Invasive Plants of Alaska

Produced in cooperation with
the U.S. Department of the Interior; the U.S. Department of Agriculture;
the Alaska Soil and Water Conservation District;
the University of Alaska Fairbanks Cooperative Extention Service,
and the Alaska Natural Heritage Program.

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Introduction

About this Book

This guide is intended for use by anyone interested in learning more about the invasive non-native plants moving into Alaska. Some of the plants described have been here for many years; some are common, others are rare and just now spreading, and still others have not yet shown up here but are likely to arrive soon. Some species in this guide are known to be serious problems in Alaska and elsewhere, while others are quite ubiquitous except in remote places.

It is our hope that as people use this guide, they will help control these species so as to retain the intact ecosystems that make Alaska unique. Many ecosystems in other states have been severely degraded due to the establishment and spread of invasive plants. By acting quickly to find and eliminate new invasive plant populations, we can prevent these species from escaping and permanently altering our Alaskan ecosystems.

Organization of this Book

Non-native invasive species come from across the globe; for this reason, detailed descriptions are used instead of regional botanical keys. Plants are organized by plant family and, within each family, alphabetically by scientific name since there are often numerous common names. A red bar at the top of a description indicates a species of greatest concern for Alaska, while other species have a black bar. All maps are derived from the University of Alaska Museum Herbarium database and the Alaska Exotic Plant Information Clearinghouse database; maps are omitted for species with too little distribution information or too few collections and those not yet present in Alaska.

Introduction

In recent years, biologists, ecologists, and land managers have become acutely aware of the global threats posed by invasive species. Invasive species can include plants, animals, fungi, insects, and other organisms that have overcome previously limiting geographical barriers through deliberate or inadvertent human activity. Simply stated, an invasive species is a species introduced into an area where it did not evolve and thus has no natural enemies to reduce its spread (Westbrooks 1998). Various theories explain why these species flourish, including exploitation of unused ecological niches, lack of natural predators and parasites, and competitive ecological advantag-

es over native species in a particular area. Regardless of the reasons behind their proliferation, invasive species are now recognized as the second greatest threat to global biodiversity, superceded only by habitat destruction.

Invasive species have been shown to dominate entire ecosystems, cause economic losses in locations all over the world, and push rare species to the brink of extinction (Myers and Bazely 2003). Millions of acres of land in the coterminous United States and Hawaii have been irreparably altered or harmed by invasive plants. In most cases, once an invasive organism becomes widespread, reversal of its spread is nearly impossible. In the United States, economic losses caused by invasive species have been estimated to exceed $120 billion each year. In terms of ecological losses, four hundred of the 958 species that are listed as threatened or endangered under the Endangered Species Act are considered to be at risk primarily because of competition with non-indigenous species (Pimentel 2004).

Alaska remains one of the most pristine landscapes in the world, renowned for its lush forests, open tundra, abundant wildlife, and vast expanses of wilderness. Alaska's cool climate and remote location were long considered sufficient barriers to invasion by non-native species. However, recent inventories have revealed new, rapidly expanding populations of invasive species throughout the state. Right now, Alaskans have a unique opportunity to protect our wild lands from the damage that will be caused by unchecked invasive species proliferation. Meanwhile, Alaska's increasing development, including mining, oil and gas extraction, construction, international trade, and a booming tourism industry, provides many opportunities for invasive plant introduction and spread.

While people have been managing unwanted weeds since the development of agriculture, concern about non-native plants that threaten natural ecosystems has only become widespread in the twentieth century (Mooney and Hobbs 2000). A growing community of concerned citizens in Alaska is now mounting a defense against further establishment and spread of invasive species in the state. A database called the Alaska Exotic Plant Information Clearinghouse (AKEPIC) has been established to track the distributions of all non-native plants in the state (http://akweeds.uaa.alaska.edu/). The Committee for Noxious and Invasive Plants Management (CNIPM) is a statewide working group that unites concerned agencies, organizations, and individuals to collaborate on invasive plant management in Alaska (http://www.cnipm.org/). Inventory and monitoring efforts, control work, and educational programs have received more support and funding each

year from various state, federal, and local sources. Efforts are also underway to monitor other organisms in Alaska, including aquatic nuisance species, invasive mammals, plant diseases, and insect pests. All of these efforts and more will be required to turn the tide.

