Appendix D Priority Management and Restoration Issues

This appendix integrates the best available biological information to aid in the development of specific restoration and management programs and projects for the LOHCP Preserve System. The information will be used in the development of the LOHCP Preserve Adaptive Management and Monitoring Plan (AMMP) that will guide implementation of management and restoration projects.

This appendix addresses management of three main factors that can impact habitat within the Bayview fine sands ecosystem: exotic plant species, incompatible recreation, and fire.

D.1 Exotic Plant Species Management

Exotic plants have been identified as one of the current stresses to the sensitive species and communities of the Baywood fine sands (USFWS 1994, Tyler and Odion 1996, JSA 1997, USFWS 1998a, 1999). In addition, future invasions are likely to greatly impact this endangered system and influence the ability of the Los Osos Habitat Conservation Plan to attain its biological goals.

This section is intended to:

1. Outline the approaches to exotic plant management;
2. Identify the techniques currently available to treat exotic plant populations;
3. Describe the distribution, ecology, and impacts of exotic plant species presently within lands that are anticipated to be included within the LOHCP Preserve System.

This information will be used to develop the specific management strategies, targets, and techniques for exotic plant management within the LOHCP Preserve System AMMP, which will also be informed by a baseline inventory of exotic plants within the preserves conducted early during implementation of the LOHCP conservation program.

D.1.1 Introduction

Though the Baywood fine sands are relatively droughty and low in nutrients (USDA 1984), exotic plant species have successfully colonized the plant communities they support. Primarily originating in regions experiencing Mediterranean climates, these species are termed “exotic” because they were not present in the region prior to the arrival of Europeans in the 1700s; instead, their presence is due to direct or indirect effects of human activity.

Though exotic plants of the LOHCP Area vary in aspects of their ecology which influence their impacts, in general, they likely compete with populations of native plants and reduce the diversity of the plant communities. In doing so, they likely degrade habitat required by native animal species, including populations of sensitive species, including the four covered species. Certain types of exotic species, such as the perennial grasses, have the potential to further degrade habitat by altering ecosystem processes including disturbance regimes, and water and nutrient cycling (D'Antonio and Vitousek 1992, Haubensak 2001). The known and hypothesized impacts of exotic plant species presently found in the LOHCP Area are further discussed in Section D.1.5.

Exotic plant species will likely present a continuing stress and challenge for management in the LOHCP Preserve System. New exotic plants will likely invade the region as a result of additional introductions (Janzen 1986, Levine and D'Antonio 2003); in additions, alterations in conditions (e.g., climate change, nutrient deposition, fire) can create new opportunities for existing species in the region to invade habitat within the LOHCP Preserve System. Once exotic plants become established, the costs of eradication and control efforts can be high; hence prevention programs will be a critical component of LOHCP Preserve System Management.

Because exotic plants can have large negative impacts on the ecosystem, plant communities, and populations of the covered species and other rare plants and animals in the LOHCP Area, they will be actively managed to reduce their distribution and abundance, as well as prevent new introductions. This section outlines the general approaches to exotic plant management which are designed to facilitate the biological goals and objectives of the LOHCP (Section 5.1).

D.1.2 Exotic Plant Management Planning

During the first three years of implementation of the LOHCP, the LOHCP Preserve System AMMP will be developed. The plan will include an exotic plant management component that will:

1. Provide baseline data documenting the current distribution and abundance of each species;
2. Outline management strategies, targets, and techniques for exotic plant management;
3. Identify a coordinated program for exotic plant management, which includes a prioritized list of exotic plant control and eradication projects, timelines and budgets for project implementation, and a detailed program for exotic plant prevention.

The Exotic Plant Management component of the LOHCP Preserve System AMMP will be developed by inventorying the exotic plants, assessing the significance of their impacts, evaluating the feasibility of their control, and ranking exotic species and specific occurrences according to the urgency of management.

D.1.2.1 Inventorying Exotic Plants

Through a systematic survey of the LOHCP Preserve System, a qualified biologist will document the distribution of all exotic species. The occurrence of exotic plants adjacent to the Preserve System should also be recorded, as feasible. For purposes of the initial evaluation of species, relative abundance categories will be assigned to facilitate assessment of impact and likelihood of control. Ultimately, a quantitative sampling regime will be used to estimate density or percent cover, which can be provide baseline data for tracking changes through time and evaluating effectiveness of management. The resulting distribution and abundance data should be incorporated into the LOHCP Preserve System geographic information system (GIS).

D.1.2.2 Assessing Impact Significance

The significance of impact of each exotic species found within the LOHCP Preserve System will be assessed based on its current impacts and the potential for it to increase in impact at a later date (Hiebert and Stubbendieck 1993). Current impact determinations will consider the distribution, abundance, and known or likely effects on species (incl. sensitive species) and ecosystem processes (e.g., succession, nutrient cycling, fire, etc.). Future impacts will be evaluated by assessing the species' reproductive ability, dispersal ability, habitat requirements, competitive ability, and known impacts in natural areas that might be similar in characteristics (e.g., soils, climate, vegetation structure, etc.) to those in the Baywood fine sand communities (e.g., Guadalupe-Nipomo Dunes).

Section D.1.5 outlines the type of information that will be incorporated in an impact assessment, which should be greatly expanded following the detailed assessment of the species distribution and abundance as part of the inventory.

D.1.2.3 Determining Feasibility of Management

For each exotic plant species, the feasibility of successful management will be evaluated. Specific management goals (prevention, eradication, and control) are discussed in the next section. In general, feasibility would be the function of four main factors:

Distribution: Narrowly distributed plants, including those limited to specific microhabitats and those that have only recently invaded, will be more feasible to manage than widespread plants.

Abundance: Plants which occur in low abundance (low population densities) may be easier to control than those that occur at high density (recognizing that impacts of exotic species can be greater at higher densities).

Biology: Several aspects of exotic species biology can reduce susceptibility to control, including presence of a seedbank, and ability to regenerate vegetatively (i.e., from stems, roots, and other structures).

Treatments: Several aspects of management treatments that will influence feasibility include (Hiebert and Stubbendieck 1993):

1. Whether effective treatments have been developed;
2. The cost of treatments; and
3. Collateral damage and potential for unintended negative impacts of treatments.

Feasibility of management will be based on a complete review of the most recent scientific literature and conversations with experienced land managers in the region.

D.1.2.4 Ranking Exotic Plants and Occurrences for Management

Based on their impact and management feasibility, exotic plant species will be ranked according to the urgency for management. A ranking system based on quantitative assessments of species impact and the management feasibility such as that developed for the National Park System (Hiebert and Stubbendieck 1993) could be used to objectively rank species; such an objective program can avoid inadvertent bias which could reduce effectiveness of the overall program.

Within the LOHCP Preserve System, habitat differs in ways that will influence the specific exotic plant management strategies, targets, and techniques. These include:

1. The species richness, distribution, and abundance of exotic plants present;

2. Exotic plant species and land use in areas adjacent to the preserve;
3. The structure and composition of the native communities, including the distribution and abundance of sensitive species; and
4. Other management projects to be implemented (i.e., recreation, fire, etc.).

D.1.2.5 Prioritize Exotic Plant Management Projects

Exotic plant management will likely consume a large portion of the budget allocated for monitoring and management within the LOHCP Preserve System. Though this is justified, given the current and potential future negative impacts of exotic plants, it is critical that the funds be used judiciously. One critical component of this is proper use of adaptive management methods to ensure that exotic plant projects are indeed effective. If project goals are not attained and/or the project does not appreciably advance the conservation goals of the LOHCP, future projects should be modified, as needed, or not conducted at all. The successful design and evaluation of projects can be facilitated by the scientific approaches to management.

Within the exotic plant management program, funds will not be sufficient to conduct all projects. An objective system of prioritizing exotic plant management will be established to facilitate the best use of funds. Within projects, cost-benefit analysis will be used to weigh to relative merits of different targets and techniques. A schedule of exotic plant management projects will be developed to reflect the priorities. Scheduling exotic plant management will also be important to address the crucial role in the season often plays in influencing treatment effects.

The priorities, schedules, and budgets will be subject to critical review by landowners and trustee agencies, and amendment per results of LOHCP management projects, availability of new information (e.g., science, new techniques), and new stresses and threats (within exotic plant management, new priorities in overall management).

D.1.3 Exotic Plant Management Goals and Approaches

Exotic plant management will follow carefully established goals, each with one or more specific, quantitative objectives. Outlined in the exotic plant component of the LOHCP Preserve System AMMP, these goals and objectives will be developed in consideration of the biological goals and objectives of the LOHCP (Section 5.1). Both long term and short-term goals will be developed and, as with all aspects of the LOHCP Preserve System management, an adaptive framework will be used to evaluate and promote goal attainment.

Three main types of goals for exotic plant management will be pursued: prevention, eradication, and control. The following sections identify the criteria that will be used to assign exotic plant species occurrences to one of each of these main treatment goals, based on the comprehensive assessment of exotic plants conducted as part of the baseline survey for exotic plants in the LOHCP Preserve System (Section E.7).

D.1.3.1 Prevent Exotic Plant Establishment

The communities of the Baywood fine sands will inevitably be subject to further invasion, as aggressive exotic plants continue to become established and spread within California, and as habitat conditions change in ways that promote invasion. Given the strong negative impacts of exotic plants on species and communities, and the large effort required to control these species, the invasion of new exotic plants will be prevented if at all possible. The opportunity costs of focusing on eradication and control efforts to the deficit of prevention will be considered in overall exotic plant management prioritizations (described below).

New invasions will be prevented through implementation of an exotic plant prevention program that will:

1. Reduce or eliminate invasive exotic plant occurrences adjacent to the Preserves;
2. Limit introduction of foreign material into Preserves;
3. Conduct education and outreach;
4. Establish methods for early detection; and
5. Plan for early eradication.

Reduce Exotic Plants Adjacent to the Preserves

Though transportation and recreation can bring seed from long distances, most exotic plant introductions will result from short-distance dispersal from areas adjacent to the LOHCP Preserves. Targeted outreach and individual coordination with adjacent landowners can be used to reduce the likelihood that new invasive exotic plants will become established within the Preserve System.

Limit introduction of foreign material into Preserves

The following steps will reduce the likelihood that new exotic plants will be introduced into the Preserve System.

1. Restoration projects will use gravel, fill, mulch, straw, and propagated plants that are 'weed free', wherever possible (Tu et al. 2001).
2. Any vehicles will be washed prior to entering Preserves.
3. Recreational trails will be managed to minimize dispersal opportunities, including by:
    a. Not connecting Preserves areas to highly invaded habitats;
    b. Removing exotic plants from parking lots, staging areas, and trailheads;
    c. Encouraging visitors to monitor themselves and their stock for weed seed; and
    d. Requiring that equestrians use only weed-free hay when recreating in Preserves.

Education and Outreach

Outreach should be used to educate adjacent landowners and Preserve visitors about the detrimental impacts of exotic plants and the steps people can take to help prevent new invasions. Residential landowners adjacent to Preserves will be encouraged not to grow invasive species including jubata grass, iceplants, and eucalyptus.

Early Detection

The Preserve System will be examined annually to detect occurrences of new exotic species. Heightened vigilance will prevent establishment following events known to promote invasion including:

1. disturbances, such as fire, roads or trails creation, landslides, or restoration projects;
2. very wet years (e.g., El Niño years); and
3. soil amendment and fertilization, including application of herbicides.

