vegetation on otherwise barren high tide roost sites on sand or gravel beaches.

Level of threat/site-specific priority for control: Seed sources are primarily offshore. Low priority for control on cobble-gravel beach. May naturally be controlled by gull trampling, possible seal haul-out activity.

Population status (distribution, abundance, age-structure): Expect variable annual shoreline population size, depending on timing of storm erosion and seedling regeneration along shoreline.

Local modes of regeneration and spread: seed only. In storm-free years, minimal beach/shoreline erosion, local seed sources may accumulate between years.

Recommended site-specific feasible control techniques: Manual pulling of pre-flowering plants (spring to mid-summer).

Genista monspessulana **French broom**

Life-form and life-history*:* Erect shrub, evergreen generally 5 to 10 ft tall. Brushy, ascending green branches; flowers in winter-spring. Produces abundant hard-coated seed, slow to germinate; persistent seed bank. Stump-sprouts from above-ground cuts, not below-ground.

Likely effects on local native plant populations: Highly gregarious, producing dense seedling-patterned stands from local dispersal. Dense stands inhibit seedling establishment of native vegetation; converts grassland, low scrub, forest herb layer to broom stands. Deposits nitrogen-rich leaf litter and root residues, facilitating invasion by weeds with high relative growth rates.

Likely effects on local wildlife habitat: not known. Flowers highly attractive to honeybees.

Level of threat/site-specific priority for control: High priority for eradication of juveniles and seed-producing stands. Eradication of persistent seed bank by exhaustion may be effectively infeasible, or at least very slow work.

Population status (distribution, abundance, age-structure): Core seed-producing populations occur primarily on the north side of the island, near residences to the boat dock, but juvenile outliers occur scattered across the island, positioned to establish new seed-producing colonies. Pattern indicates high potential for rapid expansion.

Local modes of regeneration and spread: seed dispersal (ballistic seed), seedling establishment.

Recommended site-specific feasible control techniques: manually pulling seedlings and juveniles in low-density, outlier stands, and fringes of seed-producing populations; use of herbicide (glyphosate) on mature stands. Pre-treatment of stands by brushcutting to generate dense, low proliferative branching of young, compact foliage, may be used to enhance coverage and reduce volume of herbicide spray application.

Hedera helix **Ivy**

Life-form and life-history: Large, wide-spreading creeping shrub or climbing liana as juvenile form; shrubby in maturity during flowering. Evergreen. Reproduces by clonal layering and seed.

Likely effects on local native plant populations: Severely reduces seedling habitat in dense evergreen ground layer canopy. Competes strongly with shrubs, herbs, young trees.

Likely effects on local wildlife habitat: not known, but likely to reduce foraging opportunities for seed-eating passerines.

Level of threat/site-specific priority for control: High level of threat for areas where it is established; moderate to high threat by seedling spread. Seedling recruitment is highest in moist, shaded habitats. High priority for eradication on East Marin Island.

Population status (distribution, abundance, age-structure): Spreading from plantings near residence to boat dock, along banks.

Local modes of regeneration and spread: clonal spread, layering along ground. Seedlings not detected.

Recommended site-specific feasible control techniques: Mature leaves resist wetting and uptake of herbicides. Physical removal by pruning, brushcutting, is extremely labor-intensive. Recommended: herbicide treatment mid-late summer when native perennial herbs have minimal leaf cover. To increase proportion of young, non-resistant shoot growth prior to herbicide treatment, prune or use brush-cutters, weed-whackers approximately 1 month before herbicide treatment (glyphosate) to stimulate new shoot growth. Use strong wetting agent (surfactant) consistent with label requirements.

Pinus radiata **Monterey pine**

Life-form and life-history: Evergreen tree 40 to 100 ft tall, with dense crown; rapid growth. Does not sucker or stump-sprout.

Likely effects on local native plant populations: Dispersal-limited populations spread vigorously from artificial coastal plantings, converting coastal scrub and grassland to pine forest in the absence of exotic tree competitors like blue gum.

Likely effects on local wildlife habitat: At East Marin Island, lacking small mammal populations, less impact to wildlife than on comparable invasions of mainland coast. Pines convert open foraging habitat of scrub/grassland to forest habitat.

Level of threat/site-specific priority for control: High long-term threat to East Marin Island from seed-bearing trees.

Population status (distribution, abundance, age-structure): All age classes present; likely long-term stability or increase in population size and density is indicated.

Local modes of regeneration and spread: seed dispersal in open or semi-shaded habitats.

Recommended site-specific feasible control techniques: girdling and wound-herbicide application for mature individuals; manual pulling, cutting for juveniles.

