Catalina Island Invasive Plant Management Plan

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Executive Summary

Invasive species are considered the second greatest threat to biodiversity worldwide, and are the leading cause of species extinctions in island ecosystems. Catalina Island, the third largest of the eight California Channel Islands off the coast of southern California, is no exception. Following the reduction and removal of several introduced ungulates such as: sheep (*Ovis aries*), cattle (*Bos taurus*), feral goats (*Capra hircus*), feral pigs (*Sus scrofa*), American bison (*Bison bison*), and mule deer (*Odocoileus hemionus*) many invasive plant species that became established during ranching, dry wheat farming, mining and quarrying operations, and landscaping of developed areas, appear to have been released from browsing and grazing pressure. Invasive plants are now considered one of the greatest conservation challenges facing the health of Catalina Island.

Over time, invasive plants have spread to varying degrees on the island, affecting flora, fauna, and ecosystem processes. The Catalina Island Conservancy (Conservancy), a 501 (c) 3 non-profit organization who owns and manages 88% (42,000 acres) of a 48,000 acres island understands that invasive plant management programs require a full understanding of the invading species' impacts, invasiveness, abundance, and distribution to make the best management decisions possible. In 2003, the Conservancy commissioned an island-wide invasive plant survey and species-led management plan, which provided the science-based information needed to develop and implement a site-led invasive plant management plan.

Since 2004, the Conservancy has aggressively targeted approximately 30 species for eradication, which nearly all of their populations have been maintained at zero density (no above ground plants), and high priority species occurring along Conservancy roads to limit their dispersal. The 2003 island-wide survey revealed that several widespread species were so abundant that other means were necessary to adequately prioritize their control efforts. To address this issue and other conservation threats facing the island, the Conservancy developed a watershed-based plan (Watershed Plan 2008) that prioritized each of the 105 watersheds or habitat management unit on the island for protection by ranking the natural resources in each unit which included: vegetation communities, and rare plants and wildlife.

By incorporating the results of the prioritized invasive plant management plan (species-led) and watershed management plan (site-led) into one comprehensive plan will allow the Conservancy to systematically address incipient species and populations before they become widespread, and species that are now widespread from impacting sites of high conservation value. Both strategies enable the Conservancy to holistically address invasive plants and protect high-value sites.

The Purpose and Scope of this Plan

Invasive plants defined

The most common and accepted definition of an invasive plant, and used by the Conservancy is, any plant introduced knowingly or unknowingly to [or spread throughout] North America after European contact, and has the ability to invade and adversely impact and degrade wildlands (Randall et al. 2002).

Why is this plan necessary?

Invasive plant management requires a long-term commitment both to remove above ground plants and to deplete the associated soil seed bank. This management plan is intended to provide the Conservancy a clear roadmap to follow as it addresses a long-term conservation challenge. Systematically managing invasive plants will enable the Conservancy to focus on-the-ground efforts on key targets, and reduce programmatic expenses through systematic and consistent implementation.

If such a plan were not developed, staff turnover and potential future changes in land management philosophy could redirect invasive plant management resources to other invasive species, populations, or other conservation challenges, resulting in years of work and resources wasted by forgetting about or abandoning valuable and intensive projects that require consistent long-term attention for successful completion. Those populations would then rebound and replenish their soil seed banks, setting the “invasive plant management clock” for that population or species back to zero. Successfully controlling invasive plants requires both consistent treatment and regular monitoring (Mack and Lonsdale 2002). This plan will guide management actions to achieve these long-term goals. As the old adage goes, “When you fail to plan, you are planning to fail.”

By creating an invasive plant computer database and associated management plan, key information will be readily available to future staff that will be able to use it to analyze changes in populations, develop monitoring schedules, and evaluate control efficacy. Invasive plant infestations are never static, and there are often too many to track with the human brain. If priority species and population information is not recorded in a database and outlined in a management plan, then that organizational knowledge can easily be lost when the invasive plant program manager relocates or dies. The epitaph of a program manager’s tombstone could read, “Here lies all the institutional invasive plant knowledge for the [Conservancy]” (Schoenig et al. 2002).

Distribution maps generated from the dataset are an effective tool for educating others about invasive plant prevention and impacts (Schoenig et al. 2002), and when seeking funding for projects and programs. This plan is intended to be used by a wide variety of Conservancy staff to support the program through fundraising, educating visitor and island communities about invasive plant impacts and management, internal and external program advocacy, and implementation.

Basing management decisions on scientifically gathered data allows the Conservancy to defend management positions, rather than entering a discussion based on anecdotal evidence or beliefs. Management of culturally sensitive invasive plants such as: trees and

ornamentals, often requires strong evidence to convince skeptics and those with little understanding of the issue. Education and outreach are essential tools for promoting the understanding of invasive species issues, and provide the foundation for invasive species prevention programs.

The impact of invasive plants on wildlands around the world is enormous (D'Antonio and Vitousek 1992), and they are a significant factor affecting the preservation of native biodiversity- one of the major challenges of this century (D'Antonio and Meyerson 2002). Land stewards entrusted with protecting natural resources are often faced with attempting to manage invasive plants through a form of triage, where they quickly identify which species will be targeted for control and which ones will be left to possibly spread. These decisions are sometimes based on anecdotal and unverified data (Pete Hollaran 2006, personal communication). Diverting limited resources to survey and inventory invasive plant populations, and prioritize their treatment might appear to be a waste of time and money when the impacts caused by invasive plants are readily apparent. Yet land managers often function as physicians who are entrusted with healing their patient (the land), and a good doctor should give his or her patient a proper examination before prescribing a remedy to cure an illness (Knapp and Knapp 2005). A proper physical will provide a sound scientific foundation for future management actions.

Funding is often very limited for invasive plant management, especially planning, and it is critical to prioritize both species and populations for control to utilize resources effectively (D'Antonio and Meyerson 2002). Managing invasive plants without the knowledge of their impacts, abundance, distribution and rates of spread has been compared to fighting a wildfire without knowing the location, size, direction and rate of spread of that fire; this can negate the effectiveness of fire fighters and potentially jeopardize their lives (Schoenig et al. 2002). Likewise, managing invasive plants without the relevant data often limits the effectiveness of management efforts while potentially wasting time and money, and thus jeopardizing the health of the ecosystem.

There are two general accepted invasive plant management strategies: site-led and species-led (Department of Conservation 1998). A species-led strategy focuses management on individual species no matter what they threaten, as these species are usually in limited abundance. However, management of invasive plants is conducted because these species threaten something. A site-led strategy focuses work on multiple species within a designated site that has been prioritized for its conservation value. In order for a site-led strategy to be effective, an exhaustive dataset of a myriad of natural resources is needed to prioritize sites for protection from wide spread invasive plants (Knapp and Knapp 2005). Fortunately, the Conservancy has an extensive natural resource dataset which includes observational and scientifically collected data on a wide variety of taxa from plants, mammals, to invertebrates. This plan is a composite of both a species-led and site-led approach.

Issues not addressed in this plan

The plan focuses on wildland invasive plants, therefore, species known to be closely tied to chronic human disturbance, agriculture, or cultivation were not included due to their limited ability to successfully invade and degrade wildland ecosystems (Steimaus 2002, personal communication). However, some of these species were surveyed for and

evaluated in 2003, but have been subsequently removed from the list of priorities since they are usually only a problem at developed or continually disturbed sites.

Control methods such as biological control and prescribed burning were not included in the array of control techniques outlined for each species, but invasive plant management considerations following a wildfire are discussed. Management of non-native marine algae or other introduced terrestrial species were not considered, as they warrant their own management strategy; however, prevention efforts for all invasive or introduced species could be combined into one outreach program.

A complementary, and often necessary, component of large population invasive plant removal is restoration by outplanting native stock (collected and propagated on-island) or by direct seeding (with seed only collected on the island). Large treated infestations create an opening that is often filled by other nearby or easily dispersed invasive plant species. Outplanting or seeding native plants expedites site recovery and increases resistance to invasion (D'Antonio and Meyerson 2002). This plan does not address restoration of treated sites because a restoration initiative would also merit its own comprehensive plan to adequately address outplanting objectives and programmatic implementation.

Non-native Annual Grasses

Approximately 35% of the island is infested with non-native annual grasses native to the Mediterranean. These species probably pose the greatest risk to the island, and to all of coastal California; however, there are no existing tools or strategies that can be effectively employed to economically manage them. If cost-effective methods or tools are developed in the future to adequately control them, then management of these species should be re-evaluated. Until that time, they will be uncomfortably tolerated.

Education and Outreach

Invasive species prevention education and outreach is often underappreciated and unfunded, and although it is not incorporated in this plan, this key component to the Conservancy's conservation programs is in development through a parallel education planning process to address negative human behaviors and a lack of understanding that threaten the ecological health of the island.