Early Eradication

Any new exotic plant species detected within the LOHCP Preserve System will be eradicated during the first year following initial detection.

D.1.3.2 Exotic Plant Eradication

Complete elimination of an exotic species from the Preserve System will be the goal of management where doing so is feasible. Species that should be considered for eradication include:

1. recently invaded exotic plant species;
2. narrowly distributed exotic species; and
3. exotic species that occur at relatively low density.

Recent invasions

Most invasions begin with one or a few individuals in a single area. Removal efforts focused on such new invasions can be successful due to the limited geographic area and the low number of individuals requiring treatment. Moreover, recent invasions of species requiring more than one season of growth prior to reproduction (shrubs, trees, and many perennial herbs) can be successfully eradicated if removed before they have the opportunity to reproduce. This can be especially important for species that develop seedbanks (populations of dormant seed) or other belowground dormant structures (e.g., bulbs, tubers) that can be difficult to locate and remove.

Narrowly Distributed Species

All else being equal, species can be more easily eradicated if they occur in a smaller geographic area, where focused treatments can successfully remove every individual. Several exotic species have narrow distributions and can be eradicated, including:

1. Species that were deliberately planted (e.g., many tree species and ornamentals); and
2. Species that are restricted to narrow microhabitats within the Preserves (e.g., along roads or creeks, near structures, etc.).

Less Abundant Species

Small populations oftentimes comprised of just a few, sparsely distributed individuals can be more readily eradicated than large populations. Presumably, conditions are not conducive to their widespread establishment; however, these species will be eradicated before they can build up potentially explosive seed banks or proliferate in response to changing conditions, such as a fire, drought, series of wet years, or global climate change.

D.1.3.3 Exotic Plant Control

Exotic plants that have strong impacts yet cannot feasibly be eradicated will be the subject of control efforts, which will be designed to reduce their current negative impacts and potential for future impacts on communities and covered species by:

1. preventing their spread;
2. reducing their abundance (e.g., density);
3. reducing their distribution; and
4. reducing their vigor.

The following guidelines will be followed to enhance effectiveness of exotic plant control projects:

1. remove individuals or isolated patches of plants which are geographically isolated from larger patches;
2. remove exotic plants along trails, which can act as corridors for invasion to intact habitat;
3. prevent the spread of populations by controlling patches at their perimeters, then working inward;
4. prevent the spread of wind-dispersed species including grasses and Asters, among others, by working from upwind (where the sources are) to downwind (where seeds are landing).

Depending on the species and community, exotic plant control will proceed via one or more approaches:

1. **Ecosystem-Level Approaches:** In these approaches, management efforts focus on controlling exotic plant species by addressing ecological processes that influence their distribution, abundance, and population performance. Such approaches may be the most cost-effective for controlling widespread and abundant exotic species over large spatial and temporal scales. Fire management, which includes both prescription burning and wildfire suppression, and grazing are two common ecosystem approaches.
2. **Functional Group Approaches:** Exotic plant species with similar ecologies can be targeted with similar methods, perhaps increasing efficiency over single species efforts. In the LOHCP Preserves, the same control methods might be used for various species of iceplants.
3. **Single-species approaches:** A single species approach will be used in cases where a species has large impacts and/or a unique ecology which requires specialized treatment, including in the case of veldt grass.

D.1.4 Exotic Plant Management Techniques

Numerous techniques have been developed to kill or damage exotic plants; these techniques are often combined to enhance their effectiveness (Bossard et al. 2000), sometimes synergistically so (Tu et al.

2001). This section describes physical, biological, and chemical techniques will be used as part of an integrated pest management strategy to manage exotic plants in the LOHCP Preserve System, by describing the basic technique, discussing its effective use, then evaluating the benefits and potential negative impacts of its use. During implementation of the LOHCP, the available scientific literature and expertise of invasive species biologists, weed scientists, and land managers in the region will be used to select the appropriate techniques for management.

D.1.4.1 Physical Control Methods

Exotic plant species can be physically controlled using manual and mechanical removal, fire, mulching, and soil solarization.

Manual and Mechanical Removal

A wide variety of techniques have been developed to remove plants or plant biomass by hand, with or without hand tools (manual removal), or using mechanized tools (mechanical removal). These include various types of cutting and girdling as well as pulling.

Cutting: Cutting exotic plants at their base using saws (manual or chain), machetes, loppers, brush cutters, weed whackers, mowers, and brush hogs (which twist off aboveground biomass) can sometimes effectively kill them. Many exotic species resprout when cut, such that physical treatments, such as stump grinding, or chemical treatments with herbicide, are required to kill them.

Girdling: An incision cut into the trunk of a tree around its circumference can sever water and nutrient transport conduits in the trunk, thus killing the tree. While left standing in many systems, girdled trees and shrubs should be removed as standing dead trees will continue to produce shade and litter and, once they fall, will negatively impact native plants directly, through crushing, and indirectly, by usurping space as the process of decomposition will be slow, leaving the dead tree on the soil surface for decades.

Pulling: Because cutting often allows plants to resprout, pulling exotic plants out by their roots is often more effective. The loose sand soil conditions in most areas of the LOHCP Preserve System will render it fairly easy to hand-pull seedlings as well as adults of many species. Pulling can be aided by weed wrenches and similar devices that feature a lever connected to a clamp which, when attached to the base of the plant, allows one to leverage the shrub out of the ground using one’s weight. The disadvantage of pulling is that some species may be facilitated by the soil disturbances that results from removing the root mass from below the soil surface.

D.1.4.2 Fire

Fire can be used to control populations of fire-sensitive exotic plant species through two main mechanisms.

Blowtorches and flamethrowers: Flames can be used to kill exotic plant individuals or patches through incineration or heat-girdling. When used during wet weather, risk of fire through the process known as ‘flaming’ is greatly reduced (Tu et al. 2001).

Prescribed burning: Broadcast burning removes aboveground individuals, and for many species with dormant seed banks, either kills seeds or induces their germination, after which seedlings can be removed (Bossard et al. 2000). In fire management, aspects of the fire regime including seasonality and intensity of the burn, among other aspects, will influence fire impacts.

Oftentimes a single burn is not sufficient, but several consecutive burns are needed to control exotic plants. For example, an initial burn can be to kill aboveground individuals and stimulate germination from the seedbank, and a second (and sometimes third or fourth) burn used to kill the newly established seedlings.

Importantly, some exotic plants are promoted by fire, which stimulates seed germination, or creates open conditions that promote their establishment and growth (Bossard 2000). Thus, burning, especially in closed canopy communities, could inadvertently benefit exotic species (Section D.3.1.2).

D.1.4.3 Mulching

Litter or other cover on the soil surface that reduces light availability and thus photosynthesis can inhibit populations of many exotic plants. To prevent new seedling establishment or resprouting following removal of adult shrubs and trees, a variety of mulches including straw and hay, sawdust and wood chips, grass or other clippings (Tu et al. 2001).

Native plants and animals of the Baywood fine sands might also be inhibited by mulches, so mulches should not be widely applied within intact habitat but may be an effective way to control dense infestations of exotics in highly degraded areas lacking native populations. For example, in dense stands of eucalyptus (*Eucalyptus* spp.), which typically contain very low diversity and cover of native plant species, cut stumps could be covered with black plastic tarps to inhibit re-sprouting and thus killed trees. This approach, known as 'tarping', might be used to remove exotic plants in other degraded sites, but should not be used as a widespread treatment within intact habitat (Horowitz 2003).

D.1.4.4 Solarization

Increasing soil temperatures by placing clear plastic sheets over moist soils, causing a greenhouse effect, can kill many seeds and thus prevent their germination. As with mulching and tarping, this treatment will kill both native and exotic plant seeds and therefore should only be used in highly degraded areas.

D.1.4.5 Biological Control Methods

Biological control methods use the natural enemies of exotic plants to reduce their abundance or vigor and thus their negative impacts on native species. Three types of biological control include biocontrol, competition through restoration, and grazing (Bossard 2000).

Biocontrol

Biocontrol is the process by which natural enemies of target species including animals, fungi, and other microbes are released into the wild to predate upon or parasitize exotic plants. Prior to their release, biocontrol agents are rigorously tested to ensure that they do not negatively impact native species and must be approved for use by the USDA. This extensive process precludes the use of biocontrol agents on all but a few of the worst pest plants.

Competition through Restoration and Management

Native plants can compete with exotic plant species, thus reducing their performance and ultimately their populations. Typically, exotic plants are problematical because they are strong competitors for resources and thus 'out compete' native plants. Restoration techniques that 'tip the balance' (Corbin et al. 2004) towards native species might enhance native biodiversity. Such techniques can include: propagating and reseeding native species, reducing the availability of nutrients through carbon addition, and facilitating succession.

Planting and seeding native species: In highly degraded areas where native plant propagule supply is limited, control of exotic plant species may be facilitated by sowing or planting native plants in conjunction with exotic plant removal or other control techniques. A very conservative protocol for procuring, propagating, and out planting plant material must be adhered to in order to protect the genetic diversity of plants within the site. In general, sowing seeds and planting seedlings or cuttings of native species into intact, preserved habitat should be limited. Preserves should maintain native biodiversity and natural community structure, and management should simply counteract, where possible, the negative impacts of anthropogenic alterations to habitat, not engineer desired landscapes. Ecological research relies heavily on examination of natural distribution and abundance patterns of species and assemblages. Planting will reduce the ability of researchers to investigate the species and community ecology in the preserves.

Reducing soil nutrient availability: Many exotic plant species in the Baywood fine sands may require higher nitrogen availability. For example, rip gut brome (*Bromus diandrus*), is found in high density in the recently abandoned pea fields where soil nitrogen is likely higher than within intact habitat. Facilitating uptake of nitrogen by soil microbes including bacteria by adding carbon via sugar (e.g., sucrose) or sawdust has been shown to reduce plant-available soil nitrogen. Such restoration may return the competitive advantage to native plants that are adapted to the low availability of soil nutrients in the Baywood fine sands (Haubensak 2001, Corbin et al. 2004).

Succession: Many exotic plants in the communities of the Baywood fine sands are early successional species that require environmental conditions characteristic of post-disturbance environments, including high availability of light and soil resources. Over time, the natural successional trajectory in coastal sage scrub and Morro manzanita chaparral communities recovering from disturbance (e.g., clearing and tillage) will likely render conditions less suitable for these species. Unfortunately, succession will also reduce suitability of habitat for native early successional species, including sensitive plants and animals such as the Morro Bay kangaroo rat. Thus, widespread late successional conditions should not be a goal in preserve management, though succession might be effective in reducing some species including veldt grass, which observations suggest decreased in abundance in coastal sage scrub at Montaña de Oro State Park (M. Walgren, pers comm.).

Grazing

Recent efforts to decrease exotic plant abundance at large spatial scales in other systems have focused on the role of grazing animals. Livestock including goats, sheep, and cattle as well as chickens have been used to control exotic plants; however, the impacts of grazers on plant communities have been mixed. Grazing has been proven effective in enhancing diversity of native forbs in mesic grasslands (Hayes and Holl 2003); however, grazing has also been shown to facilitate, rather than reduce, populations of some exotic plant species and increase the distribution of exotic plants by vectoring weed seed through animal droppings (Tu et al. 2001).