Poa annua see annual grasses

Rubus discolor **Himalayan blackberry**

Life-form and life-history: Robust sprawling and suckering shrub, nearly evergreen, to 10 ft tall. First-year canes (primocanes) vegetative, bearing hooked thorns or prickles; lateral branches flower and fruit second year. Canes senesce after fruiting. Vegetative canes act like stolons, swelling and rooting on contact with ground; adventitious shoot buds on lateral roots act like rhizomes; these form clonal colonies. Regenerates also from deep-set below-ground buds. Birds disperse fruit and seed; establishes readily by seed, favoring moist microhabitats.

Likely effects on local native plant populations: Large colonies can cover ground layer, shrub layer of native vegetation and persist indefinitely. May prevent disturbances from recovering native vegetation.

Likely effects on local wildlife habitat: unknown. Abundant large fruits attractive to passerines. Abundant flowers attractive to bees.

Level of threat/site-specific priority for control: Moderate threat of spread in sheltered or moist sites; low threat in exposed south-facing slopes

Population status (distribution, abundance, age-structure). Locally abundant, dominant on sites of past slope failures of north shore.

Local modes of regeneration and spread: suckering, layering, seed.

Recommended site-specific feasible control techniques: Vigorously regenerates from suckers, resprouts of stumps, for years after cutting even to ground level. Treat with glyphosate spray during spring vegetative growth or early flowering. Relatively reduced uptake/response to glyphosate after fruiting. Thorns dangerous: handle with rose-pruning gloves. Even protective gear becomes tangled in canes.

Oxalis pes-caprae **Bermuda-buttercup, Bermuda-sorrel**

Life-form and life-history: perennial clonal fleshy herb, spreading from bulbils (viviparous production of bulbs in maturing inflorescence) and bulbs formed on fleshy rootstalks. Dry-season dormant, vegetative emergence in fall; flowering December-April in coastal California. Forms dense mat-like stands in winter-spring, rapidly senescent in summer.

Likely effects on local native plant populations: strong interference with seedling establishment of almost all fall-germinating/winter-germinating plants, especially annual native herbs. Proliferates fastest in disturbed soils, but also invades intact soils.

Likely effects on local wildlife habitat: not known.

Level of threat/site-specific priority for control: Despite infrequent and slow long-distance dispersal, local clonal spread is rapid and intensive, even in harsh coastal bluff and grassland. Significant potential to reduce diversity of native grassland vegetation, interfere with seedling regeneration of a wide range of species. High priority for removal before populations spread; difficult to control established stands without impacting surviving native plants within stands.

Population status (distribution, abundance, age-structure) [survey]

Local modes of regeneration and spread: bulbils, below-ground clonal spread of bulbs.

Recommended site-specific feasible control techniques: Systemic herbicide only. Digging, pulling, hoeing, black plastic/solarization are generally ineffective because of persistent dormant bulb population, fragmentation of resistant bulbs.

Tetragonia tetragonioides **New Zealand spinach**

Life-form and life-history: short-lived perennial forb; procumbent, often mat-like, nonclonal; evergreen, fleshy. Produces abundant buoyant seed, often deposited in dense maternal seed-shadows in absence of shoreline erosion.

Likely effects on local native plant populations: Limited to shoreline habitats, bluffs, disturbed soils. Likely to compete with native shoreline annuals, perennials; if established on landslides above sea level, gravity dispersal of seed may colonize and dominate extensive areas downslope.

Likely effects on local wildlife habitat: None known for this locality.

Level of threat/site-specific priority for control: In absence of organic tidal litter accumulations, seeps in coastal bluffs nutrient-enriched soils (factors promoting invasiveness and dominance by this species), the local level of threat may be moderate. However, ease of preventing invasions at early stages indicates a high priority for control.

Population status (distribution, abundance, age-structure) [survey]

Local modes of regeneration and spread: littoral transport, deposition in drift-lines near the high tide line. Gravity dispersal occurs if seed parents establish on bluff slopes above sea level.

Recommended site-specific feasible control techniques: Manual removal, with bagging of seed-bearing plants. Local bulk disposal on island on upland sites would be difficult: fleshy plants are heavy, burdensome to transport. Disposal piles under clear or black plastic above high tide line, for solarization during June-August months, may be most feasible disposal option. Herbicide treatment by glyphosate would probably not affect viability of ripe or near-ripe seed; not recommended.

Vinca major **periwinkle**

Life-form and life-history: evergreen perennial forb, procumbent from dense crowns with below-ground buds; clonal by layering (rooting of prostrate shoot segments). Fragmentation rather than seed dispersal is the most likely mode of spread in coastal California; local distribution is often limited to spread from persistent plantings on embankments, riparian zones.

Likely effects on local native plant populations: Dense evergreen mats exclude ground layer species of coastal scrub and grassland, oak woodland understory. Most invasive in semishaded or shaded slopes or mesic soils.