Background

Catalina Island and the Catalina Island Conservancy

Catalina Island is the third largest (75 mi^2) of the eight Channel Islands off the coast of southern California (Schoenherr et al. 1999) and is home to over 240 non-native plant species (30% of the Island's flora), including nearly one hundred invasive species that now threaten the Island's 422 native plant species (including 32 endemic plant taxa) and it's unique and endemic vegetation communities. Nearly 100 endangered, threatened or species of special concern, as well as imperiled and sensitive habitats, on Catalina are impacted to differing degrees by invasive plants. Catalina is home to six flora and fauna species that are listed as either endangered or threatened, of which four of them have

been identified in the Federal Register as being threatened with extinction by invasive plants.

Catalina Island has experienced many changes in land use over the last two centuries. Activities such as development, agriculture, mining, sheep and cattle ranching, sport hunting, military activities, presence of feral pigs and goats, and wild bison, erosion control, outdoor recreation, and extensive planting of non-native vegetation have all contributed to the introduction and establishment of invasive plant species. The conservation threats facing the island are the direct result of these past and present land uses. Catalina is the only Channel Island that has an incorporated city or roughly a 1 mi^2, and a year-round population of over 5,000 people, and receives over approximately 1.2 million visitors annually. The ownership of Catalina Island is divided between the Conservancy (88%), Santa Catalina Island Company (SCICo.) (11%), and 1% owned by private residents and other entities.

In 1972, the Conservancy was formed, and in 1975 88% of the island was transferred from the SCICo., a for-profit corporation, to the Conservancy. The mission of Conservancy is "to be a responsible steward of its lands through a balance of conservation, education, and recreation." Having a diverse mission of conserving lands open to recreation can result in conflict with regard to invasive plant management, and therefore a need for best management practices incorporated into island operations is essential in balancing both elements.

For nearly 15 years the Conservancy has pursued an active and aggressive science-based conservation program aimed at restoring the island ecosystems to a healthy state. Animal control programs have been conducted to sustain Catalina's sensitive species and protect its habitats from the impacts of introduced ungulates. The Conservancy has successfully removed all feral goats (*Capra hircus*) and nearly all feral pigs (*Sus scrofa*) from the Island, and reduced the island's herd of introduced American Bison (*Bison bison*) to 150 individuals. However, 2003 invasive plant survey results have indicated that the abundance and distribution of invasive plants on Catalina is much worse than was originally thought, and the Conservancy is witnessing an enormous population expansion of several highly ranked invasive plant species. These species include: *Carduus pycnocephalus* (Italian thistle), *Foeniculum vulgare* (fennel), and *Phalaris aquatica* (Harding grass) on the West End of the Island where bison have been excluded for over 15 years and the Feral Animal Removal Program first began over a decade ago. Although essential to the recovery of the Island, these animal control programs appear to have released some invasive plant species from grazing and browsing pressure, and the Conservancy believes that this is a precursor of what is to come if the eradication and reduction of feral herbivores from the East End of Catalina is completed.

In the 1990's following the removal of cattle from Santa Cruz Island, fennel populations exploded from hundreds to thousands of acres within a brief period of time, covering nearly 10% of the island (Schuyler 2004, personal communication). Learning from this unforeseen consequence, the Conservancy is working hard to prevent this from happening on Catalina Island. Now is the time to stem the tide of invasion before the problem becomes too enormous to remedy.

Invasive Plant Impacts

Homogenizing Biodiversity

The invasion of native plant communities by introduced species threatens native species richness not only locally, but also worldwide, thus decreasing biodiversity (Coblentz 1990; LaRoche 1994; Williamson 1996). The current geologic epoch (Holocene) has been referred to, by some ecologists, as the Homogecene (Purvis 2003), due to the unprecedented rate of human assisted organism dispersal and successful establishment of taxa to new locations throughout the globe (Hobbs and Humphries 1995), "like an anthropogenic blender mixing the world's biota" (Olden et al. 2004). On Catalina Island alone, roughly 37% of the flora is non-native (Knapp 2007, personal communication). Rare taxa may be at a greater risk of extinction, due to their smaller population sizes, as invasive plants degrade habitat needed for survival. Invasive species are the leading cause of extinction in island ecosystems (Vitousek 1990), and Catalina is one of the last contiguous stretches of land in southern California is saved relatively free from development. When invasive plants cause the local extinction of an organism, a collapse of the trophic structure may result. This is based on the concept of Trophic Cascade, where a native keystone species is removed, and the other dependent species perish after its absence (Vitousek 1990). Since island floras tend to be depauperate compared to their mainland counterparts, the loss of a species could potentially have negative consequences to the health of the sensitive island ecosystem. However, no keystone species have been identified on Catalina, and none may exist in this ecosystem (Klinger 2007, personal communication). The Federal Register has specifically identified invasive plant species as a threat to survival of nine federally listed threatened or endangered plant species found on Catalina Island.

Invasion by plants is not as dramatic of an occurrence as wildfire, oil spills or clear-cutting, but invasive plants are spreading at an alarming rate (D'Antonio and Vitousek 1992). Before the arrival of humans to the Hawaiian Islands, one non-native species would become naturalized (established) every 70,000 years, but today a non-native species arrives every 18 days (D'Antonio and Vitousek 1992). In the U.S. National Parks alone, invasive plant species are expanding their range by 8-12% per year (Hiebert and Stubbendiek 1993). This is currently equivalent to an area the size of Delaware becoming newly colonized by invasive plants each year (Carpenter and Murray 2000).

Although dispersal is a natural process, the exponential increase in global commerce and travel has rendered natural barriers such as mountain ranges, deserts, and oceans ineffective as obstacles to plant dispersal (Levin et al. 2002). The Catalina Channel is now ineffectual as a barrier to dispersal with nearly 1.2 million people visiting the island each year. Invasive plants disperse and become naturalized 1,000 times faster by humans than they would under human-aided conditions. Watercraft, aircraft, automobiles, and outdoor equipment are all effective vectors by which invasive plants can be dispersed (Babbit 1998). Humans also spread invasive species deliberately for landscaping. The same characteristics that make a plant horticulturally desirable such as: needing little care, being drought tolerant and easy to propagate, and producing abundant flowers (and thus seeds) also make them invasive. The rate of invasive plant dispersal by humans increases with an

increase in human populations (Hodkinson and Thompson 1997), and with Catalina Island in close proximity to one of the largest urban areas in the world, future invasions are inevitable. The installation and future use of the Trans-Catalina Trail system will undoubtedly result in new introductions; however, a portion of these invasions can be prevented through increased awareness and outreach such as interpretive programs and signage at key transportation nodes. In 2007, horse feed imported to the Saddle Club at Middle Ranch was found to harbor seed and plant parts of *Cirsium arvense* (Canada thistle), a new species for the island, and highly invasive, after a Saddle Club member promptly reported the contaminant to program staff. If the Saddle Club member was not aware of the issue, the introduction would have gone without notice, and subsequently could have become a larger problem to remedy.

Hybridization

Invasive plants can hybridize with closely-related native plants, potentially causing a decrease in the native species populations in two ways. First, when an invasive plant hybridizes with a native taxon, the hybrid offspring can become more invasive than the invasive parent plant if a doubling of chromosomes occurs (creating a fertile individual). The new invasive offspring, which usually have greater vigor than its weedy parent, can then outcompete the native parent population, resulting in a decrease in the native taxon's range (Randall and Hoshovsky 2000). Secondly, the hybrid offspring remains sterile, the native population can still be affected by the reduction of its fertile offspring through crossbreeding with the non-native sterile species (Randall and Hoshovsky 2000).

Closely related species within the same genus hybridize more easily than those species that are more distantly related. Management issues relating to control of hybrids are more complicated than those involving control of easily recognizable invasive plant species. Hybridization between native and non-native species is considered one of the greatest unrecognized threats to biodiversity (Vila et al. 2000; Perry et al. 2002). On Catalina, hybridization appears to be occurring between *Opunita ficus-indica* (invasive mission cactus) and *O. littoralis* and *O. oricula* (native prickly pear cactus).

Alteration of Ecosystem Processes

Due to the high rate with which invasive plant species can spread and the lack of "check and balances," such as disease and preadors from the invasive plant's home range, invasive plants can alter the functioning of native ecosystems that they invade (D'Antonio and Vitousek 1992; Carpenter and Murray 2000). Ecosystem processes such as nutrient cycling can be altered by invasive plants, which can lead to less desirable soil conditions for native taxa. For example, the invasion of the nitrogen-fixer *Myrica faya* (fire tree) on the Hawaiian Islands has increased the level of nitrogen in the soil of formerly nitrogen-deficient sites, making these soils more conducive to further invasion and persistence of fire tree in the ecosystem. Native Hawaiian plants are adapted to the nitrogen poor soils and do not fare well when competing under the altered soil conditions. This type of change in nutrient cycling can lead to the alteration of primary successional ecosystems (Vitousek 1990).