As with all management in the LOHCP Preserve System, techniques that match natural processes to which the native species are adapted are more likely to have beneficial effects. It is not known whether the native communities of the Baywood fine sands are evolved under a regime of native grazers (e.g., elk, antelope) and therefore might benefit from grazing to reduce exotic plants.

Grazing may degrade native communities by reducing populations of sensitive species and causing soil disturbance which can cause soil erosion and enhance invasion and spread of exotic species such as veldt grass and jubata grass. As a result of the strong potential for such negative impacts, grazing is only recommended as a method of removing dense infestations of exotic plants (and low native plant cover) in areas for which there is no other conceivable removal method. Grazing should avoid areas with populations of sensitive plants and animals, where soils remain intact (i.e., have not been mechanically disturbed), and where the topography is steep. In these cases, the smallest effective grazers (e.g., sheep and goats, not cattle) should be penned into the designated area and removed immediately following treatment.

D.1.4.6 Chemical Control Methods

In chemical control, herbicides are used to kill exotic plants or inhibit their growth. Herbicide use has been evaluated as a control technique for many exotic species that occur in LOHCP Preserve (Bossard et al. 2000), with some tests by State Parks staff having been conducted in the communities of the Baywood fine sands (M. Walgren, pers comm.).

The following herbicides were identified as appropriate for use as part of an integrated pest management strategy, to control exotic plant species in the Morro Dunes Ecological Reserve based on consultation with Joel Trumbo, California Department of Fish and Wildlife Senior Environmental Scientist (Lands Program, Wildlife Branch) who serves as a pest control advisor (J. Trumbo, pers. comm. 2018). The list was developed based on review of the exotic plant species subject to management (Section D.1.5), the special-status species and other sensitive resources in the reserve and broader LOHCP region, and the risk-assessment analysis prepared by the United States Forest Service (USFWS 2018).

- Glyphosate: non-specific herbicide recommended for annual herbs, grasses, perennials, and trees;
- Imazapyr: non-specific herbicide recommended for perennial herbs and trees;
- Triclopyr amine: broadleaf-specific herbicide recommended for annual and perennial broadleaf species, and trees;
- Triclopyr ester: broadleaf-specific herbicide recommended for trees and Himalaya blackberry;
- Aminopyralid: broadleaf-specific herbicide recommended for perennial herbs, especially asters, and trees;
- Chlorsulfuron: broadleaf-specific herbicide recommended for perennial broadleaf species, especially mustards;
- Fluazifop-p-butyl: grass-specific herbicide recommended for annual grasses; and
- Sethoxydim: grass-specific herbicide recommended for annual and perennial grasses.

These herbicides can be applied to trees using a cut stump, frill cut, or basal bark techniques, and foliar application for herbs, grasses, and vines.

Information about their use and risk-assessment analyses (except for triclopyr and triclopyr ester) are provided by the United States Forest Service (USFWS 2018). These pesticides are anticipated to be appropriate for upland habitats in other LOHCP Preserves. Additional herbicides developed during the anticipated 25-year period of LOHCP implementation should be evaluated for use based on analysis of their effectiveness at controlling exotic plants, risk to special-status species and other sensitive resources, and cost-effectiveness.

Potential negative impacts of herbicide use to control exotic plants in the LOHCP Preserve System include:

1. collateral damage to native species, including sensitive plants and animals;
2. facilitation of additional exotic plant invasions, due to disturbance and/or increase nutrient availability associated with the die-off and herbicides themselves;
3. contamination of groundwater due to the porous nature of the Baywood fine sand soil.

In general, the risks of herbicide use can be reduced by using one or more of the following precautions (Hoshovsky and Randall 2000):

1. selecting chemicals that are selective (kill only one or a few species), are non-toxic to animals, degrade rapidly under environmental conditions of the region, are immobilized on soil particles and therefore unlikely to reach groundwater, and are not easily volatilized; and
2. applying the herbicide so as to minimize inadvertent spread, including by spot treating the narrowest area possible, using a dye to determine where the application is going, and applying only in appropriate weather conditions (no rain, low wind).

Additional precautions that can be used in the LOHCP Preserve System include avoiding areas occupied by sensitive species and relocating sensitive species such as Morro shoulderband snail from the treatment area prior to herbicide application.

Like all potential management techniques, chemical control methods can have both positive and negative effects via direct and indirect mechanisms, all of which should be considered in evaluating the potential use of herbicides. Chemicals will be used to control exotic plant species through an integrated pest management approach and will be the follow the manufacturer’s label.

D.1.5 Exotic Plant Species in the LOHCP Preserve System

This section outlines the current and potential future impacts of exotic plant species based on the current available information. This information will be updated and augmented based on the exotic plant inventory conducted early during implementation of the LOHCP (Section D.1.2.1).

Table D-1 lists the exotic plant species that are known or likely to occur in land anticipated to be included within the LOHCP Preserve System. Based on current information, proactive management is currently recommended for a subset of these (Table D-2). Table D-3 lists control techniques which may be effective in managing these aggressive exotic species.

D.1.5.1 Perennial Veldt Grass (*Ehrharta calycina*; Poaceae)

Distribution and Abundance

Perennial veldt grass is the most abundant and widespread exotic plant in land proposed for inclusion in the LOHCP Preserve System. It is found in all of the coastal sage scrub communities and occurs in disturbed areas, including along trails, in the central maritime chaparral communities. Though veldt grass is widespread, the species is generally absent from areas of dense canopy cover in central maritime chaparral and coast live oak woodland. Though patchily very abundant, veldt grass occurs very sparsely in some areas (i.e., <10% cover). The factors that limit its distribution and abundance are poorly understood.

Impacts

Perennial veldt grass invades coastal sage scrub and central maritime chaparral communities in areas of soil disturbance, including roads and trails, then establishes in gaps between shrubs. It attains high cover (>50%) in disturbed coastal sage scrub found on the Baywood fine sands, where it likely reduces the cover and species richness of native plants by competing for limiting soil resources. In addition, the dense thatch it produces may preclude native plant establishment. Perennial veldt grass is credited with transforming shrublands (e.g., central maritime chaparral and coastal sage scrub) into grasslands through the grass-fire cycle (Pickart 2000)—the process through grasses invade shrublands and promote frequent fire, through their highly flammable fuel, which then eliminates shrubs, resulting in type conversion (D'Antonio and Vitousek 1992)

Potential Future Impacts

Though perennial veldt grass is already relatively widespread and abundant, it too may increase in distribution and abundance in the absence of exotic plant management. Seedling establishment is facilitated by disturbances. Within central maritime chaparral, the species is primarily restricted to open, chronically disturbed areas including trails. Management designed to facilitate native shrub establishment, including fire and fire surrogates, as well as wildfire, could facilitate the spread of veldt grass into these relatively uninvaded communities.

In areas where perennial veldt grass is already abundant, its abundance may decrease through time. Many of these areas were disturbed as a result of agriculture (clearing and tillage) which facilitate the invasion and proliferation of perennial veldt grass. Though the species may slow the rate of shrub recolonization following disturbance, succession may ultimately create conditions which are unsuitable for perennial veldt grass persistence, including greater shrub canopy. This process of succession reducing veldt grass abundance (but not distribution) has been observed in the dune lupine community at Montaña de Oro State Park (Walgren 2004).

Proposed Treatments

The treatments proposed for perennial veldt grass control vary, depending on characteristics of the habitat area to be treated. In small, outlying patches consisting of a few sparsely distributed perennial veldt grass plants, plants should be pulled, with care given to reduce the amount of soil disturbance to the extent possible. Plants should be removed from the site using plastic bags in order to prevent seed dispersal when plants are in fruit. Treated areas should be revisited to pull seedlings which may recruit (Nowell 2004).

Many areas anticipated to be included in the LOHCP Preserve System contain perennial veldt grass infestations which are large and dense. In these areas, manual removal will likely prove ineffective at controlling the invasive plant which instead will require chemical control. In larger areas where veldt comprises less than 90% of the relative cover, the grass specific herbicide Fusilade, mixed with a 0.5% no foam surfactant, should be applied to the leaves of plants during the active growth phase prior to seed head development (approximately November-April; Nowell 2004). Where veldt grass comprises more than 90% of the relative plant cover, and there are no sensitive plant species, veldt grass can be chemically controlled using a 2% solution of Roundup (glyphosate) broadcast sprayed over the treatment area.

D.1.5.2 Iceplants

Species

Land anticipated to be included within the LOHCP Preserve System supports two species of iceplant (species in the family Aizoaceae):

1. fig marigold (*Carpobrotus edulis*); and
2. round-leafed iceplant (*Conicosia pugioniformis*).

Sea fig (*Carpobrotus chilensis*) may also be present in the area.

Distribution and Abundance

Both round-leafed iceplant and fig marigold occur in gaps between shrubs within the coastal sage scrub and central maritime chaparral communities, where they are fairly widely distributed, due to their ability to colonize soil disturbances and gaps (Albert 2000, Albert and D'Antonio 2000).

Impacts

Owing to their rapid lateral growth (shoots can grow up to 1 m per year; D'Antonio 1990b), the long-lived perennial fig marigold can form large, impenetrable mats that compete with native seedlings (D'Antonio 1993) and reduce shrub growth (D'Antonio and Mahall 1991). Fig marigolds can also lower soil pH and increase soil organic matter (D'Antonio 1990a); in doing so, can increase the invasibility of sandy soils such as the Baywood fine sands (Albert 2000).

Though shorter-lived that fig marigold, round-leafed iceplant readily colonizes disturbances and gaps and grows very rapidly, allowing it to compete with native plants for space and resources. Round-leafed iceplant may similarly alter soil conditions and facilitate invasion, though this has not been examined (Albert and D'Antonio 2000).

Potential Future Impacts

In the absence of careful, targeted management efforts, iceplant species will likely increase in distribution and abundance. Individuals will persist within the gaps that are maintained in the open canopy conditions of the coastal scrub communities. In addition, fire management to maintain and enhance native communities and populations of fire-adapted species will create opportunities for establishment (D'Antonio 1993, D'Antonio et al. 1993). Herbicides and die off associated with control can increase soil nutrient available and facilitate invasion. Thus, careful management of these two species will be essential to attaining the conservation goals of the LOHCP.

Proposed Treatments

Physical treatments are recommended for round leaved iceplant and small patches of fig marigold. Both species can be manually removed through pulling and cutting. Because remaining roots and pieces of branches can reestablish, care must be taken to completely remove the roots and all branches from the site. Follow up monitoring and treatment will be needed to remove new recruits and other exotic plants that invade the site.

Manual removal of fig marigold may be very time consuming and costly in the many areas of the Preserves where it has formed large patches. In these virtual monocultures, the application of glyphosate (i.e., Roundup) is recommended as a 2% solution of foliar spray. Since Morro shoulderband snail can inhabit ice plant mats, pre-treatment surveys should be used to locate, capture, and relocate to the nearest protected soil habitat outside of the treatment area to reduce take in the form of injury and mortality to individuals that could result from manual or chemical treatment of iceplants.

D.1.5.3 Jubata Grass (*Cortaderia jubata;* Poaceae)

Distribution and Abundance

Jubata grass presently has a narrow distribution and occurs at low abundance within land anticipated to be included in the LOHCP Preserve System. At the Bayview Unit of the Morro Dunes Ecological Reserve, jubata grass occurs in the Morro manzanita community in and around an area of extensive soil erosion associated with the old Broderson Road on the western edge of the reserve.