Likely effects on local wildlife habitat: Displaces seed-producing and fruit producing vegetation (blackberry, perennial forbs) used by passerine birds.

Level of threat/site-specific priority for control: Very localized high level of threat around established populations on East Marin Island; low level of threat by spread remote from existing colonies. High proportion of oak woodland understory occupied indicates high priority of control, however.

Population status (distribution, abundance, age-structure): Apparently persisting and clonally spreading locally from old plantings. Invasive spread appears limited to north-facing slopes of oak woodland understory.

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Local modes of regeneration and spread: Clonal, layering.

Recommended site-specific feasible control techniques: Glyphosate foliar spray application on young, herbaceous spring vegetative growth (new shoot length ca. 5-15 cm), or black plastic blanketing where feasible. Manual removal is not recommended because of soil disturbance on slopes, likelihood of erosion and facilitation of invasion by competing weeds, especially *Genista monspessulana*. Post-control revegetation with *Rubus ursinus* and heavy local oak leaf litter mulching is recommended.

Appendix 2

Propagation and Transplanting techniques and schedules for selected native Marin Island plant taxa

1. Provenance and collection: Source populations should generally be local Marin Islands populations, unless specific justification for off-island reintroduction from nearby Marin mainland populations is given. No commercial "native plant" sources should be used. In general, at least 20 seed-parents should be sampled for seed or clonal propagation. Greater number and distribution of seed parent collection is desirable. For seed, numbers of seed should be approximately normalized among maternal parents.

2. Propagation: Stock are generally propagated for either direct transplanting, or for production of first-generation seed sources

Transplants of woody and perennial plants should be grown for bare-root transplanting in late fall/early winter (onset of cool, wet weather in Nov-Jan, variable dates) to mid-winter (mid-February). Container propagation is not necessary.

Tussock-forming perennial graminoids (grasslike plants) and perennials (other than taprooted plants with caudex-like rootstalks) may be propagated by late fall divisions of clumps. Divisions consist of either individual shoots or clusters of branched shoots with attached roots or root primordia. Evergreen plants should have approximately 2/3 of leaf area cut back to reduce transpiration demand of propagule. Rhizomatous and stoloniferous perennials may be propagated by sections of rhizomes with shoot buds evident. Field-harvested propagules should be kept moist and shaded immediately after harvest. Propagate in sheltered lathhouse or cool greenhouse in winter, using moist, well-drained amended soil medium (sand/peatmoss/compost; sand/vermiculite/peatmoss/soil). Supply dilute (1/10 label recommended concentration) of soluble salt fertilizer when new shoot growth is evident. **Examples**: *Achillea, Agrostis, Artemisia douglasiana, Aster chilensis,Carex* spp. *Dudleya* sp. *Festuca rubra, Festuca californica, Iris* sp.*, Lonicera hispidula, Luzula comosa, Melica* spp.*, Monardella villosa, Nasella* spp., *Solidago californica*, *Stachys ajugoides*.

Taprooted perennials with narrow, caudex-like crowns, and all **bulbs**, and **trees**, should be **seed-propagated**. Seed should generally be collected as soon as it is ripe, and sown in early fall. Seed should be sown in flats in light, fine sand/peatmoss/fine vermiculite, at depths approximately equal to seed diameter. Sown flats should be moistened beginning in late October, and kept moist consistently after in sheltered outdoor temperatures and semi-shade of lathhouse or screened greenhouse. Fertilize as for vegetative divisions, when second seedling leaves appear. Seedlings of bulbs may be grown directly in flats to produce small bulbs for transplanting; withhold water gradually after June to harden off bulbs. Seedlings of perennial forbs should be transplanted to containers or outdoor beds for growing on at 3rd or 4th leaf/leaf-pair stage. Grow with supplemental watering in well-drained medium throughout growing season to increase growth for adequate transplant size. In fall, after natural leaf senescence, remove about 2/3 of any remaining green leaf area, leaving terminal green leaves (if present) and lift bare-root plants for transplanting directly to field conditions.

Store in shaded, moist cool (below 15° C) conditions, packed in loose, moist peatmoss; transport within 24 hr. Examples: *Aesculus californica, Artemisia californica, Baccharis pilularis, Brodiaea* spp., *Bromus carinatus*, *Camissonia ovata, Chlorogalum, Cynoglossum, Dudleya, Elymus glaucus, Erigeron foliosus, Eriogonum, Eriophyllum, Eschscholzia, Heteromeles, Lathyrus, Lomatium, Lotus scoparius, Mimulus, Potentilla, Quercus, Sambucus, Sisyrinchium, Tritelia, Wyethia, Zigadenus.*

Buckeyes are readily propagated by prompt collection of ripe fruits, and planting them in 1 gallon containers in fall, barely covering the surface of the large seed. They germinate in winter to spring, and can be transplanted and grown in nursery field plots to develop taproots. They can be transplanted bare-root to island sites during winter dormancy. Alternatively, seed can be directly planted in favorable sites, buried to a depth equal to one seed diameter, any orientation. Coast live oak acorns can similarly be directly seeded to relatively sheltered sites, but with lower expected survivorship than buckeyes. Oak seedling survival should be expected to be relatively higher in semi-shaded or north-facing slopes, and very low in south-aspect exposed slopes.

