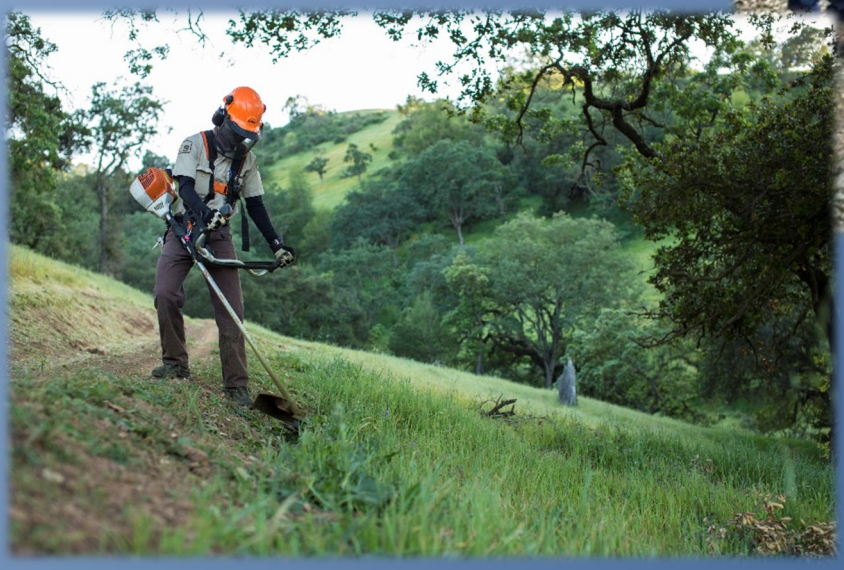
FINAL

Integrated Pest Management Guidance Manual



OPEN SPACE AUTHORITY
SANTA CLARA VALLEY

Integrated Pest Management Plan

Guidance Manual for the

Santa Clara Valley Open Space Authority

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OPEN SPACE AUTHORITY
SANTA CLARA VALLEY

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Acknowledgements

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With permission from the staff at the Midpeninsula Regional Open Space District, Sections 4-7 as well as the glossary draw heavily on content presented in their Integrated Pest Management Guidance Manual (May and Assoc. et al. 2014) and the Draft Environmental Impact Report for the Integrated Pest Management Program Guidance Manual (Ascent Environmental, Inc. 2014).

Glossary

This section provides operational definitions for some of the terms used in this plan.

Active management: Physical actions intended to manage natural resources or built facilities for a desired outcome. Active management may include physical control (hand, mechanical control), or chemical control of pests or manipulation of their habitats. For example, mowing yellow star-thistle to remove it from an infested rangeland would be considered active management. In contrast, ***passive management*** includes design and cultural practices intended to change human behavior or the physical environmental in a manner that discourages pests from occurring. For example, installing boot cleaning stations, or requiring ranchers to inspect feed for yellow star-thistle seeds would be considered passive management.

Allelopathy: The suppression of growth of one plant species by another because of the release of toxic substances. The effect of suppressing the growth around a plant resulting from the release of toxic substances.

Basal rosette: A cluster of leaves spreading outward from the base of a low-growing plant. In thistles, such as yellow star-thistle, a basal rosette forms just before the plant bolts (i.e., sends up a main stem on which flowers are produced). Often, the timing of pest control treatment of plants is recommended for the "basal rosette stage."

Bolt: Process by which a young plant sends up a main stem on which flowers are produced. The timing of pest control treatment of plants is often recommended for either just before or just after bolting.

Broadleaf: Plants possessing broad (as opposed to needlelike or grass-like) leaves. Most of the trees and shrubs on Authority preserves are broadleaves. Pest control treatments prescribe different treatments for broadleaf plants than for grasses, sedges, and needle-bearing trees such as pine trees.

Containment: A pest control strategy that focuses on establishing a pest-free area (e.g., a mowed or cleared area around a well-established population of invasive plants), and ensuring, through active management, that the target pest does not move past the defined area into the surrounding (pest free) areas. Containment is typically used when eradication of a target pest is no longer considered a viable option.

Control: A pest control strategy that focuses on reducing the number, amount, or extent of a pest over time to achieve a defined tolerance level. Control may result in full eradication of a pest, or reduction in the pest such that it no longer causes economic or environmental damage, or human health concerns.

Eradicate: A pest control strategy that focuses on eliminating all members of a target pest population.

Gigging: A pest control method typically used to kill bullfrogs, fish, and other aquatic pests whereby the animal is speared with a trident or spear while in water.

Herbicide: A pesticide (see definition below) intended for preventing, destroying, or controlling plant pests.

Herbivory: A type of predation typically used to describe the consuming of plants by animals. Herbivory has an impact on the health, structure, and diversity of natural plant communities. For example, low level herbivory can remove aging roots and leaves, allowing new growth of young roots and shoots resulting in healthy plant growth. At high levels, herbivory can damage plants, changing the composition, and reducing the quality of the natural plant community.

Homopteran Insect: A suborder of insects, including cicadas, aphids, and scale insects, having wings of a uniform texture held over the back at rest.

Hypercalcemia: An abnormally high level of calcium in the blood. In pest control, hypercalcemia is usually associated with rodenticide use.

Injurious: The term "injurious wildlife" refers to a defined list of species identified in either the federal Lacey Act (18 U.S.C. 42) or related implementing regulations (50 CFR 16). The U.S. Fish and Wildlife Service Office of Law Enforcement plays a role in preventing the introduction of invasive species into the U.S. through the enforcement of the Lacey Act which makes it illegal in the United States to import injurious wildlife, or transport such wildlife between states without a permit. Species are placed on the list when they are determined to be injurious to: human beings; the interests of agriculture, horticulture, forestry, or wildlife; or wildlife resources in the U.S.

Insecticide: A pesticide (see definition below) intended for preventing, destroying or controlling insect pests.

Insipient (invasive population): A population (usually referring to an invasive plant) that is small, but is beginning to reproduce and become established in a location or a region.

Metamorph (amphibian): A major change in the form or structure of some animals or insects that happens as the animal or insect becomes an adult. For amphibians, a metamorph refers to the stage of development between larval and adult. For example, the stage between a tadpole and adult frog. Some pest control techniques recommend treatment timing before or after the metamorph stage.

Multibenefited: actions that benefit multiple conservation values, such as biodiversity, water quality and supply, scenic resources, cultural resources, and working lands protection, among others.

Non-Native Species: An introduced, alien, exotic, non-indigenous, or non-native species. Includes species living outside their native distributional range, which have arrived there by human activity, either deliberate or accidental. Some introduced species are damaging to the ecosystem they are introduced into, others have no negative effect and can, in fact, be beneficial as an alternative to pesticides in agriculture for example. Refer to the definition of pest and invasive species (below) to differentiate non- native species that cause harm from other non-native species.

Noxious weeds: A plant species that has been designated by country, state, provincial, or national agricultural authority as one that is injurious to agricultural and/or horticultural crops, natural habitats and/or ecosystems, and/or humans or livestock. These weeds are typically agricultural pests, though many also have impacts on natural areas. Many noxious weeds have come to new regions and countries through contaminated shipments of feed and crop seeds or intentional introductions such as ornamental plants for horticultural use.

Pest Species: Insects, animals, or plant species that are incompatible with the Authority's goal of protecting and restoring the natural environment, and with providing opportunities to enjoy and learn about the natural environment. Several categories of pest species are defined below:

- **Invasive species** are animal or plant species that invade and dominate sufficiently large areas, causing a reduction in biodiversity. They proliferate in the absence of natural control and interfere with the natural processes that would otherwise occur in natural areas. Once established, invasive species can become difficult to manage and can eliminate native species or otherwise alter the ecosystem. Invasive species are targeted in natural areas and rangelands. Invasive species can alter ecosystem processes by changing biotic ecosystem characteristics (such as plant community composition, structure, and interactions; trophic relationships; and

genetic integrity) and abiotic characteristics and processes (such as fire regimes, erosion, sedimentation, hydrological regimes, nutrient, and mineral conditions, and light availability).

- **Structural and agricultural pests** include insect, plant, and animal pests that damage occupied buildings, formal landscapes, or agricultural crops, or pests that are a health threat to humans working in, living in, or visiting the buildings. Examples of structural pests include termites, ants, rodents, and stinging insects in buildings, and weeds in formal landscaped areas. Examples of agricultural pests include insects, weeds, and burrowing mammals such as moles and voles that damage crops. Structural and agricultural pests are targeted in buildings, recreational facilities, and agricultural properties.
- **Nuisance pest species** include species that commonly occur on Authority lands, such as stinging insects, but whose presence can be incompatible when their proximity or behavior conflict with human use of buildings and recreational facilities in the preserves. For example, hornets that locate their ground nests in trails must be removed if they are stinging hikers and horses using the trail. Branches and other types of vegetation must be trimmed back from trails, parking lots, picnic tables, and benches to allow safe visitor use. Similarly, vegetation must be cut back from the sides of roads to keep them open for patrol, maintenance, and emergency vehicles. Problem pest species are targeted in areas with focused visitor use.

Pesticide*:* A substance or mixture of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm during or otherwise interfering with the production, processing, storage, transport or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or substances which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies. Pesticide is a broad term that encompasses:

- **Herbicides** (substances intended to control plant pests),
- **Insecticides** (substances intended to control insect pests),
- **Rodenticides** (substances intended to control rodent pests),
- **Other Substances,** such as **Fungicides** (substances intended to fungus pests) and **surfactants** (substances that adhere pesticides to surfaces such as plant leaves) and other substances often used with other pesticides to increase treatment results.

Pre-bait: A substance used to attract pests (e.g., rodents or other animals) to a feeding site as a preliminary step to use of a rodenticide or other pesticide to control the target pest.

Propagule: Any vegetative portions of a plant, such as a bud, stolon, root, tuber, rhizome, or other offshoot, that aids in the dispersal of the species and from which a new plant may grow. In pest control, follow-up treatments for invasive plants often focus on prevention and control of propagules after the initial mature plants are treated.

Rhizome: A modified subterranean stem of a plant that is usually found underground from which a new plant may grow. Plants often send out roots and shoots from these modified stems, resulting in vegetative (asexual) reproduction of a plant. In pest control, follow-up treatments for invasive plants often focus on prevention and control of rhizomes after the initial mature plants are treated.

Root Crown: The junction between the root and shoot portion of a plant. Crown sprouting is the ability of a plant to regenerate its shoot system after destruction of the above –ground portions of the plant. Crown sprouting plants typically have extensive root systems in which they store nutrients allowing them to survive after damage to the above-ground parts of the plant. In pest control, follow-up

treatments for crown-sprouting plant species often focus on control of resprouting vegetation after the initial mature plants are treated.

Shooting: A plant that sends up shoots (new growth) from the underground portions of the plant. In pest control, recommended treatments are often timed for when invasive plants are actively 'shooting' or sending up new growth.

Seed Bank: In natural systems, the natural storage of seeds, often dormant, within the soil below the parent plant. In invasive plant control, treatment often focus on long-term management of plants that sprout from the seed bank, often years after the initial removal of mature invasive plants.

Taproot: A large, somewhat straight to tapering plant root that grows downward that forms a center from which other roots sprout laterally. The taproot system contrasts with fibrous root system, which typically have with many branched roots. Pest control of invasive plants often focuses on removal of the entire taproot to kill the target invasive plant.

Tolerance Levels: The level at which pests can be present without disturbing or disrupting natural processes, causing economic damage, degrading intended uses or human enjoyment of built facilities.

Acronyms and Abbreviations

Acronym or Abbreviation	Meaning
Authority	Santa Clara Valley Open Space Authority
BAOSC	Bay Area Open Space Council
BMPs	Best Management Practices
CAC	Citizens Advisory Committee
Cal-IPC	California Invasive Plant Council
CDC	Center for Disease Control and Prevention
CDFW	California Department of Fish and Wildlife (formerly Ca. Dept. of Fish and Game)
CDFA	California Department of Food and Agriculture
CDPR	California Department of Pesticide Regulation
CEQA	California Environmental Quality Act
CIPM	Center for Invasive Plant Management
CNDDB	California Natural Diversity Database
CNPS	California Native Plant Society
CRLF	California red-legged frog
CRPR	California Rare Plant Rank
CTS	California tiger salamander
DE	Diatomaceous Earth
ESRI	Environmental Systems Research Institute
FAQs	Frequently Asked Questions
IPM	Integrated Pest Management
MSDS	Material Safety Data Sheet
NISC	National Invasive Species Council
NRCS	National Resource Conservation Service
OMRI	Organic Materials Review Institute
OSP	Open Space Preserve
SCOSA	Santa Clara Valley Open Space Authority
SOD	Sudden Oak Death
TNC	The Nature Conservancy
UCANR	University of California Agriculture and Natural Resources
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
WM	Weed Manager
WMA	Weed Management Area
WUI	Wildland-Urban Interface

1 Introduction

This document was developed to guide efforts by the Santa Clara Valley Open Space Authority (Authority) to manage pests in its open space preserves and facilities following an integrated pest management approach, which is designed to protect human health and environmental quality.

1.1 Open Space Authority

The Authority is an independent special district established in 1993 to preserve key portions of the natural environment in order to balance continuing urban growth. Managed by an independent board of directors, the Authority's jurisdiction includes the Santa Clara County excluding the northwestern portion which is within the Midpeninsula Regional Open Space District, and the City of Gilroy.

The Authority protects key lands through acquisition of fee title and conservation easements, as well as contributing funds to joint conservation efforts. As of 2021, the Authority owns 14 open space preserves totaling 16,446 acres. (Figure 1). In addition, the Authority manages 1,464 acres of conservation lands that are owned by other government agencies or non-profit organizations.

On the Authority's open space preserves, the Authority implements resource management strategies that are designed to:

- Protect native habitats and species, which includes conserving rare, threatened and endangered species;
- Protect and restore water resources to benefit local communities and the environment;
- Reduce the risk of wildfire; and
- Provide opportunities for compatible, nature-based recreation and education

Mission

The Open Space Authority conserves the natural environment, supports agriculture and connects people to nature, by protecting open spaces, natural areas, and working farms and ranches for future generations.

Our Vision, Our Valley, Our Future

We envision the Santa Clara Valley and its surrounding hillsides as a beautiful place where a vibrant network of interconnected open spaces, trails, wildlife habitats and thriving agricultural lands enrich the region's cities, making our Valley an exceptional and healthy place to live, work, learn and play. In our vision of the Santa Clara Valley:

- A well-managed network of open spaces, farms and ranches sustains our natural heritage and provides resilience to a changing environment
- All members of our community are aware of the values of nature and have convenient access to local recreational and environmental education opportunities
- Our drinking water is safeguarded by protecting our local creeks and watersheds, from their headwaters in the surrounding hills to the Bay
- Community investment in nature -- and the essential benefits that nature provides -- sustains and enhances a healthy environment and economy
- The rich heritage of the Valley's agriculture is thriving, with locally grown foods contributing to healthy communities and creating a sense of place and pride in our region
- The Open Space Authority contributes to the region's quality of life by building and sustaining public and private partnerships in all our communities.

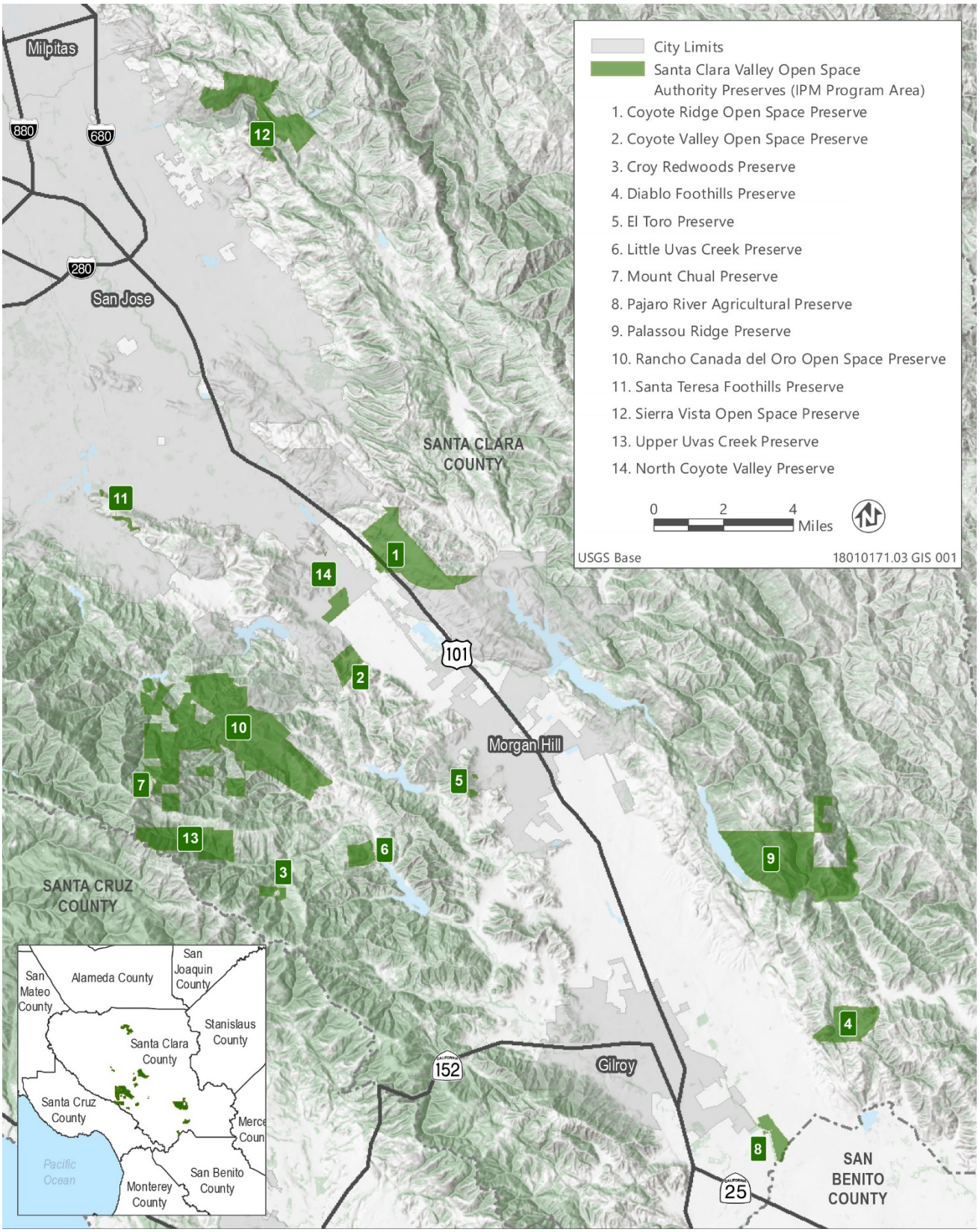

Figure 1: Santa Clara Valley Open Space Authority's Open Space Preserves

1.2 Pests

Though native plants and animals are critical components of the natural ecosystems that the Authority protects, certain species have negative impacts on natural lands. Most of these *pests* are *exotic species*, that are not native to the region and instead, were introduced deliberately or by accident through human activities.

As described in greater detail in Sections 3 through 7 of this manual, exotic plants, animals, and pathogens can negatively impact native species through a variety of mechanisms, alter natural ecosystem processes, create a fire hazard, and degrade recreational opportunities within the Authority's lands.

Additionally, some native plant and animal species are regarded as pests in certain circumstances; these include:

- rodents such as mice and rats, that colonize buildings;
- stinging insects such as wasps that establish around buildings and in picnic areas;
- plants with spines (e.g. spiny cocklebur) or oils that cause allergic reactions (e.g. poison oak) that occur along trail corridors and other areas of human activity; and
- plants that are poisonous to cattle (e.g. larkspurs) that occur in grasslands managed using conservation grazing.

These pests require carefully designed and implemented management strategies to conserve the open space values, while protecting human health and safety.

1.3 Pest Management Approaches

A variety of approaches can be used to manage pest plants and animals. Broadly speaking, these include:

- **Physical Control:** Manual or mechanical techniques, including cutting and pulling for plants, and trapping for animals, also includes use of a biological control agent, such as an insect or pathogen, to control exotic plant populations;
- **Chemical Control:** use of pesticides, which are chemical substances used to prevent, destroy, or control pests, such as herbicides for plants, insecticides for insects, and fungicides for fungal pathogens;
- **Cultural Control:** altering human activities, including cultivation, grazing, and prescription burning, to control plants, and techniques for managing waste, to discourage pest populations; and

Each of these general approaches features a variety of specific techniques, which vary in their effectiveness, efficiency, and risks, including potential impacts to human health. The costs and benefits of each often depend on the specific circumstances of the pest infestation, including the ecology and impacts of the pest species, its population size and distribution, and its location with respect to other conservation values (e.g. rare species) and human facilities and activities (e.g. structures and trails). As a

result, it is not feasible to prescribe one treatment for each type of pest; instead, this manual outlines an approach to determining the appropriate treatment based on the relevant factors that influence its effectiveness, efficiency, and risks.

1.4 Integrated Pest Management

Integrated pest management (IPM) is a science-based, decision-making system used to design and control pest populations to limit their impacts as well as risks to people and the environment. The six main components of an IPM program are (May and Assoc. et al. 2014, UCANR 2016):

1. **Correctly identifying the species** and understanding its life cycle and ecology;
2. **Monitoring and assessing the pest's distribution and abundance** to gauge its impacts;
3. **Setting thresholds for targeted control,** designed to limit pest impacts while avoiding unnecessary and potentially costly treatment;
4. **Assessing site conditions to identify appropriate control treatments**;
5. **Using the least harmful suite of control methods,** by targeting the most vulnerable stage in its life cycle, and using biological, cultural, physical/mechanical and chemical management tools; and
6. **Preventing pest problems** through implementation of best management practices and early detection and rapid response program, among other prevention approaches.

The specific factors used to prescribe treatments, as well as the treatments themselves, vary depending on the type of pest and the environment in which it occurs.

1.5 Guidance Manual Objectives

This manual was developed to facilitate the design and implementation of pest management strategies that are effective, cost-effective, protect human health and safety, and safeguard natural resources including native species and water quality. It was developed pursuant to the Authority's IPM policy (Section 2, specifically IPM Policy 4 which calls for the Authority to "develop and implement a Guidance Manual to standardize pest management and IPM procedures." This manual reflects the Authority's mission (Section 1.1) and is consistent with other resource management policies, including the Conservation Grazing Policy (SCOSA 2012).

The IPM policy and manual are designed to inform the decision making process in the management of the Authority's open space preserves; the policy and manual do not apply to privately-held land over which the Authority holds conservation easements. In addition, the Authority's work to manage land held by other entities will follow the policies and plans of those entities.

This manual was developed based on review of existing scientific literature and plans documenting best approaches to effective pest management and draws heavily from the Midpeninsula Regional Open Space District's Integrated Pest Management Program Guidance Manual (May and Assoc. et al. 2014). It also integrates pest management approaches that have been successfully implemented by the Authority over the past several decades.

Because the approaches to controlling pest management differ depending on the type of pests and the environment in which they occur, the IPM approaches to pest management outlined in this manual are presented in five sections:

- Section 3: Management of Invasive Plants in Natural Lands;
- Section 4: Management of Invasive Animals in Natural Lands;
- Section 5: Management of Invasive Plants in Agricultural Lands;
- Section 6: Management of Pests in Structures; and
- Section 7: Management of Pests in Recreational Facilities

Rather than incorporating the wealth of information available about pest management techniques, which are rapidly involving through new scientific research and technical innovations, this manual focuses on outlining IPM approaches for each of the above situations. It incorporates by reference a series of resources, including organizations, websites, and books, which can provide information about pest management techniques (*Resources*).

This IPM approach incorporates an adaptive framework designed to achieve the Authority's land management goals over time (Section 1.1), by integrating newly developed scientific techniques and the lessons learned from monitoring treatments, to update the plan.

2 Integrated Pest Management Policy

The development of this guidance manual was informed by the Authority's IPM policy, which was developed with input from the Citizens' Advisory Committee (CAC) and partner agencies and organizations.

IPM Policy 1: Develop pest management strategies and priorities to:

1. Manage invasive species in natural areas and set priorities for their control to maximize the benefits for sensitive native communities and species and loss of biodiversity.
2. Manage pests on agricultural properties to support existing uses, while also protecting human health and surrounding natural resources.
3. Manage pests and potential human interactions in recreational facilities to minimize conflict, ensure visitor safety and enjoyment, and protect the surrounding natural resources.
4. Manage pests in buildings to support existing uses, while also protecting human health and surrounding natural resources.

IPM Policy 2: Take appropriate actions to prevent the establishment of new invasive species to Authority lands, especially new invasive plants in natural areas, rangelands, and agricultural properties.

1. Develop and implement best management practices to reduce the risk of invasion of exotic species into open space preserves, as part of steps to manage facilities, recreation, and vegetation, including through conservation grazing.
2. Implement an early detection rapid response program, which includes routinely inspecting areas that are most susceptible to invasion.
3. Focus on preservation of habitat with intact native vegetation and target populations of invasive species before they are widespread.
4. Stay abreast of regional invasive plant species issues and their management by coordinating with partners and neighboring landowners.
5. Promote visitor and staff education to prevent the spread of invasive species.

IPM Policy 3: Manage and monitor invasive species through an adaptive management framework that includes the following measures designed to promote long-term effectiveness, including:

1. Develop and maintain an inventory of invasive species on Authority lands.
2. Prioritize treatment of invasive species based on the benefits of treatment for sensitive species, as well as the risk posed by failure to control them, the ability of treatment to enhance other conservation values, including working lands, scenic values, and cultural resources, and their feasibility.
3. Prescribe site-specific strategies for control that provide the best combination of protecting Authority resources, human health, and non-target organisms that are efficient and cost effective in controlling the target species, and that reflect the species' biology and life-cycle.

4. Use the most appropriate method(s) to control invasive species including by integrating multiple management techniques such as grazing, manual removal, and mowing. Where pesticides are necessary, apply according to the label using all safety precautions and take all measures needed to protect the environment, health, and safety of visitors, employees, neighbors, and the surrounding natural areas including water and soil resources.
5. Monitor treatment effectiveness and adapt control techniques based on results as well as the latest research on invasive species ecology and management, and new methods and tools.
6. Plan for repeat treatments as needed based on species regenerative capabilities.
7. Coordinate and cooperate with adjacent landowners, neighbors, and other responsible agencies to control species regionally, wherever feasible.
8. Use prevention techniques such as early detection rapid response, training, use of volunteers, and BMPs.

IPM Policy 4: Develop and implement a Guidance Manual to standardize pest management and IPM procedures.

1. Evaluate the general types of pests and also individual species that will be subject to management, based on an assessment of their impacts on the ability of the Authority to achieve its mission;
2. Develop goals for management of types of pests, and criteria for assigning species or suites of species to the goals based on the costs and benefits of control;
3. Identify a suite of alternative management techniques that are cost-effective and safe;
4. Develop a framework for prioritizing management, given that resources are inherently limited; and
5. Identify best management practices to be implemented during pest management, to limit impacts to non-target species, other natural resources, and human health and safety, and facilitate environmental review of the IPM program (i.e. under CEQA).

3 Guidance for Invasive Plant Management in Natural Lands

Invasive plant species present a major challenge to the conservation values of the Authority's open space preserves. If not well managed, invasive plants can:

- Reduce native biodiversity, by displacing native plants and animals;
- disrupt natural ecosystem processes and the services they provide the community, such as by limiting stream flows and the public water supply;
- present a fire risk, by creating unnaturally high fuel levels;
- interfere with conservation grazing, by creating noxious forage for livestock; and
- degrade the cultural landscapes, recreational opportunities, and scenic resources, by altering the species composition of natural communities in the landscape.

Successful, long-term management of invasive plants requires careful planning to address the myriad factors that influence the effectiveness of invasive plant control treatments, limit their impacts on non-target species, restore native plants in treated areas, and prevent establishment of new occurrences. The widespread nature of invasive plants necessitates that work be prioritized to maximize effective use of available resources for management.

This section provides background information about exotic plant species in the Authority's open space preserves (Section 3.1), and then outlines the elements of a stepwise process for managing them (Section 3.2). The *Resources* section of this document provide more detailed information about management techniques, which are beyond the scope of this guidance manual, which is instead designed to provide the framework for planning and implementing invasive plant management.

3.1 Introduction

3.1.1 Exotic Plant Species

Authority lands support populations of plants that are not native to California that have been introduced from other regions of the world. Some introductions have been deliberate, as in the case of purple vetch (*Vicia benghalensis*) and Harding grass (*Phalaris aquatica*), which were seeded to enhance forage for deer and cattle. Most exotic species were introduced accidentally as part of other human activities, including livestock grazing and agriculture, with many arriving with the European settlers in the 17th century. A few species are ornamental plants, that were also deliberately planted. These species are relatively localized and typically have much lower impacts, due to their limited distribution and abundance.