Current Impacts

An extremely large bunchgrass, jubata grass competes with native plants for space and soil resources.

Potential Future Impacts

In the absence of management, jubata grass will likely expand its distribution and abundance. The species produces up to 100,000 mature seeds per individual inflorescence, and windborne seed can disperse more than miles (DiTomaso 2000). The distribution and abundance of jubata grass within the natural communities of the LOHCP Preserve System is likely currently limited by the lack of appropriate conditions for seedling establishment, which appear to be created by disturbance. Such events that remove established biomass including activities associated with management, such as fire and other exotic plant removal efforts, may enhance the distribution and abundance of this plant.

Proposed Treatments

Pampas grass adults should be removed through cutting using a chain saw or weed eater. Seedlings should be removed through hand pulling or with a shovel. Manual removal may facilitate establishment of seedlings or other exotic plants, necessitating that the site be monitored and follow up treatments be applied as needed.

D.1.5.4 Annual grasses

Species

Land anticipated to be included in the LOHCP Preserve System supports several species of annual grasses including:

1. oats (*Avena* spp.);
2. rip-gut brome (*Bromus diandrus*); and
3. red brome (*Bromus madritensis* ssp. *rubens*).

Distribution and Abundance

Annual grasses primarily occur at low abundance in a few localized habitats, including along trails and underneath isolated coast live oaks. The primary exception is the high-density populations of rip-gut brome that are found in a recently abandoned pea field in the northeastern portion of the Plan Area.

Impacts

Dense patches of annual grasses compete with native plants in the Baywood fine sands, especially native herbs, because their fibrous, shallow roots can take up limited soil resources. This competition can be greatest for native seedlings, which experience reduced establishment in dense patches of annual grasses.

Potential Future Impacts

Abiotic conditions in the Baywood fine sand communities including low soil moisture and nitrogen availability may restrict the distribution and abundance of annual grasses to specific microhabitats, or as in the case of the abandoned pea field, areas of greater nutrient availability. Any factor that might alter these conditions, including nitrogen deposition (Brooks 2003), a series of years with above average rainfall, or fire or other disturbance (Brooks 1999), could enhance the spread of these species. With increase abundance, these species would not only compete with native species on a larger spatial scale but could also increase the density of fine fuels in the dry season, and thus promote wildfire.

In other systems, fire has promoted establishment of annual grasses, including red brome (Brooks 1999)and cheat grass (*Bromus tectorum*; Young et al. 1987) which in turn have reduce establishment of perennial herb and shrub seedlings. The resulting dominance of annual grasses further promotes wildfire which again favors grasses, thus resulting in the type conversion of shrublands to grasslands (D'Antonio and Vitousek 1992).

Proposed Treatments

In areas where annual grasses occur in low abundance, manual removal through hand pulling is recommended. Care should be used to reduce the soil disturbance and thus potential to enhance the spread of other exotic plants. Annual grasses should be pulled prior to setting seed during early spring (i.e., by April). All biomass should be removed from the site.

In areas where rip-gut brome or other annual grasses have become abundant, application of the monocot-specific herbicide Fusilade, with a 0.5% no foam surfactant can be applied during the growing season (January-March) but before seed head development.

D.1.5.5 Exotic Trees

Species

Non-indigenous tree species presently found within land anticipated to be included within the LOHCP Preserve System include:

1. Eucalyptus (*Eucalyptus camaldulensis* and *E. globulus*; Myrtaceae)
2. Monterey pine (*Pinus radiata*; Pinaceae)
3. Monterey cypress (*Hesperocyparis macrocarpa*; Cupressaceae)

Distribution and Abundance

Exotic trees occur with a very limited distribution at very low abundance, relative to other exotic plants. Of the tree species, *Eucalyptus* spp. are the most widespread. Monterey pine and Monterey cypress occur in only a few, isolated stands.

Current Impacts

The native communities of the Baywood fine sands are dominated by shrubs and herbs and contain only short statured trees such as coast live oaks (*Quercus agrifolia*). The exotic trees are much larger than the native trees; as a result, they compete with native plants for light and soil resources, and produce a dense layer of litter (leaves, bark, and small limbs). Eucalyptus bark, leaves, and roots also feature phenolic acids and volatile oils that have deleterious effects on other plants species (Sasikumar et al. 2002, Florentine and Fox 2003). Through these mechanisms, exotic trees reduce the diversity and cover of native plants, and alter habitat conditions for native animals, including Morro shoulderband snail which was negatively associated with eucalyptus (Walgren and Andreano 2012). In addition, the fuels they produce increases the risk of wildfire (Tyler and Odion 1996).

Potential Future Impacts

Originating in fire-prone communities, these species are adapted to fire, and produce high densities of seedlings following fire. As a result, they have the potential to spread during management designed to enhance the native communities (Section D.3; Tyler and Odion 1996, Tyler 1996). Even in the absence of fire, eucalyptus seedlings establish readily on the periphery of current groves, which have thus expanded over the past century and will likely continue to expand in the absence of management.

Proposed Treatments

Adult exotic trees should be removed through by cutting. To avoid soil disturbance and management costs, the stump and roots of large trees can be left intact. The stumps of species likely to resprout should be covered with thick black plastic tarps and/or a topical herbicide (e.g., Triclorpyr) to kill the tree. In many cases, removal of adult trees will facilitate establishment of seedlings, which should be removed with hand pulling. All tree biomass should be removed from the site. The site should be monitored to ensure other exotic plants such as iceplant and veldt grass to not invade the site.

D.1.5.6 Ornamental Plants

Species

A variety of ornamental plants have been deliberately planted in land anticipated to be included within the LOHCP Preserve System; specifically, adjacent to homes on the south side of Highland Drive in the Bayview Unit of the Morro Dunes Ecological Reserve. Species include exotic pines (*Pinus* sp.) and succulents (*Agave* spp.)

Current Impacts

Due to their very limited distribution and abundance, the impacts of the ornamental plants are likely limited. However, these species can compete with native plants and alter habitat for native animals; they may also promote wildfire.

Potential Future Impacts

While their narrow distribution and low abundance suggests that the ornamental plants may not be prone to spreading, changes in environmental conditions associated with disturbances (incl. fire and recreation), climate variation or change (e.g., El Nino years, greater precipitation), or other alterations associated with succession (soil development, etc.) might provide these species with opportunities to invade the natural community and displace native species.

Proposed Treatments

Ornamental plants will be targeted for removal through physical means, with the specific techniques varying depending on the habit of the plant. Trees and shrubs should be cut using a chain or hand saw. Herbs and succulents should similarly be cut or potentially pulled, with care given to avoiding soil disturbance associated with removing roots where possible. All biomass from these plants should be removed from the site. Follow up treatment may be required to kill or remove stump sprouts, seedlings, or other new recruits. However, physical mechanisms should successfully eradicate the ornamental plants of the LOHCP Preserve System.

D.1.5.7 Native Invaders

Plants native to California but not to the Bayview fine sands communities of Los Osos may also negatively impact communities and covered species of the LOHCP Preserve System. Though naturally occurring in California, such species might occur within the Los Osos communities solely due to anthropogenic factors. As a result, native Baywood fine sand soil species are not adapted to competition with neither these species nor the habitat conditions they create.

Presently, it is not known whether there are any native invaders within land anticipated to be included within the LOHCP Preserve System. Such species will be documented during the exotic plant inventory, after which management will be designed and implemented to eradicate or control them, as appropriate.

Genetic erosion, or the loss of native genetic diversity, can result when non-local genes are introduced as a result of the translocation of plant materials. In the LOHCP Preserves, the threat of genetic erosion is most acute for the Morro manzanita, as species of the genus *Arctostaphylos* are known to readily hybridize. If manzanita species other than those which naturally occur in the Baywood fine sands (*Arctostaphylos cruzensis* and *A. tomentosa*) are transplanted into areas within or near the LOHCP Preserve System, they might hybridize with the *A. morroensis,* thus altering the genetic structure of the populations. This can reduce the fitness of native species by disrupting locally adapted gene complexes required for persistence in the unique environment. To prevent the risk of genetic erosion, landowners should be apprised of the potential impacts of planting manzanita species not native to the Los Osos region, as may be sold in local nurseries.

D.1.5.8 Exotic Plant Management Resources

Techniques available for exotic plant management efforts are continually being developed, evaluated, and refined. Specific treatments for exotic plant management projects will be developed based on the most up to date information available. Recent references available including Bossard et al. (2000), the *Weed Control Methods Handbook* (Tu et al. 2001) and the Weed Society of America's *Herbicide Handbook* (Weed Society of America 2002). Numerous organizations share their information regarding exotic plant management on the World Wide Web. These include: The Nature Conservancy Wildland Invasive Species Team (http://tncweeds.ucdavis.edu/about.html) and the California Invasive Plant Council (CalIPC.org). Searching the web for "exotic plant control" will bring these as well as well as hundreds of other websites containing invaluable information to inform exotic plant management including examples of weed control plans and methods of prioritizing exotic plants for control efforts, among others.

D.1.6 Techniques to Avoid Impacting Sensitive Species

Exotic plant management will be a crucial component of LOHCP Preserve System management. Indeed, when evaluating the conservation benefit of the LOHCP, the four scientists of the Scientific Advisory Committee cited effective control of exotic plant species as *the* main factor which will likely determine whether the biological goals and objectives for the Preserve System will be attained. Of particular concern is the control of veldt grass and iceplant species.

Though designed specifically to enhance habitat for sensitive species, many exotic plant management techniques have the potential to cause inadvertent, short-term negative impacts to sensitive species. Many types of physical, chemical, and biological techniques could cause short-term declines in plant and animal populations due to the impacts of trampling alone. Such impacts are not limited to exotic plant management; instead, many projects designed to enhance habitat have the potential to cause inadvertent negative effects.

As with all management projects, the goal of exotic plant management is to maximize the beneficial effects for the covered species, other sensitive species, and the natural communities, while reducing the potential for such inadvertent negative impacts due to management. The main technique that will be used to accomplish this goal is the pre-project survey, in which the area proposed for treatment is carefully examined for the presence of sensitive species. Depending on the project, the species, and the extent of the occurrence within the treatment area, sensitive plants and animals can be avoided or translocated (i.e., safely relocated to nearby suitable habitat out of harm's way).

In the absence of studies evaluating the impacts of herbicides on sensitive species, the resource agencies are understandably concerned about their potential negative effects, especially given the large areas of the LOHCP Preserve System which have become infested and merit treatment. Steps can be taken to prevent exposure of sensitive animals to the chemicals during treatment. Pre-project surveys can be used to determine whether sensitive species such are present. If they are and cannot be avoided or translocated, the occupied habitat can be treatment using non-chemical methods that are appropriate. These and perhaps other steps should be described in a memorandum of understanding or other formal agreement between land managers and agencies concerned about potential herbicide impacts, to allow their use in the LOHCP Preserve System.

Experienced resource managers and weed specialists have developed herbicide treatment protocols which are designed to reduce or prevent impacts to non-target plants. Using low-pressure backpack sprayers equipped with large droplet nozzles to spray only when winds are less than 10 miles per hour and ground moisture is minimal greatly reduces the potential for herbicides to land on non-target species (Nowell 2004) Monocot specific herbicides (e.g., Fusilade) can further reduce potential impacts to broad leaved plants when treating veldt grass or annual grasses.