Invasive plant species can increase the rate of soil erosion by diverting stream flow in watercourses, by replacing a deeply tap-rooted native species with a shallowly rooted invasive plant. Resulting erosion by water, wind and gravity, strips away valuable plant liter

and topsoil, and releases sediments that flow downhill into streams, rivers and water bodies, resulting in the alteration of flood channels and degradation of water quality (Lacey et al. 1989). Infestations of coastal dunes by *Carpobrotus edulis* (Hottentot fig) promote the stabilization of naturally migrating sand, which results in an unnatural parallel orientation of dunes to the shoreline (Randall and Hoshovsky 2000). One experiment simulating rainfall onto high elevation areas of Montana infested by spotted knapweed found that plots with spotted knapweed had 56% to 192% higher sediment runoff than plots dominated by native bunch grasses (Lacey et al. 1994).

Fire regimes can also be altered by invasive plants, such as *Arundo donax* (giant reed), which remains flammable throughout the year in riparian habitats which tend to be less fire prone. Increased fire frequency, such as that caused by invasion of native desert landscapes by Mediterranean annual grasses, not only drastically affects the land, but also result in atmospheric change on a global scale (Randall and Hoshovsky 2000).

Allelopathic chemicals found in the tissue of some invasive plant species can be released, and may affect the growth or germination of nearby native plant species. Not only are individual plants affected by allelochemicals, but plant succession, vegetation patterns, seed preservation, germination of fungal spores, nitrogen cycling and mutualistic associations are also affected (Einhellig 1995). Invasive plant species such as *Mesembryanthemum crystallinum* (crystalline ice plant) accumulate salt in their tissues, which is deposited on the soil when they die (Randall and Hoshovsky 2000), inhibiting the germination of native species.

Threats to Native Flora and Fauna

Fourteen percent of the federally listed endangered species nationwide in 1996 became increasingly threatened as a result of plant invasions (Chen 2001). When a plant becomes established, it can compete with native plant species for resources such as light, water, space and nutrients (Brown et al. 2002). A decrease in any of these resources could lead to a decrease in the abundance of native plants (Foster-Huenneke and Thomson 1994). Competition for resources has been documented to have caused a decline in 18% of endangered species (Wilson 1999). Research in riparian habitats of the American Southwest desert regions have shown lower bird diversity and density in areas dominated by *Tamarix ramosissima* (Salt cedar), versus areas of native cottonwood-willow dominated vegetation (Hass 2002).

Alteration of ecosystem processes most likely has the most long-lasting affects to flora and fauna, nonetheless, competition with invasive species can have significant localized impacts.

Invasive plants outcompete native vegetation for space. Simply put, every location that an invasive plant infests is an area unoccupied by a native plant. *Acroptilon repens* (Russian knapweed) has been documented to outcompete native species on over one million acres within the United States (Whitson 1999). Such a large area dominated by one species results in the loss of regional, and possibly global, biodiversity.

Without light, plants cannot photosynthesize the vital carbohydrates that are needed for growth. If one plant can outcompete another for light, it will have the advantage of utilizing

its newly acquired energy to compete for other important resources such as nutrients and water. On the island of Hawaii, the globally invasive *Pennisetum setaceum* (fountain grass), landscaped with in Avalon, but with no known interior infestations, has altered the structure of the rare tropical dry forest ecosystem understory. Fountain grass can outcompete native seedlings for light (Cabin et al. 2002), thus preventing them from accessing other resources and further limiting their growth.

When invasive plants alter nutrient cycling or availability, they usually put native species at a disadvantage (D'Antonio and Vitousek 1992). The weed *Myrica faya* (fire tree) increases the nitrogen input in nutrient-poor soil. This would be thought to benefit native vegetation, but most Catalina native taxa are not adapted to nutrient rich soils. Thus, the nutrient contribution by fire trees aids in the promotion of itself, further exacerbating the problem (D'Antonio and Vitousek 1992).

Many invasive plant species such as *Tamarix ramosissima* (salt cedar) require larger amounts of water for survival than do many native plants (Hass 2002). These invasive plants lower surface and ground water levels to a point where native flora and fauna cannot access it, forcing them to either migrate or die. This subsequently alters the local microclimate and trophic structure (Randall and Hoshovsky 2000). Areas where large stands of *T. ramosissima* are present lack the expected native components of willows, cottonwoods, and surface water, but once *T. ramosissima* has been removed, land managers have witnessed the rapid return of both native vegetation and surface waters (Hass 2002).

Competition for pollinators can lead to the decline of native plants as well as the proliferation of invasive plants (Brown et al. 2002). Invasive plants with showy flowers or large quantities of nectar, such as *Nicotiana glauca* (tree tobacco), are heavily visited by native hummingbirds that would otherwise pollinate native plants like *Epilobium canum* (California fuchsia). Therefore, hummingbird populations could be unnaturally high on Catalina Island (Schueller 2004).

Degradation of Wildlands Recreation Value

Although difficult to quantify, invasive plants degrade the recreational quality of wildlands (Richardson and van Wilgen 2004; Eiswerth 2005). Monostands (large infestations of a single species) of spiny invasive plants infesting trails, roads, and campgrounds can degrade wildlife viewing and hiking experiences, and since recreation is a key element of the Conservancy's mission, this is a major concern. As wildlands are degraded by invasive plants, recreationalists may choose to visit sites with more comfortable hiking experiences and greater wildlife viewing opportunities. Coordination between the Conservancy's Trails and Invasive Plant Management Programs and Facilities Department is essential to ensure that the recreational value of the interior is maintained or enhanced through invasive plant prevention and management in areas of human use such as trails, roads, campgrounds, and day-use sites.

Benefits of Invasive Plant Species

Ecological interactions are complex, and although invasive plant impacts have been well documented, in some cases invasive species can benefit select native wildlife or provide ecosystem function and structure. It is wise to fully understand the relationships among

native and non-native species, and how invasive species function in the ecosystem before proceeding with invasive plant control activities (D'Antonio and Meyerson 2002) of widespread species. Native wildlife have been known to utilize invasive species on Catalina Island: native hummingbirds feed on nectar from non-native *Nicotiana glauca* (tree tobacco) flowers (Schueller 2004, personal communication), and ravens are commonly seen eating the fruits of *Ficus carica* (fig tree) and *Phoenix canariensis* (Canary Island date palm) (John Knapp 2007, personal observation). The fruits of the invasive *Carpobrotus edulis* (Hottentot fig) are commonly eaten by the San Nicolas Island fox (Julie King 2007, personal communication). Introduced sheep and cattle once grazed *Foeniculum vulgare* (fennel) on Santa Cruz Island, keeping it in lower abundance; however, following their removal, *F. vulgare* expanded from hundreds to thousands of acres infested (Peter Schuyler 2004, personal communication). Unintended consequences could result from the failure to adequately anticipate and understand the possible ecological effects of proposed invasive plant management activity (Brenton and Klinger 1994; D'Antonio and Meyerson 2002).

Invasive Plant Management

Vision and Goals

Catalina Island has endured a long history of landscape-level damage associated with introduced ungulates and land-use, and now a significant portion of those disturbances have been eliminated or reduced. The Conservancy's overall conservation objectives with regard to invasive plants are to ensure that they do not 1) impede the desired ecosystem response trajectory, 2) decrease the abundance or distribution of rare native taxa, 3) negatively alter ecosystem function, or 4) contribute to native species extinctions.

The CHIRP invasive plant management project's goals are:

1. Prevent the reduction or loss of native Catalina Island flora and fauna, due to the direct or indirect impact(s) caused by invasive plants, by actively controlling invasives with the safest, most effective and economical methods available;
2. Increase the Conservancy's and partner agencies knowledge regarding invasive plant distribution, impacts and management strategies;
3. Stop invasive plant introductions, establishment and spread on Catalina Island by increasing invasive plant awareness in staff, contractors, local residents and visitors through education programs, and improving cultural practices and partnerships.

The CHIRP invasive plant management project manages invasive plant species on an island-wide scale, utilizing adaptive management techniques to preserve, restore, protect and improve Catalina Island's unique natural and cultural resources.

Methods:

Awareness

Current treatment efforts on Catalina address a portion of existing invasive plant species problems, but until the island community is fully aware of the invasive plant threats and impacts new invasive species, including invasive plants, will continue to be dispersed to and throughout the Island. Development and implementation of prevention measures need to be fully addressed immediately by the Conservancy, and incorporated into the operations of the Santa Catalina Island Company, Two Harbors Enterprises, Southern California Edison, SBC Communications, Univeristy of Southern California, and Wrigley Institute of Environmental Science, and their contractors in order to stem the tide of invasion.