While definitions vary from one source to another, a few terms are helpful to frame a discussion of invasive plants in our state.

- **Native** plants are those that live or grow naturally in a particular region.

- **Exotic, alien, non-native,** or **non-indigenous** plants are plants whose presence in a given area is due to accidental or intentional in troduction by humans. The majority of non-native plants are beneficial to society, including staple crops and ornamental plants.

- **Naturalized** plants are exotic plants that reproduce consistently in their new environment and sustain populations over many life cycles without direct intervention by humans.

- **Invasive plants** are exotic plants that produce viable offspring in large numbers and have the potential to establish and spread in natural areas. Some references define invasive species as exotic plants that have a negative effect on ecosystems or cause economic losses or harm to human health.

- A **weed** is any plant, native or exotic, whose presence is undesirable to people in a particular time or place.

- A **noxious weed** is a plant species that has been defined as undesirable by legal statute.

The species presented in this book include both plants considered to be invasive in Alaska and lower priority exotic plants. It is not always obvious what impact a particular species will have in a new environment, and so most land managers agree that it is best to assume that no plant will be harmless outside of its native range.

The species in this book have been broadly categorized into three groups. The most information is given for those that are already demonstrating their invasive potential in Alaska or those that have recently arrived or are likely

to arrive in the future and are considered invasive elsewhere. These are the species of greatest concern, indicated by a red bar at the top of a description. Species of lesser concern, indicated by a black bar and less information presented, are included for the sake of inventory and control efforts in remote portions of the state. While these species may be less invasive than the others, they can still impact natural ecosystems. A special section is devoted to trees and shrubs that may or may not be invasive in Alaska but could have profound impacts in the worst-case scenario.

Impacts

Direct impacts of invasive plants include competition for space, soil, light, or water with native plants, which can lead to reductions in populations of native species or even elimination of entire populations of rare or endangered species.

Indirect effects are harder to quantify as they are based on the ways in which a plant interacts with other organisms, the greater plant community, and physical processes in the system. Often, these impacts are only discovered after the species is well established and widespread or through careful experimental analysis. Competition by invasive plants can prevent the establishment of native trees and shrubs after a disturbance event like a fire or flood, disrupting the natural successional processes of grassland, shrubland, or forest development. Displacement of native plant communities can lead to loss of food sources and habitat for wildlife. Invasive plants can also induce drastic changes in ecosystem function by affecting critical elements like soil chemistry, groundwater tables, or the frequency and intensity of wildfires.

A few examples of indirect impacts for particular species include:

- Ornamental jewelweed (*Impatiens glandulifera*) produces large quantities of nectar, drawing pollinator bees away from native plants and thereby reducing the ability of the native species to reproduce.

- White sweetclover (*Melilotus alba*) and scotchbroom (*Cytisus scoparius*) can disrupt nutrient cycling processes by fixing nitrogen in the soil. Native species previously occupying the site may have been well adapted to nitrogen-poor soil. Once nutrient levels are raised, the native species loses its advantage over competing species.

- Japanese knotweed (*Polygonum cuspidatum*) is believed to affect insect populations by adding litter (fallen leaves and other plant parts)

to rivers or streams at different times of the year and in greater quantities than usual. This could change the composition and populations of insect communities in streams and possibly affect salmon that feed on those insects.

- Kudzu (*Pueraria montana*) and Japanese knotweed alter soil structure with their dense growth of roots. Some researchers suspect that kudzu actually accelerates soil erosion by loosening the soil and hides the erosion from view with its dense cover of foliage.

- Invasive plants can act as reservoir of plant diseases, especially plant viruses that spread to crops and cause losses for growers. They may also act as alternative hosts for sap-sucking insects that can spread diseases from plant to plant. When a host species is widespread or found along highway corridors, it can act as a rapid conduit for the spread of plant diseases among croplands.

Economic impacts of invasive plants are widespread in today's society. The most obvious case occurs through competition with crop plants used for food or forage, for the worst agricultural weeds in the United States are non-native (Pimentel et al. 2004). Other adverse effects of invasive plants include livestock poisoning, structural damage, clogged waterways, and losses to sport and commercial fisheries.

