Land Manager's Guide to Developing an Invasive Plant Management Plan

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Abbreviations

BMP	best management practice
Cal-IPC	California Invasive Plant Council
EDRR	early detection and rapid response
Guide	*Land Managers Guide to Developing an Invasive Plant Management Plan*
IPM	integrated pest management
Plan	invasive plant management plan
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service

Chapter 1

Introduction

European beachgrass
Ammophila arenaria
CREDIT: USFWS

1.1 Purpose

The *Land Manager's Guide to Developing an Invasive Plant Management Plan* (Guide) is intended to help natural resource managers develop a strategic, integrative, and adaptive invasive plant management plan (Plan) (figure 1). More importantly, this guide covers the *process* of invasive plant management planning, whether you are developing a stand-alone Plan or integrating invasive plant management into other land management planning efforts such as vegetation management, fire management, species/ecosystem recovery planning, or climate change adaptation. The Guide is applicable at any scale, wherever invasive plants (terrestrial or aquatic) are a conservation concern and where resources will be expended to prevent, reduce, or eliminate them.

The Guide addresses topics common to many land management situations but also recognizes that each situation is unique given the diversity of environmental, legal, political, and other factors that can influence a site. Common constraints—such as limited staff or funds, site accessibility, spatial scale, sensitive resource concerns, and political or cultural issues—can impact where, when, and how we manage invasive plants and are addressed throughout the Guide, as applicable. This Guide is not intended to prescribe specific methods or techniques for invasive plant prevention, control, or inventory/monitoring. Furthermore, it does not address specific policies or regulations, as these can differ according to the agencies or organizations involved. Rather, it guides the process of decision-making to meet site-specific needs and conditions.

This Guide describes a step-wise process for developing and documenting an approach to managing invasive plants, and points to a wealth of freely available resources and examples. The intent is to help land managers develop effective Plans, even when management resources are limited and variable. Information in this Guide integrates and builds upon the best available information, including published and unpublished literature, decision-support tools, expert opinion, and past invasive plant management or integrated pest management (IPM) planning guides (such as Olkowski and Olkowski 1983; Tu and Meyers-Rice 2002; U.S. Fish and Wildlife Service [USFWS] 2004; IUCN 2018).

This Guide helps land managers address these key questions:

- Why is invasive plant management needed?
- What are the desired outcomes—management objectives?
- Which invasive plant species should be a management focus and where?
- What is the status (distribution, abundance) of invasive plants?
- What management strategies should be implemented? Who will implement? Where and when will they be implemented? Cost?
- How will the effectiveness of strategies be evaluated?
- What is the process for learning and adapting management strategies over time?

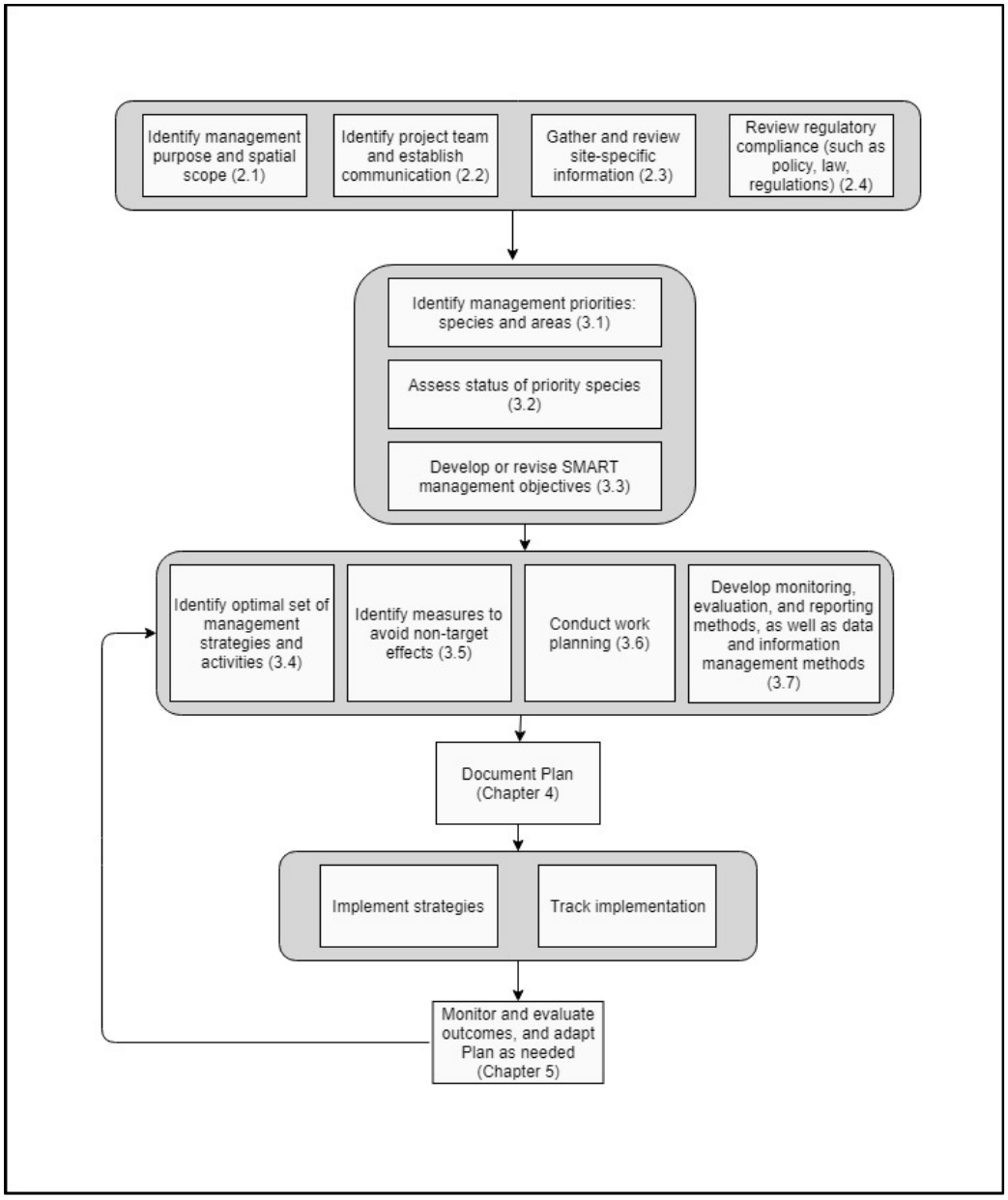

Figure 1. Strategic and adaptive invasive plant management cycle. Numbers in parentheses refer to sections of the Guide where information on that topic is located.

1.2 How to Use This Guide

This Guide is designed to take you through the major phases of developing a Plan (table 1): preparing to write the Plan (chapter 2), analyzing the situation and designing a management strategy (chapter 3), writing the Plan (chapter 4), and evaluating outcomes and adapting management strategies (chapter 5). A glossary follows chapter 5. Appendix A provides a list of useful online resources, appendix B provides plan examples, and appendix C provides a structured checklist of questions which serve as a Plan template.

Table 1. Steps for developing a strategic, integrative, and adaptive invasive plant management plan.

Step	*Description*	*Guide location*
Identify management purpose and spatial scope	The management purpose identifies the reasons why a Plan is needed, its intended audience(s), and how it will be used. The spatial scope identifies the geographic area where management activities prescribed by the Plan will occur and sets the stage for what types of information should be gathered to inform the Plan.	Section 2.1
Identify project team and establish communications	The project team is the larger group of people involved in your invasive plant management program, including land managers, stakeholders, researchers, governing boards, and other key players. The project team often includes a smaller core team who coordinates the planning effort and is ultimately responsible for developing and implementing the Plan. Identify the means for communication during the planning process, both within and outside your organization.	Section 2.2
Gather site-specific information	Gather basic information (plans, reports, data) for your sites, including organizational vision, conservation priorities, management goals and objectives, invasive plant issues, and management history. Identify gaps in information that need to be filled.	Section 2.3
Review regulatory compliance	Gather and review organizational policies and legislation that apply to invasive plant management planning or actions within your scope.	Section 2.4
Identify management priorities: species and areas	Select and document plant species that will be the focus of the Plan. A Plan may focus on a single species or address multiple species. If multiple species are being considered, prioritize which species are most critical to address. Define management areas within the Plan scope and prioritize where to focus management efforts.	Section 3.1
Evaluate the status of priority invasive plants in priority areas	Assess invasive plant abundance, distribution, pattern of spread, and spatial relationships with abiotic and biotic features in the environment.	Section 3.2
Develop SMART (specific, measurable, achievable, results-oriented, time-bound) management objectives	Develop statements that detail what success would look like as a result of your invasive plant management program.	Section 3.3
Develop optimal set of management strategies	Develop a suite of strategies to meet your SMART invasive plant management objectives using the best available information.	Section 3.4
Identify measures to avoid non-target effects	Use the best available information to develop measures to prevent, avoid, or mitigate any potential negative effects on humans, natural or cultural resources, or infrastructure as a result of invasive plant management activities.	Section 3.5
Work Planning	Describe who, what, where, and when invasive plant management activities will occur; this step guides on-the-ground implementation.	Section 3.6
Develop inventory, monitoring, and evaluation methods	Identify methods to track implementation of management activities, monitor plant community status and trends, and assess and report on progress in attaining invasive plant management objectives (or thresholds for management action).	Section 3.7
Develop data and information management methods	Develop data standards and structures for ensuring the data are easily accessed, understood, and utilized to their fullest potential.	Section 3.7
Write your Plan	Summarize your planning process and results of your analysis.	Chapter 4
Adapt your Plan (as needed)	After implementation, monitoring, and evaluation, revise your Plan at a regular interval to incorporate new information and other changes in approach.	Chapter 5

Terminology Matters

The language and terminology used to describe invasive species varies among countries, agencies, organizations, professionals, and members of the public. Terms like ***alien, non-native***, ***invasive***, ***pest***, and ***weed*** are often used interchangeably in scientific literature, confusing readers and even muddling the science (Lockwood et al. 2013). In this Guide, ***non-native species*** are defined as species found outside of their natural range, and ***invasive species*** are non-native organisms whose introduction causes or is likely to cause economic or environmental harm or harm to human, animal, or plant health (Executive Order No. 13751, 2016). It is important to emphasize that not all non-native species are invasive. Likewise, there may be native species that cause harm to ecosystems or human health (often referred to as ***native nuisance species***). Throughout this Guide we use the term ***invasive*** but recognize different terms may be preferred by different users and that planning efforts may also include native nuisance species.

alien: with respect to a particular ecosystem, an organism—including its seeds, eggs, spores, or other biological material capable of propagating that species—that occurs outside of its natural range (Executive Order 13751, 2016). Synonymous with ***non-native***, ***nonindigenous*** and ***exotic***.

aquatic nuisance species: a nonindigenous species that threatens the diversity or abundance of native species or the ecological stability of infested waters or commercial, agricultural, aquacultural, or recreational activities dependent on such waters (Nonindigenous Aquatic Nuisance Prevention and Control Act 1990).

noxious weed: any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment (Public Law 106-224).

pest: organisms that damage or interfere with desirable plants in our fields and orchards, landscapes, or wildlands, or that damage homes or other structures. Pests also include organisms that impact human or animal health (University of California Statewide IPM Program 2018).

weed: a plant that causes economic losses or ecological damage, creates health problems for humans or animals, or is undesirable where it is growing (Weed Society Science of America 2016).

1.3 Invasive Plant Management: An Overview

There are many reasons to manage invasive plants in natural areas. Most often cited are the threat invasive plants pose to native biodiversity and the alterations to natural processes. Many studies have demonstrated how invasive plants can alter ecosystem processes, structure, and composition, as well as the genetic makeup of native species populations through hybridization (Bossard et al. 2000; DiTomaso et al. 2013; Foxcroft et al. 2017; Hobbs and Humphries 1995; Lockwood et al. 2013). Invasive plants can also negatively impact infrastructure or other parts of the built environment (such as damaging irrigation systems) or pose harm to humans (such as increasing wildfire intensity or frequency). Finally, invasive plant encroachment may alter aesthetics or interfere with a recreational or cultural value of a place or property.

An important aspect of developing an invasive plant management plan is to make clear connections between the rationale(s) for managing invasive plants and your organization's mission, resources of conservation concern, and management goals. Such connections help land managers focus management efforts (set priorities), help stakeholders and others understand the motivation and need for management, and can ultimately increase management support. After addressing *why* your organization must manage invasive plants, the bulk of the planning process is focused on *how* your organization will manage those plants. The foundational principles for how to manage invasive plants is based on IPM, which is a decision-making process that integrates management goals, consensus building, pest biology, monitoring, environmental factors, and best-available technologies to achieve desired outcomes while minimizing unwanted effects.

Why Develop a Plan?

Successful invasive plant management is a lot more complicated than simply killing weeds—it requires a strategic and adaptive approach that is well-documented (figure 1). As Ben Franklin said, "if you fail to plan you are planning to fail." The planning process itself provides the opportunity for focused analysis, prioritization, and being clear about what you hope to achieve – your objectives. A well-crafted Plan provides guidance for a consistent management approach over time with parameters for adapting actions as environmental conditions or available resources change. It documents where you are now, where you would like to be, and how best to get there.

Almost all land managers can point to shortages of funding and resources as barriers to successful invasive plant management. A well-crafted Plan can help address these problems by identifying and documenting priorities for action in the face of limited and variable resources. A Plan can also help address other common barriers to successful invasive plant management, such as:

- **Lack of understanding about the impact of invasive plants.** The degree to which invasive plants harm priority conservation targets and impede the attainment of site goals may not be well-understood. This lack of understanding—especially among leadership within an organization or by important stakeholders—can lead to a lack of support and resources. The planning process itself provides a platform for building collective understanding, support, and consensus among management staff, leadership, partners, landowners, and local communities. Without consensus and support, a Plan simply becomes irrelevant.
- **Lack of prevention and early detection and rapid response (EDRR).** Despite the higher economic and ecological returns per unit effort they provide, prevention and EDRR are often overshadowed by already abundant and widespread invasive plant issues. Although there may exist a need to manage existing invasive plant infestations, placing little or no emphasis on preventing new invasions or further spreading can lead to economic and ecological harm (Cusack et al. 2009). The challenge is to balance managing well-established invasive plant infestations, preventing new infestations, and responding to new infestations before they become widespread. Plans should highlight the need for prevention and EDRR and detail exactly how these activities will actually be carried out.

- **Lack of inventory and monitoring of invasive plants.** Inventory and monitoring are essential to successful invasive plant management (DiTomaso 2000; Olkowski and Olkowski 1983; Stohlgren and Schnase 2006), but in the face of limited resources, managers often plan and implement their management strategies with little to no data about the status of the infestations they intend to manage or whether their strategies are actually working. This paradoxical dilemma is difficult to overcome, as many land managers feel the need to use limited resources on controlling invasive plants rather than on conducting inventory and monitoring. Without inventory and monitoring, we lack evidence that our strategies are creating the desired result, have no basis for learning and adapting, and leave no legacy of knowledge for those who come after us (or for communicating with the public), and therefore risk repeating failures.
- **Lack of an integrative approach**. A single-strategy approach, such as only using a chemical control method for long periods, can lead to species resistance, unintended non-target effects, and ultimately failure over the long term. Ideally, employing multiple management strategies that work together is more successful over the long-term than any one single strategy.
- **Lack of SMART (i.e., specific, measurable, achievable, results-oriented, time-bound) invasive plant management objectives and a built-in process for evaluation and feedback.** Without SMART objectives describing the expected result(s) of invasive plant management and a process for evaluation and feedback, managers lack a basis for evaluating progress, testing assumptions, learning, and adapting. We risk repeating practices of the past without regard to whether implemented strategies are working (or not) at different spatial and temporal scales.
- **Action is more reactive than proactive.** Ideally, the establishment of highly invasive species is wholly prevented, detected, or eradicated in the early phases of invasion. An introduced species can remain at low levels for a long period of time (such as years) before rapidly expanding. This is known as the *lag phase*. Whether or when a species leaves the lag phase and rapidly expands can depend on several factors including (1) development of genotypes that allow the species to spread, (2) changed environmental conditions that promote rapid population spread, or (3) continuous expansion of the species population that goes unnoticed until it becomes widespread (Hobbs and Humphries 1995). It is more cost-effective to remove or prevent establishment of invasive species before they become widespread and abundant—in other words, taking a more proactive than reactive approach.

Principles of Integrated Pest Management

The concept of IPM was first articulated by University of California entomologists in the 1950s, and in 1972, the concept of IPM became part of national policy with the establishment of an interagency IPM Coordinating Committee. While historically focused on insects and disease-causing organisms affecting agriculture, IPM now applies to all pest taxa and non-crop situations such as invasive plants in natural resource conservation areas.

The term *integrated* means to apply a combination of management techniques that work better together than separately. Using an integrated management approach increases the likelihood of success and reduces the likelihood that a pest will become immune (i.e., develop resistance) to a management technique, particularly in the case of herbicides.

Integrated Pest Management (IPM)

"A science-based decision-making process that incorporates management goals, consensus building, pest biology, monitoring, environmental factors, and selection of the best available technology to achieve desired outcomes while minimizing effects to non-target species and the environment and preventing unacceptable levels of pest damage" (USFWS 2010).

While the concept and policies surrounding IPM have evolved over time and vary across organizations and agencies, contemporary descriptions have common elements (for example, USFWS 2004; DiSalvo and Parson 2011; Flint and Gouveia 2014; UC-IPM 2018) such as:

- Know your resource (site description: ecosystems and landcover, infrastructure, conservation goals, etc.).
- Know your pest; identify priority pest species and understand their ecology and harm (or potential harm).
- Assess the status of pest populations.
- Prevent pest problems.
- Use a combination of techniques to control pest populations.
- Develop guidelines or thresholds for management action.
- Describe your expected management outcomes or results (objectives).
- Build consensus and regularly communicate with those who may be affected by your pest management program or who can contribute expertise.
- Monitor management outcomes, learn, and adapt management.