Most of the exotic species in the open space preserves are ***naturalized*****,** meaning that they reproduce on their own in natural lands. Arguably the greatest richness (number of species) and abundance (e.g. density) of naturalized exotic plants occur in the preserve grasslands. Many of these species are native to European areas, where their adaptations to the Mediterranean climate including long summer drought and, in many cases, oligotrophic (low-nutrient) soils are said to have 'pre-adapted' them to California's grasslands. Fertilization of low nutrient soils, including serpentine soils, through nitrogen deposition has been found to promote growth of exotic plants, particularly European annual grasses, which then outcompete species adapted to growth on serpentine soils (Huenneke et al. 1990, Weiss 1999).

Historic land use including cultivation and livestock grazing may also have promoted the invasion and spread of these now ubiquitous species, which include grasses such as oats (*Avena* spp.), bromes (*Bromus* spp.), barleys (*Hordeum* spp.), and fescues (*Festuca* spp.); forbs including filarees (*Erodium* spp.); and clovers (*Trifolium* spp.).

3.1.2 Exotic Plant Impacts in Natural Lands

Exotic plants can negatively impact native plants and animals and alter natural systems through a variety of direct and indirect mechanisms (Table 1). Exotic plants can also alter culturally important landscapes, by altering the natural community structure and species composition, such as when French broom (*Genista monspessulana*) invades a native grassland. Exotic plants can degrade recreation opportunities, by constricting trail corridors and blocking scenic vistas.

3.1.3 Invasive Plant Species

Sixty-five (65) exotic species found in the Authority's open space preserves are regarded as *invasive* by the California Invasive Plant Council (Cal-IPC) (Cal-IPC 2019), because they aggressively spread, outcompete native plants, degrade habitat for native animals, and in some cases, can modify ecosystem processes such as hydrology, fire regimes, and soil chemistry (Table 2). These invasive plants have been categorized according to Cal-IPC standards based on their impacts as follows:

- **High**: Nine species (14%) 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:** Thirty-three species (52%) have substantial and apparent ecological impacts on physical processes, plant and animal communities, and vegetation structure, though not as severe as those that are rated in the high category. 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**: Twenty-three species (34%) 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 dispersal. Ecological amplitude and distribution are generally limited, but these species may be locally persistent and problematic.

These ratings are based on expert interviews and scientific literature throughout California; impacts can differ depending on the conditions of the occurrence including the population density and the area in which it occurs, including sensitive habitat. Notably, the suite of invasive plants impacting serpentine grasslands includes species that are not typically considered highly invasive in more widespread ecological systems, including the California annual grasslands found on non-serpentine soils. Accordingly, the Authority classified invasive species according to priority for management within their lands. The list of species, including their Cal-IPC rating and Authority prioritization is found below (Table 2).

Table 1: Selected impacts of exotic plant species within the open space preserves

Impact	Description	Examples within the Authority's Open Space Preserves
Outcompete Native Plants	Invasive plants can deplete soil moisture and nutrients, shade-out native species, compete for limited space, and/or create conditions that deter native plant establishment, such as dense thatch.	Invasive herbs (grasses and forbs) in grasslands complete with native herbs and reduce native plant species richness and abundance.
Alter Community Structure	Invasive plants alter the structure of native communities, oftentimes degrading habitat for native animals.	Invasive annual grasses convert forb-dominated communities including the wildflower fields on serpentine soils, to grasslands, thus degrading habitat for the Bay checkerspot butterfly (*Euphydryas editha bayensis*). Invasive shrubs such as French broom convert grasslands to shrublands.
Alter Hydrology	Invasive plants can evapotranspire excessive amounts of water, thus reducing water flow or depth.	Giant reed (*Arundo donax*) in the Upper Pajaro River may reduce water flow and depth required by native species including California red-legged frog.
Alter Nutrient Availability	Exotic plants and organic matter to the soil over time, and, in the case of legumes can fix nitrogen; these inputs can ameliorate inimical soil conditions and promote further invasion by specie otherwise intolerant of the serpentine soil conditions.	Soils enriched with nitrogen by French broom can promote growth of invasive herbs following French broom control. Clovers (*Trifolium* spp.) can enrich serpentine soils.
Promote Fire in Non-Fire Adapted Systems	Invasive plants can create fuel conditions that promote fire, which can kill native woody species that are not adapted to fire. Fires that kill woody species can result in type-conversion of shrublands to grasslands as part of a grass-fire cycle (D'Antonio and Vitousek 1992)	Invasive grasses create fine fuels that promote fire in shrublands where widely spaced native shrubs and sparse herbs typically will not sustain fire. In non-fire adapted systems such as coastal scrub and chaparral, grass-fire cycles can convert shrublands to grasslands.
Impede Conservation Grazing	Exotic plants that are unpalatable or even noxious for cattle, can impede use of cattle grazing as a management tool to promote native plants, and maintain short-structure conditions in grasslands that are required by many native animals.	Dense patches of milk thistle (*Sylibum murinum*) and purple star-thistle (*Centaurea calcitrapa*) in the Coyote Ridge OSP can impeded effective cattle grazing of the serpentine grasslands, which is needed to reduce competition from dense exotic annual grasses on native annual forbs.

Table 2: Invasive plants known to occur within the Authority's open space preserves

Scientific Name[1]	Former Scientific Name[2]	Common Name(s)	Cal-IPC Rating[3]	Authority Priority	Life Form
Aegilops triuncialis		barbed goat grass	High	High	Annual grass
Ailanthus altissima		tree of heaven	Moderate	High	Tree
Avena barbata		slender wild oat	Moderate	Low	Annual, Perennial grass
Avena fatua		wild oat	Moderate	Low	Annual grass
Brachypodium distachyon		annual false-brome	Moderate	Moderate	Annual, Perennial grass
Brassica nigra		black mustard	Moderate	High	Annual herb
Brassica rapa		turnip, field mustard	Limited	Moderate	Annual herb
Brassica rapa var. *rapa*		field mustard; turnip	Limited	Moderate	Annual herb
Briza maxima		rattlesnake grass	Limited	Low	Annual grass
Bromus diandrus		ripgut grass	Moderate	Low	Annual grass
Bromus hordeaceus		soft chess	Limited	Low	Annual grass
Bromus madritensis ssp. rubens		red brome	High	Low	Annual grass
Carduus pycnocephalus		Italian thistle	Moderate	High	Annual herb
Carduus tenuiflorus		Italian thistle	Limited	Low	Annual herb
Carthamus lanatus		woolly distaff thistle	High	Moderate	Annual herb
Centaurea calcitrapa		purple star-thistle	Moderate	High	Annual, Perennial herb
Centaurea diffusa		diffuse knapweed	Moderate	Moderate	Perennial herb
Centaurea melitensis		tocalote	Moderate	Moderate	Annual herb
Centaurea solstitialis		yellow star-thistle	High	High	Annual herb
Centaurea stoebe ssp. *micranthos*	*Centaurea maculosa*	spotted knapweed	High	Low	Perennial herb
Cirsium vulgare		bull thistle	Moderate	High	Perennial herb
Conium maculatum		poison-hemlock	Moderate	High	Perennial herb
Cynara cardunculus		artichoke thistle	Moderate	High	Perennial herb
Cynodon dactylon		Bermuda grass	Moderate	Low	Perennial grass
Cynosurus echinatus		bristly dogtail grass	Moderate	Low	Annual grass
Cytisus scoparius		Scotch broom	High	High	Shrub
Dipsacus fullonum		wild teasel	Moderate	Low	Perennial herb

Table 2: Invasive plants known to occur within the Authority's open space preserves

Scientific Name[1]	Former Scientific Name[2]	Common Name(s)	Cal-IPC Rating[3]	Authority Priority	Life Form
Dittrichia graveolens		stinkwort; stinkweed	Moderate	High	Annual herb
Elymus caput-medusae	*Taeniatherum caput-medusae*	medusa head	High	High	Annual grass
Erigeron canadensis	*Conyza canadensis*	horseweed		Moderate	Annual herb
Erodium cicutarium		redstem filaree	Limited	Low	Annual herb
Eucalyptus globulus		blue gum	Limited	High	Tree
Festuca myuros	*Vulpia myuros var. hirsuta*	rattail sixweeks grass	Moderate	low	Annual grass
Festuca perennis	*Lolium multiflorum*	rye grass	Moderate	Low	Annual, Perennial grass
Foeniculum vulgare		fennel	Moderate	High	Perennial herb
Genista monspessulana		French broom	High	High	Shrub
Geranium dissectum		cutleaf geraniium	Limited	Low	Annual herb
Helminthotheca echioides	*Picris echioides*	bristly ox-tongue	Limited	Low	Annual, Perennial herb
Hirschfeldia incana		summer mustard	Moderate	High	Perennial herb
Hordeum marinum		Mediterranean barley	Moderate	Low	Annual grass
Hordeum murinum		wall barley	Moderate	Low	Annual grass
Hypochaeris glabra		smooth cat's-ear	Limited	Low	Annual herb
Hypochaeris radicata		rough cat's-ear	Moderate	Low	Perennial herb
Lepidium draba	*Cardaria draba*	heart-podded hoary cress	Moderate	High	Perennial herb
Marrubium vulgare		horehound	Limited	High	Perennial herb
Medicago polymorpha		California burclover	Limited	Low	Annual herb
Mentha pulegium		pennyroyal	Moderate	Moderate	Perennial herb
Nicotiana glauca		tree tobacco	Moderate	Low	Tree, Shrub
Oxalis pes-caprae		Bermuda buttercup	Moderate	Moderate	Perennial herb
Pennisetum clandestinum		kikuyugrass	Limited	Low	Perennial grass
Phalaris aquatica		harding grass	Moderate	High	Perennial grass
Plantago lanceolata		English plantain	Limited	Low	Perennial herb
Raphanus sativus		radish	Limited	Low	Annual, Biennial herb

Table 2: Invasive plants known to occur within the Authority's open space preserves

Scientific Name[1]	Former Scientific Name[2]	Common Name(s)	Cal-IPC Rating[3]	Authority Priority	Life Form
Rubus armeniacus	*Rubus discolor*	Himalayan blackberry	High	Moderate	Shrub
Rumex acetosella		sheep sorrel	Moderate	Low	Perennial herb
Rumex crispus		curly dock	Limited	Low	Perennial herb
Salsola australis	*Salsola tragus*	Russian thistle	Limited	Moderate	Annual herb
Salsola soda		glasswort	Moderate	Moderate	Annual herb
Salsola tragus		Russian thistle; tumbleweed	Limited	High	Annual herb
Senecio vulgaris		common groundsel		Moderate	Annual
Silybum marianum		milk thistle	Limited	High	Annual, Perennial herb
Stipa miliacea var. *miliacea*	*Piptatherum miliaceum*	smilo grass	Limited	Low	Perennial grass
Torilis arvensis		tall sock-destroyer	Moderate	Moderate	Annual herb
Tribulus terrestris		puncture vine	Limited	Moderate	Annual herb
Trifolium hirtum		rose clover	Limited	Low	Annual herb
Verbascum Thapsus		woolly mullein	Limited	Low	Perennial herb
Vinca major		greater periwinkle	Moderate	Moderate	Perennial herb

[1] Baldwin et al. 2012
[2] Hickman et al. 1993
[3] Cal-IPC 2019

3.1.4 Ongoing Invasions

Invasions of new exotic plant species will continue as humans continue to transport materials from around the world into the Bay Area, a global economic hub. Global climate change will also increase the rate of biological invasions by altering the suitability of habitats and promoting disturbance (e.g. floods and fires) which facilitate invasive plant establishment (Brook et al. 2008). Maintaining biodiversity in the Authority's open space preserves will require steps to prevent invasions (Section 3.2.1) and an adaptive approach to addressing invasive plant management as conditions change (Section 3.2.8).

3.2 Approaches to Managing Invasive Plants in Natural Lands

Management of invasive plants in natural lands is one of the primary strategies for biodiversity conservation in the open space preserves. It can also facilitate the Authority's work to protect and restore water resources, conserve working lands, and provide opportunities for nature-based recreation and education (SCOSA 2014a).

Invasive plant management is complex, can be resource-intensive, and, in many cases, requires a sustained effort to be effective; achieving the management goals will require careful, long-term planning and adaptation.

This section outlines approaches to managing invasive plants in natural lands. The approaches are presented as part of a step-wise process that is designed to achieve the goals, over time, as part of an adaptive management framework, as illustrated below (Table 3, Figure 2).

Rather than attempting to synthesize the wealth of technical resources available to aid successful planning and implementation of invasive plant management work, this document provides guidance for how to approach invasive plant management. The *Resources* section lists websites that provide information to plan, implement, and in some cases fund, invasive plant management, including many technical guides.

Figure 2: Adaptive management framework for invasive plant management in natural lands

Table 3: Summary of the step-wise approach to managing invasive plants in natural lands

Step and Section	Purpose	Key Elements
Prevent (Section 3.2.1)	Prevent the establishment of new invasive plant occurrences, to limit impacts and management costs	• Implement Best Management Practices to prevent accidental introductions during preserve management. • Coordinate with neighboring landowners to prevent spread of invasive plants from adjacent properties. • Engage the public to prevent them from vectoring invasive plant materials into the preserves. • Implement an early detection and rapid response program to detect and eradicate new invasive plant occurrences before they can spread.
Inventory (Section 3.2.2)	Identify invasive plants and map the most important occurrences to inform their management.	• Develop and update a list of invasive plants known or likely to occur in the open space preserves. • Identify species that are priorities for targeted control (i.e. species or guild-specific control, rather than general vegetation management such as conservation grazing). • Determine priority areas for mapping invasive plants, including areas that are more susceptible to invasion and sensitive to impacts of invasive plants. • Map invasive plants following protocols designed to obtain accurate, repeatable data (Table 6) that can be used to monitor changes over time, including to assess effectiveness of treatments as part of monitoring.
Set Goals (Section 3.2.3)	Determine the management goal for each occurrence	• Select the most appropriate goal for management of the occurrence based on its size, the ecology of the species, the conditions of the site in which it occurs, and the proven effectiveness of treatments.

Prioritize (Section 3.2.4)	Prioritize the invasive plant occurrences for management using criteria designed to maximize the sustainable benefit for the conservation values.	• Score each mapped invasive plant occurrence based on the following criteria designed to reflect their priority for management (Table 7):
		  ○ Benefit of control for biodiversity conservation;
		  ○ Potential for further impacts to biodiversity posed if management is not taken;
		  ○ Additional benefits from control including engagement of public in volunteer stewardship, promoting agricultural, cultural, recreational and scenic resources; and
		  ○ The relative ease and safety with which the goal can be achieved.
		• Categorize occurrences based on their score as follows:
		  ○ High: will be treated wherever possible;
		  ○ Medium: will be treated as resources allow, including in conjunction with high priority occurrences;
		  ○ Low: will only be treated where doing so can extend benefits of treating high and medium priority occurrences, and when little effort is required.

Strategize and Treat (Section 3.2.5)	Develop comprehensive strategies that identify "who, what, when, where, why, and	• Devise strategies for each occurrence based on the invasive species' ecology, unique conditions of the occurrence including its density, and the system in which it occurs (Table 8). • Develop control techniques using an integrated pest management approach (Table 9) including appropriate use of herbicides (Appendix A) based on the best available information about what is effective, including

Table 3: Summary of the step-wise approach to managing invasive plants in natural lands

Step and Section	Purpose	Key Elements
	how" of each treatment	scientific reports (*References* and *Resources*), and results of monitoring of similar and/orprior projects. • Incorporate protection measures for sensitive biological resources (Table 12). • Document the treatment following methods that will enable evaluation of its effectiveness and overall level of effort on invasive plant management (Table 13).
Restore (Section 3.2.6)	Re-establish the natural community structure and species composition, to suppress invasive plants and promote native biodiversity.	• Assess whether active restoration techniques will be required because passive restoration will be insufficient to protect soil and water quality, and establish native plant cover to recreate natural communities. • Evaluate the advantages and disadvantages, as well as financial costs and benefits, of various restoration treatments for the site (Table 14). • Use weed-free materials and closely monitor restoration sites to detect and eradicate invasive plants introduced in off-site materials or by equipment.
Monitor (Section 3.2.7)	Monitor changes in the invasive plant occurrences and track invasive plant control work and evaluate its effectiveness over time.	• Conduct effectiveness monitoring in a subset of treatment areas, to evaluate treatment success and compare the effectiveness of alternative treatments at achieving the treatment goals. • Map new invasive plant occurrences encountered, as feasible, and update the invasive plant species inventory every five years, or as resources allow, to maintain a current database of invasive plant species occurrences to inform management.
Adapt (Section 3.2.8)	Adaptive invasive plant management over time to incorporate lessons learned and address changes in conditions.	• Develop annual work plans to adjust priorities based on changes in invasive plant species occurrences, and treatments based on new scientific information and results of prior monitoring. • Every five years, or as resources allow, revisit all elements of the program and make adjustments, where needed, to promote achievement of the overall goals.
Educate (Section 3.2.9)	Educate Authority staff and the public to promote effectiveness of the invasive plant management program.	• Work with staff to stay abreast of new invasive plant management information and techniques, through website and literature review, and participation in workshops, trainings, and conferences. • Increase public support of and assistance with the invasive plant management program, through information provided on websites, e-newsletters, kiosks, docent and volunteer programs, and interpretive signage.

3.2.1 Prevent

Preventing new exotic plant invasions will be the most cost-effective method of limiting impacts of exotic plants in the Authority's open space preserves. Many invasive plants feature adaptations designed to promote their rapid spread, including well-dispersed and abundant seed. This can lead to exponential increases in their disturbance and abundance as well as their impacts to native plants and animals and the cost of their control. Detecting and eradicating invasive plants before they spread not only greatly reduces the cost of control but can also prevent their impacts on biodiversity and other conservation values.

To limit future invasions, the Authority will implement a suite of prevention strategies (inset box) to minimize the likelihood that new invasive plants will become established and eradicate new invasive plant occurrences before they can spread.

Prevention Strategies

Plan: Assess project areas and incorporate invasive plant prevention strategies for facilities development and maintenance, vegetation management, and other preserve activities that can promote invasive plants.

Avoid Moving Invasive Plant Materials: take steps to prevent workers, visitors, grazing animals, and equipment from vectoring invasive plants into preserves.

Reduce Vegetation and Soil Disturbance: Limit the extent of bare soil conditions that promote invasions and carefully monitor these areas.

Practice Early Detection and Rapid Response: Regularly monitor preserves, with an emphasis on new invasion pathways, to prevent establishment of new invasive plant occurrences.

Adapted from Cal-IPC 2012.

3.2.1.1 Best Management Practices

The Cal-IPC (Cal-IPC 2012) has assembled a comprehensive list of best management practices to prevent the spread of invasive plants during a variety of management activities conducted in natural lands, including:

- Construction and facilities maintenance;
- Vegetation management;
- Revegetation and landscaping;
- Fire and fuel management; and
- General operations including travel, waste disposal, and cleaning and maintenances of equipment and clothing.

This document will serve as a resource for the Authority when planning and implementing these and other types of projects and activities with the potential to promote the invasion and spread of exotic plants in natural lands. Specifically, during project planning, the measures will be reviewed and incorporated in related planning documents, including California Environmental Quality Act compliance documents, and contractor specifications. The BMPs will also be reviewed along with other invasive plant management topics during periodic trainings of Authority staff (Section 3.2.9).

The cost-effective implementation of these programs can be enhanced by identifying the most likely mechanisms of invasion (i.e. trails, roads) and the areas that are most susceptible to invasion. Table 4, below, lists common sources of invasive plants and identifies preventative measures and best practices that will be implemented, if feasible, to reduce the risk associated with each.

Table 4: Key strategies to prevent new exotic plant invasions

Category	Description	Best Management Practices
Facilities Construction and Maintenance	Minimizing the transport of seed and plant parts by vehicles and machinery into preserves.	• Locate facilities including parking, picnic, and staging areas on the perimeter of preserves. • Avoid importing materials including topsoil, fill, and gravel, and where necessary, use 'weed free' materials. • Avoid working in invasive plant infestations until after plants have been eliminated from the site. • Perform work that has the potential to transmit exotic plants, first in uninfested areas and then later in infested areas. • Wash all vehicles and equipment (e.g. mowers) to avoid transporting exotic plant seed or other propagules.
	Maintain native plant cover	• Limit road and trail grading to that which is necessary. • Avoid anthropogenic disturbances that create open conditions that are favored by invasive plants • Reseed with native plants using 'weed-free' seed sources following construction, intensive invasive plant abatement, or other disturbance.
Recreation	Minimizing the transport of seed and plant parts by recreators.	• Require or encourage equestrians to use weed-free hay. • Educate trail users about exotic plant invasions and encourage their help in identifying new invaders.
Conservation Crazing	Minimize soil disturbance	• Avoid extensive soil disturbance associated with intense cattle grazing; promote diffuse utilization by cattle. • Locate corrals on the perimeter of the preserve, in areas that can be frequently monitored and readily treated for invasions.
	Quarantine livestock	• When feasible, quarantine livestock in corrals or small pastures for at least 24 hours, to minimize transport of seed or other plant propagules into the remainder of the preserve.
	Manage supplemental feeding	• Limit supplemental feeding to designated areas on the perimeter of the preserve that can be closely monitored and readily treated for invasions. • Use only certified weed free hay.
Adjacent Properties and easements	Limit potential for spread from adjacent properties	• Limit disturbance along the perimeter of properties (e.g. avoid mowing and disking) • Work with neighbors to limit planting of invasive species in their landscaping and avoid disturbance along their property lines which can promote invasion into the preserves. • Work with easement holders and lessees to limit disturbance associated with maintaining and utilizing rights-of-way through preserves (e.g. utility corridors).

3.2.1.2 Coordinate with Other Landowners

The Authority will coordinate with others responsible for management of invasive plants on adjacent lands in the region to:

- share information about control techniques and their effectiveness;
- share information about invasive plant occurrences and treatment strategies near property boundaries; and
- stay abreast of emerging threats, including new invasive plants.

This coordination can occur through participation in meetings and other activities of the Santa Clara Weed Management Area, as well as through other opportunities to coordinate on natural resource management. Additionally, as resources allow, the Authority will partner with adjacent landowners and others to manage invasive plants across property boundaries.

3.2.1.3 Engage the Public in Preventing New Invasions

As part of the Authority's broader public and visitor education and outreach program, the Authority will enlist the assistance of open space preserve visitors and stewards, to help reduce plant invasions. Specifically, the Authority will encourage equestrians to use 'weed free feed'—hay and other materials that do not contain invasive plant species such as yellow starthistle, which can invade natural lands. Outreach materials will also encourage users to inspect and clean their vehicles, bicycles, boots, and clothing to avoid dispersing invasive plant seed and other materials into the open space preserves. The Authority will also incorporate invasive plant identification and management in its docent and volunteer training.

3.2.1.4 Early Detection/Rapid Response Program

Early detection and rapid response will enable the Authority to eradicate new exotic plant species that invade the open space preserves before they have a chance to spread and establish a seed bank, and before they cause significant impacts to the sensitive biological resources.

3.2.1.4.1 Detection Methods

Each open space preserve will be examined to detect occurrences of new exotic species twice annually, or as resources allow, once in the late spring and once in the mid-summer, to coincide with the two main flowering periods for annual species, to detect occurrences of new exotic species.

During each monitoring event, staff trained to identify invasive plant species, including any new invaders in the region, will inspect areas that are most susceptible to invasion, including:

- roads, trails, parking lots, staging areas, utility access areas (e.g. right-of-ways), building sites, and other areas accessed by vehicles, equipment, and livestock;
- areas of recent disturbance, including fire, vegetation management (e.g. fuel breaks), facilities maintenance or construction, or restoration; and

- areas of intense livestock use, including corrals, staging areas, water troughs, supplement feeding areas, ponds, and 'loafing areas' (e.g. ridgetops, swales, or under trees).

Heightened vigilance should be used during periods when invasions are more likely to occur, including:

- disturbances, such as fire, landslides, or other natural disturbances;
- facilities construction or maintenance, including road and trail work;
- resource management projects, including intensive invasive plant control and restoration projects;
- very wet years (e.g. El Niño years); and
- following application of soil amendment and fertilization, including application of herbicides.

Staff conducting the early detection surveys should have on-hand the following resources:

1. **Maps of Existing Invasive Plant Occurrences:** Hard copy or digital maps (e.g. spatial data layers) of existing invasive plant occurrences subject to species-specific control will be on hand, to provide the baseline for the search and prevent recordation or treatment of already identified occurrences that might not be priorities for treatment.
2. **Watch List**: A list of invasive plants that are subject to species-specific control within the open space preserves, as well as species on the Watch List available from Cal-IPC, which is updated twice each year (Cal-IPC 2016a).
3. **Species Identification Cards:** Effective identification can be aided through review of identification cards for target species known or likely to occur in proximity to the open space preserve system, including species on Cal-IPC's Watch List. Cards have been created previously by Authority staff and have also been created by Cal-IPC. The cards are laminated and put in a binder placed in all Authority vehicles. (Cal-IPC 2016b), and new cards can be added as needed.

To the extent practicable, all Authority staff and contractors working for the Authority will be trained to identify invasive plants, as feasible, to promote their detection during the course of routine preserve activities, including resource management, facility management, and interpretation. Authority docents and volunteers can also assist with this effort. This will enable staff and contractors to detect invasive plant occurrences during the course of their routine work in the preserves.

3.2.1.4.2 Assessment Methods

Each new occurrence should be assessed for the appropriate response. The assessment should include the following:

1. **Species identification:** particularly for new species, Authority staff should collect and key out species to ensure they are positively identified prior to treatment;
2. **Areal Extent:** the approximate area occupied by the occurrence (e.g. 1,000 square feet, or 20 feet by 5 feet)

3. **Cover:** the absolute canopy cover of the species within the area occupied (e.g. 40% cover);
4. **Life Stage**: the period in the plant's life cycle, such as seedling, juvenile, adult for perennial species;
5. **Phenology**: the stage in the plant's annual cycle of flowering and fruiting (e.g. in bud, in flower, in fruit, etc.)
6. **Site Factors Influencing Control:** An assessment of the factors that might influence control methods and effectiveness, including proximity to a road or trail, or location with respect to sensitive habitat of special-status species.

This information will be used to formulate a treatment plan or response.

3.2.1.4.3 Response

The goal of early detection and rapid response is to eradicate any new invasive plant species detected during the first year if feasible, with follow up treatments utilized to ensure the species has been eradicated. Staff conducting the surveys will have equipment on hand to treat any occurrences that can be positively identified and readily treated. This equipment will include hand tools (shovels, Pulaski, sheers, etc.) and heavy duty bags for disposal of propagules that can promote spread. Other species will be treated pursuant to the treatment plan developed based on the assessment above.

3.2.2 Inventory

An inventory of invasive plant occurrences within the open space preserves provides a solid foundation for the design and implementation of an effective invasive plant control program. Spatial data identifying the location, areal extent, and absolute cover of invasive plant occurrences is essential to setting goals for their eradication or control, prioritizing management based on their benefits, risks, and feasibility, and developing and implementing effective management strategies to achieve the goals, based on aspects of the occurrence and the site conditions. A spatial database for invasive plant occurrences also provides the baseline for monitoring effectiveness of the control efforts and informing modifications as part of an adaptive management strategy (Section 3.2.7).

This section outlines the recommended approaches to create and maintain a spatial database that provides the most essential information about species and communities that can be used to plan and monitor invasive plant management in the open space preserves. The inventory will be conducted through a three-step process:

1. Identify the invasive plant species that will be subject to targeted control;
2. Prioritize areas for mapping; and
3. Map target invasive species in areas based on their priority.

3.2.2.1 Identify Species for Targeted Control

Due to the large size of Authority's current preserve network, which features 14 properties totaling 16,197 acres, and its diverse ecosystems and prior land uses, it is not feasible to comprehensively inventory, much less successfully control, all occurrences of invasive plant species.

The Authority will use available information about invasive plant species, their impacts on biodiversity and other conservation values, and the effectiveness of various control techniques, to screen invasive plant species for *targeted control*. In targeted control, treatments are applied to individual species or guilds of species with similar ecologies (e.g. thistles or late-season annual forbs) to achieve specific management goals. General vegetation management techniques, such as conservation grazing and prescribed fire, can be used to control populations and reduce the impacts of invasive species that are not subject to targeted control, including many widespread invasive annual grasses such as ripgut brome (*Bromus diandrus*) and Italian rye grass (*Festuca perennis*).

The species selected for targeted control will be identified by:

1. Creating a list of known or likely invasive plant species within the open space preserves; and
2. Evaluating each species for targeted control based on a series of criteria based on their impacts and feasibility of targeted control.