Predicting Impacts

Many species appear to be in the early stages of introduction into Alaska. How do we determine the level of threat that a species poses? Unfortunately, the potential impacts of many species remain matters of speculation, and our knowledge of their effects often comes too late, when the damage done becomes all too obvious. Although the threats posed by invasive species in Alaska continue to be debated, if we wait until their impacts are known before trying to control their introduction and spread, we will be too late.

The behavior of an invasive species in other parts of the world, especially those with a similar climate, can be a strong predictor of its potential effects in a new location. This approach, while limited by the fact that the plant may not behave exactly in Alaska as it has in other places, remains our best predictor of probable future effects when a species has not yet become established here. Close examination of recently established invasive plant populations can also provide us with important information. For instance, a small population of orange hawkweed (*Hieracium aurantiacum*) rapidly took

over a meadow on Kodiak Island after being accidentally introduced there. The meadow contains a species composition typical of meadows found in many other areas around the state, and so we hypothesize that the orange hawkweed could invade meadows elsewhere in Alaska.

A more systematic approach is used by the Invasive Plant Ranking Project, a cooperative project led by the University of Alaska Natural Heritage Program (refer to http://akweeds.uaa.alaska.edu/akweeds_ranking_geo.htm). Species are objectively ranked for a series of ecological and physiological factors that contribute to invasive potential. From this, the degree of invasiveness each species poses is predicted for each of Alaska's three major eco-geographic regions: South Coastal, Interior, and Arctic. The resultant numbered ranking system can be used to prioritize species for strategic management.

How to Identify Plants

Plant species are primarily described by botanists in terms of flower and fruit structure, because these characteristics tend to be less variable within a genus or family than the vegetative characteristics of leaves, stems, and roots. Most guidebooks also include vegetative features as a secondary aid for identification.

Many excellent books are available for plant and weed identification for our region. A number of titles are listed in Appendix C. The most comprehensive include ***Flora of Alaska and Neighboring Territories*** (Hultén 1968) for the entire state and ***Plants of the Pacific Northwest Coast*** (Pojar and MacKinnon 1994) for Southeast Alaska. These books contain information on how to identify plants and features helpful for distinguishing particular plant families. They also present many native plant species that could potentially be confused with the non-native species in this guide.

Besides identification guide books, two tools that are helpful are a 10X magnifying glass or hand lens and a 6" flexible plastic ruler graduated in inches and centimeters. A photograph or physical specimen is helpful for later reference and consultation with experts if a positive identification cannot be made in the field. A Global Positioning System unit is valuable for pinpointing exact plant locations, so that the site can be easily found in the future.

What can I do?

There are many things you can do to prevent the introduction and spread of invasive plants in Alaska:

- Learn about invasive species that may be found in your area and report new findings. The distribution maps in this book show the currently known ranges of these plants. If you find a species in a location not included in the map, contact your nearest University of Alaska Cooperative Extension Service office. Those interested in submitting data on invasive plant locations can get instructions from the AKEPIC website (http://akweeds.uaa.alaska.edu/).

- Clean shoes, vehicles, recreational gear, ground-disturbing tools, and heavy equipment before traveling out of an area infested with invasive plants or into an area free of them. Use particular care when returning from out of state.

- Use only certified weed-free hay and mulch.

- Help with local community weed control efforts or organize a community weed pull yourself.

- Plant only native species or non-invasive exotic species. Consult the Voluntary Codes of Conduct for Gardeners published by the Cooperative Extension Service for further guidelines. Use only certified grass seed mixes and beware of "wildflower" seed mixes. A directory of Alaska native plant sources is maintained by the Department of Natural Resources Division of Agriculture (http://www.dnr.state.ak.us/ag/NEWnative_directory.htm).

- Spread the word! Alaska doesn't need the problems brought by invasive species, but they can only be prevented by vigilance and collaboration.

Management

In Alaska, we are in the enviable position of being able to focus our attention on the early stages of plant invasions when the chance of management success is greatest.