Prevention

The most cost-effective method to address invasive plants is to prevent them before they colonize or become established (Zavaleta 2000). Preventing species introduction or establishment will also eliminate impacts to the ecosystem. Appendices 18 and 19 outline a variety of prevention measures that could be adopted and implemented by island entities over time. Implementing prevention measures may require a change in the operational culture of each entity and its contractors and concessionaries. However, by instituting small prevention practices, awareness of the invasive plant crisis will increase among island residents and visitor communities, thus paving the way for implementing further strategies.

All residents, staff, and visitors to the island must be educated to 1) become aware of routes of introduction, and the threats presented by introduced organisms, 2) ensure that their own clothing, pets, and recreation and commercial equipment are free of plants, animals, seed, and soil, and 3) ensure that boats, aircraft, vehicles, and heavy equipment are maintained free of these contaminants.

Management of Non-native Plants in Human Use Areas

Invasive plants should no longer be planted for landscaping, even if they were once planted for this reason on the island. Invasive species currently used in landscaping throughout the interior and Conservancy property include but are not limited to *Acacia melanoxylon, Eucalyptus spp., Opuntia ficus-indica, Pinus halepensis,* and *Schinus molle*. Ideally, these species should be replaced over time with native plants. By landscaping with Catalina native species, wildlife habitat can be extended to reclaim disturbed sites, and be used to teach about the Island's unique plant species. It is important to recognize the cultural value that some invasive plant species have in landscaped areas such as Haypress, Airport-in-the-Sky, and Middle Ranch when weighing their management as invasive plant species. In particular, invasive tree species removal can be controversial, and measures should be taken to inform Conservancy staff and the public regarding the impacts and management actions of invasive trees.

Exclusion

Several watersheds have been identified as relatively "weed-free" or free of specific invasive plant species. The goal is to maintain the absence of invasive plants in these

locations. Implementation of this goal will include: 1) controlling roadside invasive plants, and 2) educating Interior users about how to clean vehicles before entering areas of high conservation value, and ensuring that their clothing, shoes and equipment contain no plant parts or soil, which may also harbor reproductive plant parts. These areas, as identified in the Watershed Plan, may in the future be designated as low impact sites, where entry would be permitted only under strict guidelines.

Control

When an invasive plant species is ubiquitous, such as Mediterranean grasses, it may be unrealistic to eliminate it completely from a site, watershed or the entire island; however, it may threaten to invade a treated population of another invasive species or high value site, which may necessitate localized treatment. The goal of control is to eliminate the plant at the immediate site; however the overall abundance of that species does not change. For example, widespread species such as *Nicotiana glauca* (tree tobacco) and *Salsola australis* (formerly *R. salsola*) (Russian thistle) occurring along roadsides will be targeted for control, but the abundance of each invasive plant species treated will most likely not be decreased significantly throughout the entire island.

Reduction

The goal of reduction is to limit the abundance of a widespread species throughout a watershed or the island. Unlike control, reduction results in a significant decrease in species abundance. Over time as a species is constantly reduced, it may then be targeted for eradication. *Foeniculum vulgare* and *Phalaris aquatica* (Harding grass) are two species that are identified for reduction and could be targeted for eradication at a later date as species' abundance is reduced to very low levels. It is important to note that previously treated populations should always be monitored for species emergence, since there is a tendency to direct resources to above ground populations, and not follow-up work on soil seed banks.

Containment

The goal of containment is to restrict a species or population to a specific area. For example *Genista linifolia* (flax-leaved broom) is found throughout the island, but mainly infests the eastern portion of the island, and is targeted for containment by eradicating populations outside of the greater Avalon watershed. In this scenario, *G. linifolia* is also being reduced in abundance, but the overall goal is to contain it to a specific area.

Eradication

Species that have recently colonized the island or are becoming established are a high priority for the Conservancy, because these species are relatively easy and cost effective to eradicate (Zavaleta et al. 2001), and their impacts are minor compared to widespread species (Zavaleta 2000). Species that have small populations are much easier to eradicate than larger ones, due to the limited seed bank present. Although some land managers throughout the world do not attempt to eradicate invasive plant species because of the preconceived notion that it is impossible to do so, it is important to remember that humans are adept at causing species extinctions (Olson 1989).

A study conducted by Rejmanek and Pitcairn (2002) of the University of California: Davis analyzed invasive plant eradication efforts conducted by the California Department of Food and Agriculture over a 30-year period. Results showed that plant

eradication success decreased exponentially and the effort (time, money, etc.) increased exponentially as the size of the invasive plant infestation increased. They also found that infestations less than 0.08 hectares had nearly 100% eradication success, and that infestations one hectare and greater had nearly no eradication success.

No matter what the management objective for a targeted invasive plant species, all above-ground plants will be controlled to zero density for each targeted populations of that species. Once all plants have been removed or treated, the population seed bank will be monitored for seedlings or resprouts until each population is eradicated. Consistent monitoring and immediate treatment is important to maintain the benefits derived from the initial treatment. Some species necessitate multiple monitoring surveys throughout the growing season, while others require only one inspection due to their reproductive cycle. Nearly all species will require repeated visits for many years to ensure that the seed bank has been exhausted. The goal for all targeted populations is local eradication (control to zero density), regardless if the species is identified for reduction, containment, or control. The overall initiative is to eliminate a problem on site, no a portion of it.

Invasive Plant Management Principles

Know the Site

The ultimate goal of all invasive plant management programs is not simply to eliminate the problem species but to protect what it threatens. For that reason, it is important to ensure that management actions do not adversely affect the site that is designated for protection. This plan outlines invasive species management in some of the most diverse and sensitive watersheds on the Island; however, inspecting the work site for sensitive resources such as: rare plants, fragile vegetation communities, wildlife, and prehistoric and historic resources is always a good idea to help reduce impact associated with management actions.

Understanding Invasion

Understanding the process of invasion enables land managers to focus treatment efforts on species and populations that can successfully be managed. There are four phases of invasion: colonization, establishment, spread, and equilibrium (Williams 1997). It is most cost effective to target species that are in the colonization phase since they have little to no seed bank, and are therefore relatively easy to eradicate. Once a species colonizes a site, the next step is establishment. This is also an ideal phase to target a species for eradication, but now a soil seed bank is developing, which will require additional management. Once an invasive plant is established, it may begin to spread at an exponential rate. Targeting it early in the expansion phase is crucial to prevent it from spreading futher, but once the invasive plant has spread too far, it can then reach a state where it is too costly to eliminate or reduce substantially. This phase (equilibrium) usually draws the most attention since infestations are apparent to even the layperson. However, resources should be directed to species that are in the beginning stages of invasion, not the final stages (Williams 1997). This is often difficult to “sell” to the layperson, especially when the species has some cultural value, since the impacts have not yet occurred on site, but have elsewhere.

Population Ecology

Small invasive plant populations have higher rates of expansion than larger ones due to their greater ratio of population edge to population area, and population edges are the sites of population expansion (Steinmaus 2003, personal communication). Once small populations have been removed, larger populations would be the next candidate to be addressed. However, be aware that targeting large populations can often result in creating many small populations that can readily re-expand. Working from the outside edge inward on larger populations is considered the best method to tackle established populations (Steinmaus 2002, personal communication).