This Guide is designed to help you consider each of these elements as you develop your Plan.

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Chapter 2

Preparing to Write a Plan

This chapter is focused on laying the foundation of your Plan—its spatial scope, who should be involved in its development, understanding which invasive plant species occur (or could occur in the future), conservation focus, invasive plant management history, and regulatory considerations.

Purple loosestrife
Lythrum salicaria
CREDIT: ©2009 Barry Rice

2.1 Identify Plan Purpose and Spatial Scope

An essential first step in the planning process is to identify the Plan's purpose and its spatial scope. The Plan should present a compelling case for why invasive plant management is needed and how it is impeding your ability to achieve your organization's mission and conservation goals. The spatial scope identifies the broad geographic area where invasive plant management activities will occur and sets the stage for what types of information should be gathered to inform the plan (section 2.3), what laws or policies will govern invasive plant management activities (section 2.4), and who should be involved in strategic analysis for the Plan and the types of communication needed (section 2.2). The Plan may focus on a single, geographically distinct site such as a park, refuge, watershed, or forest, or a collection of sites within a large landscape. The scope could also be more thematic in nature, such as a particular ecosystem within a landscape.

2.2 Identify Project Team and Establish Communication

The project team is the group of people who are involved in developing a Plan. The project team can be a small group of people who do most of the work (core team), decision-maker(s), stakeholders (such as the public or adjacent landowners), invasive species experts, and others who will implement the Plan or who have a vested interest in conservation activities or outcomes at your site. It's worth carefully considering your project team's composition and, if needed, pushing your organization to recognize the importance of this step. The ultimate utility of a Plan can depend heavily on who is involved in its development. Project team members will likely include representatives from the implementing organization but may include others outside the organization. Being outside the organization might mean these individuals play different roles on the team, but they may still be essential for successfully implementing your invasive plant management program.

The core planning team—those who will be closely involved with moving the process forward—should form at the start of Plan development and then promptly identify everyone who should be

involved within the broader project team and revisit the Plan scope. The composition of the project team may change as you move through Plan implementation, although it is usually helpful to maintain continuity. Once you have identified the project team, identify and communicate roles. Begin communicating with your team early in the planning process to help everyone understand the planning process, their roles, and how information will be shared.

Who Should Be on the Project Team?

- People who will develop the Plan
- People who will implement the Plan
- Key decision-makers
- Partners or other important stakeholders
- Technical advisors

It is critical that communication continues throughout the planning process to help build consensus, ensure the time and resources you spend on planning are not wasted, and the team is connected and supportive of the final product. While some Plans will be primarily internal, for others the external use will be just as important. Near urban areas, or in high-use areas, land management decisions may be politically charged, and a great deal of public review and participation may be needed to develop a Plan that reflects the interests of all stakeholders. Political leaders may need help in understanding the factors that go into developing a Plan, and a communication strategy for outreach to the broader community may be needed. Beyond their perspective as stakeholders, community members can also be a great resource for ideas and assistance. General tips for improving communication during the planning process are listed below:

- Design the Plan to suit the needs of the target audience(s).
- Make the Plan readable; minimize jargon and technical details that are not explained.
- Communicate early and often with all levels of management in your organization on the need for the Plan.
- Anticipate potential internal and external concerns; develop a communications approach to address these concerns.
- Design an ongoing process for building consensus between technical experts, decision-makers, and stakeholders.

2.3 Gather and Review Site-Specific Information

Gathering and reviewing information relevant to the Plan scope will provide a foundation for developing your Plan and increase how efficiently it is developed. Information should be gathered to answer questions such as:

- What is the focus of conservation at the site, and what are the associated conservation goals?
- What are current and potential invasive plant species that prevent attainment of conservation goals, and how do they prevent attainment of goals?
- What is the current distribution and trend of each invasive plant species?
- What strategies have been employed to manage species currently and previously, and how effective have they been?
- From whom is support needed for Plan development and implementation? Where might obstacles and resistance to invasive plant management support be likely to materialize?

Table 2 lists information that would typically be gathered and used to inform development of a Plan.

Table 2. Common types of information to support invasive plant management planning.

Item	*Source*	*Rationale*
Personal knowledge or expertise	Interviews with leadership, invasive plant program staff, adjacent land owners, and local (or regional) invasive species experts.	Increases understanding about current invasive plant issues, future potential invasive plant issues (early detection), management history, management effectiveness, and potential barriers to successful management.
Site surveys	Tours of management areas with staff familiar with the areas and history of invasive plant management efforts.	Increases understanding about conservation targets, sensitive species issues, invasive plant threats, stress, status, and trends; informs invasive plant management strategies.
Management plans and records	Site-specific or surrounding landscape conservation plans; past invasive plant management plans, reports, or management records; and stakeholder lists.	Identifies conservation targets, goals, or existing invasive plant management objectives within the spatial scope or in the surrounding landscape. Increases understanding about the status and trends of invasive plant threats and the harm they cause as well as understanding of potential management strategies. May identify restrictions on management methods.
Spatially referenced information	Maps or spatial data: site boundaries, management units, landcover, vegetation communities, hydrology, roads/trails, infrastructure, cultural resources, sensitive species locations, and invasive species distribution.	Increases understanding about the status and trends of invasive plants, relationships with other environmental features (biotic and abiotic). Informs priorities for invasive plant management (what species and where) and strategy development.
Invasive plant lists	Site-specific invasive plant lists, management plans, natural resource reports, and outside databases (from state invasive species councils, natural heritage programs, NatureServe Explorer, EDDMapS, herbaria, etc.).	Informs what species should be the focus of management. If there are multiple plant lists for a single site, compile into one list and standardize taxonomy (such as to the International Integrated Taxonomic Information System standard, available at *www.itis.gov*).
Early detection plant lists	Web-based species occurrence databases like EDDMapS and CalWeedMapper and information from early detection networks, county agricultural extension agents, and weed management areas.	Informs what species should be the focus of early detection efforts.
Non-native plant invasiveness rankings and legal status	Invasive species risk assessments conducted by larger landscape agencies or organizations, such as invasive plant councils; includes federal and state noxious weed lists.	Informs prioritization of non-native plants species for management.

2.4 Review Regulatory Compliance

Compliance with regulations (acts, laws, policies, regulations, permits, certifications, etc.) is always a component of developing and implementing invasive plant management programs and may ultimately influence the types, location, and timing of invasive plant management activities at your site. While regulatory compliance is an important component of planning, it is not a focus of this Guide, as requirements can vary geographically (such as by state) and across private and public organizations.

We recommend consulting within your organization to gain a clear understanding of the policies, laws, permits, required training, and other regulatory compliance applicable to invasive plant management activities within the Plan's scope. If your organization has limited knowledge or experience with regulatory compliance issues, reach out to similar organizations in your area who may have more expertise. In the case of federal or state agencies or for Plans that encompass public lands, be sure to review your agency's regulatory framework. It is always useful to reach out to invasive species experts, within or outside your organization, to better understand the regulatory framework that will influence invasive plant management planning and implementation.

Chapter 3

Analyzing the Situation and Designing a Management Strategy

This chapter guides you through analysis of information gathered (chapter 2) to identify your priorities, define what you want to achieve (objectives), and design a management strategy. *Strategies* here refers to a collection of activities that work together to achieve a particular outcome—the objective(s). Ultimately, the level of detail provided about strategies and associated activities should be tailored to the situation and intended users of the Plan. For example, if the Plan is intended to direct on-the-ground management activities, then a high level of detail is warranted.

Section 3.1 covers identifying priority species and areas, and section 3.2 covers evaluating the status (abundance and distribution) of priority species in priority areas. Setting invasive plant management objectives and establishing strategies are discussed in sections 3.3 and 3.4, respectively. Section 3.5 covers how to avoid non-target effects, or the unintended impacts of carrying out invasive species management. The final two sections—section 3.6 and 3.7—discuss how you will implement your plan. Section 3.6 addresses work planning, a critical step in which you will document what needs to get done, where, and when, as well as how much it will likely cost; work planning is an essential step in ensuring that your Plan is implemented effectively and consistently over time. Section 3.7 discusses establishing inventory, monitoring, and evaluation procedures.

Water hyacinth
Eichhornia crassipes
CREDIT: USFWS

3.1 Identify Management Priorities: Species and Areas

One key aspect of any invasive plant management planning process is prioritization: selecting which species to work on, where, and when. Ideally, prioritization is conducted before significant resources are invested in invasive plant inventories, early detection, or management actions. Managing for all non-native species everywhere within a site is impractical. Natural resource managers are often constrained by funding, available resources, time, and personnel, and several have developed credible ways to make decisions about which invasive plants to focus on and where (such as Hiebert and Stubbendieck 1993; Randall 2000; Skurka Darin et al. 2011; USFWS and Utah State University 2018).

The prioritization process (shown schematically in figure 2 below) is an opportunity to develop or refine the focus of invasive plant management activities, ensuring resources are dedicated where they are most needed. Ideally, decisions about what invasive species to focus on and where should be transparent, repeatable, and defensible (Hiebert and Stubbendieck 1993; Randall et al. 2008; Warner et al. 2003). This approach helps build consensus and support, fosters continuity in management over time as people or

conditions change, and builds in management flexibility as funding and staff levels change. Prioritization does not mean that a species or area identified as "low priority" should never be addressed; even low priority species and areas may be addressed at some point in the future. Alternatively, it is worth evaluating if there are invasive plant species currently under management that shouldn't be. It's important to remember prioritization is intended to inform decision-making rather than to make decisions directly. Prioritization results should be discussed among your project management team to make final decisions.

While most teams find both species and area prioritizations useful, there may be cases where there are few (such as fewer than five) invasive plants of concern within or adjacent to the Plan's spatial scope, negating the need for species prioritization. Here, the decision process may shift to where invasive plant management should be focused, especially when the scope encompasses thousands or millions of acres.

The following sections describe the general process and tools for prioritization. Also, see appendix A for tools and resources for prioritization and appendix B for links to reports or plans that contain invasive plant prioritization examples.

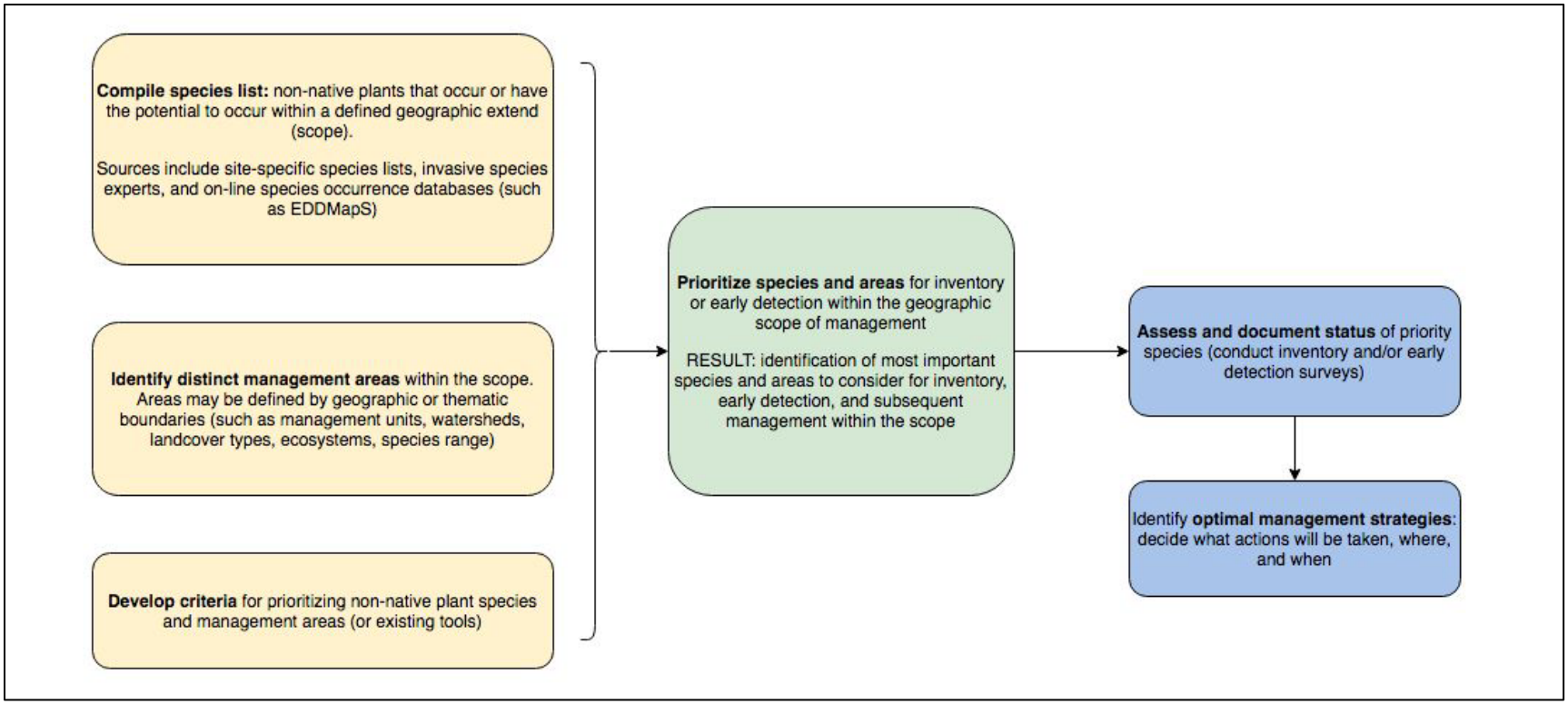

Figure 2. Generalized work flow for prioritizing species and areas for management. Initial prioritization informs what species and where inventories or early detection surveys should be focused and more generally where management efforts should focus. Subsequent inventory or early detection surveys provide details to inform and direct on-the-ground management action (what to do, where/what populations, and when). Survey data also provide a basis for evaluating progress over time.

3.1.1 Identify and Prioritize Plant Species

The first step in species prioritization is to compile a list of non-native plant species known to occur within the Plan spatial scope as well as species with the potential to occur in the future. Ideally, a list of current and potential species is compiled from available sources and scientific names are standardized to your preferred taxonomic standard (such as the International Taxonomic Information System). Once compiled, the lists can then be prioritized by the project team using one or more criteria (table 3).

Many larger landscape organizations such as the U.S. Department of Agriculture (USDA) and state invasive plant councils have assessed invasiveness or "noxiousness" of non-native plant species to wildlands across large landscapes of the United States (see table 4 for examples). These assessments are based on risk assessment criteria such as the NatureServe *Invasive Species Assessment Protocol* (Morse et al. 2004), and they often rely on scientific literature and expert knowledge to provide a comprehensive review of species ecology, biology, distribution, and impacts on the environment. While these larger landscape lists can be a useful tool in identifying management priorities, when used alone, they may not provide enough information to identify local scale priorities. For example, when many of the species on your list are found on one of these larger landscape lists, management priorities may be less apparent. In such cases, it may be useful to apply additional criteria (table 3) or use a tool (table 5) to help identify site-specific priorities. A more structured approach can help teams come to consensus on which species should be a focus of management as well as provide a legacy of information about how decisions were made. An example of a species prioritization exercise from the Klamath National Wildlife Refuge Complex is provided in figure 3.

3.1.2 Identify and Prioritize Management Areas

A first step in prioritizing areas for management is to define the areas of your Plan's spatial scope that are under management consideration. Over the long term, the intent may be to manage invasive plants across all areas within the Plan's spatial scope, but when resources are limited, area priorities help inform where to use those resources. Areas should have clear boundaries defined by one or a combination of features such as jurisdictional management boundaries, ecosystem types, vegetation communities, sensitive species populations/habitat, watersheds/hydrology, soils, or topography. Several criteria can be used to help decide which areas within the Plan's spatial scope are a priority for managing invasive plants. These include the current level of infestation, risk of invasion, and importance to high value conservation resources; table 6 provides a list of criteria often used to prioritize areas, and table 5 provides a list of prioritization tools. An example of an area prioritization from the National Park Service Golden Gate Recreation Area is provided in figure 4.

Table 3. Criteria commonly used to prioritize species for invasive plant management.

Category	*Criteria*
Larger Landscape Invasiveness	The degree to which a species is likely to cause harm to wildlands or overall biodiversity. Invasiveness rankings have been developed for larger landscapes and are based on expert opinion and comprehensive review of the scientific literature (see table 5).
Status and Habitat Suitability	Characteristics of the species within the Plan's spatial scope. Includes criteria such as presence or proximity, abundance, distribution, and habitat availability/potential to spread.
Ecological Impacts	The severity of current or potential impacts the plant causes (or could cause) on conservation targets within the Plan's spatial scope.
Difficulty of Control	The difficulty of managing the species within the Plan's spatial scope. Includes criteria such as cost, time, and technical difficulty.
Larger Landscape Importance	The degree to which the species is a priority for management on adjacent lands or in the larger landscape.
Other	The degree to which a species is important for management because of political, public, cultural, or other reasons (defined by the user).

Table 4. Examples of invasive plant ranking systems.