Annual herbs should be propagated as above for seed-grown perennials, except seed harvest should occur upon ripening. Light addition of fertilizer during pre-flowering growth will maximize seed production. Examples: *Clarkia rubicunda, Claytonia perfoliata, Crassula connata*, annual *Lupinus, Lotus, Phacelia distans.*

3. Transplant microsite selection and preparation: Site selection for should approximately match plant associations, aspect, exposure, and plant density similar to those of established populations that are successfully reproducing. Sowing sites should have surface leaf litter removed or thinned to expose the soil surface, or be lightly scarified with a rake. Expert judgment from restorationists or botanists familiar and experienced with local Marin flora should provide on-site guidance for transplanting.

4. Transplanting timing and methods: Sowing of annual seeds should occur in late summer or fall, prior to first significant (soil-wetting) rainfall. Vegetative transplants should occur during moist, cool winter months (generally prior to Feb 15), during periods of frequent rains or overcast skies, with day temperatures below 15°C. Soil pit excavation should be avoided for transplants; tile spade should cut narrow opening in soil, pulled back to insert roots and set crown to original natural soil level, with roots spread as deeply in cut as possible; press moist soil firmly back into place around roots. Do not transplant into clay loam during saturated soil conditions.

5. Aftercare (rock/scree/litter mulch, watering, shadescreen): Temporary sheltering of transplants may be provided to ameliorate stress from desiccation. Small poultry mesh cages with fiberglass screen covers fastened over them, or cones of loose brush (twigs) may cover transplants, for no more than 50% shade. No watering should be needed for winter transplants in normal rainfall patterns. Flag transplant sites to facilitate recovery of sowing/transplant locations.

RECOMMENDED LOCAL EAST MARIN ISLAND SPECIES FOR GENERAL REVEGETATION OF DISTURBED OR WEED-CLEARED SITES
(see Section 5.2.3)

Oak woodland

Aesculus californica
Carex barbarae
Carex globosa
Quercus agrifolia
Rubus ursinus

South shore bluffs

Artemisia californica
Eschscholzia californica (seed)
Lotus scoparius

South grassland

Nasella spp.
Agrostis pallens
Tritelia laxa

West and East grassland

Chlorogalum pomeridianum
Elymus glaucus
Leymus triticoides
Zigadenus fremontii

North shore bluffs

Claytonia perfoliata (seed)
Festuca californica (seed or divisions)
Heteromeles arbutifolia
Mimulus aurantiacus

LOCAL EAST MARIN ISLAND SPECIES RECOMMENDED FOR POPULATION AUGMENTATION

The following species are locally threatened by either chance extinction due to small population size, habitat instability, or declines and fluctuations in habitat quality. Their risk of local extinction would be decreased by increasing the number of local colonies. Species recommended below have high feasibility or ease of successful propagation and transplanting. Difficult subjects such as *Piperia michaelii* may require intensive propagation efforts, and should be attempted only if expertise is available, and other species populations are secured. Augmentation is not suggested as an alternative to protection and management of existing populations. Transplant or seeding sites should generally be attempted only within local natural patterns of distribution (e.g. within local habitat types or vegetation units in which species are known to occur)

Amsinckia sp. (if rediscovered)
Camissonia ovata
Cynoglossum grande
Erigeron foliosus var. *franciscensis*
Eriogonum nudum
Festuca californica
Iris macrosiphon
Luzula comosa
Monardella villosa
Phacelia distans
Potentilla glandulosa
Stephanomeria elata
Wyethia angustifolia

Appendix 3 Vegetation Maps – East Marin Island 2004

Vegetation maps (section 3.3) represent 2004 vegetation and plant population conditions (integrated winter through summer phases) pertinent to vegetation management and future monitoring. Individual maps are explained below.

Map 1 – Overstory trees, East Marin Island

Two types of overstory trees were mapped as either canopy cover, individuals, or both. Mature Monterey pine and blue gum over 1 foot diameter breast height (DBH) were individually mapped in the field by GPS units. Pine and blue gum canopies were delineated from 2003 aerial photography. Coast live oak woodland (including California buckeye) canopies were also delineated from 2003 aerial photography. Small or isolated individuals of these species were not mapped as overstory canopy, but are included in other vegetation units. Approximate positions of canopy-obscured buildings were delineated from overlays of maps provided by Kroll (1991) for orientation.