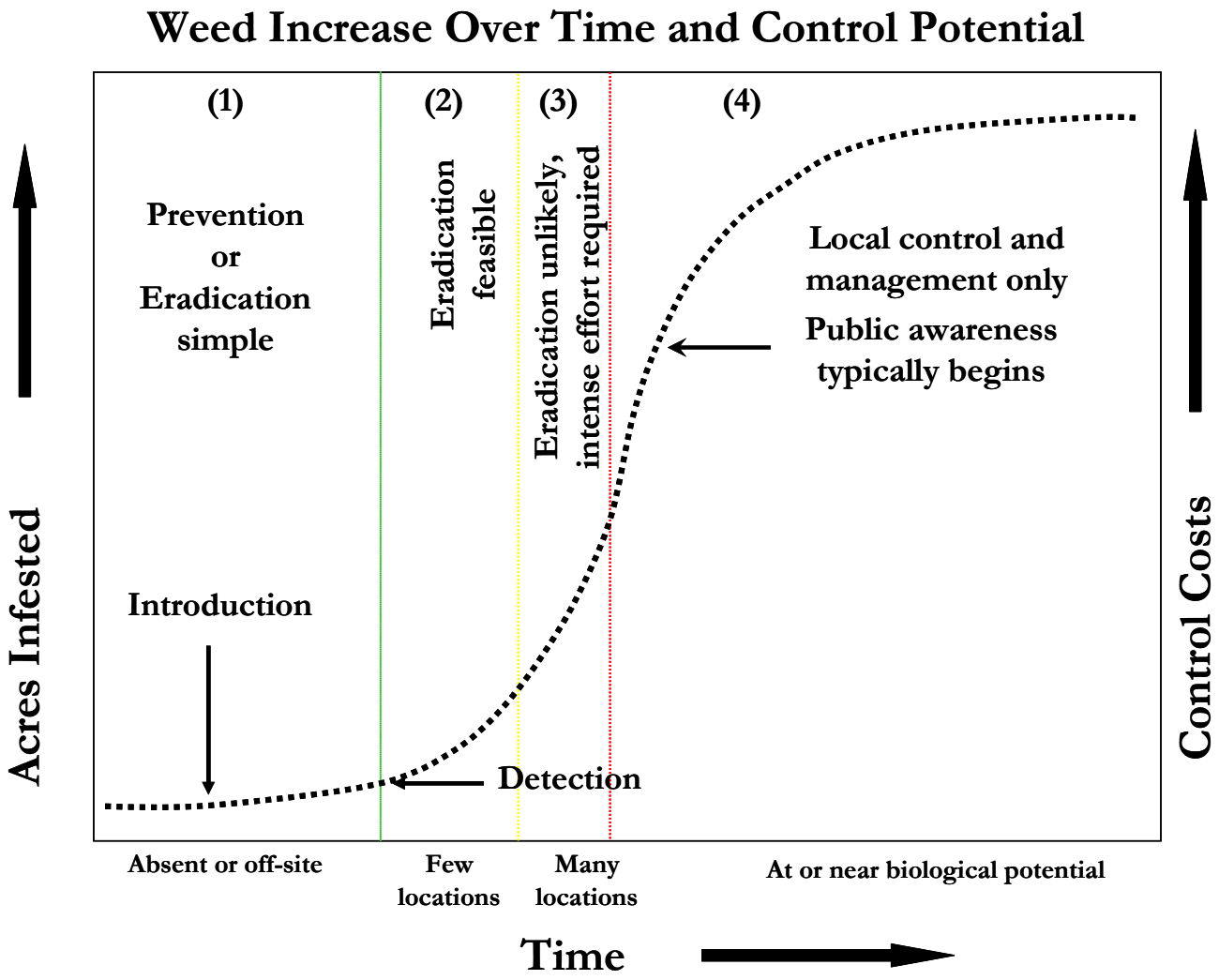

Figure 1. An illustration of the process of invasion, and the optimal time to initiate management activities. (Siemens and Tu 2007).

Working the Watershed

When managing invasive plant populations, work should typically start at the top of a watershed, or up-wind in areas with predominant wind patterns to avoid reinfestation of

the site. However, this general rule would be broken if a site of high conservation value occured mid-watershed and was threatened by invasive plants. When treating infestations on steep slopes, treatment should start at the far end of the population working back towards the exit route so that you are not “painted into a corner.”

Prevention Practices

Invasive plant hygiene must be a routine practice when managing invasive plants (Coulston 2002). Clothes, equipment, and vehicles must be inspected and thoroughly cleaned of all plant parts and visible soil prior to starting work or when moving from site to site. Open pockets on clothing and joints of equipments such as weed wrenches are perfect spots where seed can be lodged and then transported to new areas. Avoid traveling through infestations, when possible, while in route to target infestations.

Worker Safety

The work site should be inspected for possible threats to weed worker safety. These may include: steep slopes or cliffs, loose substrate, falling or rolling rocks, poison oak, cactus, and poisonous animals. Sharp and heavy tools and herbicide must be carried properly to avoid injury to or the contamination of the weed worker. Once at the site, tools must be stored in a safe of a location when not in use. Power tools and associated gasoline fuel must be placed in a similar safe area with attention to fire hazards such as light flashy fuels and direct sunlight and heat. A Pulaski must also be readily available on site when using power tools inorder to help suppress a fire. Appropriate personal protective equipment (PPE) must be provided for all workers, and properly worn at all times while working. Each worker or crew should carry a first aid kit. Appendix 17 outlines how to prevent fire ignitions with regard to invasive plant management work.

Herbicide Safety

Every applicator must read the herbicide label prior to ever using a particular herbicide, and each applicator has to participate in an annual herbicide safety training, and corresponding records kept on file for three years. Re-read the herbicide label prior to using a herbicide if enough time has passed that the applicator cannot easily recall the pertinent information such as first-aid response, signal word, environmental considerations etc. The label is the law. All weed workers must have access to sufficient eyewash to flush both eyes in case of emergency. Herbicide containers and application equipment must be placed securely on the ground away from areas where weed workers will rest or eat.

Herbicides and application equipment must not be transported inside a vehicle and should be isolated from personal gear, food and drinking/washing water. Avoid contaminating gear and equipment, and assume all gear used is contaminated. Gear that is known to be contaminated should be cleaned by wiping it down with soapy water and a clean rag. Appendix 10 covers appropriate first-aid response to herbicide contamination of workers. Citations related to pesticide use are extremely costly and can be given to either the organization or the applicator; depending on who is at fault.

Herbicide labels and corresponding Material Safety Data Sheets (MSDS) are displayed in binders hanging in the Middle Ranch Barn to the right of the laundry facility, and a set should always carried in each vehicle used for invasive plant management. Labels and

MSDS should be replaced January 1st of every year in the event that information has been updated and changed.

Environmental Safety for Herbicide Applications

Prior to applying herbicides, weather and site conditions must be carefully taken into account. In order to avoid drift to off-target plants or open water, spray applications should not be made when wind speeds are 10 mph or greater (the herbicide label should be checked for specifics). For some herbicides, applications should not be made when temperatures exceed 85° F or during conditions when temperatures are over 80° F. However, even when overall weather conditions do not permit foliar applications, site specific microclimate conditions may be within an acceptable range for application. Constantly monitoring wind speed and direction, and temperature is vital to reducing off-target impacts due to weather conditions.

Inspect the site for open water, as some herbicides cannot be applied near open or running water such as streams, reservoirs, or the sea. Inspect soil texture, since some herbicides do not adsorb (bind) to clay colloids, and thus may leach readily through sandy soil.

Herbicide storage areas should have spill kits and absorbent material such as cat-litter, and herbicide containers should have an appropriate spill-well incase of leaks or spills related to mixing. Containers that could fall over or are stored upon shelves should be be properly restrained to prevent breakage in the event of an earthquake.

Herbicide Resistance

Switching between herbicides with different modes of action, e.g. enzyme inhibitors such as Glyphosate or hormone mimics such as Clopyralid or Triclopyr, will help to reduce the risk of developing herbicide resistance within a population or species. Herbicide resistance can develop when an invasive species population is frequently and repeatedly treated with an herbicide that has the same mode of action. Over time, only those plants that are unaffected remain and are able to reproduce and pass on their resistance traits to offspring. It is the responsibility of the weed worker to take measures to avoid herbicide resistance (Cousens and Mortimer 1995). It is important to note that simply switching between herbicide products or brands does nothing to reduce development of herbicide resistance, only altering between different modes of action. Tracking herbicide use by population is vital to properly prevent the development of resistance.

Herbicide Effectiveness

Several factors contribute to the effectiveness of systemic herbicides such as Clopyralid, Glyphosate, Impazapyr, and Triclopyr, and their application should only occur under the optimal conditions. Applicators must consider the pH of the water mixed with the herbicide and its mineral content, particularly calcium and magnesium (water ‘hardness’). Water should be tested at least each year. Presence of algae in water used for mixing will greatly negatively affect herbicide activity, since herbicides are readily bound to organic matter. Therefore, water sources such as reservoirs, streams, and ocean should not be used for mixing herbicides. Utilizating high saline water from the ocean for tank mixes can alter soil chemistery, and thus defeating restoration objectives. Plant phenology and vigor, and the presence of dust on the leaves of the

target species also greatly affect herbicide effectiveness, especially herbicides such as Glyphosate that readily adsorb to soil coloids. Always consult the herbicide label regarding specific requirements and restrictions.

Specimen Collection

When an unknown plant sample is collected in the field for identification back in the office, it should be handled as a highly invasive plant species until it can be determined that it is not. Ziploc-style bags (without holes) should be brought in the field to safely transport a specimen (See Appendix 19). If a proper container is not available that can ensure that propagules are not dispersed in transit, then take a photograph of the specimen and record the population with a global positioning system (GPS unit) following mapping protocols (Appendix 15). Ensure that the specimen, if not kept as a herbarium record, is properly disposed of by sealing the specimen in a hole-free Ziploc bag with a small amount of water to encourage molding and destruction prior to disposal in the garbage.