Prevention is the most effective method for protecting against biological invasion. Prevention tools include education, legislation, and the use of best management practices. Education about the threats posed by invasive plants and the irreversible nature of their impacts will provide the most lasting resistance for Alaska. While leaps and bounds have been made in the last few years on this front, Alaskans remain less informed about this problem than residents of other states and, as a result, inadvertently promote these plants rather than confronting them. Without education, invasive plant management efforts are more likely to meet with apathy or resistance than support.

Currently, Alaska has a limited noxious weed law that addresses few of the species presented herein and focuses on agricultural weeds rather than invasive plants that threaten ecosystems. Many other states have revamped their laws to be inclusive of both agriculture and wildland invasive plant threats by prohibiting the cultivation, sale, and transport of invasive plants.

Best management practices include many steps that can be taken to prevent spreading or promoting invasive plants. One very effective deterrent is to wash vehicles and equipment before leaving infested areas or entering uninfested areas. Hikers are similarly advised to wash mud off of footwear, clothing, and gear before entering natural areas. Fill materials for construction projects should be obtained from weed-free sources or processed to remove or destroy any invasive plant materials. Mowing and trimming should be timed while invasive plants are flowering so that they do not have the opportunity to produce and spread seeds. Plant materials sold in nurseries or imported from outside of Alaska are increasingly likely to be contaminated by invasive plant material and seeds. Voluntary codes of conduct for gardeners and nurseries have been developed in Alaska to provide guidance on best management practices for plant cultivation. Farmers, gardeners, livestock owners, and dog mushers have the option of using certified weed-free mulch and hay through a certification program recently initiated in Alaska. Floatplanes and boats that move from one body of water to another should be cleaned if aquatic invasive species are present. These are just a few of the

best management practices that will inhibit the spread of invasive species in Alaska.

Finding Infestations

Many agencies and individuals contribute data annually to the Alaska Exotic Plant Information Clearinghouse (AKEPIC), a database for reporting locations of non-native plants found throughout the state. Cooperators search for non-native plants and record their locations, along with information about the size and density of infestations. AKEPIC should be the first stop for anyone working to combat invasive plants in Alaska. The database can help you see what other people working in your area have found in the past and identify places where further scouting may be necessary. Current data are available for download and can be used to generate maps for your particular area.

Scouting an area as large and undeveloped as Alaska presents many challenges. We obviously cannot comb every square foot of the state looking for the next problem. Instead, we must use a combination of strategy and intuition to find invasive plants. Some concepts can help us narrow down the areas where we should look for invasive plants:

- Invasive plants usually first establish in areas disturbed by human activity. Therefore, cities, towns, and settlements are good places to begin scouting.
- Invasive plants often spread into new areas along disturbance pathways such as roads, trails, railroads, pipelines, and rivers.
- Intersections of pathways, such as a bridge across a river, are among the most effective places to find and treat incipient problems.
- Areas disturbed by natural processes are also at risk, including shorelines, floodplains, avalanche chutes, receding glaciers, burned lands, and windthrown forests.

Assessing Infestations

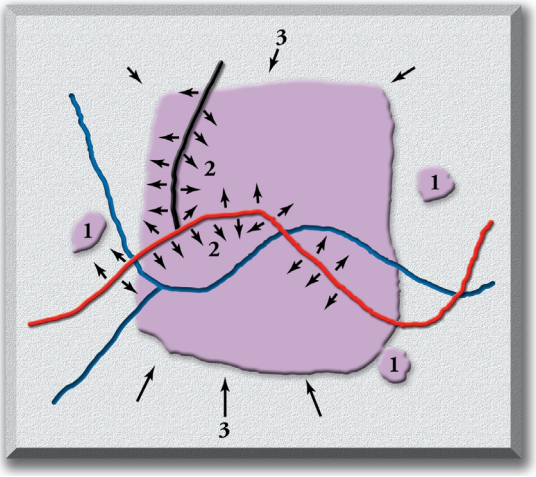
Once an infestation has been found, it is helpful to determine its size, density, and change in distribution over time. An infestation can be quantified by estimating the area of infestation as well as the percent cover and/or stem count of the species of concern. Record as much data as possible, as it will be helpful in sharing information with cooperators, getting advice from experts, and giving workers guidance for managing the problem.