3.2.2.1.1 Develop a Regional Invasive Species List

A list of species known or likely to occur in the open space preserves will be used to identify species for targeted control and inventory. The initial list developed for this manual was created by combining the following two databases:

1. **Cal-IPC Invasive Plants in Santa Clara County**: An annotated list of invasive plants that have been documented to occur in Santa Clara County was created by exporting the list of species from CalFlora, the online database of plant records in California (CalFlora 2016), and then annotating the species list with information from the Cal-IPC inventory (Cal-IPC 2019), including the life form (e.g. annual grass, perennial forb, shrub, etc.) and Cal-IPC invasiveness rating. The most widely accepted common names for species were also added from Jepson e-flora (2016), the online database of California flora.
2. **2019 Invasive Plants (SCOSA 2019a):** This spreadsheet listing the plants that the Authority currently targets for control was assembled by Authority staff based on their prior invasive plant mapping and management work and updated in 2019.

The combined list of invasive species known or suspected to occur in the Authority's preserves, as well as species that are in the region and may invade the preserve is included in a database (Excel workbook) that will be used to facilitate the early detection/rapid response efforts to prevent establishment of new invasive species (Section 3.2.1).

3.2.2.1.2 Select Species for Targeted Control

The regional invasive plant species list was independently reviewed by open space technicians involved in invasive plant work within the open space preserves as well as other Authority staff to identify and prioritize species for targeted control. These species were selected based on the following three main criteria:

1. Ecological impacts:
2. Invasive potential;

3. Feasibility of targeted control, based upon:
    i. Relative distribution and abundance with open space preserves;
    ii. Response to control treatments;
    iii. Occurrence on adjacent lands; and
    iv. Suitability of volunteer work for control.

The first two criteria were adapted based on the Cal-IPC state-wide assessment, to reflect unique circumstances in the region and in Authority preserves in particular, including the biological systems and species. The list includes 67 species, of which 21 (31%) are high priority, 16 (24%) are medium priority, and 30 (45%) are low priority species for targeted control (see Table 2, Section 3). The list includes six shrubs and trees, 29 biennial or perennial herbs (grasses and forbs), and 32 annual herbs (see Table 2, Section 3).

3.2.2.2 Prioritize Areas for Mapping

Due to the large size of the Authority's preserves, invasive plants targeted for control will need to be mapped over time. The sequence of mapping will reflect the priority for biodiversity conservation including the immediacy of management. This section outlines initial criteria that will be used to identify priority areas for mapping by developing and integrating spatial data layers that reflect the following:

1. Areas that are more susceptible to invasion; and
2. Areas more sensitive to invasive plant species impacts.

3.2.2.2.1 Identify Areas Susceptible to Invasion

Certain areas of the preserves are more susceptible to invasion than others owing to a variety of factors including:

- Prior and current land uses, particularly cultivation, grazing, and development of roads, trails, buildings, and other infrastructure, including utility corridors;
- Land use activities near the preserve, particularly those along the perimeter;
- History of fire or other disturbances including landslides;
- Areas where vegetation has been removed including as part of fuel breaks or restoration projects; and
- Communities that are more susceptible to invasion, including grasslands, savannas, wetlands, and riparian areas, as opposed to shrublands and dense woodland or forests.

These areas can be mapped and integrated into a GIS layer that identifies areas that are more susceptible to invasion. In addition to prioritizing areas to be mapped as part of the inventory, this layer can serve as a tool to facilitate efforts to detect and eradicate new invasive plant species (Section 3.2.1.2).

3.2.2.2.2 Identify Areas Sensitive to Invasive Plants

Invasive plants can more negatively impact biodiversity where sensitive biological systems are present. The following will be mapped in open space preserves, to further prioritize invasive plant mapping and treatment (Section 3.2.4).

1. Sensitive Communities: aquatic or terrestrial systems that meet one or more of the following criteria:
   - Listed as a 'special community' on the Department's current list of sensitive plant communities (CDFW 2010);
   - Ranked S1 or S2 on The Nature Conservancy Heritage Program; and/or
   - Identified as locally rare or unique, including disjunct occurrences or more widespread communities.

   Table 5, below, lists the sensitive communities identified within the Authority's Greenprint (SCOSA 2014a).

Table 5: Sensitive plant communities within the Authority's jurisdiction and open space preserves (BAOSC 2012, SCOSA 2019b, 2021)

Sensitive Communities	Acres within the Authority's Jurisdiction	Acres within the Authority's Open Space Preserves
Coastal Terrace Prairie Grassland	100	0
Coastal Scrub	3,371	186
Black Oak Forest / Woodland	46	0
Canyon Live Oak Forest	110	0
Valley Oak Forest / Woodland	2,284	38
Coulter Pine Forest	198	0
Knobcone Pine Forest	4	0
Sycamore Alluvial Woodland	6	0
Central Coast Riparian Forests	1,717	97
Serpentine Barren	40	0
Serpentine Grassland	11,618	1,532
Serpentine Scrub	1,054	46
Serpentine Leather-Oak Chaparral	1,560	30
Serpentine Hardwoods	6,036	395
Serpentine Conifer	55	0
Serpentine Riparian	75	13
Total	**28,274**	**2,337**

2. Special-Status Species Habitat: Areas that provide habitat for special-status species, including:

- **Federal Endangered Species Act**: listed or proposed for listing as threatened or endangered;
- **California Endangered Species Act**: listed or candidates for listing;
- **Fully Protected Species**: listed under California Fish and Game Code;
- **Species of Special Concern**: species of special concern on the special animals list (CDFW 2015);
- **Species of Conservation Concern**: species identified by the USFWS as being of conservation concern;
- **California Rare Plant Rank**: plants that are rare, threatened or endangered in California (CRPR Lists 1B and 2, CNPS 2016);
- **Western Bat Working Group**: species ranked as 'high' or 'medium' on the Regional Priority Matrix; and
- **CEQA**: other species that meet the definition of rare or endangered under CEQA, including those are not listed but known to be very rare or declining.

The locations of sensitive communities and special-status species occurrences or habitat will be integrated in a GIS layer that can be used to prioritize areas for inventory and invasive plant control. This composite layer can inform other aspects of the Authority's planning and management as well.

3.2.2.2.3 Integrate the Priority Areas

The spatial data layers illustrating areas that are more susceptible to invasion and those that are more sensitive to the impacts of invasive plants will be overlaid in GIS, to create a composite layer that identifies priority areas for mapping invasive plants as part of the inventory. Areas that are more sensitive and more susceptible should be mapped first, followed by areas that are only more susceptible and then areas that are only more sensitive; as resources allow, other areas should be subject to mapping.

3.2.2.3 Map Invasive Plants

Invasive plants will be mapped in areas of the preserves in order of their priority. Mapping will be conducted following a protocol designed to capture accurate, comparable, and repeatable data, so that occurrences can be remapped to evaluate changes and determine the need for adaptive management, using the most cost effective methods.

3.2.2.3.1 Mapping Goals

The goals of mapping invasive plant occurrences within the Authority preserves are:

1. Provide spatial information about the invasive plant occurrences that can help the Authority implement steps to control invasive plants, including set goals, prioritize species and areas for treatment, and develop strategies for treatments which can vary based on the site conditions;
2. Provide accurate locations for pre-emergent treatments;
3. Track changes in invasive plant occurrences over time;

4. Evaluate effectiveness of treatments at achieving the management goals; and
5. Tracking the level of effort for treating invasive plants over time.

To be effective overall, mapping should provide the greatest amount and most accurate and comparable information that can be obtained in the most cost-effective manner.

3.2.2.3.2 Mapping Software and Hardware

A variety of software and hardware options are available to map invasive plant species occurrences and their treatment over time. Historically, the Authority utilized resource grade global positioning systems to collect spatial data, which was then processed using ArcGIS geographic information system software (ESRI 2016). In 2015, the Authority began utilizing the Weed Manager system—an integrated system of multiple software components that enables organizations engaged in land management to map invasive plant species and monitoring their treatments over time (CalFlora Weed Manager 2016). The system includes Observer Pro, a mobile application that allows the Authority staff to map new invasive plant occurrences and update existing records in the field, using a global-positioning system-enabled tablet or smartphone that runs the application. The customizable software allows the Authority to identify the data fields to be collected based on the invasive plant management program. The subscription-based system is designed to evolve over time as subscribers provide feedback to enhance its utility.

In developing this manual, the Authority piloted work with Weed Manager and compared it to alternatives, including developing *de novo* databases to map weeds using resource-grade GPSs, and ArcGIS. The key advantages of using Weed Manager are:

1. The spatial is uploaded to the cloud (i.e. offsite server access via internet), where it is readily available for use by all users, such that the data do not need to be uploaded/transferred to multiple devices in order for the current open space technicians and other staff to have the information available for use;
2. New records can be readily related to prior records, allowing the Authority to track changes in invasive plant occurrences due to treatments or other factors; and
3. The tablet or smartphone hardware is more user-friendly as well as cost effective than resource-grade GPS, and the data acquired has sufficient accuracy for the purposes of the Authority.

Future invasive plant mapping systems may also be developed and will be evaluated for use in the future, as time allows.

3.2.2.3.3 Mapping Methods

In order for the spatial data to achieve the mapping goals (Section 3.2.2.1), including facilitate monitoring (Section 3.2.7), it should be collected following a protocol designed to obtain accurate, comprehensive, and repeatable information.

Invasive plant occurrences can be mapped as either points, lines, or polygons. Points located in the center of the patch are easier to collect but provide less information about the spatial distribution of the species than polygons, which delineate the patch boundaries. Polygons, on the other hand, can be time consuming to collect, particularly using mapping rules designed to make the data comparable.

The mapping rules that are most effective at providing the greatest amount and most accurate and comparable information in the most cost-effective manner to achieve the mapping goals (Section 3.2.2.3.1) will depend on a variety of factors including aspects of the: 1) invasive plant species, including its size, 2) the specific occurrence, including the shape, and 3) the landscape, including complexity of the vegetation and the terrain and other aspects that can influence feasibility of mapping. For these reasons, it is not feasible to come up with one set of mapping rules that present the best solution for all invasive species occurrences. At the same time, different mapping rules for the unique circumstances will reduce the comparability of the data and can present challenges to mapping implementation.

Recognizing these limitations and tradeoffs inherent in any mapping program, the following mapping rules are recommended to provide the greatest amount and most accurate and comparable information that can be obtained in the most cost-effective manner to achieve the mapping goals (Section 3.2.2.3.1). In general, new occurrences will be mapped as points for efficiency in the field and treated areas will be mapped as polygons to capture more accurate boundaries of occurrences. The following are intended to serve as guidelines for staff when mapping plant occurrences:

1. **Geometry for Mapping Occurrences:**
    a. If mapping points, record a point near the center (centroid) of patches.
    b. If mapping polygons, map the outer limits of patches that are 0.05 acres, or approximately 2,000 sf or greater;
    c. Use lines to map any long (>100 feet), narrow (<10 feet) patches that might be smaller than 0.05 acres, such as invasive plant occurrences along trails and roads;

2. **Defining Patches:** a patch should include one or more individuals of the same species that are within the following separation distances of each other:
    a. Herbaceous plants: 10 feet;
    b. Shrubs: 15 feet; and
    c. Trees: 30 feet.

    Plants that exceed this distance should be recorded in a new patch or as a point.

3. **Mapping Patches:** The perimeter of patches should be mapped using the method that provides the most accurate information in the most time-efficient manner. This may include:
    a. **Heads-up Digitizing**: drawing the polygon boundaries using diagnostic features observable in the aerial imagery, such as the signature of the vegetation, topography (e.g. ridgetop) as observed in a hillshade or topographic map layer, or other mapped features such as roads and trails; and
    b. **Walking the perimeter of the patch with the GPS**: the perimeter of the patch can be recorded as a continuous line (track) or by recording points at the vertices of the polygon.

3.2.2.3.4 Occurrence Documentation

Table 6, below, lists the information that should be recorded for each mapped occurrence (individual point or polygon) to inform its management and monitoring.

Table 6: Information to be collected for each mapped invasive plant occurrence.

Variable	Description	Coding
Unique ID	Unique identifier for the occurrence.	In Weed Manager, these are automatically assigned. For other systems, use the species six-letter code[1] followed by a sequential number from 1,000. For example, CENMEL083 is the 83rd mapped patch of *Centaurea melitensis*, or tocalote.
Observer	Full name of the person recording the occurrence	First name then last name
Date/Time	Date and time the occurrence was recorded	Recorded as follows to enable chronological sorting in the database: year-month-date hour: minute: second (e.g. 2016-03-24 08:30:15) This is automatic in Weed Manager
Scientific Name	Scientific name based on Jepson Manual 2 for the dominant plant	As in CalFlora, which follows the Jepson Manual 2 (Baldwin et al. 2012)
Common Name	Common name for the dominant plant	Name selected from the CalFlora Weed Manager application.
Additional Plants Present	Additional plants of interest that are interspersed with main occurrence	Common names
Preserve Name	Name of the preserve that the occurrence is on or near	Full name of the preserve without 'open space preserve'
Location Description	Brief narrative description of the location based on notable landmarks	Narrative text
Number of Plants	Estimated number of plants	Use the following categories: • 0 • 1 • 2-10 • 11-50 • 51-100 • 101-1,000 • 1,001-10,000 • >10,000
Percent Cover	Absolute cover of the area within the mapped patch, or for points, the area circumscribed based on the point diameter provided, that is comprised of the canopy of the species.	Visual estimate using the following categories: • 0-1 • >1-5 • >5-25 • >25-50 • >50-75 • >75-95 • >95-100
Distribution	General characterization of the invasive plant species distribution within the mapped area.	Use the following categories (Figure 3): • Single plant • Scattered plants • Single patch

Table 6: Information to be collected for each mapped invasive plant occurrence.

Variable	Description	Coding
		• Scattered dense patches • Dense monoculture
Notes	Any notes about the occurrences that can inform management	Narrative text
Dimensions	For points only, the dimensions of the patch which can be converted to area.	Near circles should be approximated using the radius; other patches should be approximated as rectangles (length x width).
Phenology		• Seedling/basal rosette • Bolting • Leafing out • Flowering • Fruiting • Mature • Vegetative • Dormant • Dead/Skeleton • Sapling
Photo	Two photos that are attached to the record	• First photo should be a close up of the plant. • Second photo is of the landscape which can help evaluate change over time and help others locate plant occurrence.

[1] Six letter species codes are created by combining the first three letters of the genus and the first three letter of the species. For infraspecific taxa, the six letter code is the first two letters of the genus, the first two letters of the species, and the first two letters of the variety or subspecies.

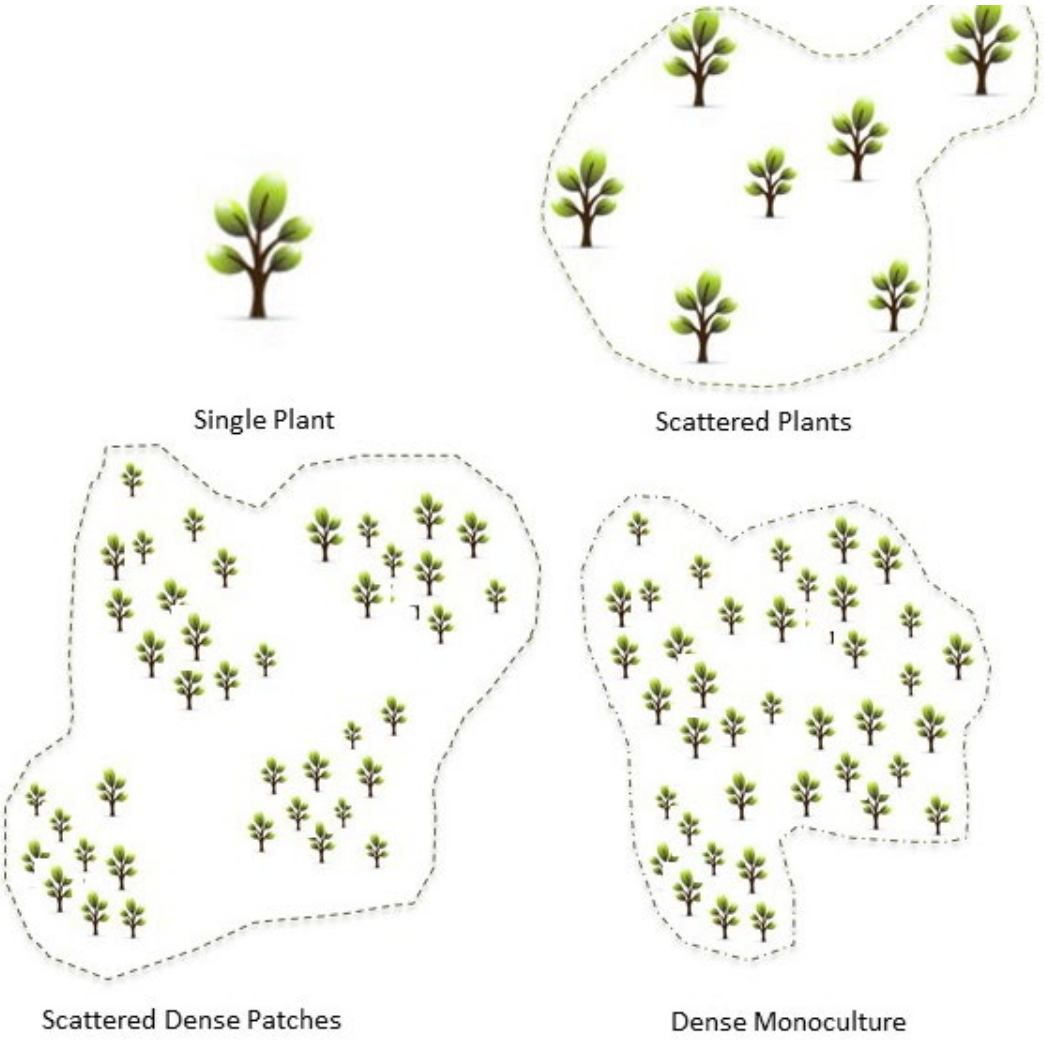

Figure 3: Plant distributions used to characterize occurrences during mapping

3.2.3 Set Management Goals

Each invasive plant occurrence, defined as a species occurring within a specific location in the Authority's open space preserves, will be assigned a goal for management. Illustrated in Figure 4, and listed in descending order of the thoroughness of the control effort or outcome, the goals are as follows:

1. **Eradicate:** Remove the invasive plant from the site, where it has a low likelihood of reinfestation;
2. **Eliminate:** Remove the invasive plant from the site, where it is reasonable to expect it will become reestablished in the next 20 years;
3. **Control Outliers:** Remove small or satellite populations of the invasive plant, where the larger core population will not be treated;

4. **Control Perimeter:** Remove small or satellite populations of the invasive plant in conjunction with treatment of the perimeter of its primary infestation; and
5. **Control Population:** Reduce invasive plant cover, seed set, or dispersal without the expectation that the species will be eliminated or eradicated.

These goals were developed based upon the system used by the Santa Cruz Unit State Parks (Hyland 2014). The types and definitions of the goals may be adjusted over time, as part of the adaptive management process, if additional or alternative management goals can promote the overall goals of the IPM program.

Each occurrence will be assigned the highest-level management goal that is appropriate and feasible, reflected in the numbers above (1-5 in which 1 is highest), , based on the ecology of the species, the site, and the effectiveness of treatments. Specific criteria that will be evaluated include:

- **The size of the occurrence,** in terms of areal extent and density of the population; all else being equal, smaller occurrences can be eradicated or eliminated more successfully than large and/or dense infestations;
- **The ecology of the species,** including its:
    - Fecundity: the number of seeds or other propagules that are produced;
    - Dispersability: the relative ability for seed or other propagules to be moved large distances;
    - Regenerative mechanisms: the means by which the plant can re-establish following removal, including from vegetation material left on site (e.g. stump sprouting, root sprouting, vegetative reproduction), and re-establishment from the *seed bank*, a dormant population of seed in the soil.
- **Aspects of the site in which it occurs**, including the:
    - Sensitivity of the site to impacts of the invasive plant, including presence of rare species or sensitive habitats, as well as other conservation values
    - Susceptibility of the site to ongoing invasion due to disturbance, proximity to roads or trails, or other factors increasing the *propagule pressure*; and
    - Competitiveness of co-occurring native plants, which will influence the effectiveness of native plant recolonization of the site following treatment; and
    - Proximity to property boundaries and natural topographic boundaries, including ridge lines (watershed boundaries).
- **Factors influencing effectiveness of the treatment**, including: the availability of effective manual, cultural, biological and/or chemical treatments for the species, and relative ease of working in the area based on site access, topography, and other factors.

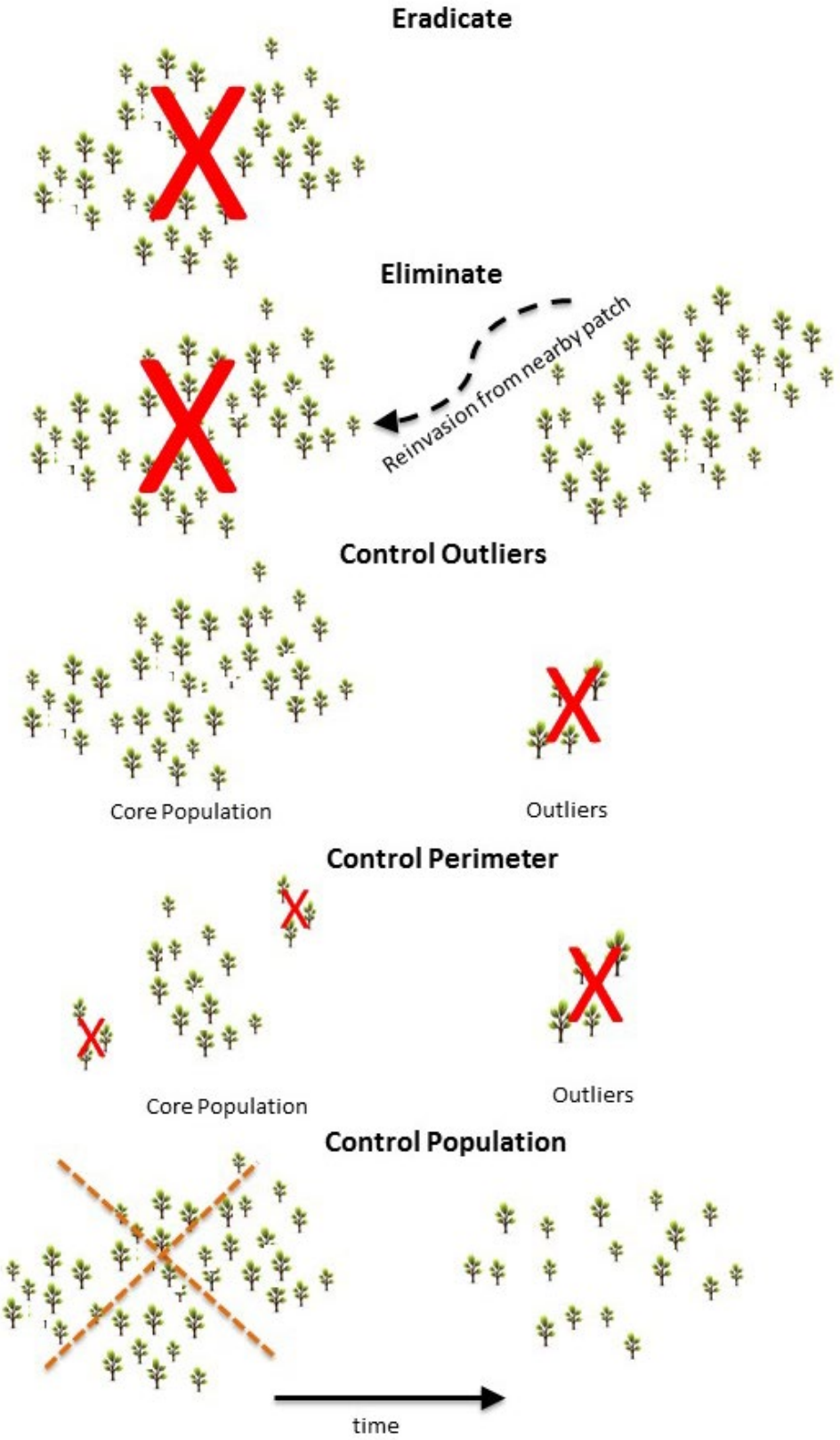

Figure 4: Illustration of the goals for invasive plant management in natural lands

3.2.4 Prioritize

Currently, the level of effort required to achieve the management goals for the invasive plants in the open space preserves outstrips the available resources, including primarily personnel time but also funding for direct costs including equipment and materials. Given the ongoing and potentially increasing rate of invasion, invasive plant management needs will likely always exceed available funding. As a result, it will be necessary to prioritize management to achieve the maximum, sustainable benefit for conservation values.

3.2.4.1 Assess Priority based on a Series of Criteria

Four main criteria will be used to prioritize invasive plant occurrences for treatment:

- **Benefit:** the enhancement to biodiversity that will result from treatment;
- **Risk:** the potential for further impacts to biodiversity posed if management action isn't taken (i.e. the opportunity cost of inaction);
- **Multibenefited:** control has additional benefits for the organization beyond simply protecting biodiversity, etc., including engaging the public through volunteer opportunities, improving relations with neighbors, promoting agriculture (grazing and row crop), and enhancing cultural, recreational, and scenic resources; and
- **Feasibility:** the relative ease and safety with which the goal could be achieved based on a variety of consideration including access, magnitude of effort required, and existence of a safe and effective treatment method.

The first three, Benefit, Risk, and Multibenefit, address what can be achieved through treatment. Feasibility assesses the constraints or the extent to which they are limited. Table 7, below, provides a concise definition of each criterion with an expanded list of considerations used to conduct the evaluation.

To determine overall priority, each criterion is scored on a scale of 1-5, in which 5 meets the criteria based on multiple considerations, 3= meets the criteria to a lesser degree/fewer of the considerations, 1=does not meet the criterion/reflects few or none of the considerations. Scores of 2 and 4 are assigned to intermediate levels. Explanations for each rating can be provided in a *Comments* field in the database, particularly where the rationale for the rating is not obvious. While assessing overall feasibility, potential volunteer exotic plant control projects can be flagged in the database using a separate *Volunteer* field.

The prioritization is conducted across all preserves, so that the management priorities reflect those of the entire preserve network, rather than within each specific preserve. The prioritization is implemented using GIS, which contains the mapped occurrence of each invasive plant, and additional spatial data layers used to inform scoring (inset box).

GIS Data to be Used for Invasive Plant Prioritization

Invasive plant occurrences

Plant community (vegetation) map, showing sensitive communities

Mapped occurrences of and habitat for sensitive species

Waterbodies (streams, ponds, lakes) which can influence use of certain herbicides

Roads, trails, and other access data

Slopes, which can influence access

Fire susceptibility and wildland urban interface boundaries

Pastures

Table 7: Criteria used to prioritize target invasive plant species occurrences for treatment. Each criterion is scored on a scale of 1-5, in which 5 meets the criteria based on multiple considerations, 3= meets the criteria to a lesser degree/fewer of the considerations, 1=does not meet the criterion/reflects few or none of the considerations. Scores of 2 and 4 are assigned to intermediate levels.

Criteria	Definition	Considerations

Benefit
 	
1= Less Benefit
5 = More Benefit
	If successful, the treatment will promote rare species populations, enhance diversity in special communities, restore natural community structure, and/or promote natural ecosystem processes.	• The treatment will maintain or promote rare species populations, by removing plants that:
		  ○ compete with rare native plants, and/or
		  ○ degrade habitat for a rare native animal.
		• The treatment will promote native species diversity in a special community (e.g. serpentine grassland, freshwater wetland, etc.).
		• The treatment will maintain or restore natural community structure, such by
		  ○ Removing trees from shrublands or herb-dominated communities;
		  ○ Removing shrubs from herb-dominated communities;
		  ○ Removing tall or dense herbs from short or sparse herb-dominated communities.
		• The treatment will promote natural ecosystem processes, including by eliminating species that affect:
		  ○ nutrient cycling, as in the case of nitrogen fixers;
		  ○ hydrologic conditions, such as by reducing water levels in wetlands, ponds or streams, or soils where moisture is limiting to native plant growth, or
		  ○ fire cycles, by creating dense and/or highly flammable fuels.
		• The treatment will promote effectiveness of other management for biodiversity, including:
		  ○ conservation grazing, by eliminating species that are noxious to cattle or other grazers, maintain or increase effectiveness of conservation grazing program; and
		  ○ fire management designed to prevent a risk of catastrophic wildfire that would negatively impact biodiversity.

Risk **1 = Less Risk** **5 = More Risk**	If successful, the treatment will significantly reduce future impacts to biological systems that will likely result from the future invasion and spread of the species	• The species is highly invasive, and will likely significantly increase its distribution and abundance in the absence of treatment. • The species has large impacts in the systems within or near the preserve, through competition and/or alterations to natural communities and ecosystem processes. • Delaying treatment will likely substantially increase the cost of future treatment. • Species is in a heavily traveled route where it can more easily be vectored. • The species is not subject to other vegetation management including conservation grazing.