System title	*Species ranking criteria*	*Web link*
Alaska Invasiveness Ranking System	Preliminary climate screening to identify species that could invade environments found in Alaska or areas with similar climate; includes ecological impact, biology, management difficulty, and distribution.	*http://accs.uaa.alaska.edu/invasive-species/non-native-plant-species-list*
California Invasive Plant Inventory	Species ecological impact, ecosystems or communities invaded, invasive potential, documentation level, and distribution.	*http://www.cal-ipc.org/plants/inventory/*
Federal and State Noxious Weed Lists	Criteria vary across states.	*https://plants.usda.gov/java/noxComposite*
Invasive Non-Native Plants That Threaten Wildlands in Arizona	Species ecological impacts, invasiveness, ecological amplitude, and distribution.	*http://www.swvma.org/invasive-non-native-plants-that-threaten-wildlands-in-arizona/*
Hawaii Weed Risk Assessment	Species ecological impact, ecosystems or communities invaded, invasive potential, documentation level, and distribution.	*https://sites.google.com/site/weedriskassessment/home*
NatureServe I-ranks	Species ecological impact, biology, abundance, management difficulty, non-target management impacts, diversity of habitats or ecological systems invaded, and distribution.	*http://explorer.natureserve.org/servlet/NatureServe?init=Species*
New York State Ranking System for Evaluating Non-Native Plant Species for Invasiveness	Species ecological impact, biology, abundance, management difficulty, and distribution.	*https://www.conservationgateway.org/Documents/New-York-State-Invasive-Plant-Ranking-System.doc*
Virginia Invasive Plant Ranking System	Species ecological impact, abundance, biology, management difficulty, and distribution.	*www.dcr.virginia.gov/natural-heritage/document/nh-invasive-plant-list-2014.pdf*

Table 5. Examples of tools for prioritizing invasive plant species and areas for management, organized from low to high levels of technical expertise required.

Tool	*Prioritization focus*	*Level of expertise required*	*Description*
Invasive Plant Inventory and Early Detection Prioritization Tool (IPIEDPT)	Species and Areas	Low	The IPIEDPT is a Microsoft Access tool that integrates larger landscape invasive plant rankings and local knowledge to generate a prioritized list of species and areas for inventory and early detection, and ultimately management. Species criteria include larger landscape invasiveness rankings, impacts (known or probable), proximity, potential for spread, and abundance/distribution. Area criteria include ecological integrity (health), level of infestation, density of vector pathways, frequency and intensity of vector events, and disturbance. Source: USFWS and Utah State University (2018). Web link: *https://catalog.data.gov/dataset/an-invasive-plant-inventory-and-early-detection-prioritization-tool*
Spreadsheet	Species and Areas	Low	Prioritization of species or areas can be done with an Excel spreadsheet. User defines criteria and scoring for species or area rankings.
CalWeedMapper*	Species and Areas	Low	Provides statewide (California) distribution data (via *calflora.org*) for invasive plants and generates a management opportunities report for user-defined areas (e.g., a National Forest, National Wildlife Refuge, ecoregion, or a county). Results from CalWeedMapper should be combined with local knowledge to set site-specific priorities. Web link: *https://calweedmapper.cal-ipc.org/*
Weed Heuristics: Invasive Population Prioritization for Eradication Tool (WHIPPET)*	Species and Areas	Moderate	WHIPPET prioritizes spatially referenced (mapped) invasive plant populations for eradication based on potential impact, potential spread, feasibility of control, and location (outlier status, proximity to vector pathways, and accessibility). Source: Darin 2008; Skurka Darin et al. 2011. Web link: *https://whippet.cal-ipc.org/pages/view/guide*
ArcGIS	Species and Areas	High	Spatial data such as invasive plant locations and environmental features (such as roads, trails, hydrology, soils, topography, ecosystem/communities, and sensitive resource locations) are overlaid and analyzed (user defined attributes) to identify priority areas and/or species (if spatial data are available) for management. Example area prioritization: National Park Service's early detection protocol (Williams et al. 2009), available at *www.sfnps.org/download_product/1256/0*

Tool	*Prioritization focus*	*Level of expertise required*	*Description*
NatureServe Invasive Species Assessment Protocol	Species	High	The protocol is a multi-criteria tool for assessing, categorizing, and listing non-native invasive vascular plants according to their impact on native species and natural biodiversity in a large geographical area such as a nation, state, province, or ecological region. The tool has typically been used to develop larger landscape invasive plant rankings but can be adapted and used at a local scale. Requires in-depth knowledge about plant ecology and impacts or an in-depth literature search. Web link: *http://explorer.natureserve.org/servlet/NatureServe?init=Species*
Alien Plant Ranking System	Species	High	The system guides users through 25 questions in three sections relating to individual species: (1) current level of impact, (2) potential of a species to become a problem, and (3) feasibility of control. The sections include questions about the distribution and abundance of species, the number of seeds they produce, and their dispersal capabilities. There are also questions about whether a species is known to seriously impact other sites. The tool has typically been used to develop larger landscape invasive plant rankings (such as for Alaska) but can be adapted and used at a local scale. Requires in-depth knowledge about plant ecology and impacts or an in-depth literature search. Source: Hiebert and Stubbendieck (1993). Web link: *http://hear.org/articles/cip_winter2002v2n1_prioritizing_weeds.pdf*

*Note: WHIPPET and CalWeedMapper are specific to California, but their algorithms may be useful for others. Both were designed and built with funding from the USDA Forest Service, State & Private Forestry.

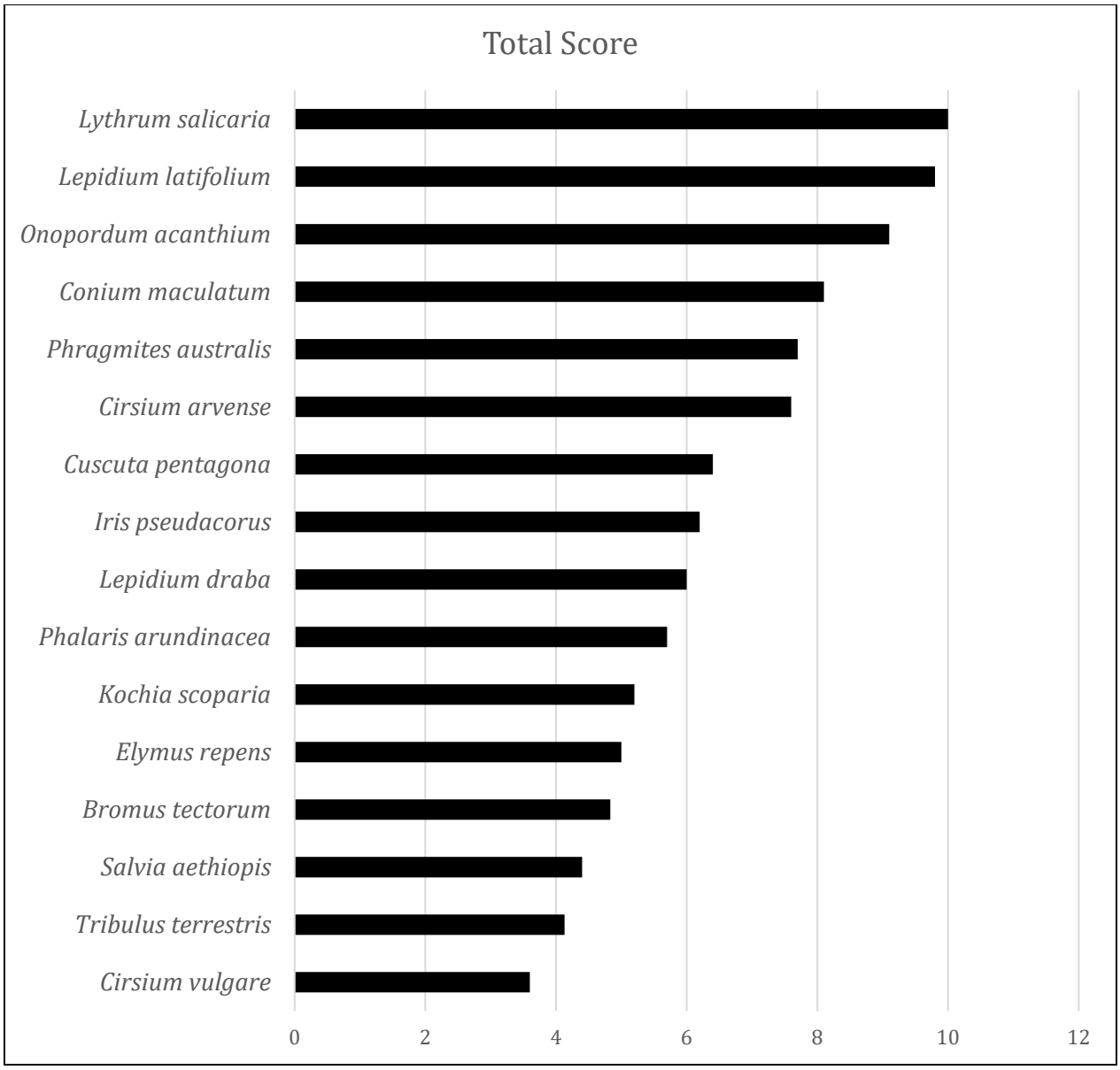

Figure 3. Invasive plant species prioritization results for Lower Klamath and Tule Lake National Wildlife Refuges: species present on-refuge (USFWS in prep.). The larger the total score, the higher the priority for management. Species prioritized using the Invasive Plant Inventory and Early Detection Prioritization Tool (IPIEDPT) (USFWS and Utah State University 2018).

Table 6. Criteria commonly used to prioritize areas for invasive plant management.

Category	*Criteria*
Importance to Conservation Targets	The importance of the area to natural resources of priority conservation concern (conservation targets) as it relates to the presence or proximity of a natural, cultural, or other important resource. Areas important to resources of conservation concern are often a high priority for detecting and removing invasive plants. These are often species, species alliances/guilds/communities, or ecosystems but can include other resources of concern, such as cultural resources.
Integrity or "Intactness" of Resources	The degree to which an area is believed to be healthy, intact, or unimpaired, with major ecological (or cultural) attributes functioning within the bounds of natural disturbance regimes. For example, ecosystem structure and processes are intact and function within their natural ranges of variation. Areas with relatively high integrity often have high conservation value and are a priority for preventing or reducing anthropogenic threats such as introduction of invasive plants.
Innate Resistance to Invasion	The innate capacity of an ecosystem (or other system) to resist establishment and spread of invasive plant species. Environmental factors that can influence innate resistance include resident native plant diversity, density of native vegetative cover, abiotic conditions such as nutrient levels, soil or water quality, and natural disturbance regimes such as flooding and wildfire.
Risk of Invasion: Invasion Pathways and Vectors	Invasion pathways and vectors provide the means for invasive plant transport from one location to another. Here, *pathways* are transportation pathways such as roads, trails, levees, waterways, etc. *Vectors* are the vehicles for transmitting or carrying invasive plant propagules along pathways, specifically human-based vectors such as hikers, cars, boats, or machinery. Criteria for assessing risk of spread from pathways and vectors include assessing the density of vector pathways (both terrestrial and aquatic) and the types, frequency, and intensity of vector events—opportunities for vectors to transmit invasive plants (such as from high recreation use or frequent management activity). Areas where terrestrial pathways are widely distributed and occur at high densities are at greater risk for invasion. Areas that experience frequent vector events (such as recreational areas) are also at risk.
Risk of Invasion: Anthropogenic Disturbance	*Disturbance* facilitates invasive plant invasions and can be described as a "relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment" (Lockwood et al. 2013; White and Pickett 1985). Here, we are focused on anthropogenic disturbances such as restoration/enhancement activities, regular maintenance activities, resource extraction, and toxic spills. Consider the intensity, duration, and frequency of human-caused disturbance events. Areas that are exposed to intense, frequent, or long-duration disturbance events are at high risk for invasion.
Infestation Level	This category considers the richness and abundance of invasive plant species within an area. Areas considered "clean" of invasive plants are often a higher priority than areas already heavily infested.
Investments	Degree of previous investment in invasive plant removal efforts.

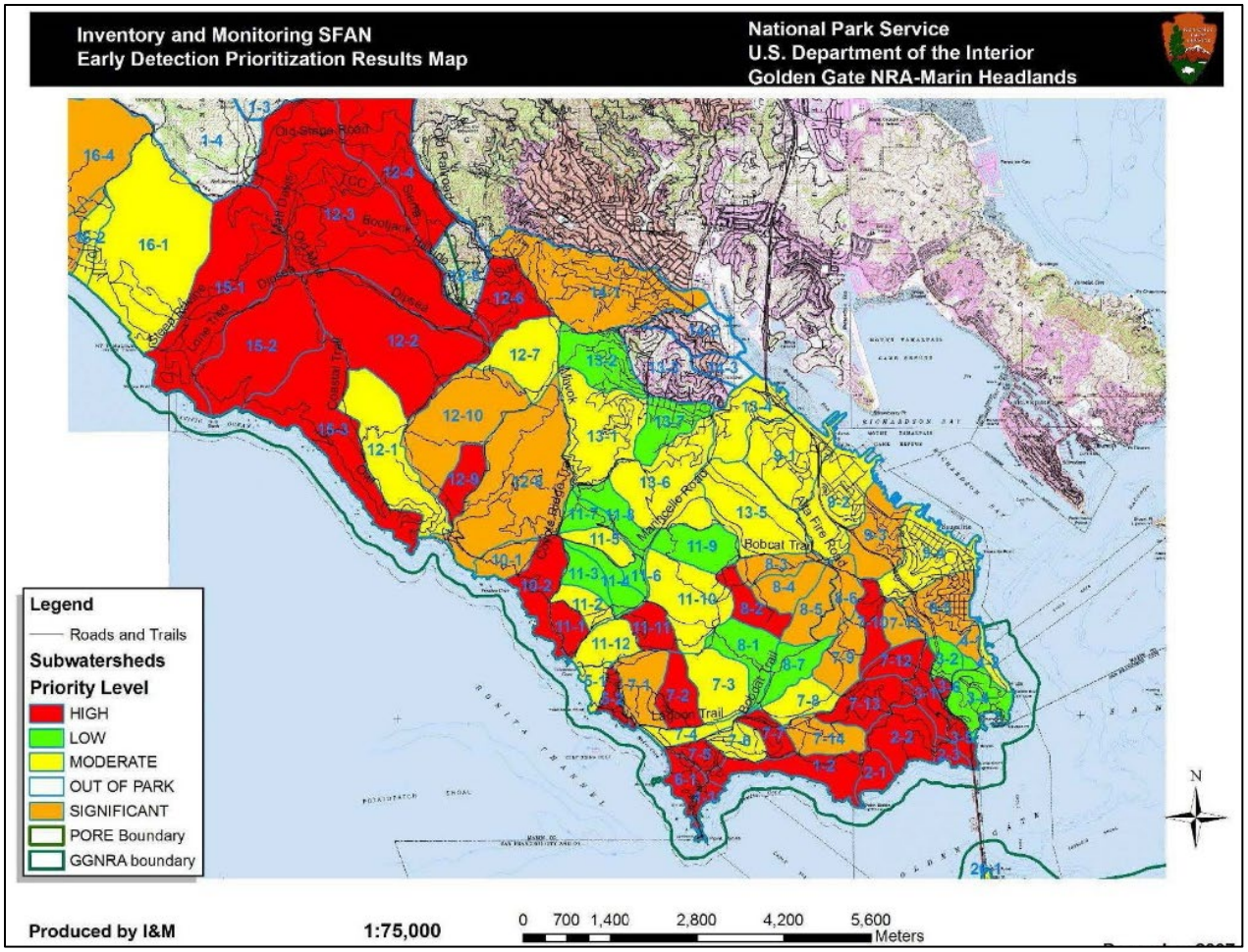

Figure 4. Map of prioritized areas (subwatersheds) for invasive plant early detection in the Golden Gate National Recreation Area, Marin Headlands, California. Hydrologic units (at a variety of scales) were used to define areas. Subwatershed prioritization criteria included abundance of rare or at-risk native species or species alliances, current level of invasive plant species richness and abundance, risk of invasion, and level of previous investment. Source: Williams et al. 2009.

3.2 Evaluate the Status of Priority Species and Areas

Some of the most important pieces of information that help managers develop an effective and efficient Plan is an understanding of the ecology as well as the status of the species they intend to manage. *Status* here refers to the location, distribution, and abundance of invasive plant species obtained through invasive plant inventories or early detection surveys. Data obtained from these surveys are used to:

- Develop specific and measurable objectives (section 3.3)—in order to ask, *where are we now?*, there must be a clear and definitive answer to the question, *where did we start*?
- Understand patterns of invasive plant introduction and spread.
- Inform the development and prioritization of management strategies.
- Guide on-the-ground management activities.
- Evaluate management effectiveness, learn, and adapt (section 3.7).

In addition, data and visualizations of invasive species status (such as species occurrence maps) can increase understanding of the invasive plant problem and may, as a result, lead to increased support. Decision-makers, the private sector, and the general public often have limited understanding of the threats posed by invasive species to the environment, economies, human health, and cultural values. Invasive species management competes for funding with many other interests. Lack of awareness, support, and funding often constrain adequate invasive species management.

If quantitative data concerning the status of priority invasive plants within the Plan's spatial scope are lacking, we recommend these surveys are conducted before developing management objectives and strategies. If this is not possible, consider the following: conducting interviews with field staff or local invasive species experts, mining online species occurrence databases, or reviewing reports or papers that contain information about vegetation within the Plan's spatial scope. Ideally, inventory and monitoring of invasive plants (or vegetation as a whole) becomes an integral component of your Plan (see section 3.7).

3.2.1 Inventories

An inventory is a type of survey that is used to determine the location or condition of a resource at a specific time. In this Guide, *inventory* refers to a catalogue of invasive species that includes information on their location, abundance, and distribution in a defined location (see the examples in figures 5–8). Inventories provide a snapshot of the distribution and abundance of invasive plants across a landscape and are critical for understanding the invasion problem, patterns of spread, and impacts (economic and ecological) and ultimately building a strategic and adaptive Plan (Rew and Pokorny 2006). When resources are limiting, consider inventorying the highest priority areas first and phasing inventory of lower priority areas over time.