There is growing consensus among experienced resource managers and weed specialists that veldt grass and iceplant species cannot be effectively controlled in over large areas such as the LOHCP Preserve System without the use of herbicides. In large infestations, physical techniques including cutting and hand pulling are regarded as ineffective or painstakingly slow at best. At worst, these methods have been found to increase the growth, distribution, and/or abundance of veldt grass and iceplant, owing their adaptations to grazing and disturbance (Sarafian 2004, Walgren 2004, and Nowell 2004).

Table D-1: Exotic plant species known or likely to occur within the LOHCP Preserve System

Species	Common name	Life form
Anthemis cotula	stinking chamomile	annual herb
Arundo donax	giant reed	perennial herb
Avena barbata	slender wild oats	annual grass
Avena fatua	common wild oats	annual grass
Brassica nigra	black mustard	large annual herb
Brassica tournefortii	Saharan mustard	large annual herb
Bromus diandrus	rip-gut brome	annual grass
Bromus madritensis ssp. *rubens*	red brome	annual grass
Cardaria draba	hoary cress	perennial herb
Carpobrotus chilensis	sea fig	succulent perennial herb
Carpobrotus edulis	fig marigold	succulent perennial herb
Chenopodium murale	sowbane	annual herb
Conicosia pugioniformis	round-leaved iceplant	succulent perennial herb
Conium maculatum	poison hemlock	perennial herb
Cortaderia jubata	jubata grass	large perennial grass
Cortaderia selloana	pampas grass	large perennial grass
Datura stromonium	jimsonweed	large annual herb
Delairea odorata		
Dipsacus fullonum	Fuller's teasel	biennial herb
Ehrharta calycina	veldt grass	perennial grass
Eucalyptus camaldulensis	Red River gum	tree
Eucalyptus camaldulensis	red gum	tree
Eucalyptus globulus	Tasmanian blue gum	tree
Foeniculum vulgare	fennel	large perennial herb
Helminthotheca echioides	bristly ox-tongue	annual/perennial herb
Hesperocyparis macrocarpa	Monterey cypress	tree
Malva neglecta	common or dwarf mallow	annual or perennial herb
Marubium vulgare	horehound	perennial herb
Melilotus spp.		annual/perennial herb
Myoporum laetum	lollypop tree	shrub/tree
Oxalis spp.	woodsorrel	perennial herb
Pennisetum clandestinum	kikuyu grass	perennial grass
Pinus radiata	Monterey pine	pine
Piptatherum miliaceum	millet mountain rice	perennial grass
Polygonum sp.	knotweed	herb
Polypogon sp.	beard grass	grass
Ricinus communis	castor bean	shrub
Rubus discolor	Himalayan blackberry	vine/shrub
Rumex acetosella	sheep sorrel	herb
Sonchus asper ssp. *asper*	prickly sow thistle	thistle
Tetragonia tetragonioides	New Zealand spinach	herb
Vicia spp.	vetch	herb/vine
Vinca major	periwinkle	ground-covering vine

Table D-2: Characteristics of invasive plant species currently found within the LOHCP Area

Life Form	Species	Common Name	CalIPC Rating[1]	Relative[2] Distribution	Relative[2] Abundance	Relative[2] impact	Initial Preserve System Strategy
Trees	*Hesperocyparis macrocarpa*	Monterey pine	*Not rated*	narrow	low	low	eradication
	Eucalyptus camaldulensis	red gum	Limited	narrow	low	low	eradication
	Eucalyptus globulus	Tasmanian blue gum	Moderate	narrow-moderate	low	moderate	eradication
	Pinus radiata	Monterey pine	*Not rated*	narrow	low	low	eradication
iceplants	*Carpobrotus edulis*	fig marigold	High	moderate-high	moderate-high	moderate-high	control
	Conicosia pugioniformis	round-leaved iceplant	Limited	moderate-high	moderate-high	moderate-high	control
perennial grasses	*Cortaderia jubata*	jubata grass	High	narrow	low	low	eradication
	Ehrharta calycina	veldt grass	High	high	high	high	control
annual grasses	*Avena* spp.	wild oat	Moderate	narrow	low-moderate	low	control
	Bromus diandrus	rip gut brome	Moderate	moderate	low-moderate	moderate	control
	Bromus madritensis	fox tail brome	High	narrow	low-moderate	low	control

[1] California Invasive Plant Council (2016) Invasive Plant Inventory (2016)

High: These species have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically.

Moderate: These species have substantial and apparent—but generally not severe—ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal, though establishment is generally dependent upon ecological disturbance. Ecological amplitude and distribution may range from limited to widespread.

Limited: These species are invasive, but their ecological impacts are minor on a statewide level or there was not enough information to justify a higher score. Their reproductive biology and other attributes result in low to moderate rates of invasiveness. Ecological amplitude and distribution are generally limited, but these species may be locally persistent and problematic.

[2] Relative ranking compared to other exotic plant species based on <u>current</u> distribution, abundance, and likely impacts

Table D-3: Exotic Plant Management Strategies and Techniques

Strategy	Plants	Management Techniques: Physical	Management Techniques: Biological	Management Techniques: Chemical	References
1.1: Eradicate from the Preserve System	Non-Indigenous Trees: *Eucalyptus* spp., *Hesperocyparis macrocarpa, Pinus radiata,* others	Adults: cut using chain saw, pile burn or remove biomass; apply a tarp or Seedlings: hand pull individually or mulch (tarp)	none	herbicide (e.g., Triclopyr) can prevent stump sprouting	Boyd 2000
	jubata grass (*Cortaderia jubata*)	Adults: cut (chain saw/weed eater); remove or burn biomass incl. inflorescences (prior to seed maturation) Seedlings: pulling, shoveling	increase in shrub/tree canopy due to succession	spot treatment, post emergence glyphosate or fluazifop-p (a graminicide)	DiTomaso 2000
1.2: Control (reduce abundance and distribution) within the Preserve System	round-leafed iceplant (*Conicosia pugioniformis*)	hand pulling or slicing taproot with tool; removal of biomass	none	glyphosate by foliar spray kills seedlings and mature plants	Albert and D'Antonio 2000
	fig marigold (*Carpobrotus edulis*)	hand pulling and removal biomass	none	glyphosate (2%) in mid-winter	Albert 2000
	European Annual grasses (*Bromus* spp., *Avena* spp.)	hand pulling (on small scale)	increase in shrub/tree canopy due to succession; grazing	glyphosate fluazifop-p	Boyd 2000
	Veldt grass (*Ehrharta calycina*): dense (>75% relative cover)	mechanical clearing followed by hand pulling of seedlings	sheep grazing; active revegetation	glyphosate (2%) in early spring fluazifop-p	Chesnut 1999, Pickardt 2000

D.2 Recreation Management

Many properties anticipated to be managed as part of the LOHCP Preserve System allow access for passive recreation, including hiking and horseback riding. When well-managed, such passive recreational uses can be compatible with the LOHCP biological goals and objectives (Section 5.1). Therefore, lands protected through implementation of the LOHCP may similarly allow recreational use.

However, observations of historical aerial images and current site conditions of several lands anticipated to be included in the LOHCP Preserve System suggest that historic uses, including more intensive historic unauthorized use by off-highway vehicles, as well as perhaps some current uses, have negatively impacted habitat by removing native plants, causing large-scale soil erosion, and promoting the invasion and spread of exotic plants. In doing so, recreation may reduce the amount of quality of habitat available to native plants and animals, and threaten populations of sensitive species, including the LOHCP covered species. By its very nature, even low-intensity forms of recreation, including hiking, can result in take of the covered species, including the Morro shoulderband snail; therefore, recreation within the LOHCP Preserve System is a covered activity of the LOHCP (Section 2.2).

This section integrates the best available biological information to:

1. evaluate the factors that influence recreation impacts in the Baywood fine sand communities;
2. describe the potential benefits and negative effects of different types of recreation; and
3. outline recommendations for managing recreation within the LOHCP Preserve System to enhance native biodiversity and facilitate persistence of the covered species.

This information can help inform development of the recreation management component of the LOHCP Preserve System AMMP, which will be prepared early during implementation of the LOHCP.

D.2.1 Potential Recreation Impacts

Authorized and unauthorized recreation on lands anticipated to be incorporated in the LOHCP Preserve System primarily consists of pedestrian use (hiking, running, and dog walking), equestrian use, and off-highway vehicle use (OHV). In addition, dune sliding occurs in Montaña de Oro State Park, just west of the LOHCP Area.

Recreation impacts natural habitat by three main mechanisms: removing biomass (i.e., killing animals, killing or reducing the cover of plants), causing soil erosion, and promoting exotic plant invasion. These impacts can directly and indirectly affect the covered species and communities negatively and positively, depending on the component of the system being evaluated and the temporal or spatial scale being addressed. As a result, it is not possible to state '*the* effect' of recreation. Instead, evaluating different types of recreation according to their specific characteristics can facilitate objective assessment of recreation impacts that should influence recreation management.

D.2.1.1 Characteristics of Recreation that Influence Impacts

Like all disturbances, recreation impacts communities and species in various ways which depend on the magnitude (intensity and severity), areal extent, shape, and return interval of use. The following assessment is based on observations and research from the Santa Cruz sandhills—an endemic community restricted to sand soil outcrops that is subject the recreational use of concern for the persistence of endangered plants and animal species (McGraw 2004a, McGraw 2004b)

Magnitude

The magnitude of the disturbance (biomass removal) depends on two factors: 1) the intensity of the recreational activity, which measures the strength of the force (pressure, sheering) and 2) the severity of the disturbance, which measures the degree to which biomass is removed. The magnitude of disturbance caused by recreation appears to follow the general basic gradient: walking < horse riding<=mountain bicycling< OHV use.

Trails used solely by wildlife are typically narrow. Trails used infrequently by pedestrians are also typically narrow. More intense recreational use including horse riding, mountain biking, and OHV use tend to create wider trails. At the Bayview Unit of the Morro Dunes Ecological Reserve, a main east-west trail just south of and parallel to Highland Drive is greater than 2 m wide and exceeds 5 m in width in several locations. While pedestrian trails are rarely incised, trails used by equestrians, mountain bikes, and OHVs, are more likely to become incised due to the intensity of the force, and the alterations to drainage that result (described below).

Areal Extent

Wider trails disturb a greater area than narrow trails. Trail width appears to be related to disturbance intensity, as recreation causing greater force, loosens more soil, and causes greater erosion; this leads to use of the adjacent, previously undisturbed area, and thus widening of the trial. Single-track trails, as they are referred to by recreation planners, invariably become wider over time if there are no barriers (i.e., fences, woody vegetation) or symbolic fences lining the trail corridor.

Shape

The shape or spatial configuration of the disturbed area, specifically the perimeter to area ratio, influences recreation impacts on habitat by affecting recolonization following disturbance. Arenas have a low perimeter to area ratio compared to trails, and wider trails characteristic of higher intensity uses (equestrians, OHVs) have lower perimeter to area ratios than narrow trails. This ratio influences the rate of recolonization following disturbance by determining the disturbance plants (and then animals) must disperse from adjacent, undisturbed habitat. Seedbanks can facilitate recovery of disturbances; however, ongoing erosion and lack of plant cover on disturbances results can reduce seed supply over time, as was observed in the Santa Cruz sandhills (McGraw 2004b).