Table 7: Criteria used to prioritize target invasive plant species occurrences for treatment. Each criterion is scored on a scale of 1-5, in which 5 meets the criteria based on multiple considerations, 3= meets the criteria to a lesser degree/fewer of the considerations, 1=does not meet the criterion/reflects few or none of the considerations. Scores of 2 and 4 are assigned to intermediate levels.

Criteria	Definition	Considerations
Multibenefit **1= Less Benefits** **5 = More benefits**	Treatment will enhance other preserve conservation values including working lands, scenic values, and cultural resources, and promote the Authority's policies and programs including community engagement.	• Treatment will promote condition of lands used for conservation grazing and cultivation on or near the preserve. • Treatment will protect cultural resources, including by promoting natural community structure and species composition in important cultural landscapes. • Treatment will enhance scenic qualities of OSA preserves, including by opening up vistas or controlling infestations along trail corridors. • Treatment can enhance the Authority's relationships with its neighbors. • Treatment presents opportunities to engage the community in volunteer stewardship. • Treatment provides the opportunity for the Authority to demonstrate and perhaps interpret its land management program to the community.
Feasibility **1 = Less Feasible** **5 = More Feasible**	Treatments are likely to be effective, and their cost are appropriate given the treatment benefits, including in reducing risk.	• A known treatment has been proven effective within the site or similar systems is available and will likely achieve the treatment goal and objective. • The resources required to achieve and then maintain the treatment goal and objective over time are relatively certain and are proportional to the benefits. • The species is either absent or effectively managed on neighboring lands, such that reinvasion from adjacent lands will not significantly impede work to achieve the treatment goal and will enable it to be sustainable. • Treatment is compatible with other activities in the preserve, including conservation grazing, agriculture, and public access (e.g. recreation, programs, etc.). • Treatment can be safely conducted using treatments that minimize risk to staff and public of exposure to harmful chemicals, steep slopes, or other unsafe working conditions.

To expedite and promote consistency of scoring, it should be conducted by preserve, working geographically; this is because factors influencing the scores are spatially correlated (i.e. co-occur). For example, a series of different invasive plant species occurrences located along a road through serpentine grassland occupied by Bay checkerspot butterfly will share common considerations for the benefit and risk scores.

The criteria and scores can be adjusted, and score multipliers (i.e. weights) can be incorporated, as needed, to ensure that the prioritization scheme continues to reflect the factors that influence efficacious and sustainable invasive plant management. The prioritization should be updated each year, as resources allow, in order to address changes in the occurrence, the results of prior control treatments, and new scientific information, among other changes (Section 3.2.8.1) and should generally be no longer than five years.

3.2.4.2 Determine Overall Priority

The scores for each criterion will be entered in the GIS database of invasive plant occurrences, or an Excel spreadsheet that can be joined to it based on the unique identifier for each occurrence. The total score, which will range between 4 and 20, will be analyzed using frequency distributions, and based on the total acres of invasive occurrences in each score, to identify the range of total score values (i.e. bins) to include in each of three more generalized priority categories: high, medium, and low.

- **High:** These occurrences are the greatest priority for treatment, as their eradication or control can result in the greatest benefits (including by reducing risk) and is relatively feasible. Efforts will be taken to treat them wherever possible.
- **Medium:** Treatment of these occurrences is important but the benefits, risk, and/or feasibility of achieving the goal are lower than for the high-priority species. They will be treated as resources allow, including in conjunction with treatment of high-priority occurrences, which reduces costs.
- **Low Priority:** These occurrences have lower impacts on the listed species, such as the benefits and/or reduced risks associated with their management, and in some cases the feasibility of treatment, is lower. These species will not be treated unless doing so requires little effort and can be readily accomplished perhaps in conjunction with the treatment of high- and/or medium-priority species.

3.2.5 Strategize and Treat

Strategies will be developed to achieve the management goal for each invasive plant occurrence identified as a high priority for treatment as resources allow. If medium priority sites can be treated in conjunction with high priority sites, strategies will be developed for them as well. They will be based upon the best available information about effective control techniques and in consideration of factors that will influence their effectiveness, as well as effects on non-target species, including sensitive habitats and special-status species, as well as people.

3.2.5.1 Strategy Elements

Strategies will identify the “who, what, when, where, why, and how” of the treatment (Table 8).

Table 8: Elements of strategies to be developed to achieve the goals for each priority invasive plant occurrences, showing examples for a hypothetical occurrence of yellow starthistle.

Strategy Component	Strategy Elements	Example
What: what is to be accomplished	Goal for the occurrence	Eradicate yellow star thistle from occurrence YST-5—a 0.1-acre infestation in Pasture 5 at Rancho Cañada del Oro.
	Objectives for each year of anticipated treatment	• 2016: Prevent spread, reduce YST cover to <20%, increase native plant cover to >50% • 2017: Prevent spread and reduce cover from to <10%, increase native plant cover to >60% • 2018: Prevent spread and reduce cover to <5%, increase native plant cover to >65% • 2019: Prevent spread and reduce cover to <1%, increase native plant cover to >65% • 2020: Eliminate YST from the site (cover=0%) and achieve at least 65% native plant cover
How: the methods that will be used to conduct the treatment and limit its negative impacts	Control Technique(s):	Graze cattle during May and June Hand pull remaining flowering plants in June or July before they set seed.
	Biomass Removal Methods	Dispose of any inflorescences in a plastic bag, as seeds can mature if left on site
	Resource Protection Measures	Flag sensitive plants in the treatment area prior to work if volunteers or others who cannot identify rare plants will be pulling.
	Safety Measures	Provide gloves for hand pulling.
	Restoration Measures	Native plant cover is high and will increase as YST is removed, such that passive revegetation is anticipated to provide the desired native plant assemblage post treatment.
When: the treatment timeline and timing	Timeline	Annually for 5 years, or as needed to achieve the goal and objectives
	Frequency	Annually
	Seasonal timing	When plants bolt and begin to flower (see *Control Techniques*)
Where: geographic information about the treatment	Access	Work crews will use the main ranch road for vehicle access and equipment/materials staging, and approach the infestation on foot.
	Geographic Approach to Treatment	Crews will treat the entire area each year, working from upslope to downslope.
Who: the personnel who will implement the treatments	Qualifications	Authority personnel experienced in YST ID will lead the hand-pulling crew.
	Level of Effort	• 2016:40 person hours (10 people for one, 4-hour volunteer event) • 2017: 32 people yours (8 people for one, 4 volunteer event) • 2018: 24 person hours (6 people for one, 4 volunteer event) • 2019: 16 person hours (4 staff for 4 hours) • 2020: 8 person hours (2 people for 4 hours)

Within the strategy categories, the "what" element will specify the goal and objectives for the treatment, consistent with the overall goal setting for the occurrence (Section 3.2.3). If the treatment is anticipated to occur over a period of years, quantitative objectives will be provided for each year to gauge the treatment progress over time, and inform need to modify it as part of adaptive management.

The "how" element will identify the specific methods that will be used to conduct the treatment, including the following:

1. **Control Technique:** the detailed treatment or sequence of treatments that will be used to treat the invasive plant;
2. **Biomass Removal:** the steps that will be taken to address the biomass, as needed, to limit its impacts;
3. **Resource Protection:** measures that will be implemented to protect native plants, animals, and other natural and cultural resources (Section 3.2.5.6);
4. **Safety:** measures that will be taken to reduce the risks to human health and safety; and
5. **Restoration:** measures to control erosion and/or establish native plants.

The "when" element will address all aspects of timing the treatment or sequence of treatments, in terms of:

1. the time of year (e.g. month or season) and/or phenological state of the plants to be treated;
2. the project timeline, in terms of the number of years that treatment will be required; and
3. the treatment frequency, in terms of the number of annual treatments.

The 'where' element will specify any geographic components of the strategy, including:

1. Access routes or staging areas to limit soil disturbance, trampling, and other negative impacts associated with the treatment;
2. Spatial phases of the treatment, such as starting on the perimeter of the patch and working inward, or beginning with the upstream / upslope extent and progressing downstream / downslope.

Finally, the "who" component of the strategy will specify the personnel involved, in terms of:

1. Qualifications required, including specific licenses such as a qualified pesticide applicators license or chainsaw certification, or skills such as native plant identification; and
2. The level of effort anticipated to implement the treatment, in person hours (or days), which might be expected to decline as treatment progresses.

Assembling the strategy information outlined in Table 8 in the database of prioritized occurrences (e.g. Excel workbook) can facilitate work planning and as well as monitoring.

3.2.5.2 Strategy Development

Strategies will be devised for each occurrence in consideration of aspects of the following:

- the invasive species' ecology, including its life history, life form, reproduction (e.g. seed production and dispersal), vegetative regrowth/reproduction potential, among others;

- the occurrence, including patch size and density and location with respect to features that could promote its spread, including roads and trails, streams, and prevailing winds; and
- the system in which it occurs, including occurrences of other invasive plants proposed for treatment, proximity to sensitive species, communities, and water bodies, as well as human activities, including trails, roads, and residences.

3.2.5.3 Control Techniques

A variety of techniques can be used to control invasive plants in natural lands (Table 9). These include chemical, cultural, and biological methods, as well as manual, mechanical, other physical techniques. Additional discussion of chemical applications is found below (Section 3.2.5.4). A detailed assessment of these techniques, which is necessary to develop effective strategies, is beyond the scope of this manual, and instead, can be found in a variety of resources including:

1. *Weed Control Methods Handbook* (Tu et al. 2001);
2. *Invasive plants of California's Wildlands* (Bossard et al. 2000); and
3. *Weed Workers Handbook* (The Watershed Project and Cal-IPC 2004)

The resources above provide detailed descriptions of the various techniques, identify the types of conditions in which they are most appropriate as well as those when they are inappropriate, and provide additional information that can be used to design strategies. Additional guides have been developed for particularly problematic invasive plants such as yellow star thistle (DiTomaso et al. 2006). Additional and updated information is often shared at invasive plant management trainings and conferences, including the Cal-IPC Symposium, Weed Management Area meetings, and the Central Coast Invasive Weed Symposium (Section 3.2.9.1).

As part of the IPM approach, the Authority will identify the most appropriate technique for each plant occurrence based on a variety of factors including the:

- Risk to the safety of staff, visitors, neighbors, or other people;
- effectiveness at killing the invasive plant;
- risk to native plants, animals, aquatic systems, and other natural resources;
- risk to cultural resources; and
- cost-effectiveness.

Techniques vary in effectiveness. In some cases, a combination of treatments is necessary to meet control or eradication goals. For example, application of herbicide following cutting French broom (i.e. a cut stump treatment) increases the rate of mortality of this invasive shrub, which can otherwise resprout. As another example, burning followed by application of a broadleaf herbicide has been found to help control yellow star thistle (DiTomaso et al. 2006).

Table 9: Invasive plant control techniques evaluated as part of the IPM approach

Category	Specific Techniques	Advantages	Disadvantages	General Circumstances when it is Appropriate
Manual and Mechanical	• Pulling by hand or with the aid of a wrench • Digging or uprooting • Scraping • Cutting, mowing, weed whipping, and brush cutting • Girdling, frilling, and drilling	• Can require limited training • Can pose limited safety concern	• Can be labor intensive • Can cause soil disturbance that promotes invasive plants • Can impact native plants and animals	• When controlling small infestations. • When working with volunteers or other large groups. • When working along trails or other facilities and public places when people are present. • For pulling or digging, when soil disturbance will not promote seedling establishment. • For mowing, when rare native plants, animals, and nesting birds are not present. • For girdling, frilling, and drilling, when large shrubs and trees can be left standing and not present a fire danger
Other Physical	• Tarping • Solarizing • Flaming • Mulching	• Can kill invasive plants in dense infestations	• Can kill native plants and animals in treatment areas	• Dense infestations/monocultures of primarily herbaceous plants or shrub seedlings. • Areas that lack sensitive native plants and animals. • For flaming, during or immediately after rain when humidity is high, and in areas lacking dense, fine fuels.
Chemical	Synthetic chemicals applied through a variety of techniques including: • Cut-stump • Foliar spray • Wicking	• Often highly effective at killing plants • Can be very cost-effective • Can be used to target specific species or groups of species (e.g. grass-specific herbicides)	• Require consultation to identify appropriate treatments • Require training to handle and apply chemicals • Can impact non-target species • Can present a risk to human health and safety	• Early in the season for herbaceous plants. • In order to prevent re-sprouting of shrubs and trees (i.e. for cut-stump treatment). • When climatic conditions are appropriate (no rain or dense fog, wind less than 5 mph). • At a sufficient buffer distances away from sensitive plant and animal populations. • When working with trained staff (rather than volunteers).
Cultural	• Cattle grazing • Goat and sheep grazing • Prescribed burning	• Can be used to treat large areas • Can have other benefits for	• Can impact non-target species as well as water resources if not	Grazing: • When controlling dense infestations of palatable plants that are not promoted by disturbance (i.e. trampling by cattle)

Table 9: Invasive plant control techniques evaluated as part of the IPM approach

Category	Specific Techniques	Advantages	Disadvantages	General Circumstances when it is Appropriate
	• Active Revegetation	habitat and fuel reduction	carefully implemented • Can be logistically challenging in areas open to the public • Some invasive plants pose a risk to some grazing animals	• At a sufficient buffer distances away from sensitive plant and animal populations that could be affected by grazers. Fire/Prescribed Burn: • When controlling dense infestations of species that are killed by fire (as opposed to fire-adapted species) • When controlling invasive plants in fire-adapted systems such as grassland, coastal scrub, and chaparral, rather than fire-sensitive systems such as riparian woodland. Revegetation: • Following disturbances that remove established native plant cover, including construction, restoration, and intensive exotic plant removal projects. • When natural recruitment by native plants is anticipated to be insufficient to suppress exotic plant reinvasion.
Biological	Release of a biological control agent, typically an insect, that targets invasive species.	Typically very targeted control (i.e. limited impacts to other plants and animals)	• Limited availability of biological control agents • Potential for biological control agents to impact native plants and animals through competition and hybridization.	• When an approved biological control agent is available, and no rare native plants could be impacted

3.2.5.4 Chemical Control

Careful and judicious use of herbicides will be an essential component of the Authority's IPM program, in which the most effective, least toxic treatment options are used to control invasive plants. While non-chemical strategies will be employed when feasible, herbicides will be used when there is no other available reasonable means to control invasive plant populations and reduce the impacts on biodiversity and other conservation values on Authority's lands in a variety of circumstances including when:

- invasive plant occurrences cover a large area that would be infeasible to treat by other means;
- controlling invasive herbs and vines that can re-establish from roots and other structures left in the ground following removal; and
- controlling invasive shrubs and trees that will resprout following cutting if they are not treated with herbicide.

3.2.5.4.1 Herbicide Selection

A variety of herbicides have been approved for use in natural lands management. They differ in the mechanisms by which they impact plants (i.e. mode of action), chemical composition, and specific formulation or brand name. These and other factors influence their effectiveness at controlling different types of plants, including grasses, broadleaf plants, and woody plants at different life stages (e.g. seeds, seedlings, vegetative plants, reproductive plants etc.). Their chemistry also determines their toxicity to humans and other non-target organisms, and their persistence in soil and water.

The Authority will evaluate herbicide characteristics, including information on the herbicide label, and available information about the effectiveness of the herbicides at controlling the target species, when selecting an herbicide. In unique circumstances, the Authority will seek recommendations from a licensed pest control advisor with experience advising on invasive plant control in natural lands.

In general, herbicides will be used that are effective against the invasive plants, not likely to drift, leach to groundwater or wash into streams, are nontoxic to people and other organisms, will not persist in the environment, and are easy to apply. A single application of a more toxic or persistent chemical may be preferable to a less persistent, less toxic compound that must be applied repeatedly. These trade-offs will be evaluated on a case-by-case basis, to minimize the negative impact to the environment.

Table 10, List of chemicals used for invasive plant control

Table 10: Pesticides Selected to Support the IPM Program

Pesticide Category	Active Ingredient	Product Formulations (Manufacturer)	Purpose
Herbicides	Glyphosate	Roundup (Monsanto or Scotts Miracle-Gro)	Nonselective post-emergent broad-spectrum weed control
	Pelargonic Acid	Scythe (Dow AgroSciences)	Broad-spectrum control of many annual, biennial, and perennial broadleaf weeds
	Aminopyralid/Triclopyr	Milestone (Dow AgroSciences) Capstone (Dow AgroSciences)	Nonselective post-emergent broad-spectrum weed control
	Clopyralid	Transline (Dow AgroSciences)	Selective broadleaf weed control

Table 10: Pesticides Selected to Support the IPM Program

Pesticide Category	Active Ingredient	Product Formulations (Manufacturer)	Purpose
	Imazapyr	Polaris (Nufarm), Stalker (BASF)	Nonselective pre-and post-emergent broad-spectrum weed control
	Clethodim	Envoy Plus (Valent)	Selective post-emergent grass weed control
	Chlorsulfuron	Telar XP (Du Pont)	Pre- and post-emergent broadleaf weed control
	Fluroxypyr 1-methylheptyl ester	Vista XRT (Dow AgroSciences)	Broadleaf annual and perennial weeds, and certain woody plants and vines
	Essential oils	WeedZap (JHBiotech)	All natural non-selective broadleaf weed control
	Dithiopyr	Dimension (Dow AgroSciences)	Pre-emergent grasses and broadleaf weed control
	Isoxaben	Gallery (Dow AgroSciences)	Pre-emergent broadleaf weed control
	Dimethylamine salt	2,4-D	Broadleaf weeds and brush control
Rodenticide	Cholecalciferol	Cholecalciferol baits	Rodent pest control (e.g., rats, mice)
Insecticides	Pyrethrin	Wasp-Freeze (BASF)	Wasp and hornet control
	Insecticidal Soap Spray	Garden Safe	Ant control
	Indoxacarb	Advion Gel Baits (DuPont)	Structural pest control (e.g., ants, cockroaches)
	Hydroprene	Gentrol Point Source (Wellmark International)	Pest control (e.g., cockroaches, beetles, moths)
	Fipronil	Maxforce Bait Stations (Bayer)	Ant control
	Boric Acid (Sodium tetraborate decahydrate)	Prescription Treatment Baits (BASF), Terro Ant Killer II (Terro)	Ant and cockroach control
	Diatomaceous earth	Diatomaceous earth	Structural pest control (e.g., ants, cockroaches)
Fumigant	Sulfuryl fluoride	Vikane, Zythor, or Master Fume	Structural pest control (e.g., termites)

3.2.5.5 Herbicide Use

Safe and effective use of herbicides requires adherence to a variety of laws and regulations, as well as additional best management practices. Crucially, herbicide use and storage must adhere to the herbicide labels—legal documents that all pesticide users are obligated to read and obey. Labels provide instructions and precautions for mixing, application, disposal, and storage of the herbicide, as well as information and precautions related to toxicology and environmental hazards. Additional safety information is contained in the material safety data sheet (MSDS) available for each product. Authority staff also receive pest control recommendations for each property from a licensed Pest Control Advisor (PCA). Authority staff work with PCAs that are familiar with invasive plant control on open space lands.

Though beyond the scope of this manual, detailed guidelines for herbicide use are provided in Chapter 5 of the *Weed Control Methods Handbook* (Tu et al. 2001), a link to which is in the *References* section.

3.2.5.6 Species and Environmental Protection Measures

Though invasive plant control is necessary to promote native plants and animals and restore sensitive habitat where it has been degraded, certain treatments have the potential to cause short-term negative impacts to sensitive biological resources, including rare plants, rare animals, and nesting birds. This section outlines some approaches to limiting those impacts, which are summarized below in Table 10. The precise nature of measures to protect rare species and nesting birds should be determined in consideration of the ecology of the species and conditions within the treatment area and proposed aspects of the invasive plant treatment. If impacts to federal or state-listed threatened or endangered species cannot be avoided, the Authority should consult with the wildlife agencies prior to project implementation.

3.2.5.6.1 Rare Plants

Many invasive plant control techniques have the potential to negatively impact rare native plant species occurring within or near the treatment area. Prior to treatment, any areas known or likely to support rare plants should be surveyed to determine whether rare species are present. Surveys should be conducted during the flower period for the rare species (typically March to July); if surveys cannot be conducted during that period, the area should be treated as potentially occupied and measures should be taken to limit treatment impacts.

If rare plants are encountered within a proposed treatment area, the treatment area or method including seasonal timing should be adjusted to avoid impacts. If that is not possible, rare plants propagules should be salvaged prior to treatment and used in the restoration, which should be designed to increase their population over that present pre-treatment, although the use of salvaged plants is dependent on the emerging science for controlling *Phytophthora* and other pest diseases (Section 3.3)

3.2.5.6.2 Nesting Birds

During the bird breeding season, which is generally February 1 and August 31, certain invasive plant control treatments can directly impact nests, which are primarily built in vegetation including invasive plants, or by causing the parents to abandon a nest. Such take of nests, eggs, or nestlings is prohibited by the Federal Migratory Bird Treaty Act (16 U.S.C. 703-712) as well as the California Fish and Game Code (Section 3503).

To prevent impacts to nesting birds, the Authority will conduct invasive plant removal outside of the nesting bird season whenever possible. When effective invasive plant control requires that treatments be conducted between February 1 and August 31, the Authority will conduct a pre-treatment nesting bird survey within 250 feet of the treatment area for raptors, and 50 feet of the treatment area for all other birds. If a nest is found within the survey area, the treatment will be delayed until the young have fledged, or the nest has otherwise been abandoned. Alternatively, the treatment area will be reduced to establish no-treatment buffer zones around the nest to avoid disrupting the nest.

Table 11: Protection measures for sensitive habitats, rare plants, nesting birds, and sensitive animals when conducting invasive plant control.

Sensitive Resource	Measure	Description
Aquatic Habitat	Conduct a Pre-Project Survey and Establish Buffers	All treatment areas will be surveyed for the presence of lakes, ponds, streams, drainages, seeps, springs, saturated soils, or similar feature that holds water at the time of treatment or typically becomes inundated during winter rains. The Authority will eliminate treatment activities within 15 feet of any aquatic features or consult with CDFW.
Rare Plants	Conduct a Pre-Project Survey and Establish Buffers	All treatment areas should be surveyed prior to work to determine the potential presence of special-status plants. Within a 15-foot buffer around special-status plants, either selective herbicides or no herbicides should be used and non-chemical treatments should be designed to avoid damage to the rare plants (e.g., pulling).
	Conduct Treatments when Species Are Not Present Aboveground	Many rare native plants are annual plants, which persist over the summer as seed that germinates in the fall with the onset of the rainy season. Conducting mechanical treatments during this time can reduce impacts to these species. Herbicide treatments conducted using chemicals that do not affect seed can similarly be conducted during this time.
	Establish Buffer Zones Around Rare Plants	Rare plant species within a treatment area should be flagged and alternative treatments that avoid impacts to them should be developed in appropriate buffer areas around them. For example, invasive plants should be cut or pulled by hand rather than weed whipped or mowed within 5 feet of rare plants. Manual treatments or selective herbicides with a hand sprayer should be used within 15 feet of rare plants.
	Salvage Rare Plant Propagules Pre-Treatment	Seed or other propagules of rare plants can be collected prior to treatment, and then utilized in restoration post-treatment.
Nesting Birds	Conduct Treatments outside of the Bird Nesting Season	To avoid impacts to nesting birds, conduct invasive plant control treatments outside of the bird nesting period, which is generally February 1 – August 31.
	Establish Buffer Zones around Nests	If invasive plant control work must be conducted during the nesting bird season (February 1 – August 31), conduct a nesting bird survey within 14 days of treatment. The survey should encompass the area within a 250-foot radius for raptors, and 50-foot-radius for other birds. If nesting birds are identified, delay work within these buffer areas until the young have fledged or the nest is otherwise abandoned.
California Red-Legged Frog	Conduct Surveys and Establish Buffer Zones	All treatment areas will be surveyed to evaluate whether they feature suitable aquatic or upland habitat for California red-legged frog (CRLF). The Authority will eliminate any mechanical or chemical treatments within 15 feet of occupied habitat for CRLF, or consult with USFWS and CDFW to identify appropriate permitting and mitigation measures.
	Limit Use of Restricted Pesticides	Herbicide use in CRLF habitat should be conducted in accordance with the California Red-Legged Frog Injunction (Center for Biological Diversity v. U.S. Environmental Protection Agency (2006) Case No.: 02-1580-JSW) by:

Table 11: Protection measures for sensitive habitats, rare plants, nesting birds, and sensitive animals when conducting invasive plant control.

Sensitive Resource	Measure	Description
		• Not applying glyphosate within 15 feet of aquatic features (including areas that are wet at time of spraying or areas that are dry at time of spraying but subsequently might be wet during the next winter season); • utilizing only spot-spraying techniques and equipment by a certified applicator or person working under the direct supervision of a certified applicator; and • not spraying during precipitation or if precipitation is forecast to occur within 24 hours before or after the proposed application.

3.2.5.6.3 Rare Animals

Authority open space preserves support numerous rare animal species that have the potential to be impacted in the short term by invasive plant control treatments. As for rare plants, the Authority will conduct a habitat assessment for rare animals, in areas known or likely to support rare species, prior to implementation of invasive plant treatments. Any species protection measures for rare animals will be developed based on careful consideration of the ecology of the animal, the conditions of the treatment area, the proposed treatment, and the applicable regulations for listed species. These include the terms of the two court injunctions that have been established to regulate pesticide use for California red-legged frog (*Rana draytonii*; Case No.: 02-1580-JSW) and 10 additional Bay Area species, including California tiger salamander (*Ambystoma californiense*). These requirements are summarized in Table 11.

3.2.5.7 Treatment Documentation

In order to track invasive plant work on an annual basis, and to enable evaluation of the effectiveness of invasive plant treatments, all treatment work will be documented in a database that captures the most relevant information (Table 12). Information to be collected will include general and specific method and treatment type, number of staff or volunteer hours required, dimensions of the treatment, and any notes about the occurrence to inform management efforts.

Table 12: Information to be collected for each treated invasive plant occurrence in addition to the data to be collected for all invasive plant occurrences (Table 5).

Variable	Description	Coding
Method	General type of method used	Use the following categories: • mechanical • chemical
Staff Hours	Indicate the number of hours spent by staff implementing the treatment	Number of person hours
Volunteer Hours	Indicate the number of hours spent by volunteers implementing the treatment	Number of person hours
Notes	Any notes about the occurrences that can inform management	Narrative text

[1] Six letter species codes are created by combining the first three letters of the genus and the first three letter of the species. For infraspecific taxa, the six letter code is the first two letters of the genus, the first two letters of the species, and the first two letters of the variety or subspecies.

3.2.6 Restore

Many invasive plants are adapted to establishing in areas of recent disturbance, which reduces competition of native plants and often creates open soil conditions required by many invasive species. Restoring formerly invaded sites to create later-successional conditions can help deter invasive plants while also recreating habitat conditions suitable for natives.

Restoration can occur passively, whereby native plants naturally recolonize following disturbance, or actively, by seeding or planting native plants, often in conjunction with treatments designed to promote their growth. Provided that native plant propagules remain on site, in the seed bank and in remnant native plants, or are in close proximity such that they can disperse into the restoration area, passive restoration can re-create the natural community structure and species composition over time. The natural successional processes can promote diverse assemblages of native plants that can be difficult to achieve with active restoration methods. Passive restoration can be less costly; managers need only control invasive plants and perhaps other exotic plant species that compete with native species. However, it can be slower and result in less dense cover than can be achieved in active restoration.

Active restoration techniques may be necessary to achieve the goals for the site (Kettenring and Adams 2011), including preventing establishment of invasive plants, in a variety of circumstances including:

1. Areas of intensive disturbance, where the native plant propagule supply may be limited;
2. Large disturbance areas, where the timeline for native plant establishment will be too slow;
3. Areas where mid to late successional conditions, characterized by denser cover of native plants including shrubs and trees, are needed to achieve the restoration goals, including to prevent erosion and suppress growth of invasive plants

Restoration may also be needed where invasive plant control has rendered the soil vulnerable to erosion, including in areas that have been denuded and/or occur on steep or erosive soils. Where invasive plants have altered soil chemistry (i.e. through allelopathy), treatments such as application of activated charcoal may be needed to restore plant-microbial relationships necessary to support native plants.

Table 13, below, outlines some general active restoration techniques that can be used to suppress reestablishment of invasive plants, restore natural community structure and species composition, and thus recreate habitat for native animals. Each of these treatments has advantages as well as disadvantages for promoting native biodiversity (Table 13). These and other aspects of restoration treatments should be designed for each site based on careful consideration of the variety of factors including the site conditions and the invasive plant species being controlled.