Map 2 – Shrub and ground layer vegetation, East Marin Island

Shrubs, vines, grasses and grasslike plants, and all forbs (herbaceous plants) were treated as shrub and ground layer vegetation, i.e. all vegetation below forest or woodland overstory layers. Approximate positions of canopy-obscured buildings were delineated from overlays of maps provided by Kroll (1991) for orientation.

Boundaries of these vegetation units are approximate because of GPS data distortion and substantial reliance on manually mapped data used to fill gaps in GPS data. Vegetation units include predominantly natural (native and non-native) vegetation, remnants and expansions of horticultural plantings, and transitions between them.

North bluff scrub: This is a heterogeneous assemblage of shrubs, grasses, and forbs under coast live oak or in its canopy gaps on nearly vertical, mesic, north-facing bluffs and wave-cut scarps (all sites of past slope failure), from high tide line to break in slope. Because it is nearly vertical, it is effectively a line on aerial photographs/vegetation maps, and it is usually entirely obscured from vertical view by tree and shrub canopies. Zonation is prominent: definitive *Eriophyllum stoechadifolium* is restricted to zone above high tide line in this unit, and occurs nowhere else on the island. Highly variable vegetation; important native species include *Claytonia perfoliata, Heteromeles arbutifolia, Holodiscus discolor, Mimulus aurantiaca, Melica torreyana, Toxicondendron diversilobum, and. Lathyrus vestitus, Polypodium calirhiza* locally common. Locally high native forb and grass richness at northwest end: *Festuca californica, Luzula comosa, Polypodium calirhiza, Leymus triticoides*, apparently in old remnant vegetation patches. This unit lacks xeric elements of coastal bluff scrub (*Artemisia californica, Eriogonum nudum, Dudleya farinosa*). It is widely and patchily invaded by *Genista, Ehrharta, Hedera, Rubus discolor.*

Northeast bluff scrub: Intermediate in composition between north and southeast bluff scrub. *Spegularia macrotheca* prominent in bedrock outcrop crevices. *Eriophyllum stoechadifolium* minimal. Most other elements of north bluff scrub present. Low potential for *Artemisia* dominance.

Southeast bluff scrub: Similar to south bluff scrub (high frequency *Artemisia californica*), but with abundant or co-dominant *Genista, Foeniculum, Echium*. *Stephanomeria elata* is very local in this unit only. *Brodiaea* locally common, associated with non-native annual grasses. Potential vegetation is dominant *Artemisia* scrub. Strong zonation vegetation according to of basal bedrock outcrops with crevice vegetation (*Dudleya* dominant), upper landslide soils (scrub).

South bluff scrub: In the south-central bluffs, unconsolidated soils dominated by past landslides and ornamental plantings at the top of the bluff (blue gum shade and litter, *Genista*) have developed a relatively equitable mix of native xeric coastal scrub elements (*Artemisia californica*, *Toxicondendron diversilobum*, *Eriogonum nudum; Dudleya farinosa* in lower bedrock exposures) and invasive non-native shrubs (*Genista, Echium*); potential vegetation is dominant *Artemisia – Toxicondendron* scrub, occasional *Heteromeles*.

Southwest bluff scrub: The most xeric phase of the south-facing bluff scrub vegetation units, and the least affected by blue gum shelter, shade and litter. *Artemisia* dominant or co-dominant; *Toxicondendron* frequent to abundant. Distinguished by locally abundant invasion of *Opuntia* from bluff-top plantings (gravity dispersal), local Carpobrotus colonies, relatively high richness of infrequent native forbs: *Eschscholzia, Pellaea, Lotus*, local *Lupinus succulentus* (introduced?), at west end, *Phacelia distans* at bluff toe/cobble beach, other spp. Otherwise similar to southeastern bluff scrub (abundant *Echium, Genista*), but lacking *Foeniculum*. Strong zonation vegetation according to of basal bedrock outcrops with crevice vegetation (*Dudleya* dominant), upper landslide soils (scrub).

Ornamental bluff scrub – succulent: Quarry cliffs and bluffs with vegetation either planted or spread from ornamental plantings, succulent non-natives *Opuntia ficus-carica, Aeonium arboreum, Pelargonium hortorum;* some *Drosantherum floribundum*, bare substrate; minimal native vegetation or none. *Genista, Chasmanthe i*nvade where soil thickness allows. Minimal zonation.

Mixed ornamental bluff scrub: A mixture of Quarry cliff succulents, *Echium candicans*, and minority of native coastal (south) bluff species. Greater blue gum shade and shelter, substantial gull nest disturbance (devegetation, guano) of soil. Local *Phacelia distans* at bluff toe. Boundaries are not clearly defined, and are approximate. Minimal zonation.