Return Interval

The time between successive disturbance events (i.e., recreational uses) determines the amount of time the system has to recover from the perturbation and therefore the impact of recreation. The same type of trampling will result in greater impacts at higher frequencies (shorter return intervals). Due to the erosive nature of the sandy Baywood fine sand soils, even low frequency use will likely denude trails.

Type

Unique characteristics of the different types of recreation also can influence their impacts. Due to their weight, the locomotion of horses can cause churn soil. This disturbance has been found to promote the invasion and spread of exotic plants, including veldt grass and ice plants (Walgren 2004). The tracks created by both mountain bikes and motorcycles can provide a conduit for water and, depending on the slope of the trail, the resulting drainage can cause substantial erosion which impacts adjacent habitat and necessitates higher maintenance costs. If not leashed and picked up after, dogs can impact wildlife including through their feces, which can spread disease.

D.2.1.2 Characteristics of Habitat that Influence Recreation Impacts

Recreation use impacts can vary depending on the habitat conditions where they occur, in ways that should be considered in planning recreational use within the LOHCP Preserve System.

Soil Conditions

The course texture of the Baywood fine sand soils found throughout much of the LOHCP Preserve System renders them inherently susceptible to erosion when disturbed. In areas of sparse plant cover, there is minimal root area to bind soil and as well as limited plant cover aboveground to intercept splash rain drops that can cause splash erosion. Direct trampling associated with recreation exacerbates soil erosion by removing plant cover and creating channels for storm water runoff, with the magnitude of these effects likely proportional to the intensity of the recreation. Once trails become incised, they channel runoff which, in turn, causes increased erosion. This positive feedback loop between recreation and erosion appears to have created the 5 m deep gully on the old Broderson Road located on the western edge of the Bayview Unit of the Morro Dunes Ecological Reserve.

Sensitive Species Distributions

Recreation may have greater impacts in the Baywood fine sand communities due to the populations sensitive species found in the habitats traversed by trails. In the absence of designated recreational trails at most sites, wildlife trails are often utilized for recreation. Recreation was observed to collapse burrows of the rare Santa Cruz Kangaroo in the Santa Cruz sandhills (Bean 2003), and might similarly affect burrows of the Morro Bay kangaroo rat (USFWS 1999), although no such burrows have been observed in recent decades. Though Morro shoulderband snails might not typically be found on recreation trails, which are denuded, their low vagility would make them susceptible to mortality by direct trampling, especially by fast-moving recreationalists.

Topography

Following biomass removal, wind, gravity, and water can move loosened sand particles and cause erosion. During high rainfall events, the permeable soil may saturate, causing water to flow overland, carrying the loosened soil with it. The extent of erosion is positively correlated with the slope of the terrain. Baywood fine sands can occur with a lope of up to 30% (USFWS 1994). Other soils in the LOHCP Preserve System, including the Santa Lucia Shaly Clay Loam, occur on slopes up to 75%, such as in the Bayview Unit of the Morro Dunes Ecological Reserve where erosion has been extensive.

Steep slopes enhance erosion by increasing the speed of water and thus its ability to transport sediment; as speed increases, the ability of water to dislodge and transport soil particles increases exponentially (McGraw 2004b). The result of such erosion is rilling and gullying of the trail, and deposition of potential deep sediment in alluvial fans where the slope becomes more gradual and water slows and thus infiltrates, leaving the sediment behind. The deposition buries and typically kills herbaceous plants, creating a disturbance that will be recolonized over time, provided deposition is not ongoing. In the area where the sediment originates, ongoing erosion will prevent new plant establishment and thus continue to erode.

Though erosion presents more of a concern on steeper slopes, even trails that follow the contour of the habitat can eventually become incised and channel water. If there is even the slightest grade, the run-off will cause erosion into adjacent habitat and require trail maintenance to avoid continued down cutting.

Vegetation

Vegetation can interact with soils and topography to influence the effects of recreational use on habitat, by determining the degree of biomass removal and subsequent erosion. Plant material including leaf litter and moss as well as dense herbaceous cover can cushion the force caused by low intensity recreation occurring at low to moderate frequency.

D.2.1.3 Potential Benefits of Recreation for the LOHCP Preserve System

Recreational access can increase public exposure to and appreciation of the Baywood fine sand communities and species; in doing so, it can facilitate conservation support and conservation action on their behalf. Public support of the LOHCP has resulted in part from community members motivated to preserve open space for recreation, which provides a way for many to experience the unique ecosystem. Thus, recreation will likely increase support for and effectiveness of the LOHCP. Land management entities may have additional reasons to allow recreation access, including that it is a key component of their mission or regulations governing management of the land, or a condition of the property’s acquisition.

Like any disturbance, recreation can promote disturbance-adapted species and help maintain open habitat conditions required by early successional species. Like wildlife trails, recreational trails can feature populations of native herbs adapted to disturbance or the open habitat it creates. These species may be important components of habitat for sensitive animals, including the Morro Bay kangaroo rat.

D.2.2 Recreation Management Strategies

The following guidelines for recreation management are designed to minimize its negative impacts on the covered species and communities. All proposed recreation within the LOHCP Preserves must be consistent with the existing regulations and policies of the landowners. For the Morro Dunes Ecological Reserve, recreational use and other access must be consistent with Title 14 of the California Code of Regulations. The HCP cannot allow uses other than those allowed in Title 14, nor can it allow uses that are prohibited in the title.

D.2.2.1 Extent of Recreation

In many properties anticipated to be managed as part of the LOHCP Preserve System, *de facto* trail use has resulted in an extensive network of trails which have removed habitat required by the sensitive species and fragmented remaining habitat. A first step in recreation management will be to close all unauthorized trails. The following series of measures can be used to promote compliance with trail closures:

1. Post interpretive signs that provide the public with the rationale for trail closure, the location of trails designated for ongoing use, and the types of use allowed;
2. Create small impediments at the entrances to closed trails (e.g., fencing that will not obstruct wildlife movement);
3. Conduct targeted outreach through presentations to user groups, and on-the-ground interactions with visitors as part of trail patrols;
4. Erect more permanent barriers; and
5. Enlist the help of law enforcement officials, when applicable.

D.2.2.2 Types of Recreation

Recreation should be limited to trail use by hikers. Limited access for equestrians and leashed dogs can be provided in very limited instances with the approval of the resource agencies.

Mountain bike riding is not feasible in the area, due to the friable nature of the fine sand soil, in which tire tracks can lead channel water and lead to gullying. Off-highway vehicle use, which is illegal within protected lands in the LOHCP Area, creates high levels of disturbance and associated impacts and will impede attainment of the biological goals and objectives of the LOHCP Preserve System.

D.2.2.3 Trail Planning

Recreation management should be carefully planned to reduce its potential negative impacts. The following are some initial guidelines that should be considered.

Trail Location

The route of a trail for recreation should be carefully selected by a team of experts including scientists, erosion control specialists, trail designers, and others experienced in designing, constructing, and managing trails. Specific objectives of the trail design should include:

1. Minimizing impacts to sensitive species including the covered species;
2. Minimizing erosion and therefore costly maintenance;
3. Minimizing the potential for the trail to facilitate exotic plant invasion by avoiding linking areas infested by exotic species to relatively uninvaded habitat; and
4. Linking trails to established trails in areas adjacent to the preserve, where possible.

Existing trails that meet these criteria should be used rather than creating new trails, in order to avoid additional disturbance and unnecessary costs. Trails that do not meet these criteria should be either modified to do so or evaluated for closure and restoration.

New trails should be sited following completion of the detailed Preserve System inventory and baseline monitoring studies, which will establish the distribution and relative abundance of covered species. Trails should be located in areas that lack the covered species, where possible, in already degraded habitat. Within the area determined by the biologists to be *least* likely to have impacts, other members of the trail design team should determine a location that will minimize the need for maintenance to control erosion.

Trail Length

The length of trail located within the sensitive communities should be limited. Trails designed to traverse the Preserve, as to link trails on both sides, should do so in a narrow portion of the property. If the trail is designed to provide for interpretation, the length should be no more than one mile.

Trail Width

To limit the area of habitat within Preserves that is lost due to recreation, trails should be no more than 6 feet wide, with hiker only trails limited to 3 feet wide. Post-and-cable fencing should be placed along the edges of trails to prevent trail widening, which tends to occur in the sandy soils, especially where only sparse plant cover occurs adjacent to the trails (e.g., in coastal sage scrub).

Trail Substrate

Permanent substrates such as boardwalks can prevent trail widening and incision while facilitating wheelchair access and should be installed, as funds allow, where equestrian use is prohibited. Artificial substrate such as rock (e.g., decomposed granite) and wood chips might be added to equestrian trails. Over time, these will likely become less effective due to displacement and decomposition and present some risk of introducing exotic plant species.

Interpretation

Trails in the LOHCP Preserve System should educate users about the uniqueness and rarity of the ecosystem, both to enhance their experience and to promote compliance with the recreational use regulations. Interpretive signs along the path or numbered posts which reference information contained in a brochure available at the trailhead can enhance the recreational experience for many visitors. Large format interpretive signs or "kiosks" posted at the trail entrance may similarly provide information and increase compliance with rules.

Trail Patrols

To reduce the amount of management and monitoring funds needed for recreation management, a volunteer trail patrol group should be established to enhance compliance with the trail use provisions in the LOHCP Preserve System. The group could conduct one or more of the following tasks:

- Conduct outreach to the public through presentations to user groups (e.g., trail riding groups);

- Patrol trails and conducts outreach to users; and
- Provide information about the use and the status of trails to land managers.

As discussed below, patrols be law enforcement officials, such as the County Sheriff, California Department of Fish and Wildlife Wardens, or others with the ability to issue citations, can enhance compliance with the recreation and other access provisions.

D.2.2.4 Trail Monitoring and Maintenance

Trails should be carefully monitored and maintained to ensure that their impacts are limited to the analysis provided in this document. The following are monitoring and maintenance recommendations to inform development of the recreation component of the LOHCP Preserve System AMMP.

Monitoring

Quarterly monitoring will be conducted to detect problems associated with trail use including:

1. Regulation compliance problems (including inappropriate uses);
2. Trail widening, incision, and erosion;
3. Creation of new (spur) trails; and
4. Invasion of exotic plants.

Maintenance

Spur trails should be closed, by obscuring their entrance with limbs or other natural coverings, and by posting signs, as needed. Erosion should be repaired, and exotic plants should be removed immediately. If one or more problems persist, and the trail fails to meet the goals of reducing impacts to the sensitive species and communities, modifications to the trail use will be needed, including limiting the types of use (e.g., hikers only) or closing the trail completely. If an alternative location could resolve the problems, the trail could be rerouted.

Enforcement

If persistent, unlawful trail use continues, enforcement action may be needed. The Department of Fish and Wildlife has law-enforcement personnel who can enforce regulations relating to recreation on their respective lands; likewise, the San Luis Obispo County Sheriff can enforce regulations on County-owned lands.

D.2.2.5 Regional Recreation Management

Recreational use should be examined at the regional level in order to enhance effectiveness of recreation management. Recreators may desire access to LOHCP Preserves to access other destinations where they recreate, including local State and Regional Parks, other open space preserves, and equestrian centers. Efforts to identify a few regional trails which can be carefully managed may limit impacts to a few isolated areas and facilitate the biological goals and objectives of the LOHCP Preserve System.