Notably, some restoration treatments can inadvertently promote invasive plant species; while potentially necessary to establish native plants, they should be designed and implemented with caution. For example, fertilizers and other soil amendments, as well as irrigation, can increase availability of nutrients and water that are often limiting factors for invasive plants, giving them a competitive advantage over native plants, which are adapted to low-nutrient, droughty soil conditions that predominate in the region.

Additionally, active restoration materials can be contaminated by invasive plant seed. These include:

- Topsoil brought in to restore areas where soil has been removed;
- Straw, mulch, or other surface treatment materials;
- Native plant seed mixes; and
- Container stock from nurseries.

Weed free materials should be used whenever possible, and all restoration sites should be subject to frequent monitoring to detect and eradicate invasive plants before they can spread.

Table 13: Active restoration techniques that can be employed following invasive plant treatment

Technique	Description	Advantages	Disadvantages
Mulch	Applying straw, shredded back, wood chips, or similar materials to the soil surface	• Can stabilize soil denuded by invasive plant removal. • Can inhibit establishment of many small-seeded, early successional invasive plants. • Carbon addition can immobilize excess soil nitrogen created by French broom, *Acacia* species, and other N-fixers, thus reducing the potential for a secondary invasion by N-limited invasive grasses.	• Can suppress re-establishment of native plants that are adapted to disturbance but inhibited by litter on the soil surface. • Can degrade habitat for native animals adapted to open soil conditions. • Can promote the invasive and spread of exotic plants if materials are contaminated.
Amendments	Applying fertilizers, mycorrhizal inoculum, or activated	Fertilizers and mycorrhizal inoculum can promote growth of native plants where nutrients are limited or imbalanced due to prior invasive plant infestation or its control.	• Can promote growth by invasive plants that are nutrient limited and outcompete native plants. • Can introduce non-local fungal strains into the ecosystem (i.e.

Table 13: Active restoration techniques that can be employed following invasive plant treatment

Technique	Description	Advantages	Disadvantages
	charcoal or other materials to promote soil fertility and plant microbial relationships	Activated charcoal can restore plant microbial relationships where invasive plants have altered them through their chemistry (i.e. allelopathy).	from inoculum), which may disrupt natural mycorrhizal relationships with native plants. • Can fertilize nearby streams and ponds, degrading aquatic habitat.
Seeding Native Plants	Applying native plant seed to treatment areas following control	Can increase the density and diversity of native plants, which can: • Restore native animal habitat • Suppress re-establishment of invasive plants.	• Commercially-sourced seed can cause *genetic erosion*—disruption of locally-adapted genetic complexes in native plant populations, particularly unique systems (e.g. serpentine) which feature unique *ecotypes*. • Seed of plants not native to the site can alter the natural community structure and species composition for native animals. • Contaminated seed can introduce exotic plants.
Outplanting Native Plants	Installing native plants grown in containers into treatment areas following control	Can more rapidly (compared to seeding) increase the density and diversity of native plants, which can: • Restore native animal habitat • Suppress re-establishment of invasive plants, particularly by planting shrubs and trees which reduce light availability	• If not locally sourced, plants can cause genetic erosion as for commercial seed (as above). • Plants not native to the site can alter animal habitat (as above). • Can spread pathogens including sudden oak death if plants from nurseries are not screened. • Contaminated container stock can introduce invasive plants (e.g. *Oxalis pes-caprae*)
Irrigation	Applying water manually, or using overhead sprinklers or to drip irrigation	• Can promote native plant seedling establishment and growth • Can enhance survivorship and growth of native plants planted from container stock	• Can promote re-establishment of invasive plants, which can outcompete native species • Can promote pathogens of native plants not adapted to moisture during the dry season. • Can degrade habitat for native animals not adapted to moist conditions in the dry season. • Costly to install and maintain

3.2.7 Monitor

The amount of time devoted to monitoring is dependent on Authority staff time. However, monitoring is an important component of the IPM Program and will be used to achieve two goals related to invasive plant management:

1. Evaluate the effectiveness of treatments at controlling invasive plants and promoting natural community structure and species composition (i.e. native plants); and
2. Assess the invasive plant species distributions in the preserves, in order to detect new species as well as other changes not due to management.

3.2.7.1 Conduct Effectiveness Monitoring

The effectiveness of invasive plant control treatments will be evaluated through one or more of a series of monitoring methods (Table 14). The methods listed in the table reflect a gradient of increasing information gained. They also represent increased level of effort required to assess and evaluate the results, such that more intensive quantitative monitoring will only be used when treatment effectiveness is uncertain.

Table 14: Methods for monitoring effectiveness of invasive plant control treatments.

Method	Description	Use
Areal Extent Mapping	A polygon delimiting the treatment area is mapped pre-treatment, and again post-treatment, and information about invasive relative species abundance and cover is recorded each time to evaluate the effectiveness of the treatment at reducing cover, abundance, and/or areal extent of the infestation. Additional information about the treatment is also recorded in treatment mapping conducted following implementation (Section 3.2.7), to facilitate evaluation of the effectiveness of the treatment and also tracking of the invasive plant management activities (Tables 6 and 11).	This approach should be used wherever practicable. A subset of occurrences of each species and within each preserve could be monitored to reduce overall monitoring effort, as needed.
Photomonitoring	Photographs are taken at specified angles from permanently monumented and georeferenced photostations before the treatment and then again the same time the year (or for multiple years) following treatment, to qualitatively assess changes in the invasive plant species abundance and also the structure and cover of plants re-establishing in the treatment area. Photos of plant occurrences and treatment are also collected in the Calflora app.	Can be used independently or in conjunction with areal extent mapping to evaluate effectiveness of the invasive plant control treatments, and restoration of the native plant community, when the treatment outcomes are uncertain.
Quantitative Monitoring	Establish replicate, permanent plots (or transects) in the treatment area pre-treatment and revisit post treatment. Alternatively, establish plots in areas receiving various treatments, as well as a portion of the invasive plant occurrence that will be untreated (control) area, to compare effectiveness of alternative treatments, including restoration treatments. Measure invasive plant density and cover as well as the cover of other native plants by species, and compare pre-and post-treatment results or results among treatments and over time.	Can facilitate assessment of the effectiveness of invasive plant control at promoting native plant diversity, and also evaluate associated revegetation treatments such as mulching, seeding, and planting. Can also be used to compare alternative control treatments (e.g. manual versus chemical) or restoration treatments (e.g. seed, out plant native plants, etc.).

3.2.7.2 Update the Invasive Plant Inventory

The status of invasive plants within the preserves will be monitored over time by updating the polygons, lines and points mapped during the initial inventory (Section 3.2.2.3). Mapping of invasive plant occurrences that are subject to control will be updated through the effectiveness monitoring outlined in Table 14, above. Existing occurrences that are not subject to control because they are low priority will be remapped during periodic inventory updates conducted every five years, or as resources allow. During such updated mapping, new invasive plant species occurrences will also be incorporated into the inventory. New invasive plant occurrences observed during early detection and rapid response will be mapped when they are encountered at which time they will also be treated, as feasible (Section 3.2.1).

3.2.8 Adapt

Invasive plant management in natural lands will be implemented through an adaptive framework designed to promote achievement of the goals of the IPM program over time. In the framework, the priorities and strategies will be adjusted based upon the following:

- Results of monitoring to evaluate effectiveness of the treatments (Section 3.2.7.1);
- Periodic updates to the inventory and mapping (Section 3.2.7.2);
- New information about control techniques from scientific literature and other reliable sources; and
- Changes in site conditions, including fire or the invasion of new exotic plant species.

The following processes of annual re-evaluation, work planning, and annual periodic updates are designed to update the program over time.

3.2.8.1 Annual Re-Evaluation and Work Planning

Each year, Authority staff will review the following information:

1. Results of monitoring to evaluate effectiveness of control treatments to date;
2. Current distributions of invasive plant species, including new occurrences mapped during the year;
3. Updated lists of invasive plant species, including species on the Cal-IPC watch list (Cal-IPC 2019); and
4. Updated prioritized list of invasive plant occurrences reflecting new information including new invasions and effects of prior management.

These materials will be reviewed to:

1. Re-assess the treatment priorities, and make adjustments to promote overall effectiveness and cost-effectiveness of the funds available for invasive plant control;
2. Develop a work plan for the year, which identifies the occurrences that will be treated by month; and

3. Update the tools used to conduct EDRR program monitoring, including the target species list and species identification cards.

Authority staff will develop an annual IPM Work Plan that documents the IPM treatment project sites for implementation. An annual IPM Program Report will be developed at the end of each year that will summarize the IPM Program work completed in the previous year, evaluate the Program's progress in meeting goals, and include any recommended modifications to be included the following year.

3.2.8.2 Additional Periodic Updates

Authority staff will also periodically update the plan for managing invasive plants in natural lands, following the step-wise procedure outlined in this chapter, applying new information, approaches, and techniques where appropriate to enhance success. Specifically, the Authority will:

1. **Update the invasive plant occurrence inventory**, including by incorporating any new records or adjusting the boundaries or information about existing records to reflect changes that have not yet been updated in the database
2. **Update the goals for management** of each occurrence, based on results of efforts to date, if any, and other new information about the site (e.g. listed species occurrences) or effectiveness of treatments to control the invasive plants;
3. **Reprioritize invasive plant occurrences** within the open space preserves, based on the benefits of management, threats posed by inaction, and feasibility of achieving the specific goal for the occurrence;
4. **Revise the strategies for invasive plant control**, based on results of prior efforts as well as new information about the most effective techniques; and
5. **Update the prevention resources,** including list of species targeted for control and on the Watch List (Cal-IPC 2016a), species identification cards, and
6. **Revise the restoration techniques,** to reflect the techniques proven most effective at restoring habitat and suppressing invasive plant establishment;
7. **Update the monitoring program,** to ensure that the most important information is collected and evaluated to refine the program;
8. **Revise the education program materials**, as needed, to ensure that Authority staff and the public continue to be educated about the threats posed by invasive plants and the important work that the Authority is doing, with their help, to control them.

After five years of implementation, the Authority will evaluate the program and adjust its elements as appropriate to enhance achievement of the land management goals (Section 1.1).

3.2.9 Educate

Long-term effectiveness of the invasive plant management program will benefit from ongoing education of Authority staff, to stay current on the latest invasive plant management issues and techniques, as well as increasing the awareness and support of the public for invasive plant management.

3.2.9.1 Staff Education

Invasive plant management is an ever-changing field. Techniques are being developed and refined to control invasive plants; meanwhile, new plants are invading the region.

The Authority's staff will stay current on invasive species issues and management through a variety of methods including:

1. Reviewing updated websites and newsletters regarding invasive plant management (*Resources*);
2. Holding internal staff trainings, which can be conducted in conjunction with the annual work planning;
3. Participating in trainings offered by outside organizations, such as Cal-IPC, which offers courses on a variety of relevant invasive plant management topics including identification, mapping, treatment, and monitoring;
4. Participating in regional and statewide meetings or trainings, such as those coordinated by the Santa Clara Weed Management Area; and
5. Attending invasive plant management conferences, such as the annual symposium offered by Cal-IPC and the Central California Invasive Weed Symposium.

3.2.9.2 Public Education

Effectiveness of the IPM program can be enhanced by increasing public understanding of and support for efforts to control invasive plants in the open space preserves. Specific objectives of the education outreach are:

1. Increase public awareness of the impacts invasive plants on the conservation values of the open space preserves, including biodiversity, working lands, water resources, scenic landscapes, and fire management, among others, to promote support of the Authority's initiatives to control invasive plants;
2. Enhance public understanding of the IPM approach to invasive plant management in open space preserves, and the steps that Authority staff take to carefully use herbicides and otherwise limit the negative impacts of all invasive plant control techniques on the natural and cultural resources as well as reduce risk to public health and safety;
3. Inform preserve visitors about the measures they can take to help the Authority control invasive plants, including by taking steps to avoid dispersing invasive plant seed on the shoes, clothes, and vehicles, using weed free hay (for equestrians);
4. Increase public participation in volunteer stewardship programs to control invasive plants in open space preserves; and
5. Inform preserve visitors on specific invasive plants so they have an increased understanding of the landscape.

To achieve these objectives, Authority Natural Resource staff will work with members of the Authority's Community Engagement Team on a variety of education and outreach projects that may include:

1. Incorporating information about invasive plants and their management and the Authority's IPM program more broadly on the Authority's website, which could include this guidance manual as well as informative case studies documenting successful invasive plant management projects with compelling before and after photographs;
2. Including information about invasive plant management including success and volunteer opportunities in e-newsletters;
3. Integrating information about invasive plant species and their management in the docent manual, so that docents can help educate the public as part of their activities;
4. Posting permanent signs at staging areas and other significant trailheads, as well as the Authority's website, that identify measures the public can take to reduce the spread of invasive plants;
5. Posting temporary signs in invasive plant treatment areas located in visitor use areas, that provide information about the project and the broader IPM program;
6. Preparing a handout of Frequently Asked Questions (FAQs) about invasive plant management and IPM, that Authority staff provide to visitors who inquire about invasive plant projects while in open space preserve; and
7. Training docents on invasive plant identification and management.

A variety of organizations, including Cal-IPC, have developed public outreach and education materials related to invasive plants, which can be readily adapted to communicate the Authority's IPM program and invasive plant management efforts to the public (Cal-IPC 2016c).

3.2.10 IPM Program Implementation

The Authority's IPM program is currently implemented by the Land Management Office staff, the Resource Management Specialist, and the Natural Resource Technician. This team is responsible for developing an annual work plan for invasive control, which will follow a general schedule (Table 15). Each year in the fall, the Resource Management Specialist and Natural Resource Technician will work with a designee from the Land Management Office to set goals and prioritize plant occurrences (Sections 3.2.3 and 3.2.4) through an Annual IPM Work Plan. As time and resources allow, a map of each Preserve with the plant occurrences categorized by high, medium, and low priorities will be created or updated. The Annual Work Plan will be given to the Land Management Office for implementation, ideally in January. During the prioritization exercise, volunteer projects will also be identified. These projects will be sent to the Authority's Volunteer Programs Administrator for scheduling.

During the main exotic plant treatment season (February – July), the Natural Resource Technician will meet with a Supervising Open Space Technician on a regular basis to refine the work plan based on weather and plant conditions, workload, and other priority projects. These meetings are also a chance to share new information and discuss if any updates to the manual are needed.

At the end of the year, Authority staff will prepare an IPM Program Report to summarize the IPM work completed and determine if adaptive management is needed.

Table 15: Generalized annual calendar for IPM Program Implementation

Activity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Prioritize Treatment and Work Plan Development												
Create/Update Prioritization Maps												
Early Detection Monitoring												
Main Treatment Season												
Monitor Treatment												
Annual Program Report and Evaluation												

3.3 Sudden Oak Death and other Diseases Caused by *Phytophthora* Species

Exotic plant diseases have the potential to negatively impact the conservation values of the Authority's preserves. Of particular concern are diseases caused by *Phytophthora* species, as described below.

3.3.1 Sudden Oak Death

Sudden Oak Death (SOD) is a plant disease caused by an exotic water mold (*Phytophthora ramorum*) that has been implicated in native oak and tanoak deaths throughout coastal California and Oregon (CA Oak Mortality Task Force 2016). The disease often results in mortality of certain species of oaks, mainly tan oak (*Notholithocarpus densiflorus*), coast live oak (*Quercus agrifolia*), black oak *(Quercus kelloggii*) and canyon live oak (*Quercus chrysolepis*) but can also cause twig and foliar disease symptoms in many other native plant species. The wholesale loss of oak tree species in coastal forests can cause major ecosystem disruptions, especially because so many native species depend on oaks and their fall acorn masts. Sick and dying trees also greatly increase the wildfire risk in native coastal forests dominated by oaks.

It is still uncertain how the invasive forest pathogen *Phytophthora ramorum* causing SOD will impact the native forests and woodlands of the greater Bay Area. Methods such as the selective thinning of California bay laurel trees, which harbor the pathogen, pesticide applications, and promoting conifers over hardwoods have all been proposed for local and landscape scale management of the SOD pathogen (Filipe et al. 2012). The SOD pathogen is extremely difficult to detect until advanced infection and symptoms are visible in individual plants. Because this pathogen is a water mold, it can move great distances through the landscape using wind (e.g., windborne transport of spores) or through water (e.g. transport of spores in waterways and through fog drop) making management very difficult at any scale (Filipe et al. 2012). The landscape scale management of high value forested areas (e.g. selective removal of diseased trees, selective removal of host plants such as California bay laurel, replanting conifers and other disease-resistant trees) may be one of the few ways to slow the spread of the disease. Authority staff should consult with the California Oak Mortality Task Force (www.suddenoakdeath.org) for the most recent information on effective control of SOD.

3.3.2 Pest Management Strategies for SOD

At this time, SOD has not been detected on Authority lands (SOD Map 2016). If Authority staff notice trees with SOD symptoms, staff will have the trees tested and consult with the California Oak Mortality Task Force. As resources allow, the Authority will participate in SOD Blitzes—coordinated surveys designed to detect the occurrence of SOD—to test trees on Authority Preserves. The following are general steps that may be taken in response to SOD infestations on Authority preserves, if needed:

- Mapping of dead oaks and submit this information to the California Oak Mortality Task Force.
- Removal of California bay trees or their branches within 15 feet of the trunks of high value oaks. This option is costly and requires regular maintenance and monitoring.
- Spot treatment of individual oaks with pest control sprays (e.g., Agri-Fos ™) intended to reduce potential for SOD infection. Due to high cost, this option should not be applied on a landscape level.

3.3.3 *Phytophthora* sp. in Nursery Stock

Recent research has documented the presence of multiple *Phytophthora* species in California native plant nurseries, restoration sites, and native landscapes. Diseases caused by *Phytophthora* species include root rots, stem cankers, and blights of fruits and leaves. When introduced into native ecosystems, various exotic *Phytophthora* species have proven to cause devastating impacts. Infected nursery stock has been shown to be the source of various *Phytophthora* introductions (Swiecki and Bernhardt 2016).

3.3.4 Pest Management Strategies for other *Phytophthora* Diseases

At this time, plants infected with *Phytophthora* or exhibiting symptoms have not been found on Authority lands. Since nurseries are a common way to introduce *Phytophthora* into the landscape, pest management should focus on prevention. This issue is newly emerging and work is underway to develop a certification system to allow consumers to purchase clean native plants with confidence. Authority staff should stay abreast of this issue and any treatment options through the California Native Plant Society, Phytosphere Research, and the U.S. Department of Agriculture.

4 Guidance for Management of Invasive Animals in Natural Lands

4.1 Introduction

Invasive animal management in natural areas first focuses on modifying the behavior of humans or the habitat to moderate or eliminate invasive animal pest problems. After these prevention actions are exhausted, invasive animal populations will be managed to a defined tolerance level. Tolerance levels focus on reducing the pest population down to a level that does not cause substantial harm to natural resources; does not cause severe economic harm/ and/or does not cause disruption of natural processes or severe displacement of native species. The Authority's goal is to maintain the long-term stability and resiliency of its natural areas.

State regulations concerning invasive animals are complex. Some invasive animals in California are regulated for sport and commercial purposes (e.g., feral pigs and bull frogs), other expressly prohibited (e.g., northern pike fish) and others are currently unregulated (e.g., snapping turtles and parrots). To control regulated game species (e.g., feral pigs), special permits obtained from the CDFW may be required. Some invasive wildlife species can be difficult to manage where adjacent landowners manage the same species for sport or profit. The Authority will prioritize specific invasive animals for management that have the greatest potential to impact natural areas. Some regulated game species (e.g., feral pigs) must be controlled under special permits obtained from the CDFW.

4.2 Pest Management Strategies

4.2.1 Non-Native Fish

Non-native fish species are generally found in man-made stock ponds and reservoirs, but some also may occur in natural sag ponds. The Authority identifies the presence of fish during aquatic habitat surveys. Active management of non-native fish in man-made water bodies will not occur unless the water body also supports protected native species such as the California red-legged frog, or in water bodies that are close to ponds with protected native species (where the chances of colony by a protected species increases if the fish population was removed). In order to control these populations, ponds are typically drained for sufficient time to eliminate all non-native fish species then refilled. As most non-native fish species are managed as game fish by the CDFW, special permits are typically required for their control.

4.2.2 Bullfrogs

4.2.2.1 Background Information

The American bullfrog (*Rana catesbeiana)* is a large, brilliant green amphibian that is native to eastern North America. Its natural range does not extend west of the Rocky Mountains and Great Plains, but it is an increasingly common invasive animal in the western United States. Bullfrogs are sold throughout the world as food, pets, fish bait, and for educational purposes. They sometimes become unwanted pets or escape from frog farms and grocery stores, and as a result have readily established themselves in all suitable habitats throughout California. American bullfrogs are most problematic in the Authority because they directly affect the federally Threatened California red-legged frog (*Rana draytonii;* CRLF) and state and federally Threatened California tiger salamander (*Ambystoma californiense;* CTS). In

habitats where they exist together, large, overwintering bullfrog tadpoles can compete with or consume CRLF tadpoles and CTS larvae, in addition to other native wildlife species such as newts, other frogs and salamanders, garter snakes, birds, and bats. Their voracious appetites have been implicated in the declines of many North American amphibian species.

In addition to competition and predation, bullfrogs spread chytrid fungus – a lethal skin disease known as chytridmycosis that impacts many of California's native amphibians (Schloegel et al. 2009). Chytrid fungus is a non-native fungal pathogen from Asia that has spread to decimate amphibian populations all over the world. Because bullfrogs are domestically raised for food and educational purposes worldwide, many that are imported to California each year carry the chytrid fungus from unregulated foreign frog farms. As these individual frogs are accidentally or intentionally released into the wild, they help to spread the fungal disease throughout the native amphibian populations.

Bullfrogs are classified by CDFW as a game amphibian and are regulated by state fishing regulations. The permits for bullfrog removal are only valid for 60 days. Bullfrog control efforts will need long-term management in order to be successful. A special permit will be required from CDFW and if listed species are present, a qualified biologist will need to be present (Leicester 2016).

4.2.2.2 Pest Management Strategies for Bullfrogs

4.2.2.2.1 Prevention

- **Education.** Education can be an important tool for the Authority in preventing captive frogs from being intentionally released onto Authority lands. Some people feel ethically motivated to release captive pets and food animals back into natural environments for humane reasons or when they no longer wish to care for them. Public outreach and judiciously placed educational materials such as signs and brochures in Authority preserves with wetlands may be a useful strategy to curb intentional releases of animals.

- **Fencing.** Exclusionary fencing to keep bullfrogs from entering non-infested wetlands is a temporary tool for use while other control methods are applied concurrently. Fencing is not considered a long-term solution because it disrupts movement of other wildlife, can entrap non-target wildlife species, and may disrupt the natural processes of the wetlands. Exclusionary fences are useful during pond draining to limit the potential for dispersal of bullfrogs out of the treatment area. Exclusionary fencing may also be used in conjunction with funnel traps to collect bullfrogs as they attempt to disperse from drying ponds.

4.2.2.2.2 Physical Control

- **Gigging or shooting.** Gigging or shooting American bullfrogs (a pest species not native to California) are two methods that are implemented with small caliber air rifles and lead-free ammunition to eliminate individual adult bullfrogs. Gigging is the targeted spearing of fish or frogs with barbed tines mounted on a long pole. Both gigging and shooting are effective and humane methods for selective removal of target adult bullfrogs. However, this treatment method alone will rarely eradicate bullfrogs from the target area because only a portion of

adults are usually found, and it does not control eggs or larval stages. Some studies have indicated that adult metamorph removal (i.e., removal of immature bullfrogs) is the most economical removal method for population suppression (Govindarajulu 2005). Egg masses can also be collected to remove additional life stages at the appropriate time of year.

- **Trapping.** Submerged funnel traps and floating cage traps can be used to control different life stages of American bullfrogs. Funnel traps designed for catching baitfish can be used to live capture bullfrog tadpoles. Floating cage taps have been successfully used to catch adult frogs. Trap designs for bullfrog removal are relatively recent and mainly rely on modifying Australian cane toad traps. Methods designed to trap multiple life stages of frogs in parallel have proven effective for bullfrog management (Snow and Witmer 2011). Though trapping is a recently-developed treatment method for bullfrogs, it may be effective especially where other sensitive amphibian species are present to which impacts must be avoided.

- **Electrical currents.** Use of electrical currents (electroshocking) to temporarily disable frogs in netting and gigging operations have proved to be effective in some control programs (Orchard 2011). 12v DC electroshockers that are typically used in fisheries management are mounted either on small boats or on backpacks, then the electroshock current is applied to the surface of the wetland. This treatment is non-specific and will affect all aquatic species within the range of the electroshocking 'wand'. Electroshocking is non-lethal, rather it shocks and lifts the affected individuals to the surface where they can be netted or otherwise collected. This treatment method, therefore, must be followed by another treatment method such as hand removal or gigging. Even with follow-up control of individuals found by electroshocking, this treatment method alone will rarely eradicate bullfrogs from the target area because only a portion of adults are usually found, and it does not control eggs or larval stages.

- **Habitat Manipulation.** Pond draining is one of the most common methods used for bullfrog control in California, especially for projects where protected species may be present such as the native California red-legged frog. American bullfrogs need a perennial water source to complete their life cycle. In contrast, California red-legged frogs and California tiger salamanders only need water during their breeding cycle. The USFWS California red-legged frog Recovery Plan recommends draining ponds that contain both bullfrog and California red-legged frog species every year to reduce the habitat suitability for bullfrogs (USFWS 2002b). Type conversion of permanent stock ponds to ephemeral wetlands can also reduce bullfrog populations across a landscape scale but permitting requirements may be a barrier to feasibility.

- **Exclusionary Fencing.** The Authority may install exclusionary fencing to keep bullfrogs from entering non-infested wetlands as a temporary preventative tool for use while other control methods are applied concurrently. Fencing is not considered a long-term solution because it disrupts movement of other wildlife, can entrap non-target wildlife species, and may disrupt the natural processes of the wetlands. Exclusionary fences are useful during pond draining to limit the potential for dispersal of bullfrogs out of the treatment area. Exclusionary fencing may also be used in conjunction with funnel traps to collect bullfrogs as they attempt to disperse from drying ponds.

4.2.2.2.3 Chemical Control

No toxicants or fertility control treatments are registered for use in controlling bullfrogs in California.

4.2.3 Other Non-native Amphibians and Reptiles

Several species of non-native turtles are known to occur in Authority ponds and water bodies. These species are common food items for Bay Area ethnic communities and/or pet species. The red-eared slider (*Trachemys scripta elegans*) is the most common species expected to occur. Red-eared sliders are managed as game fish species in California. The Authority does not actively manage red-eared sliders unless the water body also supports protected, native species such as California red-legged frogs. The Authority will attempt to trap non-native turtles and remove them in compliance with CDFW when they share habitat with protected, native species. Traps are designed specific to the target species and meant to capture the turtles without harm. Traps would be checked daily for release and documentation of any native species and removal of any non-native species. A qualified biologist determines if any native species are present in the trapping area and consults with CDFW and USFWS if special status species are present. In special cases, ponds are drained for sufficient time to collect and eliminate non-native amphibian species (in compliance with CDFW Code) and then refilled. See information on pond draining presented above for bullfrogs.

4.2.4 Feral Pigs

4.2.4.1 Background Information

Feral pigs (*Sus scofra*) are one of the most destructive wildlife species in California and continue to expand their range throughout the entire United States. Feral domestic and wild Eurasian pigs are not native to North America but have been introduced in multiple events. These wild pigs have hybridized to become unique, abundant invasive pests in California, and they are thought to be one of the most prolific large mammals on earth (West et al. 2009).

Any pig living unassisted in the wild in California is classified as a game animal by current CDFW Code, which regulates the sport harvest of game animals in California. Pigs have extremely generous allowable methods of sport take and can be harvested year-round in unlimited quantities with a hunting license and valid pig tag. Because they are also regulated as an agricultural pest in California by the USDA – APHIS Wildlife Damage Control Services and the CDFA, their management is often regulated by depredation permits from the CDFW. These permits can be obtained by private growers, ranchers, or other land owners and public agencies when proof of economic damage can be documented to the CDFW.

Pigs are mammals that are capable of extremely high reproductive rates when environmental conditions are favorable. In California's Coast Ranges, they can reach high population densities because of cool weather, year-round access to water, and food (including acorns, a favored food source) through the winter months. Their invasive potential is largely because of their ability to quickly increase population size; they reach sexual maturity at young ages, females can have multiple litters each year, and natural mortality rates are generally low with few native predators. They can also disperse over large distances to invade new habitats, preventing effective management on a local basis.