Oak bluff transition: This is an artificial vegetation unit comprising a heterogeneous zone between coast live oak woodland and northeast bluff scrub, (described above), with relatively weak resolution as a vegetation unit. Areas in this unit apparently developed on landslides, scarp edges, or other disturbance patches, such as cut/fill trails or sites of past plantings. It is interpreted as a disclimax phase of either oak woodland understory or coastal bluff, depending on landscape position and exposure (dense canopy shade, canopy gaps, lack of canopy). It includes patches of native-dominant northeast bluff scrub, non-native dominant patches (*Hedera, Rubus discolor*). These "transitional" vegetation patches are variable in age, ranging from mature relict native soil and vegetation, to recently invaded gaps. Boundaries are not clearly defined, and are approximate.

Ornamental/woodland transition: This is another artificial, heterogeneous, poorly defined vegetation unit that describes transitions between horticultural plantings and coast live oak woodland understory, usually at or near the vicinity of gardens or paths with former earthmoving. Boundaries are not clearly defined, and are approximate.

Ornamental ruderal: This is a derelict horticultural unit with variable recolonization by non-native weeds and native elements of coastal scrub or grassland vegetation, largely artifacts of past cultivation and earthmoving.

Ornamental/grassland transition: Similar to Ornamental ruderal, but distinguished by relatively greater proportion of grassland species; may be unstable, tentatively distinguished artificial unit.

East grassland: East grassland is distinguished by prevalence of native perennial bulbs (Liliaceae *sensu lato*), ranging from bulb-rich (high bulb frequency) to bulb-poor areas that in summer otherwise appear to be merely weedy non-native annual grassland. This unit is visually quite distinct from other grasslands in spring (March-April). Important species include *Tritelia laxa, Chlorogalum pomeridianum*, and *Zygadenus fremontii*. Occurs under pine and oak shade with canopy gaps. Relatively well-defined unit as a whole, but boundary resolution is variable and probably unstable, especially at woodland and *Genista* edges. (Figure 17)

Central grassland: Central grassland is distinguished by high frequency of native perennial grasses *Elymus glaucus*, *Agrostis pallens*, and patchy distribution of rein-orchid *Piperia michaelii*, and many native perennial forbs. Bulbs are patchy or lacking, and are mostly *Tritelia*. Bunchgrass, *Nasella* spp. is occasional or local; annual non-native grasses are frequent to abundant. Occurs under blue gum with canopy gaps.

South grassland: South grassland is distinguished by moderate frequency of bunchgrass, *Nasella* spp. (increasing to the south) and *Agrostis pallens* (increasing to the north), infrequent or absent bulbs, presence of scattered *Lomatium* and *Perideridia*, rare patches of *Aster chilense, Monardella villosa, and Solidago californica*, infrequent xeric coastal scrub species (*Artemisia californica, Eriophyllum confertiflorum*), and widespread invasion by non-native annual grasses, *Genista*, and *Echium*. Occurs under blue gum with canopy gaps.

West grassland: West grassland is relatively similar to south grassland in character, but is distinguished by local abundance of *Leymus triticoides* (extreme west point, shell midden soils), greater shade and tree litter from blue gum and Monterey pine, and more advanced transition to scrub and *Genista*. It also supports a population of *Piperia michaelii*, and some *Tritelia* patches, similar to central grassland. Gull or goose nesting disturbances are evident. Possible burrows in light midden soils.

Grassland/scrub transition: a general designation to poorly defined or transitional (ecotonal or dynamic) areas with patchy grassland, remnant grassland species, and at least locally abundant scrub of variable composition, but usually including *Genista, Heteromeles arbutifolia*. It may be interpreted as an area with expected change in boundary conditions.

Understory scrub transition: General equivalent of grassland/scrub transition (above), not limited to grassland transitions; includes erratic areas of high-density *Genista* stands, for heterogeneous native and non-native scrub vegetation with little evidence of past planting or earthmoving (contast with ornamental scrub transition).

Cobble beach *Cressa*: Intertidal upper foreshore zone dominated by lag armor of angular cobbles (fragmented greywacke bedrock of cliffs), with underlying pebbly clay-silt bound by rhizomes of *Cressa truxillensis*; forming stable vegetation. *Salicornia virginica, Distichlis spicata, Jaumea carnosa* absent or rare. (Figure 9)

Brackish high marsh: nontidal lagoon fringe of dominant *Distichlis spicata, Jaumea carnosa, Salicornia virginica*; saline seasonally wet soil.

Lagoon: brackish (peak summer salinity circa 17 ppt) washover-flooded perennial pond, influenced by washovers during highest tides; supports sparse *Ruppia maritima* with epiphytic algae (Figure 19).