Integrated Toolbox

It is often necessary to have a myriad of tools and techniques (Appendix 8) in a manager's "toolbox" to tackle multiple species. Invasive plant species, site, or weather conditions are never the same, and having a range of options enables land managers to adapt to constantly changing conditions. It is vital to record and track management techniques in order to determine the most effective control method, and in some cases adapt existing ones, or develop new ones. Taking time during the winter season when there is fewer species to treat to assess the past year's control efficacy and planning efforts from databased treatment records is essential to learn from mistakes and capitalize on successes. Drawing upon techniques and methods from other disciplines, or augmenting tools not currently used in the invasive plant management trade may be creatively applied to further conservation goals.

Cultural controls

Many troublesome invasive plants are highly dependent on ongoing disturbance, whether natural (fire, flood, landslide, etc.) or artificial (browsing, grazing, mowing, disturbance by foot or vehicle traffic). Where appropriate, measures should be taken to protect vulnerable areas from further disturbance.

Physical and Mechanical Control

Physical and mechanical control methods such as pulling, grubbing, cutting, girdling, or mowing, will be used on species that do not resprout e.g. annual grasses or brooms, or can be successfully killed without herbicide. These methods utilize a wide array of hand and power tools, including: weed wrenches, loppers, handsaws, cordless drills, brush cutters, chain saws, power hedgers, and tractors.

Chemical Control

Herbicide application is another tool that is utilized when mechanical or physical techniques are not effective alone, or are not the best treatment option due to possible collateral damage, or weather conditions. Whenever feasible, techniques such as cut-

stump, drill-and-squirt, hack-and-squirt, glove-of-death, and basal bark application will be used to reduce both drift and the amount of herbicide used in the environment. Herbicides (Appendix 11) with the lowest EPA rating, “caution” such as Glyphosate, will be preferred to minimize the recognized risks to the applicator. All recommended use and safety regulations and California state guidelines will be followed. Selective herbicides will be used to treat populations of invasive dicots where native monocots are present. Similarly, herbicides selective for monocots only, will be used as appropriate where invasive grass species grow among desirable dicot plants. A selective herbicide effective only on thistles (*Asteraceae*) and herbaceous taxa in the pea family *(Fabaceae)* will be used for such invasive plants as *Cynara cardunculus* (artichoke thistle) or *Lathyrus* spp. (sweet pea). Very low rates of a non-selective herbicide (Appendices 12 and 13) such as Glyphosate will be carefully applied to susceptible species found invading robust perennial native vegetation, which should not cause irreparable damage to the native species.

The three main herbicide delivery systems used by the Conservancy are truck-mounted spray rig, backpack sprayer, and spray or squeeze bottles. A truck-mounted sprayer (150 gallons) can be used when treating roadsides and other areas accessible to these vehicles. Small populations or those found further than the length of the spray-rig hose are usually treated with herbicide contained in a backpack sprayer (up to four gallons), lab-style squeeze bottles, or hand spray bottles, ranging in capacity from one-half ounce to one quart.

Handheld bottles are easy to carry and maneuver, especially in dense vegetation and on steep slopes, but they contain a very limited amount of herbicide. Backpack sprayers can carry considerably more herbicide than a spray bottle, but are heavy and cumbersome when hiking over rough terrain and thick vegetation. A truck mounted spray rig can hold large amounts of herbicide to treat large infestations. The truck mounted spray rig hose is not as heavy as a backpack sprayer, but has a limited range (< 600 feet) and is at times unwieldy. The best container will be selected based on a combination of terrain, vegetation, population size, and weather conditions to ensure safety and efficiency.

Mapping and Monitoring

When working in a watershed that has known infestations of priority invasive plant species, weed workers should constantly conduct ad hoc surveys while en route to conduct a treatment. It is important to map all new invasive plant populations using the mapping protocol (Appendix 15), and regularly monitor treated populations based on the reproductive life cycle and seasonality. Failing to monitor treated populations consistently will mostly likely result in wasted work if treated plants resprout or seedlings that have germinated from the soil seed bank are allowed to reach reproductive age (Grundy and Jones 2002, Coulston 2002) (Fig. 2). Soil seed banks for some species such as *Genista linifolia* (flax-leaved broom) can remain viable for over 50 years. It is important to know how long each species’ seed bank can last, and to monitor all treated populations for that duration of time or longer. Once all above-ground plants of a population have been completely removed, and the site yields no new seedlings, the

monitoring schedule can be implemented for each species based on the time it would take a plant to reach reproductive maturity. For example, if it takes *Foeniculum vulgare* (fennel) only six months to produce seed following germination, then a six-month monitoring schedule should be implemented for all treated *F. vulgare* populations. A two-year monitoring schedule will be implemented for all treated populations of *G. monspessulana* or *Spartium junceum* (Spanish broom) since it would take two years or more for seedlings to reach reproductive maturity.

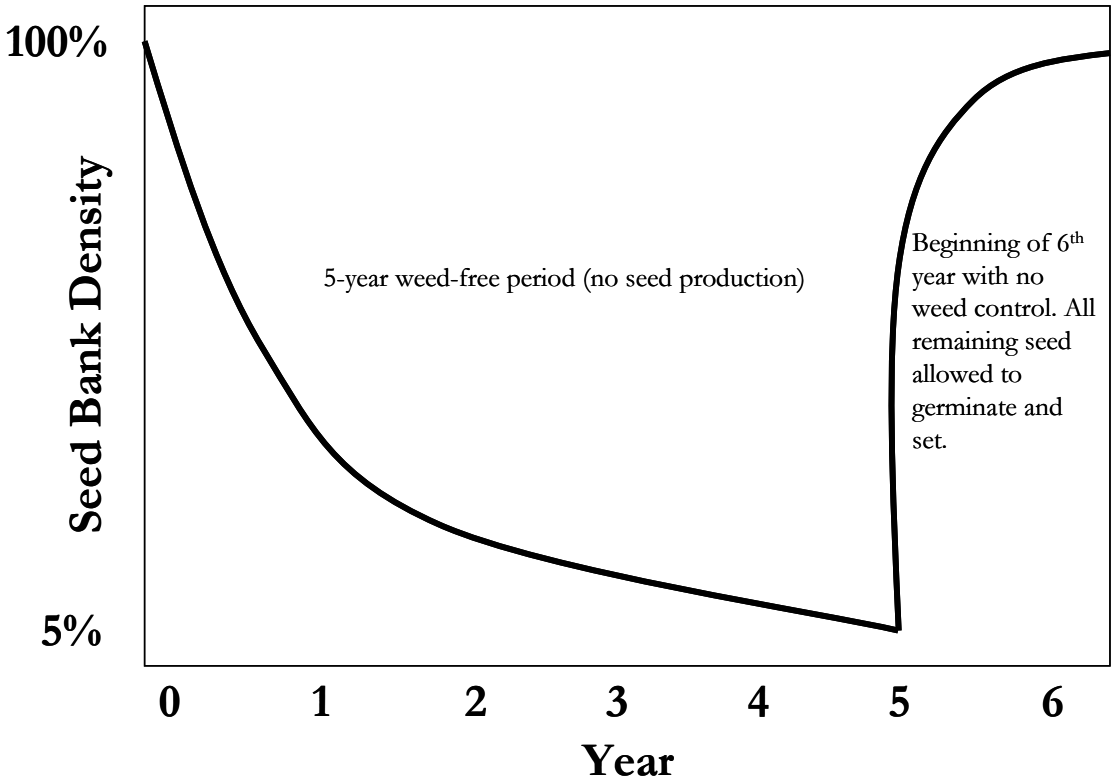

Figure 2. The following illustration demonstrates the need for consistent seed bank monitoring following the removal of all above ground plants (Burnside et al. 1996).

With each successive season as soil seed banks are depleted, monitoring of treated populations can be achieved in a shorter amount of time. Once all originally targeted sites have been monitored, new populations can then be addressed within the treatment schedule. It is important to note that consistently monitoring treated populations is a key component of an invasive plant management program. Unfortunately, it is often viewed as unnecessary or superfluous, especially when funding is tight, and as such, is usually the first program element to be eliminated. Without monitoring and follow-up treatment, all previous work can be wasted if propagules are allowed to grow and produce more seeds. This resets the “seed bank viability clock” back to zero.

Priority Invasive Plant Species

Setting Priorities

There are two general accepted approaches to managing invasive plant species: species-led and site-led approaches ([New Zealand] Department of Conservation 1998). Invasive plants are managed because they threaten something, not because they are simply unwanted. Knowing which resources are on site, and which ones require protection, and how invasive species threaten them is vital to making the best management decisions possible.

Species-led

The first priority is to prevent new invasive plant introductions. This is accomplished by 1) closing avenues for invasive plants dispersed by humans, 2) regularly monitoring all the related "ports of entry," and 3) regularly and systematically monitoring the entire island for new invasive plants vectored in by wind, ocean currents, or birds.