> "An inventory serves to diagnose the weed problems within a landscape, and not until the diagnosis is complete can comprehensive and complete management actions be taken. In a sense, weed inventories [or early detection] are as critical to land health as medical exams are to human health, and a tangible weed map is just as vital to a land manager as an x-ray would be to a medical professional."
>
> Andersen and Dewey 2007

3.2.2 Early Detection

Early detection monitoring consists of systematic and repeated surveys of areas deemed high-risk for becoming infested with new invaders and is typically focused along likely routes of invasion and in areas believed to be un-infested ("clean" areas). Early detection surveys are focused on detecting the location of invasive species that are not yet established within a defined area, but the potential for establishment exists (Olsen et al. 2015). Early detection is critical for documenting new and highly invasive species for eradication before they become established, widespread, and abundant and cause both economic and ecological harm.

3.2.3 Inventory and Early Detection Methods

There is not a prescriptive, "one-size-fits-all" method or approach for invasive plant inventories or early detection. The methods will vary depending on survey objectives, species detectability (influenced by abundance, phenology, color, or size), spatial scale, ecosystem type, budget, and available expertise.

In the broadest sense, there are two basic approaches to inventory and early detection surveys: (1) ground-based and (2) remote. Below we provide a summary of these two approaches adapted from the USFWS's *Invasive Plant Inventory and Early Detection Guide* (USFWS in prep.).

Aerial invasive plant survey

CREDIT: Wildlands Conservation Science, LLC.

As the name implies, *ground-based inventory methods* are those in which the surveyor is observing and recording the location of invasive plant infestations from the ground. Depending on the terrain and accessibility of the site, many of these ground-based methods can be carried out on foot or with the aid of vehicles such as trucks, ATVs, boats, etc., that can enhance the efficiency of the survey. Ground-based methods include corridor surveys, grid-based surveys, full coverage swaths, opportunistic sampling, line transects, belt transects, permanent plot monitoring, and photo points.

As compared to ground-based methods, *remote methods* are generally accomplished by sensors deployed on planes, helicopters, and drones from which visual data are collected (collectively referred to as *remote sensing*). Remote methods also include aerial mapping of invasive plant populations by human observers from a helicopter.

The ability to detect weeds remotely depends on the unique properties of the weed of interest, the size or extent of the infestation, and the spectral and spatial resolution of the sensors employed (Bradley 2014). In some cases, the spatial extent or size of the images available is in direct conflict with image resolution. For example, flying at a lower altitude to capture more detail will require more passes to cover a given area. An integral part of remote sensing is performing a field-based accuracy assessment to ground-truth results.

There are many remote sensing methods that have been used to survey invasive plants. Excellent descriptions of different techniques as well as examples of how those techniques have been used have been published by several authors (Bradley 2014; Huang and Asner 2009; Lass et al. 2005; Madden 2004) and should be read by those considering remote sensing approaches to invasive plant inventory; many of these reviews are summarized in table 2 of USFWS (2018). The U.S. Forest Service Remote Sensing Applications Center website (*https://www.fs.fed.us/eng/rsac/*) also provides excellent guidelines on plant characteristics needed to employ remote sensing techniques as well as criteria for selecting the best approach for a given survey objective.

The USFWS's *Invasive Plant Inventory and Early Detection Guide* (2018) summarizes factors to consider when planning these surveys and points to existing survey methods, protocols, and mapping guides.

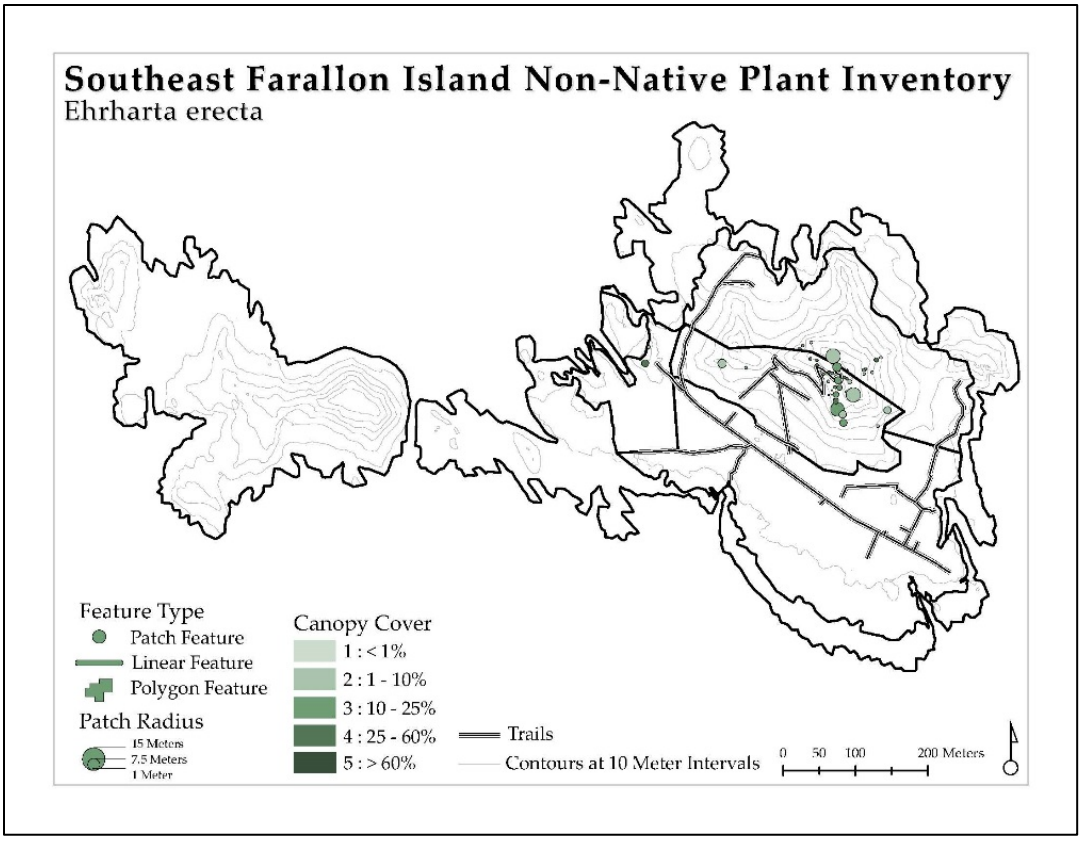

Figure 5. Farallon Island National Wildlife Refuge invasive plant inventory map: *Erharta erecta*. Results of island-wide inventory using field-based mapping methods. Source: Holzman et al. 2016.

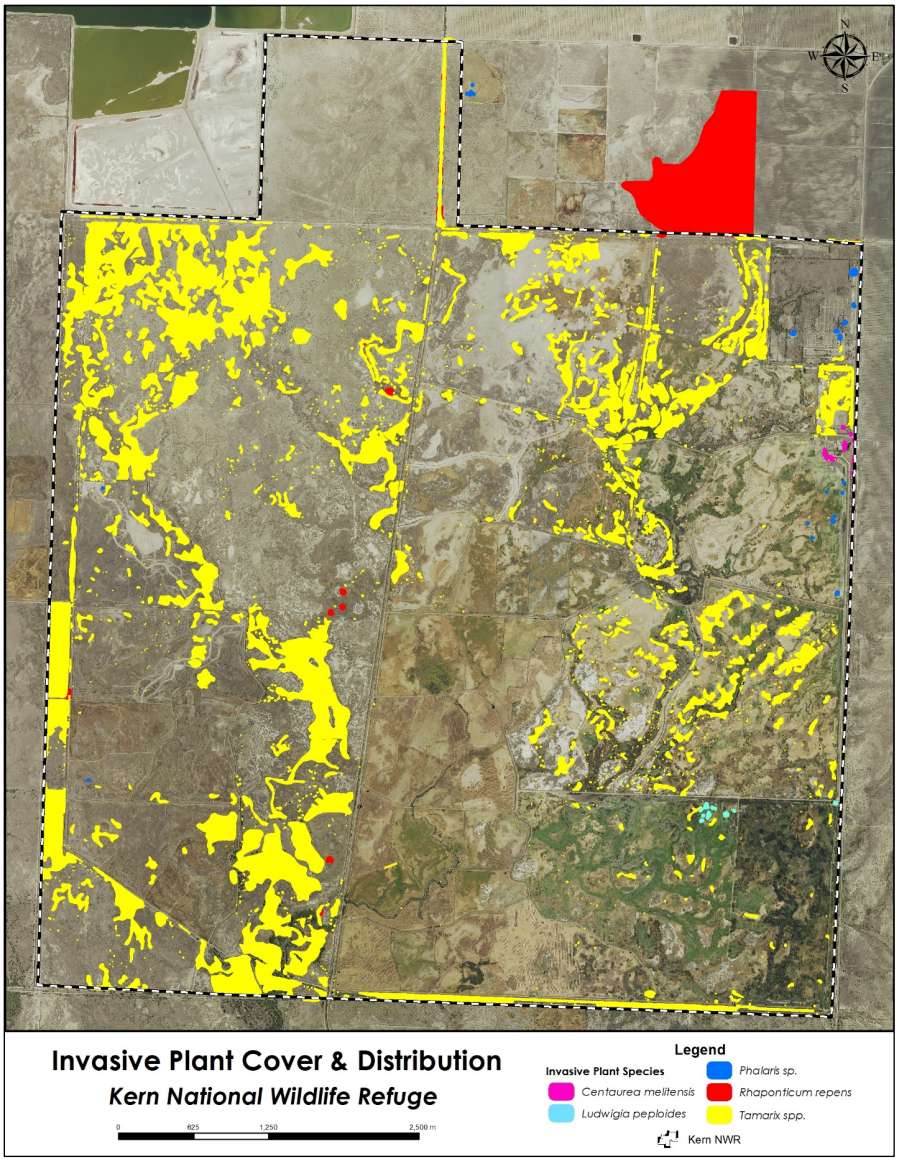

Figure 6. Kern National Wildlife Refuge invasive plant inventory map. Inventory conducted using aerial (helicopter) field-based mapping methods. Source: Ball and Olthof 2017.

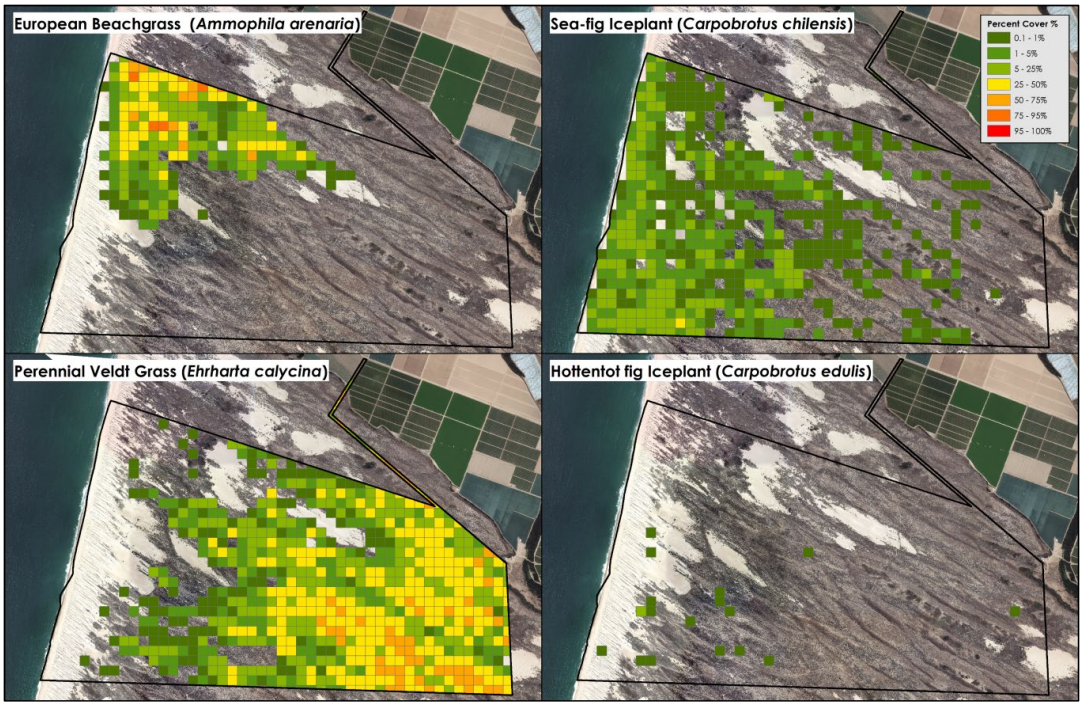

Figure 7. Guadalupe-Nipomo Dunes National Wildlife Refuge invasive plant inventory map. Inventory conducted using aerial (helicopter) grid-based mapping methods. Source: Ball and Olthof 2017.

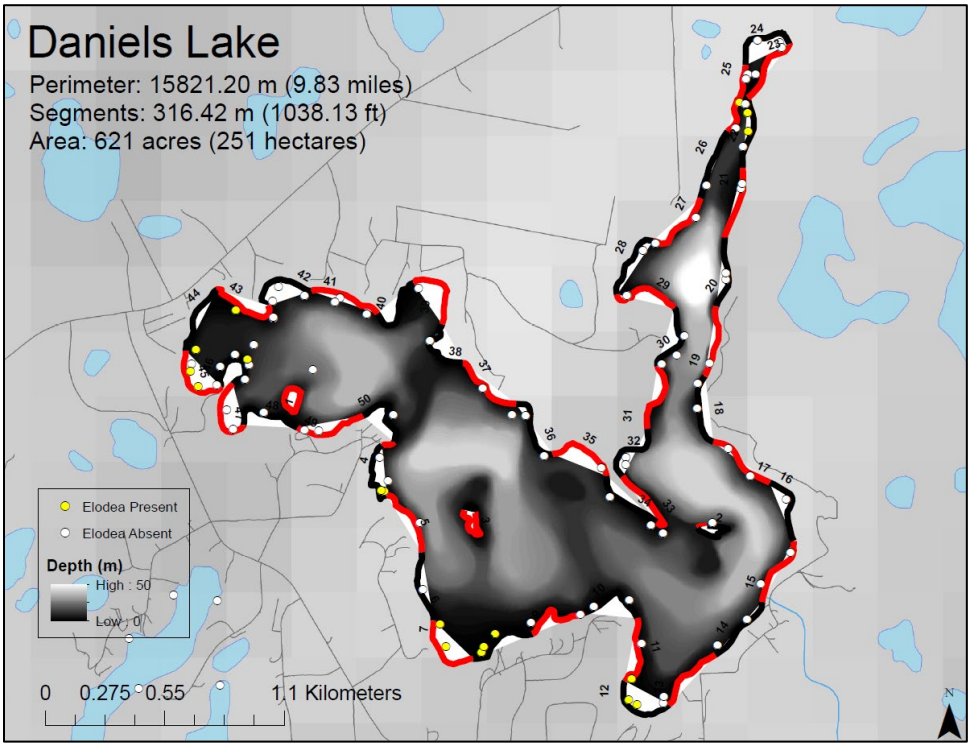

Figure 8. Results of early detection surveys for the aquatic plant Elodea (cross between *E. canadensis* and *nuttallii*) at Daniels Lake, Kenai Peninsula, Alaska. Field-based survey. Source: Bella n.d.

3.3 Develop Invasive Plant Management Objectives

Put simply, an *objective* is a statement detailing the desired outcome or result of management—what success looks like. Depending on the invasive plant management situation, expected outcomes likely fall into one or more of the categories below:

- Preventing introduction of new and highly invasive species
- Containing the extent/preventing further spread of existing infestations
- Reducing the cover of existing infestations
- Eradicating species

Four questions an objective should answer:

1. What is the expected change and where?
2. How much change do you want to see, and in what direction?
3. What needs to be measured to evaluate change?
4. Over what time period is change expected to occur?

Although mentioned previously, it's worth repeating here the importance of well-crafted objectives; they provide the foundation for evaluation, learning, and adaption of management to ultimately improve outcomes. They help us answer the following questions: *is our management program working?* and *if not, why not?*

To answer these questions, we first need to know what the desired impact is—the objective. Second, we need to track whether strategies were implemented or not. Third, we need to monitor attribute(s) of invasive plants (spelled-out in the objective).

A well-crafted objective meets the following SMART criteria (Foundations of Success 2009).

- Specific—*what is expected* and *where* are clearly defined so that all people involved in the project have the same understanding of what the terms in the objective mean.
- Measurable—definable in relation to some standard scale (numbers, percentage, fractions, or all/nothing states).
- Achievable—achievable and appropriate within the context of the project site and available resources. Considerations: people, technical capacity, funding, and political, economic, and other constraints.
- Results-oriented—focuses on the result of management actions, not the actions themselves.
- Time-bound—specifies when results are expected.

Avoid ambiguity by wording objectives clearly. A clearly worded objective is easy to understand and difficult to misinterpret. Avoid or minimize using words and terms that are subject to interpretation without numeric/measurable values attached, such as *high quality*, *reduce*, *enhance*, and *restore*. Objectives should contain a measurable element that can be monitored to evaluate progress; it should be clear from the objective what needs to be measured.

Objectives—no matter how measurable or clearly written—must be achievable. Avoid setting your program up for failure. If you cannot resolve constraints on achieving an objective, then consider discarding or rewriting it. Consider both short- and long-term objectives. Be realistic about what is required to successfully achieve an objective, and use sound professional judgment to develop reasonable expectations of time, staff, and funds available to pursue the objective. Objectives should specify an end result rather than state the action(s) that will be taken; when reading a results-oriented objective, it should be clear what success looks like in terms of the result, not the actions taken (such as how many gallons of herbicide sprayed in a given year). Examples of objectives and how well they pass the "SMART test" are provided in table 7.

Table 7. Examples of invasive plant management objectives and the degree to which they are SMART (specific, measurable, achievable, results-oriented, and time-bound). Generic area names are provided in cases where objectives are drawn from existing plans.