D.3 Fire Management

Fire is a natural ecosystem process in the Baywood fine sands ecosystem, and an important component of the disturbance regime in the upland communities therein. During the past century, fires have been actively suppressed in order to protect lives and property. This widespread fire exclusion will likely decrease native biodiversity and populations of covered species, by reducing or extirpating species that require fire or the habitat conditions it creates. On the other hand, fire has the potential to reduce populations of the covered species directly, by killing individuals, and indirectly, by promoting the invasion and spread of exotic plant species. Because of this conundrum, fire presents many important concerns for effective long-term management of the LOHCP Preserve System.

More information is needed about the factors that influence the effectiveness of fire as a management technique for attaining the biological goals and objectives of the LOHCP Preserve System. Filling these data gaps will require scientific examination of the fire ecology of the system prior to large scale implementation of fire management. In the intervening time, management efforts will be needed to reduce the threat of arson and wildfire, which have the potential to degrade habitat and threaten the persistence of sensitive species.

This section synthesizes the available scientific information relevant to fire management in this system, including empirical studies from the Baywood fine sand communities, empirical studies from ecologically similar systems, and current ecological theory. This information is used to:

1. Describe the known and potential positive and negative impacts of fire;
2. Recommend approaches to fire management for the LOHCP Preserve system; and
3. Recommend approaches for the fire management component of the LOHCP Preserve System AMMP to be developed early during implementation of the LOHCP.

D.3.1 Fire Ecology of the Baywood fine sand Communities

Fire is a component of the natural disturbance regime in central maritime chaparral communities in California, including the Morro manzanita chaparral communities (Tyler and Odion 1996, Tyler et al. 2000, Odion and Tyler 2003). Previous research in this and other maritime chaparral communities of the Central Coast suggests the following aspects of fire regime (Greenlee and Langenheim 1990, Tyler and Odion 1996, Odion and Tyler 2002):

1. Return interval (time between burns): 80-100 years;
2. Fire season: summer (when fuels are dry); and
3. Severity: complete stand replacement.

During periods of drought, fires may have naturally occurred during the winter as well.

Due to the differences in plant species and thus fuel availability, the plant communities of the Baywood fine sands may have experienced somewhat different fire regimes—characteristics of fire including type, severity, areal extent, and return interval (Sousa 1984). For example, the persistence of bare sand soil between shrubs in coastal sage scrub may reduce the frequency of ignition and fire spread rates when compared with the central maritime chaparral communities and perhaps oak woodlands, which feature greater woody plant cover. More information is needed to identify potential differences in the fire ecology of these systems.

D.3.1.1 Potential Ecological Benefits of Fire

The native species of these communities are adapted to aspects of the fire regime, and many may require recurring fire for their persistence. It has been suggested that fire has been a dominant force in chaparral communities for the past two million years (Axelrod 1958). As a result of their long evolutionary history with fire, plant and animal species in the region have likely adapted to fire and the conditions it creates, as described below.

For many species, prescription fire may only be beneficial if it mimics critical aspects of the natural fire regime. These species may have evolved specific life history or other ecological traits as adaptations to particular aspects of fire, such as the seasonality of occurrence, the return interval, the severity, and the intensity, among other factors. As a result, deviations from the natural fire regime might reduce the effectiveness of prescribed fire and, in some cases, negatively impact the sensitive species and communities it is designed to enhance.

The following describes the known and hypothesized effects of fire.

Removes Established Vegetation, Litter, and Woody Debris

Fire is an agent of disturbance which removes established plant cover over large spatial scales. In addition to live plants, fire can consume leaf litter and woody debris that can build up on the soil surface between fires. In Morro manzanita chaparral, a prescription burn killed all live plants and consumed the dense litter accumulation, though burned shrub skeletons of Morro manzanita persisted (Tyler et al. 2000).

Facilitates Native Plant Establishment

Fire can facilitate native plant establishment by a variety of mechanisms, including:

1. reducing competition and allowing establishment of species that have been competitively excluded by the dominant shrubs and trees which can form a contiguous canopy during the course of succession;
2. reducing herbivory by small mammals that inhabit shrub canopies and can prevent seedling establishment; and
3. stimulating seed germination through the heat and/or the charate (chemical products of fire) (Keeley et al. 1985, Keeley and Keeley 1987, Swank and Oechel 1991, Tyler 1995, Baskin and Baskin 2001).

These effects of fire might facilitate success of the biological goals and objectives of the LOHCP Preserve System by: enhancing native plant species diversity, facilitating establishment of sensitive species, including Morro manzanita and Indian Knob mountainbalm, and increasing habitat quality for Morro Bay kangaroo rat, by enhancing populations of three hypothesized food plants *Acmispon glaber, Croton californicus,* and *Horkelia cuneata* (USFWS 1999)

Reduces Exotic Plant Abundance

In other systems, fire has been shown to reduce the abundance of exotic plant species (Smith and Knapp 2001, Bebawi and Campbell 2002, Alexander and D'Antonio 2003). Indeed, fire is often used as a control strategy for many invasive species in California (Hastings and DiTomaso 1996, Bossard et al. 2000, Bebawi and Campbell 2002), as discussed in Section D.1.4.2. By disproportionately reducing the abundance of exotic species, fire has been shown to facilitate populations of sensitive plants (Pavlik et al. 1993, McGraw 2004a).

It is not known whether the effects of fire on exotic plant abundance were examined in the prescription burn conducted to examine fire effects on Morro manzanita regeneration at Montaña de Oro State Park. Prior to the burn, veldt grass averaged 13% cover while red brome averaged less than 1% cover (Tyler et al. 2000). These data were derived from permanent plots which may have been sampled since the fire in 1998, though these data are not available.

Several exotic plant species presently found in the LOHCP Area including perennial veldt grass are facilitated by fire in other systems, leading to acute concern that fire will enhance their invasion and spread (Section D.3.1.2).

Alter Soil Conditions

Fire can reduce soil nutrients (Christensen 1977, Clark 1989, Johnson et al. 1998), organic matter (Perry 2000), and microorganisms in the soil (Clark 1989). By reducing soil fertility, fire resets the process of soil succession. This may prevent establishment of aggressive, exotic plants which might be able to invade the Baywood fine sands as they become more amenable to plant growth during the absence of fire.

In other maritime chaparral systems, fire has been shown to increase available nitrogen and phosphorus, which are important nutrients that limit plant growth. In doing so, it may enhance plant recolonization.

Fire also volatizes chemical compounds in soils, including those derived from the decomposition of plant litter and root exudates (Clark 1989). Many such compounds, including those from *Arctostaphylos* spp. are hypothesized to be allelochemicals—chemicals that inhibit the germination, establishment and/or growth of other plant species (Keeley et al. 1985). Though the pattern of plant distributions with respect to dominant woody vegetation including *Arctostaphylos* suggest that chemical compounds may restrict plant establishment, careful experiments would be required to implicate allelochemicals as the cause of these patterns.

Fire can also create hydrophobic polymers in the soil that reduce water infiltration, thus influencing soil moisture availability and plant growth. Fire severity, soil texture, and soil moisture influence the extent to which fire renders soils hydrophobic (Huffman et al. 2001, MacDonald and Huffman 2004).

D.3.1.2 Potential Negative Ecological Consequences of Fire

Fire may also have direct and indirect negative consequences for the covered species and communities of the Baywood fine sands. Not restricted to fire alone, these impacts likely also pertain to fire surrogates—disturbance treatments designed to simulate the effects of fire. Three potential negative impacts of fire are:

1. Facilitate exotic species invasion and spread;
2. Reduce sensitive species populations; and
3. Cause soil erosion.

Facilitate Exotic Species Invasion and Spread

Fire might promote the invasion and spread of exotic plant species into the communities of the Baywood fine sands. Like many of the native plant species that prescribed fire would be intended to facilitate, many exotic plants presently found in the LOHCP Preserve System establish readily following fire. These include including veldt grass, red brome, jubata grass, Eucalyptus, Monterey pine, Monterey cypress, and the two iceplant species, fig marigold and round-leaved iceplant (Bossard et al. 2000).

The risk of exotic plant spread following fire is most pronounced in the closed-canopy communities, including the Morro manzanita chaparral and the coast live oak woodland. In these areas, exotic plant species are primarily restricted to old road, trails, and gaps between shrubs adjacent to roads and trails; this distribution pattern suggests that they are limited by competition from dominant shrub and tree cover. As in other closed canopy communities, fire might promote expansion of exotic plants currently present at low abundance or in high light available microhabitats, and create opportunities for new species to invade (Zedler and Scheid 1988, Hobbs and Huenneke 1992, Haidinger and Keeley 1993).

Fire could also enhance the abundance of exotic plants where they are already disturbed within open canopy communities, such as coastal sage scrub. For example, veldt grass has been observed to resprout vigorously and releases seed into the burned area often the first spring after the fire (Walgren 2004

Cause soil erosion

Fire can increase soil erosion by removing established vegetation and other ground cover, including litter (Clark 1989). Water erosion can by increased as a result of a reduction in the roots binding the soil, increased erosive effects of rain drops landing directly on the loose sand soil lacking ground cover, and increased overland flow of water during high rainfall events. In some cases, fire can alter soil chemistry rendering it hydrophobic and thus resistant to infiltration, further exacerbating water erosion (Clark 1989). Wind and gravity can also cause erosion in the absence of dense vegetation cover following fire.

Erosion caused by water, wind, and gravity can uproot plants, bury plants in soil deposition, and inhibit new plant establishment on the thin soil that remains; these effects may be more pronounced on slopes. In the Bayview Unit of the Morro Dunes Ecological Reserve, recreation (and perhaps historical vehicle use) removed established vegetation on the old Broderson Road on the west end of the Preserve. Originating on the steep slopes (50-75%) to the south, soil erosion has led to the formation of a deep (>5 m) gully in the Baywood fine sand soils which support dense stands of Morro manzanita.

Reduce Covered Species Populations

Fire will kill individual plants and many animals and thus have immediate direct negative effects on many populations, including the covered species. However, for most species in these fire-prone communities, short-term population reductions will be offset by longer term population increases resulting from enhanced establishment and growth, in the case of plants, or greater survivorship and reproduction, in the case of animals. Presently, populations of Indian Knob mountainbalm and Morro

Bay kangaroo rat are precariously small, due in part to habitat destruction, fragmentation, and degradation (Appendix B); as a result, the population reductions might threaten their persistence. In addition, habitat fragmentation may restrict recolonization of the enhanced habitat by many of the animal species.

Current available information suggests that populations of Morro manzanita, Indian Knob mountainbalm, and Morro Bay kangaroo rat require fire to persist (USFWS 1994, Tyler and Odion 1996, USFWS 1999, Tyler et al. 2000). Management fires used to enhance populations of the two endangered plants would be located in senescent stands where removal of dense woody vegetation, including adults of the two sensitive species, would facilitate seedling establishment. Management burns could also be used to create the characteristics of habitat preferred by Morro Bay kangaroo rats, including open vegetation comprised of early successional subshrubs and perennial herbs thought to provide the seeds needed by the small mammals (i.e., *Croton, Horkelia,* and *Lotus*). Burns conducted in areas occupied by Morro Bay kangaroo rat might also kill individuals unable to escape the fire.