Pigs cause damage to California agriculture and native fish and wildlife. Their destructive rooting behavior is visible in many natural areas. Rooting increases erosion and soil sedimentation, decreases water quality, directly reduces native plant species (e.g., ingestion of tubers, acorns), and promotes the establishment of non-native and invasive plants in disturbed soils (Seward et al. 2004, Kotanen 1995). They also create competition for food resources that would normally be consumed by native wildlife (especially winter acorns), spread disease to wildlife, and consume ground nesting birds, reptiles, amphibians and small mammals (TNC 2009, Barrett 1982). Wild pigs are also estimated to cause $1.5 billion of crop damage annually through the direct consumption and damage to crops, transmission of disease to livestock, and other damages to property and agricultural infrastructure (USDA 2009).

4.2.4.2 Pest Management Strategies for Feral and Wild Pigs

The Authority would need to work with the California Department of Fish and Wildlife to develop a management program to capture feral pigs using baited traps and humane termination (shooting). Permitting would be arranged through an MOU for pig depredation across all properties or through a pig depredation permit on a case by case basis (Kasteen 2016). As part of the program, the Authority would coordinate with other regional land management agencies that are controlling feral pig populations.

4.2.4.2.1 Prevention

Exclusion of pigs with pig proof fencing can be effective in preventing high value areas from being invaded by pigs. Fencing must be maintained annually to be effective. Pig-proof fencing is usually very expensive to install and maintain, and also has the possibility of restricting the movement of native animal species. It is an effective strategy for protecting extremely high value natural areas, agricultural lands, or archeological sites in small areas.

4.2.4.2.2 Physical Control

- **Shooting.** Shooting (either hunting or professional depredation) is the most common method for feral pig control throughout California (CDFW 2013). Though state sport hunting is regulated in such a way to offer some control of pig populations, there can still be a population increase above target levels because pigs often change their behaviors to avoid hunting pressure. Permitted depredation hunting with the assistance of tracking dogs or using nighttime vision aids and thermal imaging can increase the effectiveness of managing populations. Shooting methods should only employ lead-free, copper-based ammunition to reduce non-target mortality to pig carcass scavengers. Shooting has limited public appeal in and near recreational facilities and may not be a practical option for the Authority in open preserves.

- **Trapping.** Trapping is the most effective means for regulating wild pig populations on a small landscape scale, although it must be done in perpetuity to maintain low population numbers. Cage- or corral-type traps are the most commonly used trap design in California. Snares have been found to be highly successful in Hawaii and Texas. Cage traps function by attracting single or multiple pigs into traps with bait through a one-way or guillotine trap door. Since pigs have large home ranges and they can disperse over large landscapes, effective trapping must focus on areas pigs are actively using. This requires the trapper to scout large landscapes or use a network of camera-traps to identify locations where pigs are actively travelling and feeding. Pre-baiting increases the effectiveness of live-catch traps. Trapping requires great effort and

costs are typically high, but it is currently one of the most effective available methods for population control. All cage trap and snaring methods must be permitted through the CDFW on a project-by-project basis.

4.2.4.2.3 Chemical Control

- **Toxicants.** No toxicants are currently registered for the control of pigs, although some are in development for Federal registration through the EPA (Lapidge et al. 2012).
- **Contraception.** Currently, no immuno-contraceptives are registered for use on wild pigs although some are in development. The Wildlife Society considers wild pig contraception controls to be impractical in the field (Fagerstone et al. 2002), so they are likely not a viable treatment method for managing feral pigs on Authority lands.

4.2.5 Brown-headed Cowbird

4.2.5.1 Background Information

The brown-headed cowbird (*Molothrus aster*) are historically native from North Dakota to Oklahoma and south central Canada (Robinson et al. 1995). Due to the change in land use in the west with the loss of forests, increase in livestock grazing, agriculture, irrigation, and human development, the brown headed cowbird has expanded its range to almost all of North America (Rothstein 1994).

Female cowbirds lay their eggs in the nests of host species, allowing the host to incubate, hatch and raise the young cowbirds until they fledge. For smaller songbirds in particular, the larger cowbird chick outcompetes the smaller host chicks for food and will be the only chick to successfully fledge from the nest. Some songbird species, such as least Bell's vireo (*Vireo bellii pusillus*) which is federally and state listed as Endangered, are thought to have declined, in part, because of expansion of the cowbird breeding range (Rothstein 1994). The least Bell's vireo is especially susceptible to parasitism because the species will generally only raise a cowbird and none of their own.

The Authority does not currently control for brown-headed cowbirds but may do so in the future to help restore habitat for least Bell's vireo in the Pajaro River Agricultural Preserve. If any of the methods outlined below are selected, permits from CDFW and USFWS will be needed. CDFW does allow control of brown-headed cowbird to reduce nest parasitism on special status species through a special letter of authorization and a scientific collecting permit (Garcia 2016). USFWS should be contacted for information for federal permitting requirements.

4.2.5.2 Pest Management Strategies for Brown-headed Cowbird

4.2.5.2.1 Habitat Modification

Certain characteristics of vegetative structure can be beneficial in decreasing the vulnerability of host nests to parasitism. Dense vegetation at the nest level may help conceal nests. Management techniques that may achieve these qualities include planting seedlings, preventing overgrazing, and restricting areas from high recreation use (Siegle and Ahlers 2004).

4.2.5.2.2 Physical Control

- **Egg Removal/addling.** Removing cowbird eggs from the host nest or addling them by shaking can be used to limit cowbird impacts on hosts. These methods are cost effective and practical where small, remote populations of hosts and/or cowbirds exist. Addling may be preferable to removing eggs since some host species may desert their nest if eggs are removed (USFWS 2002a). However, if the host eggs have already been damaged it better for the host to desert this clutch and re-nest. Eggs can be removed using adhesive tape.

- **Trapping.** Trapping is the predominant method used for cowbird population control. Trapping efforts are typically highly successful in reducing local parasitism rates and can be a somewhat quick and easy cowbird control method (USFWS 2002a). Trapping requires daily monitoring in order to supply fresh water and food for captured birds and to release non-target species. It is generally assumed that trapping programs will continue for many years unless the target host species has increased markedly.

4.2.5.3 Chemical Control

Currently there is no feasible method of inhibiting breeding of large cowbird populations although DiazaCon looks like a promising compound, more research is needed (Siegle and Ahlers 2004).

4.2.6 Feral Pets

4.2.6.1 Background Information

As with non-native turtles, domestic animals are sometimes released by preserve visitors, or wander into preserves on their own. Some people feel ethically motivated to release captive pets and food animals back into natural environments for humane reasons or when they no longer wish to care for them. As a result, domestic cats, dogs, rabbits and other species end up living in preserves, and utilizing native rodents, plants, and insects for food.

4.2.6.2 Pest management Strategies for Feral Pet

4.2.6.2.1 Prevention

Education can be an important tool for the Authority in preventing pets from being intentionally released onto Authority lands. Public outreach and judiciously placed educational materials such as signs and brochures in Authority preserves may be a useful strategy to curb intentional releases of animals.

4.2.6.2.2 Live Capture

Utilize catch pole or otherwise trap dogs, cats, turtles, rabbits and other domesticated animals found escaped or released in the preserves and return them to their owners or turn them over to local animal control departments or animal shelters.

5 Guidance for Management of Invasive Pests in Agricultural Lands

5.1 Definition and Purpose

Some Authority lands encompass crop fields that are actively managed as agricultural operations. The Authority currently has one agricultural preserve with row crops (the Pajaro River Agricultural Preserve) and may acquire other agricultural properties in the future. A site-specific Agricultural Management Plan will be developed with tenants on each of the Authority's agricultural preserves. These site-specific plans will guide the agricultural activities to ensure compatibility with natural resource protection and low-intensity public recreation.

This Guidance Manual does not replace the requirements of the individual agricultural management plans, nor does it present the full range of agricultural options. These guidelines are to provide staff with tools and resources that are consistent with IPM principles to select the safest, least harmful, and most effective treatment options for agricultural pests.

The Authority has a separate grazing program and policy for rangelands that addresses how the Authority uses grazing as a management tool to conserve biodiversity while protecting water quality, cultural resources, scenic values, and recreational opportunities (SCOSA 2012). Therefore, management of rangelands is not included in this document. The Authority is administering an Urban Open Space Grant Program which could fund urban garden projects. Guidelines for the Urban Open Space Grant Program encourage sustainable materials, systems, and practices that enhance wildlife habitat and provide environmental benefits.

5.2 Agricultural Farms and Fields

The purpose of IPM on agricultural properties is to manage pests to maintain the specific land uses (e.g., crop production), while also providing natural resource protection and visitor access. Agricultural pests that may be encountered include weeds, pathogens and insects in croplands; and rodents in farm field and buildings.

The Pajaro River Agricultural Preserve is an agricultural preserve owned by the Authority and leased to a farmer. It contains row crops and fallow fields. The Authority is currently working on a restoration and agricultural management plan for the Preserve which will guide both the restoration and the compatible agricultural practices that will be incorporated in management of the Preserve. The Authority acquired agricultural lands in North Coyote Valley. Future uses and management of lands in Coyote Valley will be guided by the Coyote Valley master planning process, which will begin in 2021. As new agricultural lands are acquired, Authority staff will work with agricultural lessees to incorporate the procedures outlined in this Guidance Manual.

5.2.1 Types of Agricultural Pests

Insect, weed, and disease management in field crops is very specific to the type of crop grown. Because the Authority has only one property that currently supports row crops, and because the type of crop

produced may change in the future, agricultural pest management is not covered under this Guidance Manual. Agricultural pest management will be would be covered in a future Agriculture Management Plan specific to each preserve. There are many resources available to help guide development of an Agricultural Management Plan, including best management practices as defined by the University of California Cooperative Extension Service and the USDA Natural Resources Conservation Science for farm production. The University of California Davis also publishes crop-specific IPM guidebooks for both organic and conventional crop production (http://www.ipm.ucdavis.edu).

5.2.1.1 Regulated Agricultural Pests

Though the definition of a pest can depend on perspective and location, some species are regulated as various types of pests by state and federal law. Plants classified as 'Noxious' are regulated by the California Department of Food and Agriculture (CDFA) and the United States Department of Agriculture (USDA). Wildlife species classified as 'Injurious' are regulated by the CDFW and United States Fish and Wildlife Service (USFWS). Other species that transmit diseases may be regulated by local, state, or federal health departments. Regulated pests pose a risk to the environment, public health, or economic resources. Often, the acceptable IPM tolerance level of regulated pests is zero, so that any detected individual initiates a management action. These are species that the Authority has a legal responsibility to control per state and federal laws and regulations, though control is often conducted by other agencies.

5.2.1.2 Pest Identification in Agricultural Farms and Fields

Due to the limited number of agricultural lands on Authority property, pest identification is the responsibility of the lessee, who is to report significant pest infestations to the Authority. Once pests are reported, they should be mapped and evaluated for impacts to the surrounding natural areas. Site-specific management needs will be determined by lessee and Authority in individual Agricultural Management Plans based on assessment of farm and field conditions, type of crops, and anticipated crop yields. See Table 16 below for pest management options.

5.2.2 Pest Management for Agricultural Farms and Fields

5.2.2.1 Prevention

The Authority will work with lessees to encourage management practices that prevent the establishment of pest species and include this information into individual Agriculture Management Plans. Prevention strategies for Authority lands in agricultural production may include:

- During development of new Agricultural Management Plans, encourage lessees to keep lands healthy through soil management, proper irrigation, and by providing sufficient habitat (refugia) for natural insect pest predators (natural enemies) in and near crop production areas.
- During development of new Agricultural Management Plans, and as practical, incorporate good stewardship practices such as rotational cropping, integrating annuals into perennial crops, implementing no-till cropping, and, where possible, promoting organic farming practices to reduce annual disturbance and increase farm biodiversity (Coll 2004).

- During acquisition planning for new preserve lands, encourage landscape mosaics (i.e., plan for a mixture of natural and agricultural or grazing lands) to help maintain natural pest predator populations.
- During lease renewal periods, monitor pest invasions at the edges of agricultural and grazing lands, especially in and near roads, trails, and fuel breaks. If needed, develop pest control requirements in the new lease.

Table 16: Pest management in agricultural lands

Pest Category	Treatment
Agricultural Insect Pests	Lessee to monitor insect damage of crops. Agriculture insect pest management to be addressed in future Agriculture Management Plans. Staff and tenants to consult crop-specific IPM guidebooks published by University of California Davis http://www.ipm.ucdavis.edu for both organic and conventional crop production and include pest management actions in the Agricultural Management Plan for individual parcels.
Rodents and Other Nuisance Pests in Agricultural Areas	Lessee to monitor rodent damage. In coordination with the Authority, lessee responsible for detection, Authority notification, and control of problem rodents in farm buildings or crop fields using procedures in the Section 6.
Invasive Plants in Agricultural Farms and Fields	**Cultural Control Options:** • Crop Rotation • Cover Crops and Smother Crops • Late-Season Planting • Planting Rates and Crop Density • Water and Nutrient Management • Crop Variety Selection • Covering/Soil Sterilization • Mulching • Soil Sterilization • Raptor posts **Physical Control Options:** • Mowing • Pulling • Green Flaming • Mulching • Use of Weedmats • Hoeing • Discing • Cultivating With Tractor Implements • Rodent Trapping • Burrow Destruction **Chemical Control Options:** To be determined by lessee and Authority in Agricultural Management Plans. Staff and tenants to consult crop-specific IPM guidebooks published by University of California Davis http://www.ipm.ucdavis.edu for both organic and conventional crop production and include pest management actions in the Agricultural Management Plan for individual parcels.

5.2.2.2 Treatment Options

Working with lessees, the Authority will determine a site-specific solution that meets the needs of the lessee, maintains the natural resource values, and addresses the identified pest issue. When feasible, non-chemical options are preferable to chemical options. Therefore, the Authority will encourage organic farming when developing individual Agricultural Management Plans with lessees. Structural pest issues on agricultural lands will be controlled using the same procedures outlined in Section 6.

Because the Authority has few properties that currently support row crops, and agricultural pest management is crop-specific, agriculture insect pest management for agricultural fields is not covered under this Guidance Manual. Staff and tenants should consult crop-specific IPM guidebooks published by University of California Davis – http://www.ipm.ucdavis.edu for both organic and conventional crop production and include pest management actions in the Agricultural Management Plan for individual parcels.

Cultural weed control methods/techniques include crop rotations, water and nutrient management, late-season planting, and cover/smoothing crops (Smith et al. 2000, Gunsolus et al. 2010). Cultural methods are the first line of defense in weed management and primary tools for organic crop production. The following lists the cultural methods as well as manual/mechanical control treatment options for invasive plants on agricultural lands:

- **Crop Rotation.** Diversifying a rotation is one of the most effective tools against weeds. Over time, routine planting and cultivation dates will select for weeds that are adapted to these strategies. Varying crops by different planting date or growing perennial crops in rotation with row crops can prevent weeds from adapting to the planting regimen.

- **Cover Crops and Smother Crops.** Off-season cover crops and smother crops are effective strategies to outcompete weeds. Cover crops occupy vacant space in an ordinarily fallow field and displace weeds that would otherwise occupy the space. Some species also have allelopathic effects on weeds.

- Smother crops are vigorously-growing crops that growers use to suppress weeds. Generally, a smother crop is not harvested, but plowed down instead. The primary risk in using smother crops is that their effectiveness in weed control may be inconsistent and unpredictable or they may become weeds themselves.

- **Late-Season Planting.** Delayed planting past the traditional planting times is an option in weed management, but depending on growing season and crop, may also reduce crop yields. Later season planting allows crop seedlings to bypass the competitive flush of weed seedlings and also allows for additional time for mechanical weed control operations.

- **Planting Rates and Crop Density.** Increasing the planting rate is another common strategy for weed management. Higher crop densities can lead to greater competitiveness against weeds. In addition, higher planting rates can compensate for crop losses that occur during mechanical weed control operations.

- **Water and Nutrient Management.** Effective water and nutrient management can ensure crops benefit from farming practices rather than weeds. Switching to drip irrigation from flood or broadcast styles, monitoring nutrient requirements instead of blanket fertilization, timing compost applications, and burying irrigation pipe may all help to reduce weed problems.

- **Crop Variety Selection**. Selecting the proper variety of a specific crop that is best adapted for local conditions can reduce the resources necessary for production and consequently reduce weed management problems. If the crop is better adapted to local conditions than the weed, the site will favor the crop over the weed.

- **Mechanical weed control.** Mechanical weed control is the most widely used weed control method for agriculture fields and can occur before, during, and after the crop is planted. This method includes primary tillage, row crop cultivating tillage, use of mulches (i.e., plastic sheeting, straw, wood chips, and sawdust), and/or soil sterilization techniques that use heat to kill weeds and weed seeds in soil. Passive sterilization uses clear plastic tarps to foster the germination of weeds under the tarp and then exposes the seedlings to hostile growing conditions and they perish and active sterilization uses extremely high temperature steam to eliminate weed seeds and bulbs with direct contact. Both processes are expensive and require specialized equipment and/or high labor output.

- **Primary Tillage.** Primary tillage is the initial step in seedbed preparation. It incorporates residues from the previous crop and can incorporate compost, manures, and other nutrients. It buries some weed seeds so deeply they cannot germinate, but it also brings other seeds to the surface allowing them greater opportunity for germination. Tillage is best combined with a forced germination program, where multiple tillage and watering events are coupled to force the germination of weeds and then eliminate them. The timing of primary tillage will encourage different weed species to predominate so the farmer must time the actions to correspond with the primary weed targets.

  A fundamental aspect to consider in seed bed preparation is the concept of providing the crop with an "even start." An even start means controlling weeds that germinate before the crop germinates. Once seed bed preparation is complete, the crop must be planted as soon as possible because if crop planting is delayed, weeds can germinate and get a head start on the crop.

- **Cultivation.** Row crop cultivating tillage is performed after the crop is planted. Cultivation kills weeds by digging them out, burying them, breaking them apart, or drying them out. In addition to controlling weeds, cultivation can break up soil crusting and thus can increase crop emergence, water infiltration, mineralization of nutrients, and soil aeration during the growing cycle.

  A short window of time usually exists for timely use of cultivation. Weeds that emerge before or with the crop are the most critical to eliminate. Weeds that emerge after crop emergence will have less negative impact on yield, but may still contribute to the weed seed bank for problems in future years. When it comes to weeds that emerge with the crop, it is best to be proactive, rather than reactive. Waiting until weeds are noticeable will limit the control options.

- **Mulches**. Mulch is any artificial or natural soil cover. Plastic sheeting, straw, wood chips, and sawdust are all common types of mulches for crop production. Mulches work by eliminating light availability to small weeds. The larger the weed, the deeper the mulch needs to be for effective control. Mulches have the added benefit of also conserving soil moisture and reducing soil erosion. Many organic types of mulch ultimately decompose into necessary plant nutrients for the following growing season.

- **Sterilization.** Soil sterilization uses heat to kill weeds and weed seeds in soil. Two types are common in agriculture, 1) passive soil sterilization with clear plastic tarps and 2) active soil sterilization with injected steam. Passive sterilization uses clear plastic tarps to foster the germination of weeds under the tarp and then exposes the seedlings to hostile growing conditions and they perish. Active sterilization uses extremely high temperature steam to eliminate weed seeds and bulbs with direct contact. Both processes are expensive and require specialized equipment and/or high labor output.

- **Manual weed treatment.** Specific manual weed treatment methods include mowing, pulling, flaming, mowing, mulching, weedmats, and hoeing.

6 Guidance for Management of Pests in Structures

6.1 Introduction

Authority properties includes structures such as the administrative office located in San Jose, and numerous buildings such as barns, un-inhabited houses, and sheds in the preserves. Certain animals and plants may be incompatible with human use of these structures or may harm the building itself. For example, rodents, ants, and similar structural pest species are typically controlled in buildings when their population numbers may result in structural damage or health risks to humans.
The purpose of pest control in Authority buildings is to manage pests for human health and safety and preserve the intended uses of the building structure. Most structural pests only become problematic when there are extra resources readily available (food, water, shelter) in and around the structure. Many of these types of outbreaks can be managed with cultural options such as changing human behavior (e.g., securing garbage, cleaning up food) or engineered control options within structures (e.g., sealing up entrances to structure).

6.2 Prevention and General Maintenance

Modern IPM programs for buildings rely on prevention as the primary structural pest control treatment option to eliminate pest problems. Active pest control is used as a last resort. Use of control options such as physical barriers, materials selection, and site modifications provide the primary means to eliminate pests from buildings and other structures without needing to use pesticides or other lethal control. Table 17 summarizes prevention and maintenance practices that can reduce structural pests.

6.3 Prevention

Preventing insects and wildlife pests in buildings include general guidelines that promote pest-resistant materials, block common access points to buildings, and promote modifications of common structures to repel rather than attract common pests. These modifications may include changing the landscaping from dense cover to one does not provide hiding locations for small mammals. Prevention also includes modifying structures by preventing access to pests through cracks, crevices, gaps or holes. Pest control and building maintenance should also be considered when retrofitting existing buildings or designing new buildings. Design guidelines are available from the International Code Council/San Francisco Department of Environment (Geiger and Cox 2012).

6.4 Sanitation and Maintenance

Many pest species are attracted to food and are present due to improper handling and storage of food and food waste, or improperly cleaning up food scraps and dishes. Uncovered garbage containers can attract rats and other pests. Storing native plant seeds in paper envelopes rather than hard sealed plastic containers may encourage mice to take up residence in storage areas. These types of pest attractants can be eliminated with human behavioral modifications. Additional strategies to reduce or even eliminate pests in the Authority's office include:

- Store food and food wastes in sealed containers;
- Provide containers, sealed cabinets, or a refrigerator for temporary food storage;

- Do not leave food or food waste in an open area overnight;
- Regularly clean dishes, floors and countertops;
- Use sealed garbage cans, or place them on a crawling insect-proof platform; and
- Rinse out cans and bottles before they are placed in a recycling bin.

Table 17:Prevention and Maintenance Practices to Prevent and Reduce Structural Pests

Maintain landscaping next to structures

- Prune vines, shrubs, and trees at least six feet away from roofs and exterior walls to prevent rodents from using them for access into buildings
- Remove and avoid planting Algerian or English ivy, star jasmine, or honeysuckle vines, which provide shelter and food sources for rats and other pests.
- Remove and avoid planting bamboo, cherry laurel, fig, pine, and roses near buildings, which encourage scale, aphid, and ant populations.
- Clear landscaping away from vent openings to crawlspaces to prevent moisture buildup.
- Remove plants and wood mulch within several inches of foundations to minimize ants and other nests. A gravel strip around foundations at least two feet wide and 0.5 feet deep of one-inch gravel or larger discourages rodent burrowing and other insect nesting.
- Select plants that attract beneficial insects such as parasitic wasp, native bees, and ladybugs.

Move stored materials away from structures.

- Store compost and trash bins away from structures as these can attract rodents, insects, and other nuisance pests.
- Store woodpiles and debris away from structures to prevent rodent, beetle, and termite infestations.

Seal off openings.

- Inspect openings to crawlspaces and other ventilation features to ensure screens are intact.
- Inspect, maintain, and use elastomeric sealant, polyurethane foam, and weather-stripping to seal all small cracks in structures, around countertops and windows, pipe breaks, and areas where pipes enter walls. Use stainless steel wool and mesh and fire block foam to re-seal larger openings in buildings and below decks.
- Add door sweeps or high density pest brushes to seal gaps greater than ¼" below doors.

Block access for rodents to climb pipes and gutters.

- In areas with Norway rats or other rodent issues, various items can be installed to prevent the rodents from climbing downspouts and pipes, including flap valves or screens in downspouts, 12"-diameter downward-facing cones or 18"-diameter discs, or a 12" band of glossy paint on exterior vertical pipes.

Reduce or move exterior lighting to prevent insects from gathering near doors and windows.

- Timers and motion detectors can be installed to minimize unnecessary lighting.
- Use reflected light instead of direct light to illuminate entryways, as insects are more attracted to direct light.
- Use yellow (sodium) bulbs to reduce insect attraction in exterior areas.

Add bird exclusion materials to lighting and other horizontal surfaces.

- Bird spikes, wires, netting, or similar materials can be installed to prevent unwanted birds from roosting or nesting on structures or on light poles.

Minimize moisture in and near structures.

- Check for proper ventilation of crawl spaces; add vapor barriers in crawl spaces.
- Ensure appropriate slopes and drainage next to structures.

Table 17:Prevention and Maintenance Practices to Prevent and Reduce Structural Pests

- Downspouts and gutters should discharge at least one foot away from walls; splash guards, rain barrels, or gutter extensions may be added to reduce accumulation of moisture near structural walls.
- Ensure that landscape irrigation does not introduce moisture to foundations – use drip irrigation and position sprinklers to avoid structures.

Exclude rodents from refuse and recycling areas.

- Enclose refuse and recycling areas with metal, concrete, or similar materials to prevent animals from climbing, burrowing, or chewing into the enclosure. Do not plant ivy around enclosure.
- Use refuse containers that are heavy duty, rust resistant, rate and damage resistant, and equipped with tight-fitting lids.

Recommendations are from the MROSD IPM Guidance Manual which were selected from the Pest Prevention By Design: Authoritative guidelines for designing pests out of structures (Geiger and Cox 2012).

The Authority's structures also include storage buildings or livestock infrastructure on Authority preserves. These additional measures may be applied in these type of structures:

- Store all pet food, animal grains, and other consumable agricultural supplies in sealed containers.
- Store plant seeds used for habitat restoration and landscaping in sealed containers.
- Monitor landscaping and rooted plant materials for pests, and treat as necessary to prevent pest outbreaks.
- Position attractive harborage areas, such as rock piles, soil storage piles, hay and erosion control materials away from buildings.
- Control food waste in work areas, outbuildings, storage areas, and other non-occupied structures. Provide sealed garbage containers in or near such areas.
- Reduce, monitor, and where possible eliminate use and import of natural materials that could introduce pests onto Authority lands such as reducing use of offsite fill (soil, gravel, and rock) and livestock feeds (hay) that may contain weed seeds. Where possible, include requirements to utilizes onsite fill, require balanced cut and fill projects, and require use of certified weed-free erosion control materials for construction projects on Authority lands.

6.5 Pest Control Treatment

Despite efforts to prevent pests from becoming a nuisance, pests may still establish themselves in Authority buildings, requiring more active pest control. Pest management options should begin with natural pest controls (such as diatomaceous earth) before using more harmful products unless there is an immediate threat to human health or safety. Strategies for some pests must use a variety of different techniques to avoid problems with pesticide resistance. Each situation will be assessed by Authority staff based on the pest, level of threat, and location.

6.5.1 Ants

6.5.1.1 Background Information

Argentine ants (*Iridomyrmex humilis*) are the most common nuisance ant species likely to be encountered in Authority structures. The Argentine ant is a non-native species from South America that likely arrived in California in the early 1900s. Argentine ants have four life stages: egg, larva, pupa (cocoon), and adult. They are social insects that live in organized colonies where different adults have specialized duties and numerous queens and workers mix freely among spatially separated nests. Unlike native ants, Argentine ants mix freely between colonies without intraspecific competition and can therefore reach high population densities compared to native ant species (Silverman and Brightwell 2008). For this reason, eradication of Argentine ant populations is impossible; if a sub-colony collapses, other nearby queens will shift to fill the void. Argentine ants are omnivorous, preferring high protein sources until those researches are exhausted and then shifting to plant and nectar based resources. They are especially fond of honeydew produced by Homopteran insects (e.g., aphids) and the pest problems of each of these species in gardens and structures are often linked.

6.5.1.2 Pest Management Strategies for Ants

6.5.1.2.1 Prevention

- Clean all kitchen and food storage surfaces regularly; sweep and vacuum kitchen floors daily. Shared-use appliances such as sinks, microwaves, and vending machines should be cleaned regularly to eliminate spills.
- Store all food properly in containers with tight fitting lids, or in the refrigerator or freezer.
- Rinse recycling waste if temporarily stored in open bins, or store waste in containers with tight fitting lids/seals or place open bins on insect-proof bases. Always line trash bins with plastic bags and regularly take out garbage to an outside storage area/dumpster.
- Do not leave pet food in bowls overnight. Wash pet food bowls after the pet is done eating.
- Inspect potted plants for nests regularly. If ant nests are found, remove the potted plant. If potted plants become a frequent harborage for ant nests, use ant-proof platforms (e.g., Antser™) or use a double saucer system for potted plants. Flooding the pot for several days can treat ant-infested potted plants.
- Inspect landscaping for aphids, scale, and other honeydew producing insects. If found, treat plants for insect pests, and manage ants in a coordinated effort to eliminate both problems.