Objective	*S*	*M*	*A**	*R*	*T*	*Notes*
Broom-free by 2003!	N	Y	Y	Y	Y	Lacks specificity: which broom species? Where?
Decrease the abundance and extent of target invasive species in management areas A and B.	N	N	Y	N	N	What are the target invasive species? By when?
Eradicate high-priority species from high-quality habitats.	N	Y	Y	Y	N	Lacks specificity about what species, where eradication will occur, and by when.
Reduce cover of non-native species in Area C by 10% by 2020.	N	Y	Y	Y	Y	Which non-native species are being referred to? Plants?
Conduct EDRR surveys on an annual basis for yellow starthistle along all road within District X.	Y	Y	Y	N	N	Statement about actions that will be taken rather than the result.
Annually spray all known populations of Elodea in Refuge X.	N	Y	Y	N	Y	What species of Elodea? Specifies the management action that will be taken rather than the result of the management action.
Eradicate barbed goatgrass from Area D by 2020, defined as finding no evidence of plants for a period of five growing seasons.	Y	Y	Y	Y	Y	SMART objective
Reduce cover of French broom in Area E to 5% by 2019.	Y	Y	Y	Y	Y	SMART objective
Populations of Spotted Knapweed at Areas B and C will decrease at a rate of 25% per year until eradicated by 2010.	Y	Y	Y	Y	Y	SMART objective

*Note: We assume objectives were written to be achievable.

Developing objectives that are achievable over the life of your Plan requires examining several key pieces of information including:

- What species and areas are a focus of management?
- What is the status of priority species within the Plan scope?
- What are the major constraints: accessibility, spatial scale, availability of people or funding, technical capacity, regulations, politics, etc.?

3.4 Develop Invasive Plant Management Strategies

An *invasive plant management strategy* is a collection of activities or projects aimed at preventing, eradicating, containing, and/or suppressing (asset-based protection) targeted invasive plant species. Deciding which activities to employ and where can be a complex process because there are many factors to consider, such as species abundance and ecology; site characteristics such as scale, sensitive resources, and accessibility; capacity to implement (people, funding, and technical expertise); and socio-political issues. If you have completed the initial planning steps—gathering site specific information, prioritizing, assessing status, and developing SMART objectives (chapter 2 and sections 3.1–3.3)—you are well-positioned to design an effective and achievable strategy.

In this section, we summarize the four basic approaches to invasive plant management (prevention, eradication, containment, and control) (figures 9 and 10) and point to techniques and resources to help you design an optimal invasive plant management strategy. In addition, appendix A lists other resources for understanding invasive plant ecology, imagery, and management techniques (prevention and control). Appendix B points to publicly available Plans and the types of information they contain; these Plans serve as examples of information discussed in this section.

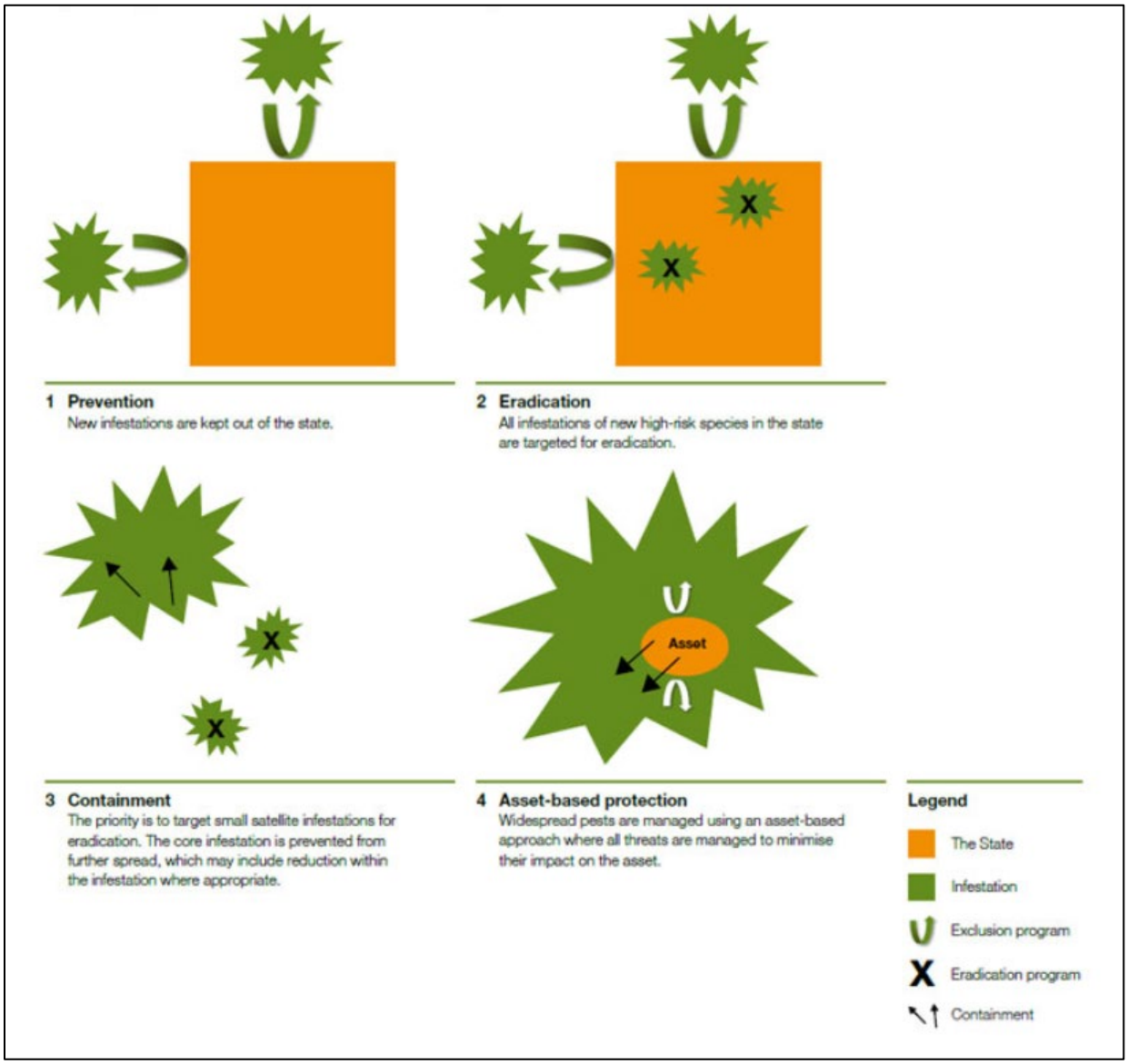

Figure 9. Approaches to invasive plant management at different stages of invasion. Source: Agriculture Victoria 2002.

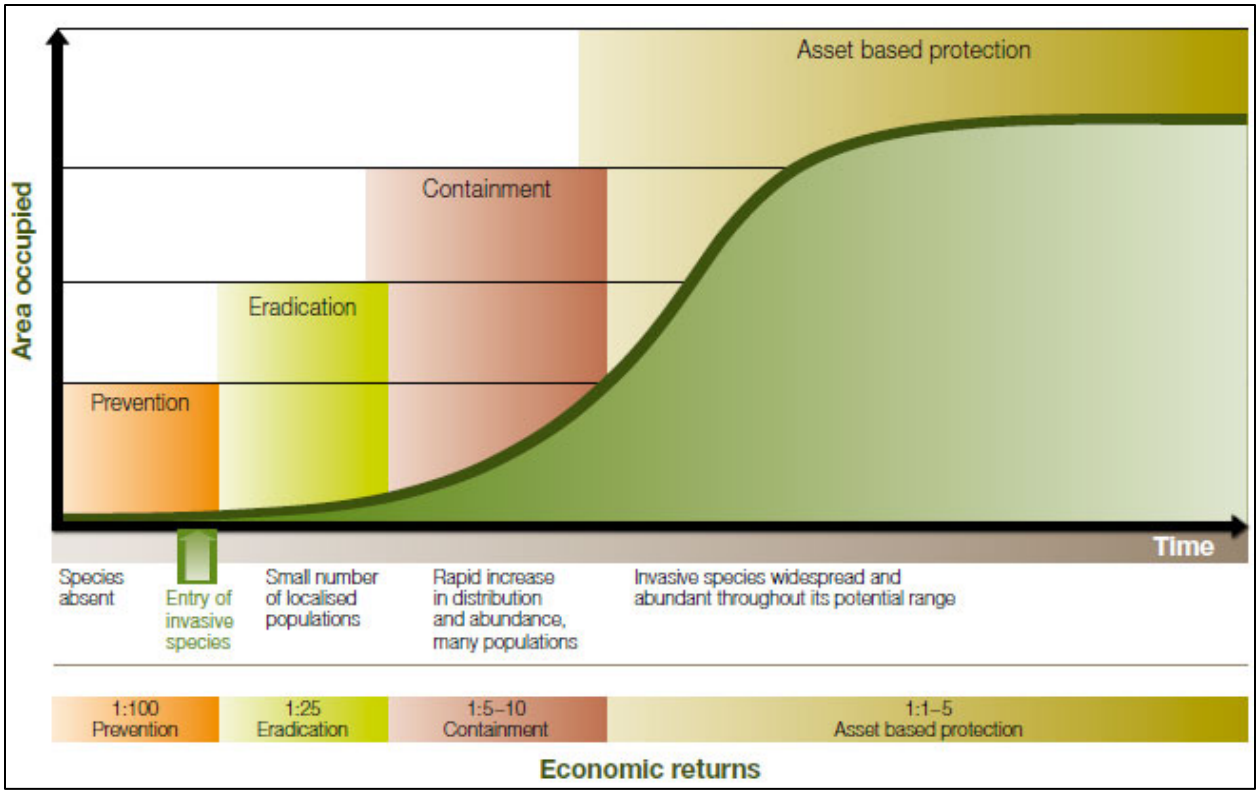

Figure 10. Generalized species invasion curve (the S-curve) and associated management approaches and cost-benefit ratios as area occupied increases. The amount of benefit for every dollar spent decreases as the area occupied increases. Source: Agriculture Victoria 2002.

3.4.1 The Four Basic Approaches to Invasive Plant Management

Prevention (or Biosecurity)

Preventing the introduction of invasive plant species is the first line of defense against invasive species (figures 9 and 10). Together, prevention with EDRR is the most cost-efficient way of reducing the economic and ecological costs of invasive species. Once established, invasive species can be extremely difficult and costly to remove. Even after successful removal, damage to food web dynamics, nutrient flow mechanisms, and other intricacies of the original ecosystem may persist.

Invasive plants are introduced (and spread) by vectors. A vector is the conveyance that moves a non-native propagule to its novel location (Lockwood et al. 2013). Invasive plants can be transported by natural means such as wildlife, wind, and water. Transport also occurs by anthropogenic means; human activities that can inadvertently lead to invasive plant introductions include:

- Importation of contaminated materials such as plants, mulch, wood, soil, gravel, or animal feed.
- Recreational activities such as hiking, biking, boating, and camping.
- Land management activities (carried out by staff, volunteers, partners, and contractors) that involve movement of people, vehicles, or tools. Examples include inventory and monitoring, routine maintenance activities (such as mowing), restoration activities, fire management activities, and invasive plant management activities.
- Other human activities that lead to disturbance or disruption of ecological processes, thereby creating novel situations and opportunities for invasion.

Examples of locations that are vulnerable to invasion include:

- **Vector pathways.** A *vector pathway* is the route between the non-native propagule source and release location (Lockwood et al. 2013). Common vector pathways include roadsides, trails, waterways, and utility corridors.
- **Areas where humans and their vehicles/tools frequent or congregate** such as buildings, boat launch sites, campsites, and vehicle or tool storage areas.
- **Areas of high intensity or frequent disturbance (natural and anthropogenic).** Disturbance facilitates invasion and can be described as a "relatively discrete events in time that [disrupt] ecosystem, community, or population structure and [change] resources, substrate availability, or the physical environment" (Lockwood et al. 2013; White and Pickett 1985). Examples of anthropogenic disturbances include restoration or enhancement activities, regular maintenance activities (such as mowing), resource extraction, and toxic spills. Examples of natural disturbance events include floods, tides, fire, and erosion.

Understanding the likely means of introduction and transport of invasive plants at your site is key to developing prevention or biosecurity strategies.

Eradication

Eradication is the complete removal of an invasive plant species (including reproductive propagules) from a defined area (figures 9 and 10). Eradication is most feasible when an infestation is small.

To understand how the size of an infestation affects whether eradication is an achievable objective, Rejmanek and Pitcairn (2002) analyzed decades of eradication efforts by the California Department of Food and Agriculture and found that eradication of infestations smaller than 1 hectare (2.5 acres) was usually successful, while only a third of infestations between 1 and 100 hectares (2.5 and 250 acres) and a quarter of all infestations between 101 and 1,000 hectares (250 and 2,500 acres) were eradicated (figure 11). Costs associated with eradication increase dramatically with size of infestation.

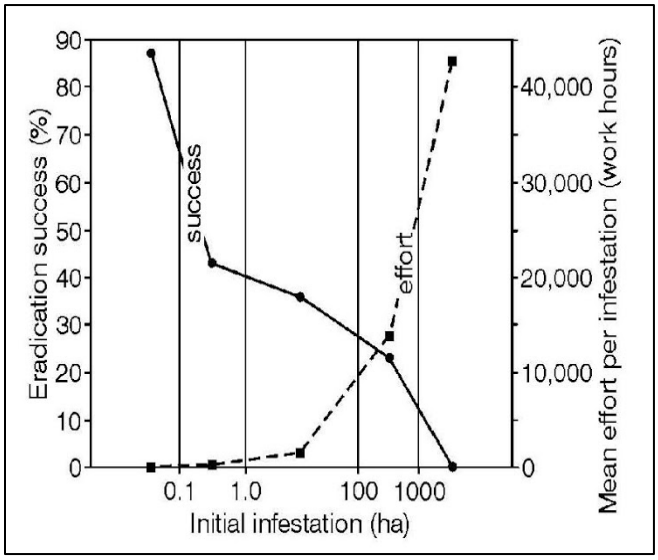

Figure 11. The dependence of the eradication success (%) and the mean eradication effort per infestation (work hours) on the initial size of infestations. Source: Rejmanek and Pitcairn 2002.

Successful eradication projects require (1) having adequate resources and commitment to see the project through to completion; (2) having an entity with authority to implement eradication; (3) fully understanding the biology of the species; (4) having the ability to detect the target species at low densities; and (5) having capacity for subsequent restoration of the system (Simberloff 2003).

Eradicating invasive plant populations when they are small requires that we first detect them and then eradicate them quickly before they become widespread and abundant—a concept commonly referred to as EDRR. Early detection involves systematic and repeated surveys for new species. Early detection surveys are commonly focused in areas at high risk of invasion such as vector pathways, areas where vectors congregate or frequent, and disturbance areas (see *Prevention* section above for more detail on this topic). USFWS's *Invasive Plant Inventory and Early Detection Guide* (2018) summarizes factors to consider when planning early detection surveys and points to existing survey methods and protocols. For example, the National Park Service has developed invasive plant early detection protocols for several of its park networks (*https://www.nps.gov/im/networks.htm*).

Along with formal early detection surveys, an organization should also have a structure in place for reporting incidental observations of potentially new and harmful invasive plant species. Observations should be confirmed by an expert, and then the priority of the species for eradication should be evaluated.

Containment

Containment is defined as any action taken to prevent establishment or to control a plant species beyond a predefined area known as the *containment unit*. *Control* is defined as the act of reducing the occurrence or abundance of invasive plants using one or more IPM chemical, biological, cultural, or mechanical removal techniques.

The containment unit comprises the area where the species currently exists (occupied zone) plus a surrounding buffer zone that is free from plants but can receive propagules (such as seeds) (Fletcher et al. 2015). Containment is typically undertaken when eradication fails or is infeasible (figures 9 and 10). Containment involves repeated searching and removal of individuals (EDRR) that arise within the buffer zone, but it can also encompass prevention activities to slow the rate of spread into the buffer zone as well as suppression of populations within the occupied zone. Containment must continue indefinitely unless the means to suppress and ultimately eradicate the core infestation become available. Given this reality, it is worth examining the cost of eradication versus long-term containment.

Containment may be a viable option (over eradication) wherever a species occupies a large area, has small dispersal distances, and has long-lived seed banks (Fletcher et al. 2015). In addition, the longer an infestation has been established and the further it has spread, the more likely containment will be cheaper than eradication (Fletcher et al. 2015). Containment may also be a viable option in the short term when resources are extremely limited. As additional resources become available, reducing—and ultimately eradicating—the extent and abundance of plants in the occupied zone may become more feasible. If containment of a species is the desired approach, your Plan should clearly define the containment strategy, including what species will be contained, how, under what conditions, and where (defining the containment unit or area). See Fletcher et al. (2015) for more information on how to assess whether containment can outperform eradication, and under what conditions it is a valid management approach.

Asset-Based Protection

Asset-based protection means limiting invasive plant control activities to portions of an infestation that directly threaten high-value conservation targets (such as areas supporting a high-valued species, community, ecosystem, or culturally significant asset) (figure 9, 10). Asset-based protection is commonly practiced when an invasive species is widespread and abundant and there is little hope of eradication. As with eradication and containment, a variety of techniques can be used to control invasive plants (see section 3.4.2).

3.4.2 Prevention and Control Techniques

Prevention Techniques

Identifying the most appropriate techniques for preventing the introduction or spread of invasive plants requires:

1. Clear objectives—knowing what you want to prevent and where.
2. Site-specific knowledge about risk—areas within your spatial scope at high risk of invasion and human activities that are likely to lead to invasion.