The second priority involves a species-led approach, where invasive plant species with limited distributions are eradicated from the island or Conservancy property. Many of these species are known to be highly invasive and damaging elsewhere and are poised to spread in similar ecosystems on Catalina. Since their population size and range are relatively limited on the island, their impacts may not be readily evident yet. However, if left unmanaged they may continue to expand as they have done elsewhere, causing difficult and more costly problems later. Orr's Law states that, "each increment [incipient invasive species or population] seems reasonable in its context, but constitutes a huge problem in aggregation." Eradicating an aggregation of invasive plant species with limited abundance will have a beneficial cumulative effect beyond what might be expected when these populations are viewed individually. Eradicating invasive plants before they become widespread is a high priority for the Conservancy. The cost to eradicate a few localized populations is comparatively minimal and impacts caused are relatively low compared to allowing them to become widespread species. Eradicating these species now will ensure they do not negatively affect listed native species or unique ecosystems in the future. The Catalina Island Ranking Plan is the foundation for the Conservancy's species-led approach.

Site-led

Sites of high resource value, as identified in the Conservancy's Watershed Plan, that harbor rare, listed, and endemic plant and wildlife taxa, and endemic and rare vegetation communities are considered for invasive plant control actions even if the invasive species threatening these sites may be rated as relatively-lower priorities for control, based on invasive species considerations alone.

Dispersal corridors such as roads and trails, entry areas such as boat landings and airstrips, and inhabited areas such as staff housing and campgrounds will be treated for a range of priority species, and carefully monitored for new introductions, since these are the areas where new invasive plants often appear first, and from where both new and existing invasive plants are readily dispersed.

In these cases, the driving force behind management efforts is not a particular invasive plant species, but rather the site itself or the resources that are threatened. The Conservancy does not have the funding or support to tackle every invasive plant species or population across the entire island, and therefore it is important to focus on key sites for those species that are unrealistic to eradicate island wide.

Invasive Plant Ranking Criteria

Invasive Species Identification

The Catalina Island Invasive Plant Ranking Plan, completed in 2004, identifies 76 naturalized species on Catalina Island that are considered invasive. Since that time several other species, such as: *Eriogonum fasciculatum* (California buckwheat), *Hedera helix* (English ivy)*, Lyonothamnus floribundus* ssp. *asplenifolius* (fern-leaf ironwood), *Opuntia ficus-indica (and hybrids with native O. litoralis* and *O. oricula)*, *Pinus pinea* (Italian stone pine), and *Limonium sinuatum* (statice), have been added to the list of invasive plants of concern; however, they have not been systematically ranked for priority of control nor have they been surveyed for. Naturalized species are non-native species that maintain self-sustaining populations without human assistance; this includes both invasive and non-invasive species.

A list of approximately 240 non-native plant species was developed from the Conservancy's 2003 unofficial flora (Knapp 2007, personal communication), which is a compilation of two past floras (Millspaugh and Nutall 1924, and Thorne 1967 and 1968), and surveys conducted by Conservancy staff and researchers. The list of naturalized species was then compared with the California Invasive Plant Council's (Cal-IPC) 2003 Invasive Plant Inventory of invasive plants in California in order to derive a preliminary list of nearly 65 invasive species. Cal-IPC is a private non-profit organization whose mission is to protect California wildlands from invasive plants through restoration, research and education. It is the leading authority on invasive plants for the State of California.

The Delphi method was then utilized to review the list of non-native plants for which species posed the greatest risk to the island and are manageable. The Delphi method involves submitting a list of suspected invasive plant species to qualified individuals such as botanists, plant ecologists, weed scientists, and land managers for review (Matlack 2002). Species such as Mediterranean annual grasses were not surveyed for since they are so ubiquitous and are relatively unmanageable. In addition, annual grassland that is typically infested by Mediterranean grasses had been previously mapped in 2000 as part of the Conservancy's Vegetation Communities Map and database (Knapp 2003). A list of 72 species was developed, and after the 2003 survey commenced, five more species were added when encountered in the field by the project principle, John Knapp, bringing the total to 76 species that were surveyed for and ranked for priority of control.

Ranking

Like many wildland areas, Catalina Island is invaded by too many invasive plant species to manage all at once. Ranking invasive plant species provides a uniform methodology

for control prioritization which allows for 1) the highest ranked and manageable species to be controlled first, 2) limited resources to be used efficiently, and 3) management decisions to be based on scientifically gathered data, and therefore defensible.

Cal-IPC's ranking system (Plant Assessment Form [PAF]) (Appendix 22) was used to determine the threat posed by each species, regardless of the site. A PAF is separated into three sections that are composed of several sub-sections; the first section is designed to assess the species' ecological impacts, the second section is designed to determine the ability to invade native habitats, and the third section evaluates the current ecological amplitude and distribution of the invasion in native habitats. Each sub-section within a main section is ranked for the level of documentation used in the assessment (as described in the literature review summary), thus providing a confidence level for the overall ranking. Sub-sections documented with lower tiers of documentation such as gray literature, observations, or anecdotes highlight information gaps that should be updated as future research is available. Instructions or examples are provided to guide the scoring for each sub-section in each section. Sections 1 and 3 yield an alphabetical abbreviation that makes up the attributes of the species. A scoring matrix is then utilized, where all possible abbreviation combinations are listed to determine each section score. A point system is then used to develop an overall score for section 2. Lastly, a matrix is used to combine all section scores to determine the species' overall score and rank. The following is a list of each sub-section by main section title:

Section 1- Ecological Impact
- 1.1- Impact on abiotic ecosystem processes
- 1.2- Impact on plant community composition, structure, and interactions
- 1.3- Impact on higher trophic levels
- 1.4- Impact on genetic integrity

Section 2- Invasive Potential
- 2.1- Role of anthropogenic and natural disturbance in establishment
- 2.2- Local rate of spread with no management
- 2.3- Recent trend in total area infested on Catalina Island and/or within California
- 2.4- Innate reproductive potential
- 2.5- Potential for human-caused dispersal
- 2.6- Potential for natural long-distance dispersal (>1 km)
- 2.7- Other regions invaded

Section 3- Ecological Amplitude and Distribution
- 3.1- Ecological amplitude
- 3.2- Distribution

The overall rank is divided into three main categories- high, moderate, and limited (Fig. 3). Species designated as high or moderate may also be assigned an additional status of "alert", which indicates species with a limited amplitude and distribution, but which have the potential to invade existing habitats in California. Ranking categories are as follows:

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

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

Limited: The ecological impacts of these species are minor. Their reproductive biology and other invasiveness attributes result in low to moderate rates of invasion. Ecological amplitude and distribution tend to be generally limited (however, they may be locally persistent and problematic). These species may be more problematic than their rank reveals if there is a lack of published literature.

Alert: This is an additional designation for some species in either the high or medium category, but whose current ecological amplitude and distribution are limited. This designation alerts managers to species that are capable of rapidly invading unexploited ecosystems based on initial, localized observations, and on observed ecological behavior in similar ecosystems elsewhere.

Not Listed (NL): These are species that have been evaluated, but for which information is currently inadequate to respond with certainty to the minimum number of criteria questions (i.e., too many “U” responses) or for which the sum effects of ecological impacts, invasiveness, and ecological amplitude and distribution fall below the threshold for listing (i.e., the overall rank falls below Low). Many such species are widespread but are not known to have documented substantial ecological impacts (though such evidence may appear in the future). All species receiving a “D” score for ecological impact (Section 1), regardless of what other section scores they receive, are by default placed into this category (California Invasive Plant Council 2003). All species ranked as Not Listed lacked sufficient documentation regarding their impacts. Although a species has been assigned a rank of Not Listed, it does not mean that it does not have impacts.

A ranking system functions similar to a filter, allowing certain species to pass through based on specified criteria. As species are subjected to more criteria, they are filtered even further. An additional ranking system or index was developed to determine the ease of control, and the abundance and distribution on Catalina Island, using number of populations, total area infested, and median population size recorded during the 2003 invasive plant survey. The number of populations a species has is an indicator of the access time needed to eradicate that species. Traveling to many populations is much more time consuming and difficult than accessing one or few populations. The number of populations is also an effective way to determine which phase of invasion a species is in or how invasive it is, i.e. many small populations could indicate that the species is in an expansion phase of invasion. The total area infested identifies the amount of area infested, and thus the extent of soil seed bank, and is an indicator of just how much

work will be needed to eradicate it. The median population size indicates how successful control efforts may be for a given species based on the size of the infestation. Typically, smaller populations have less seed in the soil, and are thus easier to eradicate.