Buckeye-fern understory: Erratic mesic outlier of oak woodland vegetation, including abundant *Polypodium calirhiza* in shade of low-growing, wind-pruned *Aesculus californica*. Mix of native and non-native forbs associate here. Local stand distinguished on steep east-facing section of south bluff scrub.

Oxalis-soap plant terrace: Apparently artificial gravel fill terrace dominated by *Oxalis pes-caprae* in winter, with abundant/co-dominant *Chlorogalum pomeridianum*. *Foeniculum vulgare* common (Figure 19). Includes *Nasella* spp, other native and non-native grassland elements.

Blackberry: Monotypic or dominant thickets of non-native *Rubus discolor*, often associated with *Hedera, Toxicondendron*, and minority native forbs. Develops mostly in treeless gaps, likely former landslides or soil disturbances rapidly colonized. Practical, artificial distinction from north bluff scrub.

Map 3a – Selected locations of infrequent native plants, East Marin Island

GPS point locations (generally accurate within 2 m) of infrequent or locally rare native plants or small populations that are difficult to locate (seasonally undetectable, remote from main populations, or obscured) were selected and assembled on this map. These provide greater specificity for some management recommendations within vegetation management units.

Map 3b – Selected locations of discrete or outlier populations of nonnative plant populations, East Marin Island

GPS point locations (generally accurate within 2 m) of outlier populations of invasive non-native plants that may be difficult to detect are included in this map. Some discrete populations (single colonies, plants, or boundary colonies) of non-native plants were selected.

Map 4 – Vegetation Management Map

The vegetation units of this map are a mixture of relatively natural and artificial vegetation units, based principally on ground layer/shrub layer vegetation in which most management activities are focused. Coast live oak woodlands are exceptions, superimposed as a dominant management unit overriding multiple understory types. Some related vegetation units with overlapping management needs and similar priorities are merged, and some geographic reference names are modified from ground layer/shrub layer map units, for recognition value (presumed use volunteers). Prescriptions for vegetation management (Section 5) are keyed to this map.

Appendix L. Marin Islands NWR Non-Native and Invasive Plant Management Priorities.

Species	Priority[a]	Year	Duration	Fall	Winter	Spring	Summer	Method
French broom (*Genista monspessulana*)	High	all	10 yr +	X	reduce effort	reduce effort	X	Cutting
Pride-of-Madeira (*Echium candicans*)	Low to moderate	1-2	2 yr	X			X	Cutting
Pride-of-Madeira (*Echium candicans*)	Low to moderate	1-10	10 yr	X			X	Cutting
Erect-ehrharta (*Ehrharta erecta*)	High	all	5 yr +	X	X	X	X	Cutting, herbicide
Jubata grass (*Cortaderia jubata*)	High	1-2	1-2 yr	X	X			Cut moderate-sized plants
Monterey pine (*Pinus radiata*)-juveniles	High	1-2	2 yr	X			X	Cutting
Perennial pepperweed (*Lepidium latifolium*)	Moderate	1-2	2 yr			X	X	Herbicide
Blue gum (*Eucalyptus globules*)-south shore	High	1-5	5 yr	X			X	Girdling, herbicide
Blue gum (*Eucalyptus globules*)- south plateau	High	1-5	5 yr	X early			X late	Girdling, herbicide
Monterey pine (*Pinus radiata*)-mature trees	High	1 - 3	4-5yr	X early			X late	Girdling, herbicide
Prickly-pear cactus (*Opuntia ficus-carica*)	Moderate	1-5	7-15 yr	X early			X late	Digging
North Shore & Old Garden ornamental removal (vinca, ivy, etc.)	Moderate	1-10	10+ yr	X early			X late	Cutting, herbicide

[a]Refer to Baye (2005), for detailed control and removal methods.

Appendix M. Management of Native Vegetation: Priority Species and Plant Assemblages.

Management of native vegetation: priority species and plant assemblages.