This information will directly inform the types of techniques and best management practices (BMPs) to reduce risk of invasive plant introduction and spread. Useful references for conducting invasive species risk assessments and identifying prevention techniques suited to your situation are listed below:

- *Preventing the Spread of Invasive Plants: Best Management Practices for Land Managers* (California Invasive Plant Council [Cal-IPC] 2012). This resource includes helpful BMPs for a range of activities. Web link: *https://www.cal-ipc.org/docs/bmps/dd9jwo1ml8vttq9527zjhek99qr/BMPLandManager.pdf*
- *Compendium of Recommended Procedures and Best Management Practices Relevant to Minimizing the Introduction of Invasive Species by Service Activities* (USFWS 2016). Covering all taxa, this resource points to a wealth of information about risk assessment methods, prevention techniques and practices, and outreach and communication materials. Web link: *https://ecos.fws.gov/ServCat/Reference/Profile/105555* (Appendix 2)
- *Guide to Noxious Weed Prevention Practices* (USDA Forest Service 2001). This guide includes helpful BMPs for a range of activities. Web link: *https://www.fs.fed.us/invasivespecies/documents/FS_WeedBMP_2001.pdf*

Ideally, a formal invasive plant risk assessment is conducted as part of the planning process. If time does not allow for an assessment, it should be called out as an activity so that prevention measures are focused on the highest-risk areas and activities.

Control Techniques

As noted above, invasive plant control is the act of reducing the occurrence or abundance of invasive plants using one or more techniques (such as chemical, biological, mechanical, or cultural removal). Several factors should be considered when selecting control techniques, including:

- Management objectives—what you are trying to achieve (see section 3.3)
- Target species ecology, distribution, and abundance
- Capacity to implement—people, cost, and technical capacity
- Site characteristics such as scale, accessibility, and politics
- Potential non-target effects
- Likelihood of success

Ideally, multiple techniques are employed for a given species or species group to avoid development of resistance (figure 12). *Resistance* is a decline in effectiveness of a particular control technique over time. Reliance on any single technique to control weeds results in selection for species or populations that can survive that practice (Coble and Schroeder 2016). A clear sign that resistance is occurring is a decline in effectiveness over time. Invasive plants can develop resistance to any type of control technique (such as mechanical, chemical, or biological), but it is more commonly associated with herbicide use. The International Survey of Herbicide Resistant Weeds (2018) reports there are currently 496 unique cases (species x site of action) of herbicide-resistant weeds globally, with 255 species (148 dicots and 107 monocots). Further, weeds have evolved resistance to 23 of the 26 known herbicide sites of action and to 163 different herbicides.

Figure 12. The process of selection for herbicide resistance. Resistance individuals (blue) increase in number over time as a result of herbicide selection pressure. Source: USA Herbicide Resistance Action Committee 2018.

Table 8 below summarizes invasive plant control techniques and related advantages and disadvantages in their use. Each technique can be carried out using a variety of methods. A review of species-specific control information (published literature, books, invasive species websites, local experts) is a necessary step in developing your overall strategy (section 3.4.3). There is no single resource for invasive plant control techniques. Appendix A provides a wealth of online resources for invasive plant management, many of which lead to species-specific control information.

Table 8. Summary of invasive plant control techniques (adapted from Tu and Robinson 2013).

Technique	*Advantages*	*Disadvantages*
Manual: physical removal of invasive plants using non-mechanical tools such as hands, shovels, picks, axes, hand-saws, or machetes	Little training is needed for safe use of many tools, and they can be used in a variety of situations; hand tools are relatively low cost and can provide very specific and targeted control. Ideal for smaller infestations.	May be time- and labor-intensive for moderate to large infestations. Some manual tools may be dangerous to use. Potential non-target effects: inadvertent disturbance to or removal of non-target species.
Mechanical: physical removal of invasive plants using mechanized tools such as mowers, brush-cutters, chainsaws, or earth-moving equipment	Many tools/equipment can be used in a variety of situations and have low implementation costs. Can provide very specific and targeted control. Ideal for small infestations.	May be time- and labor-intensive for moderate to large infestations. May require qualified individuals or training to operate some mechanized tools or equipment. Potential non-target effects: inadvertent disturbance to or removal of non-target species.
Cultural: land management practices such as grazing, prescribed fire, or irrigation/flooding	Control of moderate to large infestations may be possible. Can be low effort and cost per unit acre relative to other techniques. In some cases, may lead to positive response by native plants.	In some cases, may lead to an increase in invasive plants if not used appropriately. Often will not completely eliminate the target species from an area. Potential non-target effects: inadvertently disturbs or removes non-target species and promotes invasive plant spread.
Biological: introduction of novel predators, parasites, and pathogens such as insects, fungi, or microbes, to attack an invasive plant species	Relatively low cost per unit acre. May keep invasive plants at a low level across large landscapes. Long-term effectiveness is limited; must repeatedly treat invasive plant infestations once biocontrol agents are established.	May be expensive to develop. Often does not lead to eradication of the target invasive species. High risk of unintended consequences to native species and communities.
Chemical: application of herbicides to kill invasive plants	May be a cost-effective approach for larger infestations and lead to effective control when used appropriately. Often a variety of application mechanisms available (ground and aerial).	High risk of unintended consequences to native species and communities. Unintended consequences may include contamination of soil or water, harm to or removal of non-target species, human exposure, and health issues for applicators. May be expensive to obtain and/or apply chemicals. Often more regulatory requirements to apply. May be controversial in some areas.
Restoration of ecosystem processes or composition	Works to bring the project site to a desired and/or native state that is more resistant to invasion over the long term.	High cost. There may be a time lag to realized benefits. May not lead to elimination of the target invasive species.

3.4.3 Selecting an Optimal Set of Strategies

An invasive plant management strategy encompasses species or area-specific activities to achieve your objectives and avoid unintended harm to natural or cultural resources (non-target effects). Developing an optimal strategy requires evaluating the impact and feasibility of different combinations of approaches, techniques, and methodologies (we refer to these combinations collectively as *activities*). We suggest brainstorming potential activities with your objectives in mind, and then selecting a portfolio of feasible activities that is most likely to help you attain your objectives. It's worth emphasizing here that

objectives should be the major factor driving the brainstorming process. Other factors used to evaluate the value of different invasive plant management activities are presented in table 9.

Tools and approaches for selecting an optimal set of strategies range from simple to complex, but most involve answering questions about the performance of a project or activity relative to your objectives, the feasibility of carrying it out, and the likelihood of non-target effects. Regardless of the method, involving your project team to build consensus around decisions is important. Tables 10 and 11 provide simple examples of evaluating alternative activities. Decision trees (figure 13) can also be a useful approach. The *Invasive Plant Management Decision Analysis Tool* (*https://ipmdat.org/ipmdat.html*) is an online decision support tool for evaluating different approaches to managing particular species. This tool does not tell you what to do; rather, it helps you evaluate various alternatives you have brainstormed.

Whether your approach is simple or complex, brainstorming and evaluating impacts and feasibility lead to more objective and transparent decisions, help teams reach consensus, provide a record of how decisions were made, and increase the likelihood that the strategy is implemented and successful.

Table 9. Factors to consider when developing an invasive plant management strategy.

Factor	*Description*
Management objective(s)	The degree to which an activity will lead to achieving a management objective
Species or species group characteristics	The degree to which the activity is well-suited to the species ecology, distribution, and abundance within the management scope
Non-target effects	The likelihood and degree to which the activity will result in unintended negative impacts on the environment or humans
Likelihood of success	The level of certainty that the activity can be successfully implemented and will work as expected
Feasibility of implementing	Cost and duration; technical expertise required and available; sociopolitical concerns; training or certifications required. Your organization may have sophisticated cost-estimating software, but in many cases a simple spreadsheet will do. Inventory data, if available, can be used to estimate costs. Cost per unit area can be derived from past management onsite or from interviews with others who have implemented similar activities.

Table 10. Simplified example of evaluating alternative invasive plant management activities for objectives focused on preventing establishment of new invasive plant populations (Objective 1), eradicating Species A from the entire site (Objective 2), containment of Species B to current extent (Objective 3), and suppressing Species C (Objective 4). Objectives drove the development of activities.

Activity	*Objective(s) addressed category*	*Impact*	*Feasibility*	*Non-target effects*
Develop and provide staff and contractor training for preventing the spread of invasive plants (BMPs); implement BMPs	1–4	High	High	Low
Develop and implement early detection protocol focused on priority early detection species	1	High	Low	Low
Eradicate all early detection species, if found, using non-chemical methods	1	High	Medium	Low
Eradicate Species A from all management areas using herbicides (alternating Herbicides X and Y)	2	Medium	High	Medium
Eradicate Species A from all management areas using mechanical (mowing) and chemical methods (Herbicide X)	2	High	High	Medium
Contain current extent of Species B using chemical control (alternating Herbicides X and Y)	3	High	High	Low
Contain current extent of Species B using manual or mechanical methods (hand pulling and mowing)	3	Medium	Low	Low
Flood areas infested with Species C, followed by active native plant restoration	4	High	Medium	Medium
Use fire to suppress abundance of Species C within areas containing rare plants	4	Medium	Medium	Low
Use grazing and Herbicide Z to suppress abundance of Species C within areas containing rare plants	4	High	Medium	Low

Notes: impact = the degree to which the action will help meet one or more invasive plant management objectives; feasibility = degree to which activity is financially, technically, and politically feasible; non-target effects = potential for harm to natural or cultural resources as a result of invasive plant management activities.

Table 11. Simplified example of evaluating alternative invasive plant management activities for objectives focused on preventing establishment of new invasive plant populations (Objective 1), keeping clean areas clean from priority invasive plants (Objective 2), eradicating Species A (Objective 3), preventing spread and reducing extent of cover of current infestations of Species B (Objective 4), and understanding distribution of priority invasive plants and using this information to refine objectives (Objective 5). Objectives drove the types of activities proposed.

Activity	*Objective(s) addressed*	*Impact*	*Feasibility*	*Non-target effects*
Conduct invasive plant risk assessment (identify high risk areas and activities)	1, 2, 3, 4	High	High	Low
Develop and provide staff and contractor training for prevention and avoiding the spread BMPs; implement BMPs	1, 2, 3, 4	High	Medium	Low
Develop and implement ED protocol focused on priority early detection species. Surveys conducted annually in high priority areas (clean areas, wetlands, areas containing rare species) and every 2–3 years in lower priority areas.	1, 2	High	Medium	Low
Eradicate Species A using a combination of non-chemical methods (hand pulling, mowing)	3	Medium	Medium	Medium
Eradicate Species A from all management areas using manual (hand pulling), mechanical (mowing), and chemical methods (Herbicide X)	3	High	High	Medium
Contain current extent of Species B and reduce abundance of infestations in high priority areas using Herbicides X and Y.	4	High	Low	Medium
Contain current extent of Species B and reduce abundance of infestations in high priority areas using goats or other herbivores.	4	High	Medium	Medium
Use fire to suppress abundance of Species B within areas containing rare plants	4	Medium	Medium	High
Conduct inventory of priority invasive plants	5	High	Medium	Low

Notes: impact = the degree to which the action will help meet one or more invasive plant management objectives; feasibility = degree to which activity is financially, technically, and politically feasible; non-target effects = potential for harm to natural or cultural resources as a result of invasive plant management activities.

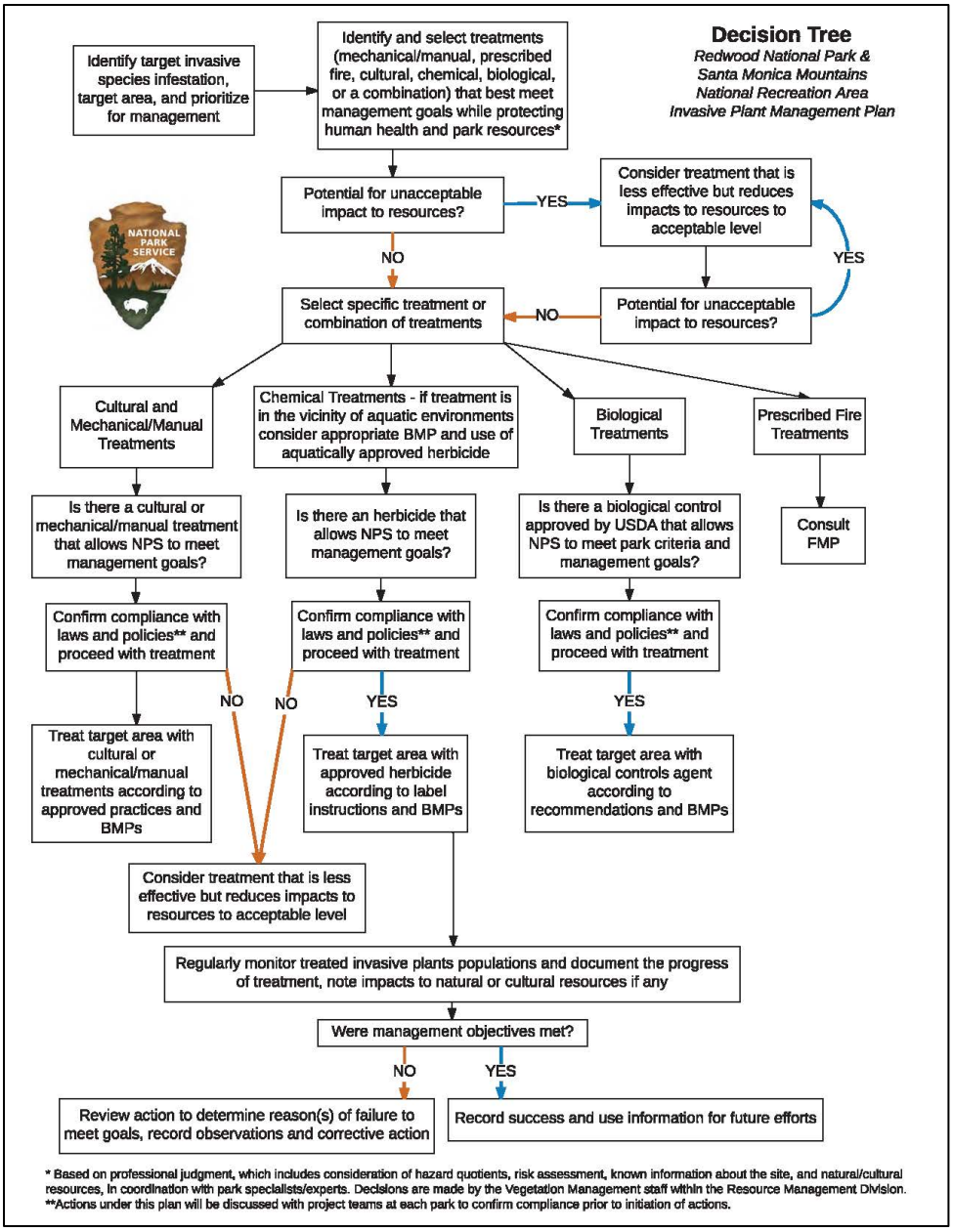

Figure 13. Invasive plant management decision tree for Redwood National Park and Santa Monica Mountains National Recreation Area. Source: National Park Service 2017.

3.5 Avoid Unintended Impacts of Invasive Plant Management

Although the purpose of invasive plant management is to prevent and reduce harm to important natural and/or cultural resources, unintended negative consequences (non-target effects) can result such as soil erosion, loss of native species or species habitat, reinvasion, secondary invasions, or further spread of invasive plants (table 12) (Zarnetske et al. 2010; Cal-IPC 2015; Pearson et al. 2016).

Table 12. List of commonly cited unintended consequences of invasive plant management activities. Many of the consequences listed here are possible with any invasive plant management activity.

Unintended consequence	*Description*
Soil disturbance, compaction, or erosion	Equipment use results in soil disturbance or compaction. Removal of plants and creation of bare ground can lead to erosion.
Water quality impacts	Chemicals or other introduced materials (such as sediment) can impair water quality.
Harm to non-target plants	People, equipment, or materials result in impairment or mortality of native plants.
Direct harm to wildlife	People, equipment, or materials result in wildlife displacement, impairment, or mortality.
Indirect harm to wildlife	People, equipment, or materials result in alteration of wildlife habitat.
Direct or indirect harm to cultural resources	People, equipment, or materials result in cultural resource damage or loss.
Further spread of invasive plants	People and/or equipment become vectors of invasive plant spread.
Create conditions for reinvasion	Activity results in soil disturbance or creation of open areas that are re-infested.
Human safety risk	Activity poses a risk to human safety.

Steps to reduce the likelihood of non-target effects include:

1. Assess the types and magnitude of non-target effects from proposed invasive plant management activities.
2. To the extent feasible, choose a portfolio of invasive plant management activities with the lowest likelihood of non-target effects.
3. Integrate BMPs into your invasive plant management program to avoid non-target effects.
4. In cases where non-target effects cannot be avoided, develop measures to help mitigate the non-target effect. This is a typical requirement of environmental permitting, which may contain specific restrictions based on the invasive plant management work in relation to high-value resources such as special-status species, sensitive species habitats, or wetlands.

A useful resource for developing BMPs to avoid non-target effects from invasive plant management activities is:

- *Best Management Practices (BMPs) for Wildland Stewardship: Protecting Wildlife When Using Herbicides for Invasive Plant Management* (Cal-IPC 2015). Among other information, the manual contains risk charts for potential impacts on wildlife for commonly used herbicides. Many of the BMPs in this document are applicable for other invasive plant management activities other than herbicide use.

Also see section 3.4.2 for a list of resources that include BMPs for preventing the spread of invasive plants and appendix B for examples of BMPs in existing Plans.