In contrast, fire provides no current known benefits for the threatened Morro shoulderband snail, which is killed by fire. Following arson in Morro Strand State Park, no live snails were not found in an where they were previously known to occur (Walgren 2003a). Based on evidence suggesting other historical colonization events (Walgren 2003a), Morro shoulderband snail may be able to recolonize the burned areas from adjacent unburned areas once habitat conditions are appropriate (Section B.1).Other sensitive species that might be negatively impacted by fire include Morro blue butterfly (*Icaricia icarioides moroensis*) and splitting yarn lichen (*Sulcaria isidifera*), which is endemic to the LOHCP Area.

By enhancing habitat conditions as described above, fire's positive effects may outweigh the direct negative effect and result in increased population size and greater likelihood of persistence. Aspects of the prescription burn including its location, size, shape, severity, seasonality, and return interval should be carefully planned to minimize direct negative impacts to the covered species and other sensitive species. As described in greater detail below, fires during the wet season, or fires which occur in stands which are too young in age may reduce populations of sensitive species, including Morro manzanita (Odion and Tyler 2002),

D.3.2 Fire Management

Effective fire management in the LOHCP Preserve System will require implementation of a carefully planned, cautious fire management program utilizing a scientifically rigorous approach to attain the conservation goals of the LOHCP. Selection of proposed treatment areas will be developed in coordination with the USFWS and CAL FIRE. Due to the risk of fire promoting the invasion and spread of exotic plant species, fire management and exotic plant management must be carefully coordinated. This section outlines guidelines for development of the fire management component of the LOHCP Preserve System AMMP, which will be prepared early during implementation of the LOHCP.

The LOHCP Preserve System AMMP will integrate the anticipated fuel reduction and fire hazard abatement treatments envisioned as part of implementation of the Los Osos Community Wildfire Protection Plan (CWPP; SLOCCFSC 2009). These treatments, which will be covered by the incidental take permit issued based on the LOHCP (Section 2.2.7), must be implemented following the avoidance and minimization measures (Section 5.2.4, Table 5-4). Within the LOHCP Preserve System, CWPP projects must be designed and implemented to ensure that they limit their short-term negative impacts on, and maximize their ecological benefits for, the covered species and natural communities within the Baywood fine sands ecosystem.

D.3.2.1 Goals

Fire management in the LOHCP Preserve System will focus on two main goals:

1. Enhancing the covered species populations and native plant communities using fire and fire surrogates; and
2. Reducing the risk of wildfire which can degrade habitat, imperil the covered species, and threaten human communities.

Oftentimes, both goals might be facilitated by the same strategies and projects.

D.3.2.2 Methods

Two general approaches to fire management are the use of prescribed fire and fire surrogates.

Prescribed Fire

In prescription burning, fires are deliberately ignited, actively monitored and managed, and extinguished following a specific burn plan. The burn plan describes the management goals of the treatment, the treatment area, the constraints of burn treatments, and the plan for the burn, including thorough safety information. The burn plan also contains the burn prescription—a specific statement of the desired fire behavior, smoke production, and environmental conditions that are required for safe and effective execution of the treatment.

Prescription fire can be used in the LOHCP Preserve System to enhance populations and communities while simultaneously reducing the threat of wildfire. In 1998, a prescription burn was conducted in the Morro manzanita chaparral and adjacent coastal sage scrub communities at Montana de Oro State Park.

Fire Surrogates

Fire surrogates are management treatments designed to mimic fire by removing or reducing plant cover. Treatments can involve the use of mechanized equipment, including masticators, tractors, and bulldozers, or be conducted manually, using chainsaws or other equipment. Following removal, biomass can be laid flat and burned, piled and burned, chipped and left on site, or hauled away. The specific treatments for removing and dealing with the plant cover are often determined by the following:

1. Intended goals of the project (i.e., biological, fuel reduction, etc.);
2. Resulting conditions (i.e., all fuel removed vs. plant cover thinned);
3. Size of the area to be treated;
4. Budget for the project; and
5. Technical staff available to implement the project.

The extent to which various fire surrogates will be successful in enhancing population growth of native species and facilitating native community structure and composition is unknown; instead, experimental examination is required to evaluate the effectiveness of these treatments. Just as with prescribed fire, the specific characteristics of the fire surrogate techniques can likely greatly influence the management outcomes.

Treatment Characteristics

Based on the best available scientific information, the following aspects of fire management treatments are likely to maximally benefit native species and communities. Most mimic known or hypothesized aspects of the natural fire regime, to which the species are evolutionarily adapted. Though primarily devised in terms of prescription burning, many of these design elements could be applied to fire surrogates as well.

Seasonality

Fire management should ideally occur during the dry season (July to November), as this is the most likely natural burn season in the system (Langenheim and Greenlee 1983, Greenlee and Langenheim 1990). In other systems where their effects have been examined, wet-season burns have failed to regenerate stands of chaparral shrubs and promote fire-following herbaceous species, due in part to increased mortality caused by heat when seeds are moist (Parker 1987, Moreno and Oechel 1991). Morro manzanita seeds soaked in water for 24 hours germinated at significantly lower rates than dry seed when subjected to a simulated fire treatment (Tyler et al. 1998).

Implementing prescribed burns during the dry season in shrublands can be logistically very difficult owing to increased risk of fire escape. Burning in the fall, when air temperatures are lower, and humidity is higher, relative to the summer season, can reduce the risk of fire escape while oftentimes still affecting the goals of the prescribed burn for chaparral species.

The prescription fire at Montaña de Oro State Park to evaluate fire effects on Morro manzanita was conducted in early November 1998, under mild temperatures and moderate humidity 10 days following 1 cm of rainfall. Though establishment of Morro manzanita seedlings was lower than required to replace the stand, the researchers attributed the lack of sufficient germination to low seed availability, and not inappropriate fire conditions (Tyler et al. 2000, Odion and Tyler 2002).

Areal Extent

Fire management should focus on creating several small (e.g., one acre) patchy disturbances rather than a single large disturbance. Small fires are less likely to extirpate populations of sensitive species and increase opportunities for recolonization by both plants and animals (Simmons et al. 1995). In addition, the variability in species composition and fuel load between communities of the Baywood fine sands suggests that fire may have been naturally patchy. The central maritime chaparral communities have a dense canopy of shrubs including chamise (*Adenostoma fasciculatum*), which is known for its flammable fuel. In contrast, the shrub cover in coastal sage scrub is sparser and interspersed by bare ground and herbaceous plant cover, which is less likely to carry a fire. Historically, fires that originated in one community type may not have burned adjacent types, thereby creating a patchier disturbance.

Creating several small disturbances rather than conducting a single large fire can be less effective for two reasons. First, individual small disturbances may not be large enough to sustain sensitive species populations, such as Morro Bay kangaroo rats which might require relatively larger areas of contiguous, early successional habitat to sustain their populations. Second, the proximity of adjacent, unburned habitat may reduce the value of the burned habitat. For example, herbivory by small mammals that predate upon chaparral shrub seedlings, including Morro manzanita and perhaps Indian Knob mountainbalm, would be greater in small disturbance areas, owing to the proximity of mature shrubs that house the small mammals (Tyler and Odion 1996). Impacts of herbivory could also be unnaturally high in small fire treatments, because small mammal populations will have fewer seedlings to predate upon in small burns compared to large burns.

Some of the negative aspects of small, patchy burns can be mitigated, such as by using exclosures to protect target species (e.g., Morro manzanita, and Indian Knob mountainbalm) from unnaturally herbivory. Unless small burns are proven ineffective for attaining the biological goals and objectives of the Preserve System and the individual management projects, they will provide the preferred fire management approach in the LOHCP Preserve System.

Treatment Area Shape

Long, narrow disturbances may reduce their direct negative impacts to sensitive species, especially animals with low vagility (Simmons et al. 1995). Treatment areas with greater perimeter-to-area ratios can be more readily colonized as well. As described above, herbivore pressure and other negative edge effects could also be greater in such long, narrow disturbances.

Severity

Severity is a measure of the degree of disturbance impact; specifically, the extent to which biomass is removed. To enhance diversity, multiple treatment areas should be designed to have different levels of severity, such that different environmental conditions will result from the burn. Such patchiness can be promoted *within* each treatment area as well, by allowing areas that do not burn to remain unburned and/or creating patches that will resist burning in advance (Simmons et al. 1995).

Return Interval

Attaining the biological goals and objectives through the use of prescribed fire will require management with the appropriate return interval—the time between successive disturbances. In fire-adapted communities, aspects of the species biology, including their life history, have been shaped by their response to fires recurring with a range of frequencies. If the return interval is shortened or lengthened, fire may negatively impact even fire-adapted species.

Because it is difficult to accurately reconstruct the historical fire regime, determining the return interval for fire in the system is challenging. To further complicate things, the different communities of the Baywood fine sands likely burned at different frequencies, owing to differences in their plant species composition and thus fuels. Hypotheses for appropriate return intervals must be developed through research examining the available fire history, the composition of communities, the age structure of species populations, and consideration of ecologically similar systems. The hypothesized return intervals should then be tested using small-scale experiments to evaluate impacts on the species and communities.

Based on their research evaluating the effects of a fire in a 40-year-old stand of central maritime chaparral, Odion and Tyler (2002) concluded that the return interval was too short; the researchers attributed insufficient Morro manzanita seedling establishment to insufficient accumulation of viable seed since the last fire. As a result, a longer return interval, such as 80 years, is recommended for Morro manzanita chaparral (Odion and Tyler 2002). The other communities of the Baywood fine sands may have historically burned at different frequencies, however. Thus, future research and cautious fire management as outlined above is needed to avoid the potential negative impacts of burning too frequently or infrequently.

D.3.2.3 Evaluating Fire Management Alternatives

The negative impacts and logistical difficulties potentially associated with using fire necessitate careful consideration of alternatives to fire management. First, as discussed above, it may be possible to use mechanical or manual removal of plant material (i.e., dead material and live shrubs and trees) to attain the biological goals of management (i.e., enhancing chaparral plant species diversity, regenerating Morro manzanita, etc.) and to reduce the threat of wildfire. Even if proven effective through experimental trials, high implementation costs and degrading effects of soil disturbance caused by work crews might render such treatments infeasible for widespread use in the LOHCP Preserve System. Such techniques will require further evaluation.

Another alternative to fire management is simply “no management”. This approach is used in wildland areas throughout the region. Because the vegetation structure (i.e., fuels) and climate of the region predispose the system to natural wildfire and render it highly susceptible to human-induced fire, preventing fire within the LOCHP Preserve Systems will not likely be possible in the long term. The consequences of wildfire in the LOHCP Preserve System could be grave, as many of the potential negative impacts associated with fire could not be prevented.

1. Negative impacts to sensitive species:
    - Even moderate sized fires could extirpate important remaining populations.
    - The return interval could be too short for sufficient Morro manzanita regeneration.
    - The season could be inappropriate (i.e., wet season) for the life history of species.
2. Invasion of exotic plants:
    - Pre-treatment to remove exotic plants would not likely have occurred.
    - The wildfire might create a larger disturbance more susceptible infestation.
    - The wildfire might occur adjacent to a highly invaded area.

Thus, a more proactive approach to fire management will likely be essential to attaining the conservation goals of the LOHCP Preserve System and will be incorporated in the LOHCP Preserve Adaptive Management and Monitoring Plan.