Species or Vegetation Assemblage[a]	Population Threat	Method of Restoration[b]	Management Goal	Time to Achieve Goal
Quercus agrifolia (Coast live oak)	• Sudden Oak Death (SOD)(*Phytophthera ramorum*) • Competition with non-native plant species	• P-Phyto-sanitation and SOD testing • R-Removal of non-native tree canopy and early stage *Genista* invasions: girdling, cutting, pulling, herbicides • R-Removal of non-native perennials (e.g., Napa starthistle, jubata grass, fennel): pulling, cutting, herbicides • V-On-site seedling transplants	• Maintain existing population (P, R) • Population expansion (5-10% increase) (R, V) • Develop monitoring plan • Monitor restoration activities: every 3 years • Develop restoration work plan	• Develop monitoring plan: year 1 • Work plan: annual • Maintain: continuous • Expand: 5-10 years
Aesculus californica (California buckeye)	• Competition with non-native plant species	• R-Removal of non-native tree canopy and early stage *Genista* invasions: girdling, cutting, pulling, herbicides • R-Removal of non-native perennials (e.g., Napa starthistle, jubata grass, fennel): pulling, cutting, herbicides • V-On-site seed/seedling transplants	• Monitor restoration: 3-year intervals • Maintain existing population (R) • Population expansion (5-10% increase)(R, V) • Develop monitoring plan • Monitor restoration activities: every 3 years • Develop restoration work plan	• Develop monitoring plan: year 1 • Work plan: annual • Maintain: continuous • Expand: 5-10 years
Native grassland and coastal scrub	• Shading and litter deposition by non-native trees • Non-native plant biomass accumulation • Competition with non-native grasses and shrubs	• R-Removal of non-native tree canopy, early stage *Genista* invasions, and other non-native invasive species: girdling, cutting, pulling, herbicides • M- Mowing, pulling, raking • V-Re-vegetation of disturbed or weed-cleared sites through collection, propagation and transplanting: *Nasella spp., Agrostis pallens, Tritelia laxa, Chlorogalum pomeridianum, Elymus glaucus, Leymus triticoides, Zigadenus fremontii* • E-Experimentation: raking trials to reduce biomass and encourage native spread	• Maintain existing native population (R, M, V) • Reduce non-native invasive plant cover by 80% (R, M, V) • Develop monitoring plan • Monitor restoration activities: every 3 years • Develop restoration work plan	• Develop monitoring plan: year 1 • Work plan: annual • Maintain native cover: continuous • Reduce invasive cover: 10-15 years

Species or Vegetation Assemblage[a]	Population Threat	Method of Restoration[b]	Management Goal	Time to Achieve Goal
Oak Woodland	• Sudden Oak Death (SOD)(*Phytophthera ramorum*) • Displacement by non-native species	• P-Phyto-sanitation and SOD testing • R-Removal of non-native tree canopy and early stage *Genista* invasions: girdling, cutting, pulling, herbicides • R-Removal of non-native perennials (e.g., Napa starthistle, jubata grass, fennel): pulling, cutting, herbicides • V-Re-vegetation of disturbed or weed-cleared sites through collection, propagation, and transplanting: *Aesculus californica, Carex barbarae, Carex globosa, Quercus agrifolia, Rubus ursinu*	• Maintain existing native population (P, R, V) • Reduce non-native invasive plant cover by 80% (R, V). • Develop monitoring plan • Monitor restoration activities: every 3 years • Develop restoration work plan	• Develop monitoring plan: year 1 • Work plan: annual • Maintain native cover: continuous • Reduce invasive cover: 10-15 years
North and South Shore Bluffs	• Displacement by non-native species	• R-Removal of non-native tree canopy and early stage *Genista* invasions: girdling, cutting, pulling, herbicides • R-Removal of non-native perennials (e.g., Napa starthistle, jubata grass, fennel): pulling, cutting, herbicides • V-Re-vegetation of disturbed or weed-cleared sites through collection/division, propagation and transplanting: *Artemisia californica,Eschscholzia californica (seed), Lotus scoparius, Claytonia perfoliata* (seed), *Festuca californica* (seed or divisions*),Heteromeles arbutifolia, Mimulus aurantiacus*	• Maintain existing native population (R, V) • Reduce non-native invasive plant cover by 80% (R, V). • Develop monitoring plan • Monitor restoration activities: every 3 years • Develop restoration work plan	• Develop monitoring plan: year 1 • Work plan: annual • Maintain native cover: continuous • Reduce invasive cover: 10-15 years
Locally threatened native plant species	Risk of local extinction from small population size, habitat instability, or declines and fluctuations in habitat quality	• Increase number of local colonies through propagation and transplanting: *Amsinckia* sp. (if rediscovered), *Camissonia ovata, Cynoglossum grande, Erigeron foliosus* var. *franciscensis, Eriogonum nudum, Festuca californica, Iris macrosiphon, Luzula comosa, Monardella villosa, Phacelia*	• Develop monitoring plan • Monitor restoration activitites: annual • Maintain or increase colony size • Develop restoration work plan	• Monitoring plan: year 1 • Work plan: annual • Maintain: continuous

Species or Vegetation Assemblage[a]	Population Threat	Method of Restoration[b]	Management Goal	Time to Achieve Goal
		distans, Potentilla glandulosa, Stephanomeria elata, Wyethia angustifolia		

[a]Refer to: Baye, P. 2005. Marin Islands National Wildlife Refuge and State Ecological Reserve Vegetation Management Plan.
[b]Determination of total cover (acres) and change of cover through time will be based on mapping efforts that are initiated in year 1.