Management Feasibility

Each species was assigned an “ease of control” or management feasibility rank of A, B, and C based on the number of populations, median population size, and ease of control for each species. All categories were assigned a numeric value ranging from one to three. Each of the three values were weighted equally, and then added together for each species. The final values were then assigned a qualitative rank ranging from A to C. The lowest numeric value corresponded to a rank of A, which indicates a high probability that the species can be eradicated, whereas a rank of C indicates an extremely low probability of eradication success.

A: high probability that a species can be eradicated.

B: depending on the level of resources invested, a species may or may not be eradicated.

C: highly unlikely that a species can be eradicated.

It should be noted that the ease of control rank is for the entire island. Some invasive plant species with limited abundance may be eradicable from a specific watershed. However, the chances of reinfestation are high when source populations are located nearby.

Managing multiple invasive plant species at the landscape level requires a systematic and transparent approach to maintain program direction to reach management objectives. Subjecting each species to a ranking scheme allows for consistent prioritization of key elements to be compared across all species. When prioritizing the management of invasive plants based on the threats they pose, land managers should target species ranked High initially, then Moderate, and so on, addressing highly invasive species first. Unfortunately, in many situations, it is usually the High ranked species that have already reached un-eradicatable proportions. This is the case for *Nicotiana glauca* (tree tobacco) on Catalina Island. The management feasibility rank (A-C) should strongly be weighed in tandem with the threat rank. A species ranked as an A indicates, regardless of its invasiveness, that it can easily be eradicated. Focusing on species that can be eradicated (rank of A) should be a priority since potential future problems can be eliminated before they become unmanageable. Incipient species expand faster than well established species. For example, *Senna didymobotria* (African senna) which is ranked as Not Listed (due to its lack of documented impacts) and an A for its management feasibility should be targeted first over *F. vulgare* (a species ranked High-C). In this example, a feasibility rank of A trumps a threat rank of High.

Once A-ranked species have been eradicated, B-ranked, and then C-ranked species should be targeted in that order. It is difficult to differentiate, based solely on rank, between species that have average ranks, i.e. a Moderate-B vs. a Limited-A. Other factors may influence management decisions in these cases, such as the level of

available resources. In the example above, when resources are scarce, it is feasible to manage the Limited-A over the more widespread and difficult to control Moderate-B species.

Each invasive plant species and its ranking is listed in Appendix 4 and 5, and the original Plant Assessment Forms for all species are provided in Appendix 22 on a compact disc attached on the back cover.

Conclusion

Following the reduction of landscape-level disturbances caused by introduced ungulates, Catalina Island is entering a new era of vegetation response. Invasive plants pose a significant threat to the recovery and integrity of the island ecosystem. The Conservancy has established a strong foundation to systematically manage the threats posed and the impacts caused by invasive plants on the island.

Incipient invasive plant species and those in limited abundance are a high priority for eradication because the cost of control at this stage is relatively low. Abundant and widespread invasive species have been prioritized for reduction and/or containment at the site and watershed. Each watershed was ranked for priority of protection based on the resources found within. Avenues of dispersal such as travel corridors are priorities for treatment to reduce invasive plant establishment and reduce further dispersal throughout the island. Sites of high conservation value such as: Gallagher's Canyon, Middle Canyon, Cottonwood Canyon, Toyon Canyon, Grand and Silver Canyons, Little Springs, Shark Harbor, Cherry Valley, Avalon Canyon, and Whites Landing will also be managed to eliminate or reduce the threats posed by priority invasive species.

In addition to prioritizing invasive species and populations for management, the Conservancy is committed to consistent treatment of infestations as a vital element in conducting a successful invasive plant management program. Similar to eradicating feral animals from the island, consistency and follow-through are essential to achieve management objectives, and maintain the benefits derived from previous work.

The Conservancy is working to effectively protect Catalina Island from invasive plants, and maintain the benefits derived from past restoration efforts. This plan is intended to serve as a transparent roadmap to holistically manage invasive plants species for decades to come regardless of staff turnover or changes in management philosophy.

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CATALINA ISLAND CONSERVANCY

HIKING USE PERMIT
ASSUMPTION OF RISK AND WAIVER OF LIABILITIES

PERMITTEE acknowledges that the area over which this permit is granted is a wild lands area, containing, without limitation, wild bison, rattlesnakes, and other wildlife, rough terrain, trails and roads, and other conditions, which are intrinsic to the environment and locale, all of which may be dangerous and/or hazardous to life, limb and property.

PERMITTEE voluntarily accepts and assumes all such risks of personal injury, wrongful death, or property damage.

PERMITTEE as consideration for the granting of this permit, for himself/herself, his/her heirs, executors, successors and assigns, waives and releases any and all claims, demands or rights of action, in law or in equity, known or unknown against SANTA CATALINA ISLAND CO., SANTA CATALINA ISLAND CONSERVANCY, TWO HARBORS ENTERPRISES, and THE DEPARTMENT OF PARKS AND RECREATION, LOS ANGELES COUNTY and their officers, directors, members, agents and employees for any loss, damage or injury of any kind whatsoever, to himself/herself or to his/her property or to the property of others, occurring from any cause whatsoever, arising directly or indirectly out of the exercise of any right granted by this permit, unless the same be attributable to the gross negligence or willful misconduct of SANTA CATALINA ISLAND CO., SANTA CATALINA ISLAND CONSERVANCY, TWO HARBORS ENTERPRISES or DEPARTMENT OF PARKS AND RECREATION, LOS ANGELES COUNTY, their officers, directors, members, agents or employees.

PERMITTEE understands that this is a release of PERMITTEE'S right to sue.

RULES & REGULATIONS

Hiking permits are required.
Bike Passes into the Interior are a benefit of Conservancy Membership.

1. No smoking or open fire is allowed anywhere on Conservancy land except at designated campgrounds or facilities pursuant to Los Angeles County Fire ordinances and Conservancy regulations. Los Angeles County Code Section 17.12.370 prohibits fires on beaches in Los Angeles County.
2. When "red flag" days are declared, no smoking or fires of any kind are allowed anywhere in the interior. Carefully read posted signs and ask Conservancy staff or rangers if you have any questions. Fireworks, sparklers, torches, candle lanterns, candle balloons, flares or any other incendiary device are strictly prohibited on Conservancy lands.
3. Pack out all trash. Limited waste collection is available at some campgrounds. Littering is a violation of Conservancy regulations and state and county laws.
4. Tree cutting or gathering of wood, including driftwood, for fires is prohibited.
5. Do not disturb, excavate, damage or deface archaeological or historical sites (middens,

habitation sites, rock art, historical structures, etc.). Leave all artifacts (bowls, shells, tools, mortars, jewelry, lithic materials, etc.) in the places where they are presently located. If you believe an artifact is at risk, contact a Conservancy ranger or staff person immediately with exact location information.

6. Collecting, harvesting, hunting, trapping or otherwise exploiting plants, animals, rocks or minerals on Conservancy lands is prohibited unless specifically authorized by the Conservancy and in conformance with local, state and federal laws.
7. Do not spread invasive plants to Catalina Island. Before coming to the Island, and when you leave, check your clothing and shoes carefully for seeds, dirt and mud. Remove all seeds or soil and dispose of them properly.
8. Do not feed or disturb wildlife, especially Island foxes, deer, bison, squirrels or ravens. Feeding wildlife is a violation of California Fish and Game laws and Conservancy regulations. Maintain a safe distance from bison. Bison are large wild animals that can cause serious injury and even death. Do not approach or harass bison and other wildlife on Catalina and always maintain a safe distance.
9. Hunting on Conservancy lands is only allowed during established hunting seasons and in accordance with the Conservancy's Private Land Management Program and the State of California's Fish and Wildlife Laws. No person who is not authorized by the Conservancy shall hunt or trap on Conservancy lands, or carry firearms, traps or other hunting equipment onto Conservancy lands.
10. Hitchhiking is prohibited.
11. Dogs and horses are allowed on Conservancy trails and roads. Dogs must be leashed at all times. Cats or other non-native animals are not allowed. All dog waste must be collected and removed. Dogs must have current vaccinations, including: tri-annual rabies; annual distemper combination (DLHPCC) and kennel cough (Bordetella). Dogs are allowed in the following campgrounds only: Black Jack, Little Harbor (excluding Shark Harbor) and Parsons' Landing. Dogs are not allowed at the Ben Weston primitive beach campsite. Los Angeles County Code Sections 17.12.290 and 17.12.300 prohibit dogs, cats and horses on any beach in Los Angeles county, including all beaches on Catalina Island.
12. Adhere to all regulations that govern your travel in the backcountry. As a visitor you have the responsibility to "leave no trace" of your presence on the natural environment.
13. Stay on roads and trails that are open for public use. Do not enter non-Conservancy lands or lands of tenants of the Conservancy without permission.