6.5.1.2.2 Physical Control

- Clean up ant trails when found with soapy water or sticky lint rollers. Note the location the ants were headed and where they were coming from. If possible, clean-up what was attracting the ants.
- Use caulking, silicone, or expanding foam to fill cracks, holes, or other entry points where ant trails originate. If multiple entry points are suspected, inject diatomaceous earth dust into cracks before sealing.
- Prune outside vegetation that is touching the structure if it supports ants, aphids, or scale. Some species, such as Citrus, are especially vulnerable to sucking Homopteran insects that attract ants. Consider replacing these species of plants with species that do not attract Homopteran pests. Treat infected vegetation by spraying with soapy water or insecticidal soap sprays, dusting with diatomaceous earth, or physically removing insects.

6.5.1.2.3 Chemical Control

Chemical control of ants includes two options: 1) direct control using sprays for instant, but temporary knockdown of individual ants and the treatment of Homopteran pests that attract ants, and 2) baits for colony control. Sweet liquid baits are useful throughout the year because adult Argentine ants only feed on sugary liquids. High protein baits are generally only useful to treat colonies during the periods of the year when they are actively expanding because such solid food is typically used by the ants to feed larvae. Baiting is generally a slower process than direct control but it has a much greater long term impact on controlling the entire local colony. Baits are taken back to feed larvae and shared with other adults and queens so they potentially can eliminate the entire colony rather than just a few individuals. Modern baits are designed to be extremely host- specific compared to generalist insect sprays. Baits target the pest directly, rather than being applied to the environment. Never use direct control (spray) around a bait station, as the spray will impede the bait's ability to attract the insects. Baits will only be used indoors in tamper-proof stations.

For the control of insects, multiple baits with different modes of action are recommended to prevent local populations from developing resistance to the pesticides. Every structural insect management program should include a few products to use in rotation to prevent resistance.

- **Insecticidal Soap Spray.** Insecticidal soaps are specially designed mixes of fatty acids that are made to penetrate an insect's covering and dissolve its cell membranes causing dehydration and mortality. Generally, the soaps are formulated to not dissolve plant cell membranes so are safe to apply directly to plants. Insecticidal soaps are not effective on all insects, but soft bodied insects, such as Homopterans, are highly susceptible. When used for ant control, soaps are most effective in controlling the Homopteran insects on plants that attract and sustain ant colonies.
- **Boric Acid Bait.** Boric acid is a naturally occurring compound found in many fruits and vegetables, but at concentrated doses it can be an effective stomach poison for insects. Baits use low concentrations of boric acid – sodium tetraborate decahydrate – in the range of 0.5 – 5% to allow for ants to ingest the bait and take it back to the colony to share with other workers before there is a lethal effect. Higher concentrations risk killing the individual before it has time

to take the bait back to the colony. Studies show that the lowest concentrations (<1%) are optimum for Argentine ant preference (Klotz 2000).

- **Fipronil.** Fipronil is a broad-spectrum insecticide common in household cockroach/ant baits and flea sprays for pets. When used as an ant bait, it is toxic to insects through ingestion where it blocks chloride channels in the central nervous system; resulting in excess neuronal stimulation and death of the target insect pest. It has higher binding affinity in insect receptor sites versus mammalian receptors so it is considered highly selective for insects and safe to use in human environments (Jackson et al. 2009). It is considered one of the most effective baits for colony control of Argentine ants in situations when boric acid-based baits are less effective (Hooper-Bui and Rust 2000, Mathieson et al. 2012). Fipronil is relatively quick-acting compared to other natural pesticides. It should be used as a last-resort option when extremely high populations of ants must be controlled quickly. Only small amounts of bait are necessary to control ants compared to knockdown sprays, which must be applied more widely in the environment to be effective. Small amounts of fipronil will be used as a last-resort option when extremely high populations of ants must be controlled quickly.
- **Diatomaceous Earth.** Diatomaceous earth (DE) is a silica-based, naturally occurring mineral product that works as a generalist insect pesticide. It is composed of the fossilized silica cases of marine diatoms that have been mined from ancient marine sediments. The dusts are considered non-toxic although care should be taken to not inhale large amounts of dust during application as all mineral and wood dusts are considered hazardous in extremely large amounts. Food-grade DE is available to mix directly in human and pet foods to manage pests that occur in bulk food storage. DE works by mechanically abrading an insect's exoskeleton that leads to dehydration and eventual death of the insect. DE is non-selective so it must be used only in specific areas where the target pests travel. The dusts are not eaten – so must be applied in areas where they will make contact with the bodies of insect pests. For ant control, it is often applied to cracks and crevices and may also be used in conjunction with caulks and foams to fill problem areas.

6.5.2 Cockrocaches

6.5.2.1 Background

One of the most common structural nuisance insect pests in North America is the cockroach (Olkowski et al. 1991). Though rarely carrying disease or causing major economic damage to our structures, it is typically considered unacceptable in our homes and workplaces; triggering psychological distress, embarrassment, and general feelings of disgust. Cockroaches do consume human foodstuffs and wastes, and can contaminate them with saliva and excrement. In some cases, they carry disease and may be linked to increased asthma rates (CDC 2013a).

Cockroaches are scavengers of plant materials; as a result, they prefer carbohydrates over fats and proteins. They consume any human food or food waste that contains significant carbohydrates in addition to materials such as pastes, glues, and soaps. Most common cockroach species can only exist in high humidity and high temperature environments such as those present in human structures.

Several different species of cockroaches occur as pests in Northern California and each has separate behaviors and habitat preferences that dictate different types of pest management. The non-native

German cockroach (*Blatella germanica*) is the smallest and most widely spread pest cockroach in North America. It has three life stages: egg, nymph, and adult. German cockroaches prefer dark, warm, and humid hiding places and they are common in basements, kitchens, and bathrooms. They are thigmotactic, meaning they prefer to rest in small cracks where their stomach and back touches surfaces during most of the day, so regular inspection of crack areas can sometimes aid in cockroach detection in buildings. Unlike ants, they are solitary insects but since preferred habitats are rare in buildings, it is common to find large numbers of cockroaches hiding in the same general areas. German cockroaches are ubiquitous in human environments that occur in temperate climates so complete pest eradication is almost never achievable. Cockroaches regularly disperse in cartons, boxes and other containers coming to and from grocery stores, warehouses, flower shops, and other shipments, and are thus are likely to always be present in human environments. Strategies such as sealing exterior cracks/holes in buildings and strict sanitation measures both inside and out of buildings will help maintain their populations at nearly indiscernible levels which should be sufficient for most Authority properties.

6.5.2.2 Pest Management Strategies for Cockroaches

6.5.2.2.1 Prevention

- Clean all kitchen and food storage surfaces regularly; sweep and vacuum kitchen floors daily. Shared-use appliances such as sinks, microwaves, and vending machines should be cleaned regularly to eliminate spills.
- Store all food properly. Store all food in containers with tight-fitting lids, or in the refrigerator or freezer.
- Rinse recycling waste if it is temporarily stored in open bins. Alternatively, store all waste in containers with tight fitting lids/seals or place open bins on insect-proof bases (Antser™ bases) and always line trash bins with plastic bags. Regularly take out the garbage to an outside storage area/dumpster.
- Do not leave pet food in open bowls overnight. Wash pet food bowls after the pet is done eating.
- Ensure all exterior windows that open have insect screens to prevent roaches from gaining entry into structures.

6.5.2.2.2 Physical Control

- Use caulking, silicone, or expanding foam to fill cracks, holes, or other entry points where cockroaches are known to hide or enter structures. If multiple entry points are suspected, inject diatomaceous earth dust into cracks before sealing.
- If hiding places are unknown, use a sticky-trap monitoring program to determine where in the building roaches are hiding.

6.5.2.2.3 Chemical Control

Only baits in tamper-proof stations will be used indoors; these chemical control options are described below.

- **Diatomaceous Earth.** DE is a silica-based, naturally occurring mineral product that works as a generalist insect pesticide. It is composed of the fossilized silica cases of marine diatoms that have been mined from ancient marine sediments. The dusts are considered non-toxic although care should be taken to not inhale large amounts of dust during application as all mineral and wood dusts are considered hazardous in extremely large amounts. Food-grade DE is available to mix directly in human and pet foods to manage pests that occur in bulk food storage. DE works by mechanically abrading an insect's exoskeleton that leads to dehydration and eventual death of the insect. DE is non-selective so it must be used only in specific areas where the target pests travel. The dusts are not eaten – so must be applied in areas where they will make contact with the bodies of insect pests. For cockroach control, they are often applied to cracks and crevices and may also be used in conjunction with caulks and foams to fill problem areas.
- **Boric Acid Dusts.** Boric acid is a naturally occurring compound found in many fruits and vegetables, but in concentrated doses, can be an effective stomach poison for insects. Boric acid dusts are highly effective for cockroach control when applied to cracks and crevices where cockroaches are known to occur. The dusts (when kept dry) have a long service life and provide control for many years after application. They are practically non-detectible to cockroaches, so unlike many other chemical products that cockroaches can detect and avoid, they offer one of the more effective methods for cockroach control (Gore and Schal 2004). Since they have such a long service life, they are effectively applied inside building walls, plenum (false) ceilings, crawlspaces and other relatively inaccessible areas where cockroaches can occur. Boric acid dusts are relatively slow acting compounds that take up to 10 to 15 days to achieve effective elimination of problem insects so they should generally be used in compliment with a baiting program to achieve full control of cockroach outbreaks.
- **Hydroprene.** Hydroprene is a synthetic insect growth regulator (IGR) that mimics juvenile insect hormones to regulate insect pest populations. Although they do not poison an insect directly to cause a lethal effect, they do interrupt the development cycle of juvenile cockroaches so they do not ever reach a reproductive stage. This mode of action can be important to reducing adult populations by preventing young insects from reaching adulthood and breeding in a long term control strategy. For this same reason, hydroprene is considered highly specific to insect pests and has low toxicity for birds and mammals, species that do not possess these same types of growth hormones. IGRs are not an ideal stand-alone control, but they are effective when used in combination with other methods to reduce populations of troublesome insects.
- **Fipronil insecticidal baits.** Fipronil is a relatively recently developed, broad-spectrum insecticide common in household cockroach/ant baits and flea sprays for pets. When used as cockroach bait, it is toxic to insects through ingestion where it blocks chloride channels in the central nervous system. This results in excess neuronal stimulation and death of the target insect pest. It has higher binding affinity in insect receptor sites versus mammalian receptors so it is considered highly selective for insects and safe to use in human environments

(Jackson et al. 2009). Fipronil is relatively quick acting compared to other natural pesticides. It should be used as a last-resort option when extremely high populations of cockroaches must be controlled quickly. As it is insecticidal bait, only small amounts of bait are necessary to control cockroaches effectively compared to knockdown sprays that must be applied much more widely in the environment.

- **Indoxacarb insecticidal baits.** Indoxacarb is a synthetic, non-systemic insecticide effective on chewing and sucking insects. When used as cockroach bait, it is toxic to insects through ingestion where it blocks sodium channels in the central nervous system resulting in paralysis and elimination of the target insect pest. It replaces more hazardous organophosphate insecticides while still providing a fast acting, quick knockdown pest control option. Indoxacarb is a quick acting insecticide and offers exceptional German cockroach control potential. In laboratory conditions, small amounts of gel baits can provide several generations of control when the product is re-consumed through feces, regurgitates, and through bodily contact from the primary exposed individual cockroach (Buczkowski et al. 2008). This product is recommended for last-resort options in challenging cockroach pest control scenarios.

6.5.3 Flies

6.5.3.1 Background

Flying insect pests such as flies can be problematic inside buildings. In our region, the most common pest fly species, also referred to as filth flies, are common house, stable, and greenbottle flies (Calliphoridae and Muscidae families). Common houseflies and greenbottle flies tend to be the most problematic groups of filth flies that cause pest problems in buildings and other public spaces. The presence of filth flies is generally indicative of unsanitary conditions, which makes them undesirable. They can also carry disease pathogens to humans through feces and regurgitation.

Pest flies breed in animal wastes and decaying organic material from which they can pick up bacteria and viruses that may cause human diseases. In addition, adult stable flies feed on mammalian (livestock) blood and can offer a painful bite. All flies undergo complete metamorphosis with egg, larva, pupa, and adult stages in their development. The female fly deposits her eggs in animal waste or moist organic material where the larvae, or "maggots," complete their development, feeding on wastes until they pupate in a dry location.

6.5.3.2 Pest Management Strategies for Filth Flies

6.5.3.2.1 Prevention

- Clean all kitchen and food storage surfaces regularly; sweep and vacuum kitchen floors daily. Shared use items such as sinks, microwaves, and vending machines should be cleaned regularly to eliminate spills.
- Store all food properly. Store all food in containers with tight fitting lids, or in the refrigerator or freezer.

- Rinse recycling waste if it is temporarily stored in open bins. Alternatively, store all waste in containers with tight fitting lids/seals or place open bins on insect-proof bases (AntserTM bases) and always line trash bins with plastic bags. Regularly take out the garbage to an outside storage area/dumpster.
- Ensure outside garbage cans and dumpsters have tight-fitting lids to prevent flies from completing their life-cycles in waste cans.
- If garbage cans do not have tight fitting lids, use cedar sawdust to layer over wet/organic waste in the trash bins to prevent flies from accessing food waste.
- Clean trash bins regularly with pressure washer or soap/water to ensure no thick layers of organic wastes build up in the bottom of cans.
- Ensure all exterior windows that open have tight-fitting insect screens to prevent flies from gaining entry from outside.
- For stables and other enclosed livestock areas, remove animal wastes on a regular basis and dispose in sealed containers or in managed compost piles.

6.5.3.2.2 Physical Control

- Use caulking, silicone, or expanding foam to fill cracks, holes, or other entry points in building exteriors where flies can gain entry.
- In problem areas, use sticky fly traps (ribbons) to capture excess adult flies and remove them from building interiors.
- Use baited electric traps for problem outside areas such as picnic grounds, barns, or livestock areas.

6.5.3.2.3 Chemical Control

In most residential and commercial situations, pesticides are not needed or recommended for control of flies, as they are not effective. Sanitation methods along with screens to keep flies out of buildings should be sufficient for nuisance fly control outside of agricultural facilities with livestock. Fly traps and strips used in problem trash areas may be effective in reducing the number of adult flies if proper sanitation practices are followed.

6.5.4 Mice

6.5.4.1 Background

The house mouse (*Mus musculus*) and deer mouse (*Peromyscus* sp.) are both small rodents that readily invade human structures in search of shelter and food. The house mouse is a widespread species that has been linked to human culture for over 1,000 years (Timm 1994). It is now found on every continent except Antarctica. Deer mice are native to California and most other parts of North America. They are common in nearly every habitat in their range – from deserts to forests and also in urban and suburban areas that interface with natural areas.

Both types of mice are omnivorous but generally prefer grain, seeds, and nuts. Both are nocturnal, have similar reproductive traits and reside in nests composed of fibrous materials. All mice species that are considered pests are capable of extremely high reproductive rates anytime during the year, making control difficult. House mice are rather plain looking versus deer mice that have light/dark fur color schemes, white feet, large eyes, and large ears.

Mouse damage includes the consumption of human foods, building nests in human structures, defecation, physical gnawing, damage to paper, clothing and other textiles and the vectoring of disease. House mice are known to carry salmonellosis, leptospirosis, and a variety of other diseases but transmission to humans is rare.

6.5.4.2 Pest Management Strategies for Mice

6.5.4.2.1 Prevention

- Ensure outside garbage cans and dumpsters have tight-fitting lids to prevent mice from foraging on human food waste. This is especially important in public gathering areas in parks and open spaces. Cans with domed lids and self-closing, hinged lids are preferred in these outside areas.
- Clean all kitchen and food storage surfaces regularly; sweep and vacuum kitchen floors daily. Shared use items such as sinks, microwaves, and vending machines should be cleaned regularly to eliminate spills.
- Store all food properly, in containers with tight fitting lids, or in the refrigerator or freezer.
- Store native seeds, hay, and other vegetation-based materials that can attract mice properly in sealed containers or designated sealed storage facilities.
- Do not leave pet food in open bowls overnight. Wash pet food bowls immediately after feeding.

6.5.4.2.2 Habitat Modification

- Use silicone caulking and stainless steel/bronze mesh to plug/fill cracks and holes greater than ¼" in the exterior of building where mice could gain entry. Focus especially on utility penetrations, as mice are known to travel along pipes/wires. Avoid using carbon steel wools and expandable foams that degrade quickly and require repeat maintenance.
- Ensure all exterior windows that open have tight-fitting insect screens to prevent mice from gaining entry from the outside when windows are opened.
- Use galvanized sheet metal to create climbing barriers and exclude mice from travelling up vertical posts where necessary (pet cages/food storage tables/etc.).
- Mouse-proof storage facilities and seasonal buildings after visitor season ends to reduce possible nesting areas.

6.5.4.2.3 Physical Control

- **Snap Traps.** Basic hardware store mouse traps offer one of the most effective means for mouse population control when executed with enough preparation, time, and effort. When uncontrolled mouse populations are present, snap traps can be used to "knockdown" large populations and then maintained to keep the population under control. Mice generally travel very short distances throughout their life – space traps approximately every six feet where mice are active. Time must be invested in determining where mice are active and then setting traps in appropriate locations. Pre-baiting will help prevent trap shyness and allow for the operator to test appropriate baits. Only highly desired baits should be used in the actual trapping program. Most mice species are not as trap shy as roof and Norway rats.
- **Box Traps.** Several types of box traps are available that are capable of trapping multiple individual mice per trapping event. These traps operate on the principal that mice are attracted to small openings and are naturally inquisitive. These traps are most successful for house mouse control. Traps should be inspected on a daily basis so live trapped mice can be humanely dispatched.

6.5.4.2.4 Chemical Control

Chemical control of mice should not be considered except under very unusual (human health and safety considerations). In the unlikely event that chemical control of mice is deemed necessary, refer to the Chemical Control sections for rats, below.

6.5.5 Roof, Norway, and Wood Rats

6.5.5.1 Background

Roof rat (*Rattus rattus*), Norway rat (*Rattus norvegicus*), and Dusky-footed woodrat (*Neotoma fuscipes*) are medium sized rodents that readily invade human structures in search of shelter and food. With the exception of the native woodrat, rats represent some of the most challenging pest rodents to control in urban environments (Marsh 1994). Roof and Norway rats can be present in very large numbers in urban areas. Their home ranges are much larger than those of mice so effective treatment is challenging and may require treatment of more than a single structure. Both the roof and Norway rat are a widespread pest species that have co-evolved with humans for thousands of years.

Dusky-footed woodrats are native California mammals that are occasionally considered pests when they invade structures from nearby wildlands. All woodrats found on Authority lands are the San Francisco Dusky-footed woodrat (*Neotoma fuscipes annectens*) which is a CDFW Species of Special Concern. Control of woodrats, as with all native species, should first focus on prevention instead of physical or chemical control.

Like cockroaches, rats trigger general feelings of disgust in humans as they are thought to be representative of dirty living conditions and squalor. They do bite, and many people in the U.S. suffer from rat bites each year. Rats are known to carry diseases that can be transmitted to humans. The majority of actual rat damage in the United States is due to structural damages caused by burrowing (Norway rats), defecation and contamination of food products, textiles and living spaces (Norway/roof/wood rats), and damage to agricultural crops and landscaping (roof rats). Woodrats

typically build elaborate nests in wildland areas, but can also be nuisance pests in structures where they make nests and cache food.

6.5.5.2 Pest Management Strategies for Rats

6.5.5.2.1 Prevention

- Ensure outside garbage cans and dumpsters have tight-fitting lids to prevent rats from foraging on human food waste. This is especially important in public gathering areas in parks and open spaces. Cans with domed lids and self-closing, hinged lids are preferred in these outside areas.
- Clean all kitchen and food storage surfaces regularly; sweep and vacuum kitchen floors daily. Shared use items such as sinks, microwaves, and vending machines should be cleaned regularly to eliminate spills.
- Store all food properly, in containers with tight fitting lids, or in the refrigerator or freezer.
- Do not leave pet food in open bowls overnight. Wash pet food bowls immediately after feeding.

6.5.5.2.2 Habitat Modification

- Inspect building exterior for possible rodent entryways. Especially inspect attics for signs of rat occupation and openings or gaps between the structure and roofs or foundations. Use silicone caulking and stainless steel/bronze mesh to plug/fill cracks and holes greater than ½" in the exterior of building where rats could gain entry. Focus especially on areas where utilities enter the buildings, as rats are known to travel along pipes/wires. Avoid using carbon steel wools and expandable foams that degrade quickly and require repeated maintenance.
- Ensure all exterior windows that open have tight-fitting insect screens to prevent rats from gaining entry from the outside when windows are opened.
- Use galvanized sheet metal to create climbing barriers and exclude rats from travelling up vertical posts where necessary (e.g., utility poles, pet cages, food storage areas, tables).
- Rodent-proof storage facilities and seasonal buildings after visitor use season ends to reduce possible nesting areas.
- If they appear to be a constant source of infestation, woodrat nests within 100 feet of buildings will be moved after consultation with the California Department of Fish and Wildlife.

6.5.5.2.3 Physical Control

Basic hardware store rat traps offer one of the most effective means for rat population control in small structures with small rodent populations. Where large rat populations are present, snap traps can be used to "knock down" the population size in conjunction with other management techniques (prevention, habitat modification) to keep the population under control. Time must be invested in determining where rats are active and then setting traps in appropriate locations. Roof and Norway rats are inherently wary of new objects in their environment, including rat traps. Pre-baiting is essential to

allow rats to associate rat traps with feeding stations, a process that may take several weeks. Only after rats have become used to traps should the trapping portion of the control effort move forward.

6.5.5.2.4 Chemical Control

The Authority is aware of the potential for secondary effects of rodenticide use in and near natural lands on native wildlife species and currently does not use rodenticide on its lands. If a future situation occurs where rodent infestations are determined to present a public health issue, the Authority will use all non-chemical control options before selecting rodenticides as a treatment option, except in instances where rodent infestations are determined to present a public health issue. The following section carefully lays out the effects and limitations of each type of rodenticide product and provides guidance for staff selection of the least toxic effective treatment option in the event that chemical control of rodents must be utilized.

Primary versus Secondary Poisoning. Non-target poisoning is divided into two scenarios: 1) a non-target animal intercepts the bait – referred to as "primary exposure"; and 2) a non-target animal ingests a prey species that has been exposed to the toxicant – referred to as "secondary exposure." Rodenticides typically have high degrees of mammalian toxicity compared to other types of pesticides so it is important to control how these compounds are presented to target rodent pests. Acute toxicant baits can attract non-target mammals and birds so these baits must be presented in environments where only rodents have a chance of encountering them.

Sealed box bait stations are now common for nearly all rodent baits used in structures to prevent pets and people from encountering the baits. Bait stations are usually designed for urban environments and they offer little protection to stronger wildlife species such as raccoons, badgers and bears that can easily open them (Erickson and Urban 2004). To better protect non-target wildlife species in the urban-wildlife interface, custom protective devices can be installed to shield bait stations from non-target wildlife species. Because predators generally prefer to catch and eat live prey, acute toxicants (the products that work quickly on the target animal resulting in a quick mortality) rarely cause secondary exposures to predators and scavengers.

Acute Rodenticide – Cholecalciferol (Vitamin D3). Cholecalciferol is a natural form of Vitamin D that is industrially synthesized from lanolin (sheep's wool) to produce human dietary supplements and rodent poison. In very high doses, it causes mobilization of calcium from the bone matrix to blood plasma, causing hypercalcemia and death. It is especially toxic to rodents and a single dose of toxicant acts as an acute poison. It is the only current rodenticide in California labeled for organic food production (OMRI 2013). Cholecalciferol is considered a novel mode of action for rodenticides and can be used in urban areas where rodents have developed resistance to other anticoagulants (Marshall 1984). It is considered a low risk for secondary poisoning in wildlife but can be a hazard to non-target pets that directly consume the bait. Rodenticides will only be used inside in tamper-proof anchored containers.

6.5.6 Skunks, opossums and raccoons

Skunks, opossums, and raccoons are native mammals that have the potential to take residence in Authority structures as unwelcome guests. All these species are extremely common on Authority lands and generally will not bother humans. On rare occasions, they may invade trash cans, open kitchens, or

den under and within structures. CDFW regulates these species as nongame or furbearer animals so they all may be controlled without permits if found causing agricultural damage or nuisance problems.

6.5.6.1 Prevention

- Ensure outside garbage cans and dumpsters have tight-fitting lids to prevent foraging on human wastes. This is especially important in public gathering areas in parks and open spaces. Cans with domed lids and self-closing, hinged lids are preferred in these outside areas.
- Clean all kitchen and food storage surfaces regularly; sweep and vacuum kitchen floors daily. Shared use items such as sinks, microwaves, and vending machines should be cleaned regularly to eliminate spills.
- Do not leave pet food in open bowls overnight. Wash pet food bowls immediately after feeding.

6.5.6.2 Habitat Modification

- Use stainless steel/bronze mesh or welded wire to plug/fill cracks and holes in the exterior of building where large animals could gain entry.
- For larger openings, such as under decks and porches, fully enclose with plywood, concrete or wire mesh to prevent animals from making dens under structures. If animals are already denning in the areas, use one-way, hinged doors to allow them out but preventing them from returning. Confirm there are no juvenile animals in the den before using one-way doors.
- For raccoons in challenging areas, a single electrified strand of wire elevated eight inches from the ground can be used to deter them entering the area.

6.5.6.3 Physical Control

All skunks, opossum, and raccoons are easily trapped with live box or cage traps. Trap design varies but solid wall traps are preferred for skunks to shield the trapper from skunk spray during the control operation. The use of live trapping methods ensures that non-target animals can be released unharmed. Current CDFW trapping regulations requires that trapped animals are either released immediately or euthanized, live animals may not be relocated without a permit from CDFW.

6.5.6.4 Chemical Control

Currently there are no toxicants or fertility control agents available in California for these species.

6.5.7 Ground Squirrels

California ground squirrel (*Spermophilus beecheyi*) is a species native to California. Although it is native, it is not a protected species. These animals can become a pest when they burrow under structures. Burrows can cause damage to the foundation of a building and to footpaths and roadways by undermining them. They can also harbor diseases harmful to humans, particularly when squirrel

populations are numerous, including bubonic plague which is transmitted to humans by fleas that the squirrels carry.

The California Fish and Game Code classifies ground squirrels as nongame mammals. An owner or tenant can control, in any legal manner, nongame mammals that are injuring growing crops or other property; tree squirrels, on the other hand, are classified as game animals and have a hunting season and require a permit by CDFW. The Authority does not control tree squirrels and does not intend to.

6.5.7.1 Prevention

- Ensure outside garbage cans and dumpsters have tight-fitting lids to prevent foraging on human wastes. This is especially important in public gathering areas in parks and open spaces. Cans with domed lids and self- closing, hinged lids are preferred in these outside areas.
- Clean all kitchen and food storage surfaces regularly; sweep and vacuum kitchen floors daily. Shared use items such as sinks, microwaves, and vending machines should be cleaned regularly to eliminate spills.
- Do not leave pet food in open bowls overnight. Wash pet food bowls immediately after feeding.
- Do not actively feed squirrels near buildings or on Authority preserves.

6.5.7.2 Habitat Modification

- Remove brush piles and debris and keep breezeways of barns clear of material.
- Exclude ground squirrels from digging under a building by installing a curtain wall of concrete.

6.5.7.3 Physical Control

Ground squirrels may be trapped using multi-catch live traps in structures and removed. This could be followed by exclusion to keep the ground squirrels out of the structure.

6.5.7.4 Chemical control

Chemical control of ground squirrels should not be considered except under very unusual circumstances (human health and safety considerations). The Authority does not currently use rodenticides and would only use it in the future as a last resort. In the unlikely event that chemical control of ground squirrels is deemed necessary, Authority staff would consult with experts to deem the least harmful and most appropriate method of control. If new chemicals are available, these would be evaluated on a case by case basis. Some resources include http://www.groundsquirrelbmp.com/ and http://ipm.ucanr.edu/.

6.5.8 Bats

Bats are California's only flying mammal. There are a wide variety of bats (more than 16 species in all) that inhabit all habitats in the Bay Area; some are solitary and others colonial. All California bat species are insectivorous and they provide an ecologically valuable service of consuming vast quantities of

insect pests such as mosquitos (Gannon 2003). Though they generally benefit humans greatly, bats secretive nature, nocturnal habits, coarse appearance, ability to fly, and habitation near humans have contributed to folklore, superstition, fear and ultimately persecution.

Some species of colonial bats can become structural pests when they establish colonies in homes or other human structures. Some species prefer dark open spaces, such as attics and basements and others prefer small cracks/crevices, such as between roof tiles/shingles or behind shutters (Greenhall and Frantz 1994). One human structure can actually support a wide diversity of bat species. Though many bat species are tolerant of humans, many humans are not tolerant of bats.

Common nuisances or damages caused by bats are noise coming from bat roosts, smells coming from their urine and guano, potential disease such as rabies and histoplasmosis, and discomfort anytime their presence is too close to humans in structures (CDFW 2008). Most bat damage can be mitigated with prevention and habitat modification techniques to make human structures less inviting or completely exclude bat roosting.