3.6 Conduct Work Planning

Up to this point, you have identified priorities, developed objectives, and devised a set of strategies to achieve your objectives. The information generated so far does not provide the specificity for implementation—this is the job of *work planning* (often referred to as *implementation planning* or *operational planning*). The purpose of an operational plan is to provide those responsible for implementing your strategy (and associated activities) with a clear picture of what needs to get done,

where, and when, as well as how much it will likely cost over a specified period of time. Commonly, organizations develop 2- to 5-year operational plans that guide annual work. Without an operational plan, it is highly likely your invasive plant management strategy will not be implemented.

The level of detail needed in an operational plan depends on the intended purpose and audience. In general, a multi-year operational plan should be developed that specifies:

- Tasks and locations associated with Plan activities
- Who is responsible for carrying out activities
- Costs associated with activities
- Performance measures or indicators—in other words, a means for assessing the degree to which an activity or task was carried out.

Because conditions change over time, such as fluctuations in funding and/or staff, the operational plan will change and should be revisited frequently (such as annually). This information is critical to informing your organization's work on an annual basis. See appendix B for examples of Plans with work planning.

3.7 Monitor and Evaluate

Following implementation of invasive plant management strategies, managers should be able to answer these key questions:

1. Were activities implemented as planned? If not, why not?
2. Are we achieving our management objectives (or moving towards achievement)?

Answering these questions requires monitoring. *Monitoring* is the periodic process of gathering data to assess outcomes relative to your actions *and* your objectives. If you intend to practice adaptive management, monitoring should be conducted so that your organization can understand whether your program is on track and identify adjustments to improve outcomes. Other important benefits include:

- Enhancing accountability, credibility, and transparency with external donors, policymakers, and the public.
- Strengthening ownership of the work by partners and stakeholders, thereby improving the sustainability of the work.
- Capturing lessons to share with the broader conservation community, thereby improving learning beyond your organization.

> "Monitoring should be done for learning, adapting, and improving. As such, it is important to collect the right information that will help you learn the most about your project site and the effectiveness of your interventions."
> Foundations of Success 2009

3.7.1 Protocol Development

Regardless of the survey purpose, any natural resource survey effort, such as monitoring invasive plants, requires a set of instructions or a protocol. A protocol should include enough detail so that someone unfamiliar with the survey understands what, why, where, by whom, when, and how a survey is conducted (USFWS 2013). This includes identification of the management objective the survey will inform, what will be measured, how measures will be taken, considerations and costs for data collection, data management, analysis, and reporting of results.

Before investing in protocol development, determine if an existing protocol could be adapted to meet your needs by searching online databases (such as the National Park Service Data Store [*https://irma.nps.gov/DataStore/*] or the USFWS Service Catalog *[https://ecos.fws.gov/ServCat/*]) or talking with local organizations involved in vegetation and invasive plant management. More detailed

information about developing monitoring protocols can be found in *How to Develop Survey Protocols: A Handbook* (USFWS 2013), *Guidelines for Long-term Monitoring Protocols* (Oakley et al. 2003), and *Guidance for Designing an Integrated Monitoring Program* (National Park Service 2012). A good resource for developing survey designs is *Measuring and Monitoring Plant Populations* (Elzinga et al. 1998). In addition, USFWS recently completed an *Invasive Plant Inventory and Early Detection Guide* (USFWS in prep.). Lastly, examples of invasive plant inventory and monitoring protocols and reports are provided in appendix B.

3.7.2 Data Management

Invasive plant management involves the collection and management of data about (1) management actions (when, where, what, by whom) and (2) the status and trends of plants. Good management of data, whether they be spatial or non-spatial data, makes the data easier to access, understand, use, and share, but is one of the most commonly overlooked aspects of invasive plant management. Over time, poor data management can result in wasted time and money because the data cannot be found or understood. Ideally, a Plan should emphasize the importance of data management and describe basic data management practices that should be followed, such as:

- Metadata standards that should be used, such as the Federal Geographic Data Committee geospatial metadata standards or the North American Invasive Species Management Association standards (for invasive plant surveys).
- Describing how data will be organized and stored (such access databases, geodatabases, or established data management systems).
- Describing naming standards for species, such as the International Taxonomic Information System.
- Establishing file naming conventions.

Well-developed data management systems and workflows can save an organization significant amounts of time and money, provide continuity of work despite staff turnover, and provide a strong legacy of information to guide future decisions. Examples of Plans with data management elements are identified in appendix B.

3.7.3 Evaluation

Evaluation here refers to the regular assessment of outcomes. Such information is used to adjust your management strategies, as needed, to achieve your management objectives. Organizations should identify a mechanism for regularly checking in to assess outcomes. Evaluation should be conducted by people who are implementing the Plan as well as those who direct or planned the work. This may include annual evaluation and work planning as well as longer-term-interval (such as 5-year) Plan updates.

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Chapter 4

Writing Your Plan

Sahara mustard
Brassica tournefortii
CREDIT: ©Ryan O'Dell

This chapter describes the suggested elements and associated content of a Plan. It parallels the content generated in chapter 3 and follows the Plan template in appendix C. Appendix B also points to publicly available Plan examples. The level of detail a Plan contains depends on its audience and intended use. For example, if the Plan's purpose is to guide on-the-ground invasive plant management activities, then a high level of detail may be needed to increase the likelihood that the Plan is carried out as intended, especially as staff change over time.

4.1 Plan Introduction

The introductory sections of a Plan state its purpose and need and provide an overview of the management context. Further topics include the spatial scope, environmental and/or cultural setting, conservation targets, existing management goals and objectives, history of invasive plant issues and management, and regulatory context. These topics are summarized below and appear in the Plan template (appendix C).

4.1.1 Plan Purpose and Need

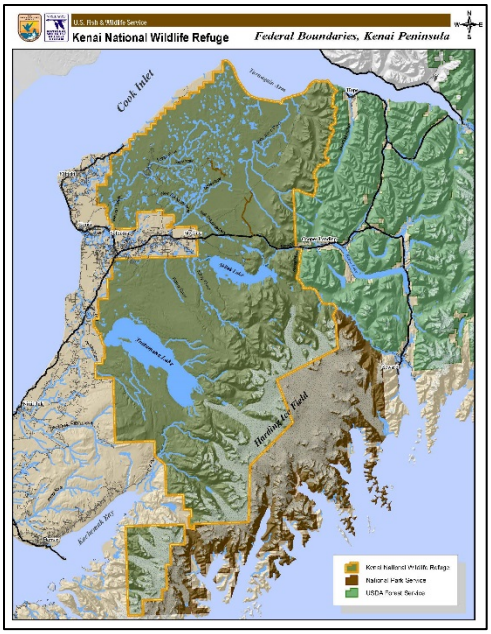
Your Plan should identify the purpose and need for an invasive plant management program, clearly articulating why the organization must take action. Plans often start by describing how invasive plants currently (or have the potential to) decrease biodiversity, degrade habitat, decrease water availability, or threaten recreational uses or infrastructure. Some also detail how invasive plant management is important for meeting the organization's conservation vision and goals. The more links you can draw between site conservation goals and how invasive plants impede those goals, the better. Doing so increases the likelihood that the need for invasive plant management is understood by leadership and other stakeholders and is ultimately supported. You may also want to consider linking invasive plant management at your site to other local, regional, or national efforts aimed at reducing harm from invasive plants.

Ideally, this section of the Plan also describes the intended audience and how the Plan should be used (and adapted) over time.

4.1.2 Spatial Scope and Setting

A clear spatial scope shows the rough geographic boundaries where invasive plant management will occur. To orient readers, it is useful to include in your Plan a text description of the spatial scope as well as maps showing boundaries, management units, and place names. Other relevant spatially referenced information may include topography, watersheds, hydrology, soils, ecosystems, vegetation communities, roads, trails, and/or infrastructure.

The setting should provide a brief background on site establishment and governance. It should also provide an overview of major environmental features such as ecosystems, landcover (such as hydrology, soils, or vegetation communities), important ecological features or functions, sensitive biological resources such as federal or state-listed endangered species, important cultural resources, and any other defining characteristics of the site that should be considered in the context of invasive plant management. This information helps to ground invasive plant management in the larger context of your organization's work. It may also point to particular challenges that should be considered when developing or implementing invasive plant management strategies.



Example of a spatial scope map: Kenai National Wildlife Refuge

SOURCE: USFWS

4.1.3 Conservation Assets and Goals

Conservation Assets

The term *conservation assets* here refers to species, communities, or ecosystems that are the focus of conservation efforts within the Plan's spatial scope. Conservation assets may also include important physical, cultural, or paleontological resources. Although you may want to conserve all biodiversity or other important features of a site, focusing explicitly on protecting all high-valued assets of a site from invasive plants is usually infeasible because of constraints on time, funding, and staff.

Channel Islands fox
Urocyon littoralis

SOURCE: https://www.nps.gov/chis/learn/nature/island-fox.htm

Your Plan should identify and describe the most valued or representative conservation assets because that effort informs (1) the species and locations on which invasive plant management should be focused, (2) the types of strategies to implement, and (3) the assessment of whether invasive plant management efforts are achieving the desired effect on assets over the long term.

It is also useful to describe how invasive plants will harm conservation assets if they were to spread and how they may cause harm in the future if invasive plant management does not occur. Specific examples will help readers understand the consequences of not adequately addressing invasive plant threats and will reinforce the need for management. Examples include how an invasive plant may outcompete native plant communities, increase fire frequency, lead to vegetation type conversions, or alter wildlife diversity.

Conservation Goals

It is important to identify and review existing conservation goals and objectives of the Plan scope (and consider including them in the Plan introduction) because they provide context, rationale, and focus for invasive plant management efforts and will help inform what species are a priority for management, where management should be focused, and the types of strategies that may be appropriate. This information is often found in conservation plans developed for the site and may be very broad or quite specific.

Existing site-specific management or conservation plans ideally contain goals or objectives that describe the desired state of resources (such as species, natural resource communities, ecosystems, or cultural resources). They may also contain specific objectives related to invasive plants, such as prevention or eradication of a particular species or a decrease in the overall extent or abundance of invasive plants. In many cases, invasive plant objectives may not yet exist or, even if they do, they may need refinement and should be re-examined as part of the planning process. Sections 3.3 and 4.4 address development and refinement of invasive plant management objectives.

Below is an example of a conservation target and related conservation goal and invasive plant management objective.

- **Conservation target**: tidal marsh ecosystem
- **Conservation goal**: By FY 2025, extent of high quality tidal marsh within Refuge X increases to 14,500 acres. High quality = unimpaired hydrology, dominated by native tidal-marsh associated plant species.
- **Invasive plant management objective**: By 2022, eradicate Algerian sea lavender at Refuge X.

4.1.4 Invasive Plant Management History

In cases where invasive plant management has occurred or is ongoing within the Plan scope, it is useful to describe management history, including focal species and locations, strategies employed, and successes and failures. This overview helps readers understand what has come before and what can be and was learned. This may include efforts to prevent, eradicate, control, study, inventory, or monitor invasive plants. When possible, cite sources of information, such as personal communications, pesticide use reports, maps, or reports.

4.1.5 Relevant Invasive Species Laws and Policies

Most Plans include a description of the legal (and sometimes political) context of invasive plant management at the site, including laws and policies governing invasive plant management planning and implementation. The level of detail here depends on the organization. Often times, relevant laws, policies, and regulations are summarized.

4.2 Methods

The methods chapter identifies who was involved in developing the Plan; information resources and processes used to inform its design; the people (public, leadership, others) or organizations who were informed of its development or engaged in the planning process; and how decisions were made. Use of a Plan by its intended audience will depend in large part on the readers' confidence that (1) the right people were involved in designing the Plan and (2) that its contents were developed using the best available information and processes. The methods chapter should describe any tools or processes that were used or developed to make decisions such as which species to focus on, which areas to focus on, and what strategies and activities to employ. This may be as simple as citing existing tools or describing new processes that were developed as part of the planning process. Lastly, it's useful to describe how the

public, stakeholders, or others were informed about or engaged in the planning process. This helps readers understand how much others already know about what has been planned, whether or not they support those actions, and any considerations that need to be kept in mind as Plan implementation begins.

4.3 Invasive Plant Priority Species and Areas

A Plan should identify and describe the species and areas that are the focus of invasive plant management efforts within the spatial scope.

4.3.1 Species Descriptions

Describe the species, or species groups, that are the focus of the Plan. These can include current invasive plant species or species that have the potential to occur in the future (early detection). A *species description* (also known as a *species account*) is basically a written summary of a species, or group of similar species, and includes the following information:

- Plant ecology
  - Plant life cycle: annual, perennial, biennial
  - Growth form: herb, shrub, tree, vine, aquatic
  - Reproduction
  - Seed longevity, dispersal distance
  - Phenology such as blooming time and best time for detection
  - Habitat
  - Dispersal mode(s)
  - Spread rates
- History of management
- Current status within the scope and/or the larger landscape, including data and maps if available
- Impacts on natural resources, ecological processes, or human infrastructure: current or potential future
- Visuals such as photos

There is a wealth of information available online to help describe invasive plant species ecology, known impacts on wildlands or agriculture, and management. A few freely available online resources are highlighted below and others can be found in appendix A:

- Global Invasive Species Database (*http://www.iucngisd.org/gisd/*)
- Invasive.org (*www.invasive.org)*
- National Association of Invasive Plant Councils (*www.na-ipc.org)*. This site provides links to invasive plant councils and weed management areas throughout the United States, each of which can provide useful species-specific information. Example: Cal-IPC maintains a detailed database of the state's top invasive plant species (*http://www.cal-ipc.org/plants/inventory/*)
- USDA National Agricultural Library (*https://www.invasivespeciesinfo.gov/plants/main.shtml*)
- USDA PLANTS Database (*https://plants.usda.gov/java/*).
- Invasive Plant Atlas of New England (*https://www.eddmaps.org/ipane/)*
- Weed Research and Information Center (*http://wric.ucdavis.edu)*

It is always a good idea to consult with local weed experts, weed management areas, or invasive species councils to identify local or region-specific resources (such as books and scientific papers). Appendix A points to several other resources, and appendix B provides a list of Plans with examples.

4.3.2 Area Descriptions

If distinct management areas have been defined for the Plan scope, provide a map showing these areas with a brief description. Types of information to consider include:

- Plant communities or ecosystems
- Sensitive resources
- Abiotic features such as hydrology, soils, or topography
- Size
- Invasive plant status: the degree to which the area is invaded by one or more invasive plant species
- Vectors or vector pathways, roadway locations and types
- Level of anthropogenic disturbance
- Maps showing area boundaries and other environmental features of importance

4.4 Objectives, Strategies, and Activities

This section of a Plan is where (1) SMART invasive plant management objectives or overall vegetation management objectives are presented and (2) strategies and associated activities to help achieve them are described in enough detail to be useful for the intended audience. Appendix B presents several Plans from a variety of agencies, providing ideas on how to craft this element of your Plan that meets your needs. Below is a list of the types of information to consider including.

- Strategy description—each strategy should be described in enough detail so that people who are expected to implement understand what needs to happen. This can include descriptions of the following:
  - Objective(s) it supports
  - The approach(es) it involves: prevention, containment, control
  - Techniques/tactics it involves such as education, research, assessments, chemical/physical/biological/cultural control
  - Where it will be implemented
  - When (years, seasonality) or how frequently it will be implemented
  - Specific activities to be implemented
  - Who will be involved with implementation
  - Training or certifications required
  - Equipment and supplies needed
  - Expected costs

Strategies can be presented in table form by species and then areas or by distinct areas.

4.5 Measures to Avoid Non-Target Effects

Most invasive plant management programs employ BMPs internally to minimize the non-target effects of their activities, but these may not be formally documented. This section provides a place to summarize the potential non-target effects of your invasive plant management activities and measures or BMPs to avoid or mitigate them. BMPs may be presented as a checklist for specific management strategies or activities and included as an appendix to your Plan to be used in the field. This section may also cite laws or policies applicable to your situation.

4.6 Work Planning and Reporting

This section of your Plan should provide enough detail for the people or organizations who must carry out the Plan. Information to include is listed below:

- A multi-year timeline for activities and surveys
- Expected annual costs
- Timing of management activities (relative to phenology of target plants and other applicable factors)
- Roles: generally who is involved in carrying out activities and surveys
- How annual evaluation and work planning will happen
- Reporting (if needed): content, format, frequency, storage, and sharing

Because annual work planning is dynamic, it can be helpful to use spreadsheets or some other data system to handle changes through time following development of the initial Plan.

4.7 Monitoring and Evaluation Methods

The monitoring and evaluation portion of your Plan should contain information about what types of surveys are needed to inform you work, links to Plan objectives or activities they support, expected frequency, and information on how they will be carried out (protocols). If a protocol exists, they can be included as an appendix or cited. If protocol development is needed, specify when and how a protocol will be developed.

This section can also include information about software or data system(s) that will be used to manage invasive plant data (spatial and non-spatial) as well as how information (files) will be organized and stored.

Chapter 5

Adapting Your Plan

It is important to remember that a Plan is not static—it should set the stage for a dynamic and flexible process of doing, evaluating, learning, and adapting. To be successful, any conservation program or project must evaluate progress and adjust to improve outcomes. This adaptive management process should ideally be built into your Plan. For instance, your Plan may specify that every 5 years your organization will revisit objectives, strategies, and other key provisions of the Plan. Additional revisions may be dictated by external forces. And the development of annual workplans will necessarily incorporate lessons learned from the previous year's experiences. The key is to provide a mechanism to periodically re-examine assumptions as well as implementation effectiveness.

A successful plan must be based on both sound project assumptions and good implementation. An adaptive management approach helps teams plan their projects such that they will be able to trace their failures back to poor assumptions, poor implementation, or a combination of the two (Salafsky et al. 2001). Otherwise, when projects do not produce desired results, the conclusion is often that strategies were not implemented as planned or the project team did not do a good job with implementation. In some cases, the same strategy may be implemented year after year without anyone really questioning whether it is achieving the intended result.

The intention of this Guide is to promote a more adaptive approach to invasive plant management, regardless of the organization or agency involved, scale, environment, or socio-political environment. We expect that new information on how to improve the practice of invasive plant management will continue to grow. We encourage you to continue to explore new and improved invasive plant management techniques and practices and to share what you learn with the larger conservation community.

New Zealand spinach
Tetragonia tetragonioides

CREDIT: ©Jean Pawek

Adaptive management is a structured process that promotes flexible, informed decisions that allow us to make adjustments as we better understand outcomes from management actions and other events. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process (USFWS 2013).

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Glossary

action: an activity designed to apply a particular strategy to a specific situation in order to help achieve an objective. Also called a *tactic*.

adaptive management: a structured process that promotes flexible, informed decisions that allow us to make adjustments as we better understand outcomes from management actions and other events. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process (USFWS 2013).

alien: with respect to a particular ecosystem, an organism, including its seeds, eggs, spores, or other biological material capable of propagating that species, that occurs outside of its natural range (Executive Order 13751 [2016]). Considered synonymous with *exotic* and *non-native*, the latter of which is used in this Guide.

aquatic nuisance species: a nonindigenous species that threatens the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural, or recreational activities dependent on such waters (Nonindigenous Aquatic Nuisance Prevention and Control Act [1990]).

asset-based protection: a strategy in which control activities for a widespread invasive species is focused on those areas where the control protects high-priority conservation assets.

best management practices (BMPs): methods or techniques found to be the most effective and practical in achieving an objective, such as preventing or reducing invasive plant spread, while making optimal use of resources (Cal-IPC 2012).

conservation target: the focus of conservation within a specified area. Conservation targets may be biological in nature (species, communities, or ecosystems) or reflect human well-being (such as culture, recreation, infrastructure, or safety). Often, a limited number of conservation targets are identified to collectively represent the full suite of biodiversity or values within a specified area (Foundations of Success 2009).

containment: actions taken to prevent establishment and reproduction of an invasive plant species beyond a predefined area or the *containment unit*. The containment unit comprises the area where the species currently exists (occupied zone) plus a surrounding buffer zone that is free from plants but can receive propagules (such as seeds) (Panetta and Cacho 2014).

control: the act of reducing the occurrence or abundance of invasive plants using one or more integrated pest management techniques (such as chemical, biological, mechanical removal techniques).

drone: An aerial machine that can be used for remote mapping. Also known as *unmanned aerial vehicle (UAV)* or *unmanned aerial system (UAS)*.

early detection: a type of survey focused on detecting the location and abundance of highly invasive species that are not yet established within a defined area (but the potential for establishment exists) or occur in small isolated populations within a defined spatial scope (Olsen et al. 2015). A process of surveying for, reporting, and verifying the presence of a non-native species before the founding population becomes established or spreads so widely that eradication is no longer feasible (U.S. Department of the Interior 2016).

eradication: the complete removal of an invasive plant species (including reproductive propagules) from a defined area.

integrated pest management (IPM): a science-based decision-making process that incorporates management goals, consensus building, pest biology, monitoring, environmental factors, and selection of the best available technology to achieve desired outcomes while minimizing effects on non-target species and the environment and preventing unacceptable levels of pest damage (USFWS 2010).

indigenous: see *native species*.

introduced: see *alien*.

invasive species: a non-native organism whose introduction causes or is likely to cause economic or environmental harm, or harm to human, animal, or plant health (Executive Order 13751 [2016]).

inventory: a type of survey that is used to determine the location or condition of a resource (e.g., presence, abundance, distribution, status) at a specific time. Inventories may also establish a beginning time-step (baseline) or reference information for subsequent monitoring (USFWS 2013). In this Guide, an *inventory* refers to a catalogue of invasive species that can include information on their location, abundance, and distribution in a defined region.

monitoring: consists of repeated survey efforts and is more complex than inventories because it is conducted to understand how resources vary over time (e.g., months to years) and space. *Baseline monitoring* can be used to produce a time series of indicators such as water salinity or fish survival. Results from this type of monitoring can be used to assess changes in a system or to develop models of system function. *Monitoring to inform management* is the other type of monitoring for which a survey protocol is developed and has the additional purpose of directly influencing a management decision. This form of monitoring may be used to evaluate model values and performance in adaptive management projects or used to identify effects on trends in attributes produced by quasi-experiments (USFWS 2013).

native nuisance species: a native species that causes harm to the environment or human health.

native species: with respect to a particular ecosystem, a species that, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem (Executive Order 13112 [1999]).

non-native species: see *alien*.

noxious weed: any plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture, irrigation, navigation, the natural resources of the United States, the public health, or the environment (Public Law 106 – 224 [2000]).

objective: a concise statement of desired outcomes that specifies what we want to achieve, how much we want to achieve, when and where we want to achieve it, and who is responsible for achieving it. A meaningful objective will be SMART—specific, measurable, achievable, results-oriented, and time-bound (USFWS 2013).

prevention: the act of preventing the introduction and spread (transmission) of invasive species. Also referred to as *biosecurity*.

pest: organisms that damage or interfere with desirable plants in our fields and orchards, landscapes, or wildlands, or damage homes or other structures. Pests also include organisms that impact human or animal health (UC-IPM 2018).

protocol: detailed instructions for conducting a survey. This includes information on sampling procedures, data collection, management and analysis, and reporting of results (USFWS 2013).

strategy: a group of actions with a common focus that work together to reduce threats, capitalize on opportunities, or restore conservation targets. Strategies include one or more activities and are designed to achieve specific objectives and goals (Foundations of Success 2009).

survey: a specific data-collection effort to complete an inventory or conduct monitoring of biotic or abiotic resources (USFWS 2013).

vector (or transport vector): the conveyance (e.g., wind, water, animal, human, mechanical, etc.) that moves a non-native propagule to its novel location (Lockwood et al. 2013).

vector pathway (or transport pathway): the route between the non-native propagule source and release location (Lockwood et al. 2013).

weed: a plant that causes economic losses or ecological damage, creates health problems for humans or animals, or is undesirable where it is growing (Weed Society Science of America 2016).

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Appendix A

Invasive Plant Information: Online Resources

Below is an alphabetized list of online invasive species information resources. There are many more resources than we could ever list here. We chose to highlight a few of the most resources—many of them point to species or location-specific resources. The U.S. Department of Agriculture (USDA) National Invasive Species Information Center maintains a list of invasive species resources by state (*https://www.invasivespeciesinfo.gov/resources/orgstate.shtml*) as well as resources by species (*https://www.invasivespeciesinfo.gov/plants/main.shtml*). We encourage users to seek out additional local or regional resources.

Center for Invasive Plant Management (CIPM) (*www.weedcenter.org).* Though no longer funded, the CIPM remains a useful resource for information about invasive plant biology, management, and education and outreach. The site provides numerous links to other web-based sources of invasive plant-related information across the United States.

Center for Invasive Species and Ecosystem Health (CISEH) (*https://www.bugwood.org/*). The mission of the CISEH is to serve a lead role in development, consolidation, and dissemination of information and programs focused on invasive species, forest health, natural resource, and agricultural management through technology development, program implementation, training, applied research, and public awareness at the state, regional, national and international levels. The site hosts a database of imagery, provides links to publications on invasive species management, and lists websites related to invasive plant management across the United States.

Invasive.org (*www.invasive.org).* Run by the Center for Invasive Species and Ecosystem Health at the University of Georgia, this site provides a wealth of information including 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 and species-specific control information.

National Association of Invasive Plant Councils (NAIPC) (*www.na-ipc.org).* NAIPC comprises state and multi-state organizations that coordinate invasive plant managers and information. Each entity typically maintains an invasive plant list and holds an annual conference. The site provides links to state invasive plant councils.

National Invasive Species Council (NISC) (*www.invasivespecies.gov).* The NISC was established to ensure that federal programs and activities to prevent and control invasive species are coordinated, effective, and efficient. The national invasive species management plan can be found on this site.

New York Invasive Species Research Institute (*http://www.nyisri.org/*). To improve the scientific basis of invasive species management, the New York Invasive Species Research Institute serves the scientific research community, natural resource and land managers, and state offices and sponsored organizations by promoting information-sharing and developing recommendations and implementation protocols for research, funding, and management.

North American Invasive Species Management Association (NAISMA) (*https://www.naisma.org/*). NAISMA is a network of professionals—land managers, water resource managers, state, regional, and federal agency directors and staff, and nonprofit organizations—challenged by invasive species. This website lists standards (weed-free forage and gravel, mapping), invasive plant management online training, and a variety of other resources useful to managers.

USDA Forest Service Invasive Species Program (*www.fs.fed.us/invasivespecies)*. This site links to the agency's policy framework for invasive species as well as its management activities, with information on research, management planning, and pest-specific control techniques.

USDA National Invasive Species Information Center (*https://www.invasivespeciesinfo.gov/index.shtml*). This is a gateway to invasive species information covering federal, state, local, and international sources. The resource library provides links to many of the sites listed in this appendix plus many more resources for managers.

USDA PLANTS Database (*https://plants.usda.gov/java/*). The PLANTS Database provides standardized information about the vascular plants, mosses, liverworts, hornworts, and lichens of the United States and its territories. It includes names, plant symbols, checklists, distributional data, species abstracts, characteristics, images, crop information, automated tools, onward web links, and references. It also includes links to federal and state noxious weed lists.

U.S. Fish and Wildlife Service: Invasive Species (*www.fws.gov/invasives)*. The website provides background on a range of invasive species topics and points to a variety of resources for land managers.

Weed Research and Information Center (*http://wric.ucdavis.edu)*. The Weed Research and Information Center is an interdisciplinary collaboration that fosters research in weed management and facilitates distribution of associated knowledge for the benefit of agriculture and for the preservation of natural resources. This is an excellent resource for control techniques by weed species.

Weed Science Society of America (WSSA) (*http://wssa.net*). The WSSA is a non-profit professional society that promotes research, education, and extension outreach activities related to weeds; provides science-based information to the public and policy-makers; and fosters awareness of weeds and their impacts on managed and natural ecosystems. WSSA publishes three professional journals: *Weed Science*, *Weed Technology*, and *Invasive Plant Science and Management*. The website provides a variety of resources—including invasive plant images, identification resources, and a list of resources for biological control—and covers the topic of weed resistance.

Appendix B

Examples: Plans, Reports, and Protocols

The tables below list invasive plant management plans, inventory or monitoring protocols, and other related guidance documents and the topical areas they address (designated by an "X"). Full citations and web links are provided at the end of this appendix.

Invasive Plant Management Planning Documents

Author, date, and title	*Species prioritization*	*Area prioritization*	*Area or species descriptions*	*SMART objectives or thresholds for action*	*Species or area specific strategies*	*Prevention*	*Inventory or monitoring*	*Work planning*	*BMPs to avoid non-target effects*
Dendra (2012). *Management Priorities for Invasive Non-native Plants: A Strategy for Regional Implementation, San Diego County, California.*	X			X	X				
Evans et al. (2003). *Invasive Plant Species Inventory and Management Plan for the Hanford Reach National Monument.*	X	X	X		X		X	X	
Hall (2015). *Integrated Vegetation Management Plan for Open Space Lands of the City of San Luis Obispo.*	X		X	X	X		X		X
Hogle et al. (2007). *San Pablo Bay National Wildlife Refuge* Lepidium latifolium *Control Plan.*		X	X		X		X		X
Marriott et al. (2013). *South San Francisco Bay Weed Management Plan.*	X		X		X	X			X
May and Associates (2015). *Vegetation and Biodiversity Management Plan: Marin County Parks and Open Space District.*	X	X	X		X	X	X	X	X

Author, date, and title	*Species prioritization*	*Area prioritization*	*Area or species descriptions*	*SMART objectives or thresholds for action*	*Species or area specific strategies*	*Prevention*	*Inventory or monitoring*	*Work planning*	*BMPs to avoid non-target effects*
Midpeninsula Regional Open Space District (2014). *Midpeninsula Region Open Space District Integrated Pest Management Program Guidance Manual.*					X	X	X		
National Park Service (2003). *Rocky Mountain National Park Invasive Exotic Plant Management Plan and Environmental Assessment.*	X	X	X	X			X		
National Park Service (2008). *Lassen Volcanic National Park Weed Management Plan and Environmental Assessment.*	X		X	X	X		X		X
National Park Service (2010). *Yosemite National Park Invasive Plant Management Plan Update Environmental Assessment.*	X		X	X	X	X			X
National Park Service (2018). *Yosemite Invasive Plant Management Program 2018 Work Plan.*	X				X	X	X	X	
National Park Service (2017). *Invasive Plant Management Plan and Environmental Assessment for Redwood National Park and Santa Monica Mountains National Recreation Area.*	X	X	X			X			X

Author, date, and title	*Species prioritization*	*Area prioritization*	*Area or species descriptions*	*SMART objectives or thresholds for action*	*Species or area specific strategies*	*Prevention*	*Inventory or monitoring*	*Work planning*	*BMPs to avoid non-target effects*
Shelterbelt Builders and MIG/TRA Environmental Sciences (2016). *Integrated pest management plan for the Bear Creek Redwoods Open Space Preserve.*	X				X			X	
U.S. Fish and Wildlife Service (2012). *Integrated Pest Management Plan for Chesapeake Marshlands National Wildlife Refuge Complex.*			X		X		X		

Notes: species or area prioritization = reference uses multiple criteria used to prioritize species or areas; SMART objectives = reference contains objectives that are focused on vegetation and are specific, measurable, achievable, results-oriented, and time-bound; prevention = reference identifies specific prevention practices or activities; inventory or monitoring = reference has an inventory or monitoring element; work planning: reference contains one or more elements that will inform implementation, such as specific tasks and when they will be carried out, costs, how new activities or projects will be evaluated, and who will implement the work.

Examples of invasive plant prioritization reports and survey protocols.

Author, date, and title	*Species prioritization*	*Area prioritization*	*SMART objectives*
Ball and Olthof (2017). *Aerial Invasive Plant Survey: Guadalupe-Nipomo Dunes National Wildlife Refuge.*	X	X	
Holzman et al. (2016). *Farallon National Wildlife Refuge Southeast and West End Islands 2016 Invasive Plant Inventory.*	X	X	X
Keefer et al. (2014). Early Detection of Invasive Species—Surveillance, Monitoring, and Rapid Response: Version 2.0.	X		X
Rew and Pokorny (2006). *Inventory and Survey Methods for Nonindigenous Plant Species.*	X		X
Williams et al. (2009). *Early Detection of Invasive Plant Species in the San Francisco Bay Area Network: A Volunteer-Based Approach.*	X	X	X

Notes: species or area prioritization = reference uses multiple criteria used to prioritize species or areas; SMART objectives = reference contains objectives that are focused on vegetation and are specific, measurable, achievable, results-oriented, and time-bound; prevention = reference identifies specific prevention practices or activities.

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Appendix C

Plan Template

This template provides an outline of the contents that should be considered for inclusion in your Plan and hyperlinks to sections of the Guide where information on that topic is located.

Chapter 1: Introduction (Chapter 2 and Section 4.1)

- Plan Purpose and Need

  Why is this Plan needed?

  Why are invasive plants a concern?

  Who is the intended audience?
- Spatial Scope and Setting

  What is the geographic scope where management activities are prescribed?
- Conservation Assets and Goals

  What are the ecological/environmental characteristics of the scope and associated conservation goals?
- History of Invasive Plant Management

  What is the history of invasive plant management within the scope?
- Regulatory Context

  What are the relevant organizational policies and legislation that apply to invasive plant management within the Plan scope?

Chapter 2: Methods (Chapter 2 and Section 4.2)

- Project Team

  Who coordinated the planning effort and wrote the Plan?

  Who else was involved in the planning process (internal and external)
- Internal and External Communication, Outreach, and Engagement

  What were the methods of communication and engagement during the planning process?
- Information Gathering

  What information was gathered and used to inform the planning process?
- Prioritization of Species and Management Areas

  What methods were used to identify priority species and areas?
- Identifying Management Strategies

  What methods were used to identify and rank alternative management strategies?

Chapter 3: Species and Area Priorities (Sections 3.1, 3.2, and 4.3)

- Species Priorities

  What plant species (one or multiple) are a priority to manage? Include ranked list of species if a prioritization process was conducted

Priority species characteristics? Such as ecology, status within the scope and surrounding areas (abundance/distribution), history of invasion, maps, imagery. Use existing species profiles for basic characteristics (if available)

- Area Priorities

  What areas are a priority to manage? Include ranked list of areas if a prioritization process was conducted

  Priority area characteristics? Such as ecological characteristics, invasion status, history of invasion, maps, imagery.

Chapter 4: Work Plan (Sections 3.3–3.6 and 4.6)

- SMART Invasive Plant Management Objectives

  What would success look like as a result of your invasive plant management program?

- Management Strategies and Activities

  What are the invasive plant strategies and associated activity (or activities)?

  When should they be implemented?

  Thresholds for implementation?

  Where will they be implemented?

  Who is responsible for implementation?

  Budget and operational requirements?

  Required training, certification, or permits

- Best Management Practices for Avoiding Non-Target Effects

  Are there any potential negative effects on humans, natural/cultural resources, or infrastructure because of invasive plant management activities?

  What measures will be implemented to prevent, avoid, or mitigate potential negative impacts?

Chapter 5: Monitoring and Evaluation (Sections 3.7 and 4.7)

- Monitoring and Evaluation

  What methods will be used to evaluate progress in implementing strategies and achieving SMART objectives?

  When and how should progress on implementing strategies and achieving objectives be evaluated?

- Adaptation

  How will monitoring and evaluation used to revise the work plan?

  How often should the work plan be evaluated and by whom?

- Data Management

  What standards or systems will be used to manage invasive plant program data?