6.5.8.1 Prevention and Habitat Modification

- Carefully assess where bats are entering structures and modify the building to exclude future entry. Since bats are extremely small, fly, and can squeeze into very small spaces, assessing bat entry points can be a tedious and challenging exercise. Evaluate spaces during day/nighttime hours, and use smoke pens and infrared cameras to assist in detecting breeches to the building envelope. Consult bat exclusion specialists for challenging structural projects.
- Install flashing, screening or netting in obvious roof/gable areas where bats can roost.
- Caulk cracks in masonry, especially chimneys.
- Use one-way trap doors to allow bats to escape roost areas after exclusionary methods are completed.

6.5.8.2 Trapping

Trapping is not recommended as its more time consuming and less effective than strategic exclusion as discussed above.

6.5.8.3 Chemical Control

Currently there are no toxicants or fertility control agents available in California for these species.

6.5.9 Feral domestic pets

Domestic pets such as feral cats and stray dogs can sometimes become structural pests. Uncontrolled feral domestic pets, unlike most wildlife, are often highly habituated to humans and therefore more likely to come in very close contact with people. These close encounters can lead to increased chances of physical injury, disease transmission, and contamination of Authority facilities.

Cats and dogs are generally considered private personal property when ownership can be established through collars, registration tags, microchips, tattoos, brands or other proof of ownership. Pets without identification can be considered free roaming, uncontrolled private property or feral (wild) animals. In California, both state and local laws govern domestic animal damage control under Fish & Game, agriculture codes, and local ordinances. Authority staff will consult local city and county ordinances and animal control departments when conducting any domestic animal control actions.

6.5.9.1 Prevention and Habitat Modification

- Feral domestic pets are often relics of old structures/settlements. If the Authority inherits older buildings/infrastructure, consider demolition or wildlife exclusion retrofitting so the structures can no longer support animals.
- Control of excessive rodent populations in structures can also help control feral cat populations.
- Ensure outside garbage cans and dumpsters have tight-fitting lids to prevent foraging on human food waste. This is especially important in public gathering areas in parks and open spaces. Cans with domed lids and self-closing, hinged lids are preferred in these outside areas.
- Ensure Authority staff have properly placed any bird feeders or bird nest boxes such that they do not also serve as cat feeding stations.
- Prohibit staff visitors from feeding feral domestic pets on Authority property. Develop education programs to encourage the public not to feed wildlife or feral animals on Authority property if needed.

6.5.9.2 Trapping

Live trapping is effective to capture problem cats but generally ineffective for dogs in California (Fitzwater 1994, Green and Gipson 2012). Because feral domestic pets may be private property, Authority staff will conduct all trapping in conjunction with local animal control departments and/or animal shelters.

7 Guidance for Pest Control in Recreational Facilities

7.1 Definition and Purpose

Recreational facilities within Authority Preserves are areas where the public use is most likely to occur. Recreational facilities include parking lots, roads and trail, bridges, gates, bathrooms, picnic areas, etc. Nuisance pests in and around recreational facilities are plants, insects, and wildlife that can temporarily affect the Authority's visitor experience in a negative manner. Sometimes managing nuisance pests involves managing the facility so that extra resources attracting the pest are no longer found (i.e., controlling trash in picnic areas). Other times nuisance pests may be removed.

The purpose of pest control in and around recreational facilities is to manage pest for human enjoyment of the natural and scenic qualities of the preserves and to ensure access on roads for safety purposes. The outdoor nature of the preserves implies a certain amount of nuisance pests are expected to be found on preserves (i.e. biting insects, poison oak). The determination of a nuisance pest can be variable depending on the tolerance level of the staff or visitors. Any pest control solution must also consider protection of the surrounding natural resources as a primary consideration.

7.2 Types of Pests

Nuisance pests include native and naturalized plants, insects and wildlife that are present throughout the region and are usually compatible with public use of the preserves. Conflict only occurs when these species become overabundant or exceptionally close to staff and visitors. For example, native social wasps in outside areas would normally be tolerated, but a wasp nest in a public bathroom would be considered an unacceptable risk to visitor health and enjoyment of Authority facilities. Other types of pests include mosquitos, ticks, rattlesnakes, and native vegetation such as poison oak, stinking, or scratching plants. Treatment is also dependent on the amount of use a facility receives. For instance, brushing (removing) poison oak at trailheads and picnic areas is more appropriate than doing so along a remote trail.

7.3 Pest Management Strategies

Many pest encounters can be managed with cultural control options such as changing human behavior. These types of activities include removing food-related trash and installing educational signs about how to identify poison oak and the harm of feeding wildlife. Other types of prevention involve engineering control such as securing garbage cans and sealing off structures. Many of the strategies for structures (Section 6) will also reduce pests in recreational facilities (such as securing openings to buildings).

Many nuisance pests can be managed through preventative treatments based on an understanding of their biology and behavior. Vegetation types that are regularly mowed with mechanical equipment have predictable regrowth times that can be incorporated into routine maintenance schedules. To prevent road and trailside vegetation from becoming a nuisance pest, mechanical brushing can be scheduled for specific times of the year to prevent the hazard from becoming a problem. Roadside brushing also serves the purpose of reducing the chances of visitors and staff encountering ticks and rattlesnakes along trails and roads.

Pest management options for nuisance pests in and around recreational facilities are the same for the insect and wildlife species in buildings (Section 6). The following describes strategies for additional nuisance pests not addressed in that section, which summarized in Table 18.

Table 18: Pests in recreational areas and their treatments

Pest	Treatment
Mosquitos	Use a combination of the following: • Inspect areas in vicinity of problem area for standing water and other potential mosquito breeding sites. Where possible, repair or drain/eliminate potential breeding habitats • Educate visitors about mosquitos and human health risks by posting temporary signs in problem areas • Protect workers by requiring use of protective clothing when working in affected areas • For ongoing pest issues, contact the Santa Clara County Vector Control District to schedule treatment (to comply with legal requirements to control mosquitos for human health and safety).
Social Wasps	For populations causing human conflict near structures use a combination of the following: • Remove or enclose attractants in well-sealed containers (trash cans, etc.) • Use baited non-toxic water traps (late winter and early spring) • Use non-toxic lure traps set approximately 200 feet apart. For nests that pose an immediate threat to human safety: • Physically remove problem nests with water jets or by digging • Use Pyrethrin aerosol spray to target individual nests
Ticks	For detections of multiple individuals in work areas or offices use a combination of the following: • Remove and destroy individual ticks • Follow preventative trail maintenance procedures for native vegetation
Rattlesnakes	For individuals within structures or recreational facilities where contact with humans is likely use a combination of the following: • Trap and relocate • Block access to structures and remove hiding places adjacent to structures and high public use areas.
Native vegetation along roads and trails (poison oak, stinging or scratching plants, brush)	For vegetation causing severe discomfort or hazards to visitors and staff, limit sight lines, or that are blocking emergency access: • Mow and prune buffers along trails and roads to reduce direct contact • Herbicide use if needed, particularly for perennial species

Table modified from MROSD IPM Guidance Manual (May and Assoc. et al. 2014)

7.3.1 Mosquitos

7.3.1.1 Background Information

Mosquitos are a family of small, midge-like flies in the *Culicidae* family. Most mosquitoes are considered a pest because they consume blood from vertebrates, including humans, and can transmit diseases and cause uncomfortable dermatitis. Mosquitos go through four life stages: egg, larva, pupa, and adult. The first three life stages are largely aquatic and last approximately 14 days. Control of wet areas, including stagnant standing rain water, stock ponds, and ponded water from leaky pipes are therefore an effective control strategy for controlling this pest species, although this strategy needs to be balanced with natural resource protection. The females of many, but not all species of mosquitoes, consume blood during a portion of their life cycle. In feeding on blood, some species of mosquitos can transmit extremely harmful human and livestock diseases, such as West Nile virus. Therefore, pest control should focus on elimination of stagnant water and wet area habitat, as well as on control of adults' population numbers, where a health concern is detected.

Although mosquitos are members of the ecosystems of natural areas, the threat of mosquito bites makes them unwelcome in and near buildings and recreational facilities. Mosquitos are generally only considered pests when their population numbers are incompatible with human health and safety, at which point the Authority will contact the Santa Clara County Vector Control District.

7.3.1.2 Pest Management Strategies for Mosquitos

7.3.1.2.1 Prevention

In addition to the actions taken by the Santa Clara County Vector Control District to detect and control mosquito populations in natural areas, the Authority can also implement many non-chemical, cultural control methods to prevent infestation or reduce the number of adult mosquitoes that come into contact with workers and visitors. Depending on the situation, the most important usually include:

- Source reduction (e.g., removing stagnant water around public use facilities), and
- Education (e.g., posting public information signs to inform visitors about mosquitos and human health risks).

7.3.1.2.2 Physical Control

- Install and maintain window screening in recreational buildings.
- Train staff to protect themselves from exposure by wearing long-sleeved clothing, tucking pant legs into socks and/or taping pant cuffs close to the body.

7.3.1.2.3 Chemical Control

Where chemical control is determined to be the only viable treatment option for a specific concern to human health and safety around a recreational facility, the Authority will contact the Santa Clara County Vector Control District for assistance.

7.3.2 Social Wasps

7.3.2.1 Background Information

Social wasps are a large group of native stinging insects that include yellow jackets, hornets, and mud daubers. Wasps' yellow and black color schemes and social behavior are shared with distantly related bees. Like bees, wasps are an important group of native insects that perform valuable ecological functions in our natural world (Hinkle et al. 2002). Most of the species in this group are generalist insect predators that are essential in their natural environments to aid in decomposition, control populations of other insects, and some even pollinate flowers like bees. Although wasps are important members of the ecosystems of natural areas, the threat of wasp stings makes them unwelcome intruders in and near buildings and recreational facilities. Social wasps are generally only considered pests when their nests are located in areas where they are incompatible with human use. For example, when social wasps nest under the eaves of buildings or alongside trails, they can sometimes exhibit aggressive protective behaviors that can threaten humans with painful and sometimes dangerous stings. Where multiple stinging incidents occur, Authority staff will consider control of wasp nests.

Wasps belong to a large group of insects in the family *Hymenoptera* that includes ants, bees, and wasps. Many genera and species within *Hymenoptera* are difficult to tell apart as they share similar body shapes and color schemes. Because many of these *Hymenopteran* insects have protective stings and bites, even some other species outside the family like flies have adapted their body styles to mimic wasps. For this reason, staff must be careful to properly identify the pest to species to ensure that it is an actual nuisance pest species that can sting, rather than a similarly shaped or colored harmless species.
Like bees, wasps are social organisms that live together in colonies where individuals have specialized roles. Queens emerge from hibernation each spring to build nests and start larger colonies composed of workers. Pupae are raised in cell-like structures within paper or mud nests that are tended by workers and queens. Different species build different types of nests – from small mud structures that are attached to ledges to aerial and underground paper-type nests. Different species also have different foraging habits. Some prefer hunting for carrion and sweet liquids while others prefer hunting live prey. The species that forage for carrion and sweet liquids are often the most problematic individuals that disturb picnickers.

7.3.2.2 Pest Management Strategies for Social Wasps

7.3.2.2.1 Prevention

- Ensure outside garbage cans and dumpsters have tight-fitting lids to prevent wasps from foraging on human food wastes. This is especially important in public picnic and gathering areas

in parks and open spaces. Can with domed lids and self-closing, hinged lids are preferred in these outside areas.

- Periodically clean the hinged-lids of garbage and recycling bins so spilled sweet liquids do not attract wasps to picnic areas.
- Ensure all exterior windows that have tight-fitting insect screens to prevent wasps from gaining entry from the outside when windows are opened.

7.3.2.2.2 Physical Control

- Install baited non-toxic water traps in late winter and early spring to reduce queens in problem areas where wasps are known to be regularly problematic.
- Install pesticide-free lure traps set approximately 200 feet apart in outside problem areas where human/wasp conflicts are known to occur (e.g. picnic areas, outside amphitheaters). Place traps between the center of human activity and natural areas in an attempt to attract wasps away from humans instead of attracting more wasps to human areas. Remove the traps when the problem is resolved so that other insects are not affected.
- Physically remove problem wasp nests with water jets or by digging them out of underground locations. Ensure pest control workers wear protective beekeeper suits to reduce the potential for dangerous stings.

7.3.2.2.3 Chemical Control

Pyrethrin Aerosol Sprays. Pyrethrin-type aerosol sprays containing d-trans allethrin and phenothrin are only recommended where immediate threats exist to human health and safety. These aerosol sprays are extremely effective at immediately eliminating single, problem wasp nests that threaten Authority staff or visitors. The pyrethrin-type sprays work as a contact neuro-poison that results in near immediate mortality of any insect (Jackson et al. 2011). The sprays offer a relatively safe and effective means for Authority staff to respond to immediate threats of wasp nests. Contact pyrethrins are completely non-selective, so care must be taken to target only the pest wasp and not to impact other beneficial insects. Contact sprays do not offer population-level control for wasps; diligent sanitation and early seasonal queen trapping are the only known methods to effectively reduce populations of stinging wasps in open landscapes.

7.3.3 Ticks

7.3.3.1 Background Information

The western black-legged tick (*Ixodes pacificus*) is a native arachnid (i.e., spider relative) that is very common in grasslands, scrub, and woodlands throughout Authority lands. Black-legged ticks are common parasites of native mammals such as deer, but they can also be problematic parasites of Authority visitors and staff. To complete their life cycles, ticks must feed on blood and for this reason

can also be dangerous vectors that can transmit blood-borne diseases such as Rocky Mountain spotted fever, Lyme disease, and tularemia (CDC 2013b). Ticks are an important part of the natural environment and are present on Authority lands in abundance. Due to their prevalence in naturally occurring deer populations that move through Authority lands, eradication of ticks in natural areas is impossible; however, some level of preventative control may be warranted in high visitor use areas in and around recreational facilities and buildings. Ticks can be especially problematic indoors where field staff work and store clothing; staff returning from field work can unknowingly introduce ticks into buildings where they can be transmitted to unsuspecting office workers.

7.3.3.2 Pest Management Strategies for Ticks

7.3.3.2.1 Prevention

- In high visitor use areas, regularly cut or mow alongside trails and picnic areas to reduce the chance of visitors and staff picking up ticks. Ticks often summit tall grass blades and shrub branches to "catch" or brush against a passing animal. Keeping vegetation cut low and pruned reduces the opportunities for ticks to utilize this strategy in areas with high pedestrian use.
- Post tick educational materials in Authority offices and at major trailheads and parking areas.
- Regularly vacuum carpeted areas where Authority employees work.
- Ensure all exterior windows that open have tight-fitting insect screens to prevent ticks from gaining entry from outside when windows are opened.

7.3.3.2.2 Physical Control

- If needed, install carbon dioxide traps to collect ticks where field staff regularly begin and end days. This may be especially effective in staff changing rooms where field clothes are shed, changed, and stored, or where staff enter their daily log information.
- Train staff to protect themselves from exposure by wearing light colored long-sleeved clothing, tucking pant legs into socks, and/or taping pant cuffs close to the body; performing regular inspections of clothing and exposed areas such as the head and neck; and showering or bathing and inspecting their bodies as soon as possible upon completion of work.
- Post educational signs with the information above to help inform visitors of tick prevention and detection strategies they can employ before and after using recreational facilities.
- As ticks are found, remove and destroy individuals. If ticks are already attached to the body, they should be sent in to Valley Health to test for Lyme disease.

7.3.3.2.3 Chemical Control

No chemical control strategies are recommended for ticks.

7.3.4 Rattlesnakes

7.3.4.1 Background Information

Rattlesnakes are the only type of venomous snake found in California. They are native to California and are considered to be important predators that help keep rodent populations under control. Rattlesnakes are generally extremely wary of humans and tend to shy away from human activities. They are not aggressive towards humans unless cornered, surprised, or stepped-on. Occasionally, they can be considered nuisance pests when they find themselves too close to recreational facilities, occupied buildings, or other areas where human encounters are likely. Though important to the natural world, the threat of rattlesnake bites makes them unwelcome pests in certain portions of Authority lands.

7.3.4.2 Pest Management Strategies for Rattlesnakes

7.3.4.2.1 Prevention

- Authority field staff can protect themselves from rattlesnake bites during workdays by wearing high-top leather boots and snake-resistant chaps or gaiters. Snake gaiters are also useful in preventing the dispersal of non-native weed seeds, since weed seeds usually do not penetrate the gaiters.
- Educational materials can warn visitors about rattlesnake hazards and suggest preventative actions such as wearing protective clothing, as described above for Authority field staff.

7.3.4.2.2 Habitat Modification

- Eliminate hiding places for snakes by trailheads, trail right-of-ways, and parking areas with brushing, removing rock and brush piles near busy human use areas especially those with children, and filling cracks and holes in publicly accessible buildings. Use stainless steel/bronze mesh or welded wire to plug/fill cracks and holes in the exterior of buildings where snakes could gain entry.

- Where rattlesnake sightings are common, manage recreational facilities during the spring and summer months to reduce suitable habitat, and especially eliminate hiding places for snakes (e.g., brushing trailheads and parking areas, removing rock and brush piles, managing localized prey populations near known snake problem area, filling cracks and holes in public accessible buildings).

7.3.4.2.3 Physical Control

- Tongs and Funnel Traps. In certain areas (especially in structures and recreational facilities where humans gather and there is potential for snakebites), the Authority may elect to capture and relocate, or eliminate single problem snakes.

- Using snake tongs, snake hooks or shovels, capture and relocate or eliminate problem rattlesnakes. Captured rattlesnakes can be placed in a secure container for relocation in the preserve to suitable habitat away from people. Occasionally, because of site conditions or the urgency of the situation, a staff member or tenant may need to kill a rattlesnake with a shovel.
- Funnel traps can be used to collect problem snakes. Traps must be checked daily to ensure that non-target wildlife is not trapped accidentally.

7.3.4.2.4 Chemical Control

Currently there are no toxicants or fertility control agents available in California for rattlesnakes.

7.3.4.3 Other Native and Domestic Mammals

Section 6.5 discusses management of skunks, raccoons, opossum, and feral cats/dogs,

7.4 Vegetation Management of Trails and Other Recreational Facilities

The majority of IPM activity associated with recreational facilities is annual brushing (i.e. pruning of vegetation along roads and trails) which keeps them open for vehicular, horse, bicycle and human foot traffic, and provides a buffer area to separate humans from pests like ticks, rattlesnakes, and poison oak. Mowers and saws may be used by Authority staff to maintain grass and shrubs near roads and trails in short stature, limb up overhanging tree branches, and remove dead or decadent vegetation. Wider strips of brushing occur along certain roads to provide access for emergency vehicles.
The following section outlines typical vegetation management actions conducted in right of way areas on Authority lands.

7.4.1 Pest Management Strategies for Vegetation Rights-of-way

7.4.1.1.1 Physical Control

Mechanically mow or brush annually to maintain existing recreational facilities:

- **Road and trail brushing**. Mechanical mowing is used to prevent nuisance vegetation from impeding roads and trails. This work is primarily mechanical work and is done with weed whips, hedgers, chainsaws, poles saws, chippers, and tractor-operated mowers. The frequency of brushing depends on the use of the road/trail, weather conditions, and location. Areas of high use or where access is needed for safety are brushed more frequently than remote locations.
- **Parking lots, gates, fences, and stiles.** Mechanical mowing is used to prevent nuisance vegetation from encroaching on or near parking lots, gates and stiles. This work is mechanical and is primarily done with weed whips.
- **Special events**. When special events occur in the preserves each year that require mowing of grassy areas for parking and walking. Events include press events, the Volunteer Recognition Event, and other gatherings.

- **Hazard and downed trees.** Hazard and downed trees are limbed or removed because they present a fall hazard across a public facility such as a trail, are blocking roads, trail, or parking lots, or are otherwise hazardous to visitors, staff, or contractors. The trees may be dead or alive. Stumps of live trees may be treated with herbicide to prevent re-growth.
- **Utility poles and boxes.** Grubbing to bare mineral dirt is used around utility poles and boxes to reduce the risk of fire.

7.4.1.1.2 Chemical Control

Chemical control is typically not used for right-of-way clearing unless perennial plants require permanent treatment (for example, some problem vegetation, such as poison oak, can be eliminated from specific locations with spot application of herbicides.), are near paved surfaces, or around utility poles. Chemicals to be used for vegetation management are listed below.

- **Glyphosate,** the active ingredient in Roundup™ (previously sold as Aquamaster™), is a broad- spectrum non-selective systemic herbicide used to control a wide variety of plants, including annual broadleaf weeds, grasses, perennials, and woody plants. It is absorbed through foliage and translocated to growing points. Glyphosate's mode of action is to inhibit an enzyme involved in the synthesis of aromatic amino acids, making it effective on all herbaceous and woody growing plants. It is a rather slow-acting herbicide with symptoms typically appearing with a week, including yellowing and stunting a young leaves and growing points, however it may take up to several weeks for a plant to die.
- **Imazpyr,** the active ingredient in Polaris™ (previously sold as Habitat™), is a non-selective herbicide used to control a broad range of weeds including grasses, broadleaf herbs, woody plants, riparian plants, and emergent aquatic species. Imazapyr has a similar mode of action as glyphosate but acts on a different suite of essential amino acids. Imazapyr is absorbed by leaves and roots, and moves to growing points; it disrupts protein synthesis and interferes with cell growth and DNA synthesis, plants die as a result of AHS inhibition. To be effective on aquatic plants, the majority of plant parts must be accessible above the waterline. Imazapyr can be useful for difficult-to-control species when glyphosate is less effective, and with much lower application rates.

Resources

The following are websites that contain invasive plant management information and resources.

The California Department of Pesticide Regulation www.cdpr.ca.gov
This site provides information about herbicide use including measures to protected listed species.

California Department of Food and Agriculture Integrated Pest Control Branch:
http://www.cdfa.ca.gov/plant/ipc/index.html)
The Integrated Pest Control Branch conducts a wide range of pest management and eradication projects as part of the Division of Plant Health and Pest Prevention Services Pest Prevention Program. This site provides the Encycloweedia, noxious weeds and weed ratings, and the CalWeed Database.

CalFlora: http://www.calflora.org/
This web-based database provides records of all wild plants (i.e. plants that occur in the wild as opposed to only gardens), including native and exotic species. It identifies species that are included on the Cal-IPC invasive plant inventory. CalFlora is also a portal for the Weed Manager database (below).

California Invasive Plant Council: http://www.cal-ipc.org
This site provides a wide range of invasive plant information specific to California. Resources include prevention, invasive plant inventory, Weed Mapper, invasive plant profiles with links to articles, publications, reports, and educational brochures.

Center for Invasive Plant Management (http://www.weedcenter.org
The Center for Invasive Plant Management (CIPM) is a hub for management information in the western U.S. Includes plant biology and management information; education information; and publications. CIPM also provides grants to weed projects in western states. Grant information is available at this site.

Invasive.org: Center for Invasive Species and Ecosystem Health http://www.invasive.org
This site provides an easily accessible archive of high quality images of invasive and exotic species of North America with identifications, taxonomy and descriptions for use in educational applications.

Invasive Species Council of California http://www.iscc.ca.gov
The invasive Species Council of California provides general information on invasive species in California including animals, plants, insects, and plant and animal disease.

National Invasive Species Council http://www.invasivespecies.gov
The National Invasive Species Council (NISC) was established by Executive Order (EO) 13112 to ensure that Federal programs and activities to prevent and control invasive species are coordinated, effective and efficient.

National Invasive Species Information Center http://www.invasivespeciesinfo.gov
This site is a gateway to invasive species information; covering Federal, State, local and international sources. The information center is maintained by the U.S. Department of Agriculture's National Agricultural Library.

The National Resource Conservation Service (NRCS):
www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/alphabetical
This site lists all NRCS conservation programs, including programs to assist with weed management.

USDA Forest Service Invasive Species Program: Control and Management
http://www.fs.fed.us/ invasivespecies/controlmgmt/index.shtml
This site provides links for more information on research, management planning, Forest Service activities, and pest-specific control and management.

Weed Manager: http://www.calflora.org/entry/weed-mgr.html
Weed Manager (WM) is a system which enables organizations engaged in land management to track weed infestations and treatments over time. The Authority is currently using this system to map and track treatment of invasive plants.

Weed Research and Information Center http://wric.ucdavis.edu The University of California's Weed RIC provides control notes and photos for invasive plants as well as agricultural weeds.

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Appendix A Best Management Practices for Pesticide Use

Best management practices (BMPs) can minimize or eliminate possible effects associated with pesticide usage to non-target species and/or sensitive habitats, as well as degradation of water quality from drift, surface runoff, or leaching.

The BMPs address mixing, handling, and application of all ground-based treatments of pesticide that will considered and utilized, as appropriate, based upon target- and site-specific factors and time-specific environmental conditions. Along with the overall IPM approach to prevent, control, eradicate, and contain pests, these BMPs to eliminate and/or reduce potential impacts to non-target resources.

A.1 Pesticide Handling and Mixing

- As a precaution against spilling, spray tanks will not be left unattended during filling. All pesticide spray equipment will be properly cleaned.
- Where possible, rinsate will be used as part of the makeup water in the sprayer tank and applied to treatment areas.
- All pesticide containers will be triple rinsed, and the rinsate will be used as water in the sprayer tank and applied to treatment areas.
- When a pesticide container is marked as recyclable, Authority staff will deliver the triple rinsed pesticide containers to the appropriate herbicide container collection site.
- All unused pesticides will be properly discarded at a local “safe send” collection.
- Pesticides and pesticide containers will be lawfully stored, handled, and disposed of in accordance with the label and in a manner that will safeguard human, fish, and wildlife health and that will prevent soil and water contamination.
- Authority staff will consider the water quality parameters (e.g., pH, hardness) that are important to ensure the greatest efficacy when specified on the pesticide label.
- All pesticide spills will be addressed immediately.

A.2 Applying Pesticide

- Authority staff will comply with all Federal, State, and local pesticide use laws and regulations. For example, Authority staff will use application equipment and apply rates for the specific pest(s) identified on the pesticide label.
- Before each treatment season and prior to mixing or applying any product for the first time each season, all applicators will review the product label pesticide label.
- Follow the label recommendations for the buffer zone from the water’s edge will be used, where applicable, and when it does not detrimentally influence effective control of pest species.
- Applicators will use low impact herbicide application techniques (e.g., spot treatment, cut stump, oil basal, Thinvert system applications) rather than broadcast foliar applications (e.g., boom sprayer, other larger tank wand applications), wherever practical.

- Applicators will use low volume rather than high volume foliar applications when the low impact methods described above are not feasible or practical to maximize herbicide effectiveness and ensure correct and uniform application rates.
- Applicators will use and adjust spray equipment to apply the coarsest droplet size spectrum with optimal coverage of the target species while reducing drift.
- Applicators will use the largest droplet size that results in uniform coverage.
- Applicators will use drift reduction technologies such as low-drift nozzles, where possible.
- Spraying will occur during low (average less than 7 mph; preferably 3-5 mph) and consistent direction wind conditions with moderate temperatures (less than 85 F).
- Applicators will avoid spraying during inversion conditions (often associated with calm or very low wind conditions) that can cause large-scale herbicide drift to non-target areas. Equipment will be calibrated regularly to ensure that the proper rate of pesticide is applied to the target area or species.
- Spray applications will be made at the lowest height for uniform coverage of target pests to minimize or eliminate potential drift. If windy conditions frequently occur during afternoons, spraying (especially boom treatments) will typically be conducted during early morning hours.
- Spray applications will not be conducted on days with greater than 30 percent forecast for rain within six hours, except for pesticides that are rapidly rain fast (e.g., glyphosate in 1 hour) or pesticides that need rain to activate the product (e.g., oryzalin) so as to minimize or eliminate potential runoff.
- Applicators will use drift retardant adjuvants during spray applications, especially adjacent to sensitive areas.
- Applicators will use a non-toxic dye to aid in identifying treated target areas and any areas of overspray or drift. A dye can also aid in detecting equipment leaks. If a leak is discovered, application will stop until repairs are made to the sprayer.
- When drift cannot be sufficiently reduced through altering equipment set up and application techniques, buffer zones may be identified to protect sensitive areas downwind of applications.
- When an application is required adjacent to a sensitive habitat area, it will only occur when the wind is blowing away from the habitat area.
- To eliminate unnecessary pesticide applications, Authority staff will examine the target area for the presence of expected pests prior to applying a pesticide product.
- Authority staff will consider the timing of a pesticide application to ensure that native plants are protected (e.g., senescence) while effectively treating invasive plants.
- Application equipment (e.g., backpack sprayer, transport vehicles) will be thoroughly cleaned and PPEs removed and properly disposed of on-site after treatments.