It is possible to use visual cues to quickly estimate the size and density of

invasive plant infestations with a little practice. See guidelines for estimation methods in the AKEPIC database manual, available at the AKEPIC website (http://akweeds.uaa.alaska.edu).

Methods used to more accurately determine the density and rate of change of a plant population involve careful measurement and statistical analysis. For more information on these methods, consult ***Measuring and Monitoring Plant Populations*** (by Elzinga et al. 1998, BLM Technical Reference 1730-1, Bureau of Land Management, Denver, CO) or the "Weed Mapping Handbook" (by Roberts et al. 1999. Montana Noxious Weed Survey and Mapping System, Montana State University, Bozeman, MT).

Another aspect of sizing up an infestation is a realistic assessment of the resources available to combat an infestation as well as potential obstacles to successful management. What tools and methods will be most effective? What are potential sources of funding? Who are the landowners? Is the local community supportive of the effort? Do the terrain and vegetation impede access for management efforts?



Finally, there are spatial considerations. The illustration above shows several patches of invasive plants (in purple) that have established in a meadow with a road (traversing left to right), stream (in blue), and trail (in black). The road and trail are believed to be acting as pathways for the species to spread. **The first priority should be to attack the outlying populations** (labeled 1). They represent the fastest moving part of the overall population, and because of their small size they can be managed more quickly and less

expensively than the larger population. Areas adjacent to the road and trail should receive the next priority for treatment, in order to keep the plants away from vehicles or hikers that could inadvertently transport seed into other areas. The lowest priority would go to the main population, which could only be managed with substantial resource inputs.

To summarize, here are some general rules for managing populations:

- Tailor your efforts to the amount of resources available to combat an infestation.
- Target outlying populations first.
- Target potential pathways for spread, like roads, rivers, and trails.
- Work from the outside of an infestation towards its center.

Treatment Considerations

Just as a farmer needs to understand the biology of a crop, weed managers need to understand the biology of the plants they are trying to control. It is important to know the answers to questions such as: What kind of soil favors the plant's growth? What conditions favor seed germination? How fast does the plant grow? Is its life cycle annual, biennial, or perennial? How long do seeds remain capable of germination in the soil? What sort of root system does the plant have? How do its seeds disperse? Does it reproduce vegetatively by stolons, runners, or rhizomes? What animals feed on the plant? What are the diseases and insects that affect the plant? Is the plant adapted to grazing? Does the plant tolerate drought, shade, full sun, or extreme cold?

As we begin to answer these questions, we start to see weaknesses in the plant's life cycle that give us an advantage in treatment. Sometimes we can even turn the plant's advantage into our own advantage. For example, a group trying to manage garlic mustard (*Alliaria petiolata*) had difficulty controlling the plant because it grew amidst dense thickets of thimbleberry, salmonberry, and cow parsnip. But garlic mustard, like many exotic plants, begins growing several weeks earlier in the spring than native herbs and shrubs. This generally gives it a head start over other plants. By pulling garlic mustard in the early spring before leaves formed on the shrubs and trees, workers were able to move through the area and see and pull up the garlic mustard with ease.

This is an example of an adaptive management strategy. Adaptive management involves formulating a strategy and tactics based on known facts, implementing them, and then following up and refining the strategy based on its successful and unsuccessful elements.

Knowledge of the timing of events in a plant's life cycle is crucial to forming an effective management strategy. For instance, it is best to execute manual and mechanical controls before seed set. Control of perennial species, and especially foliar spray herbicide applications, is most effective during the period in the plant's life cycle when resources are being translocated from leaves to the root system. This often occurs prior to a dormant period.

Use caution in handling plants that are setting seed and soil that may be contaminated with seeds. Wash stations are recommended for removing all soil and plant debris from workers' clothing and footwear in such cases. Working before seed set can minimize contamination, but it is always necessary to take steps to avoid movement of soil or seed to unaffected areas.

Treating plants after seed set may sometimes be necessary. If a small population is discovered that is in the midst of producing seeds in an isolated location that may not be visited in the following year, why not put a bag over it and cut it down? Even if a few seeds escape, it is better management than permitting thousands of seeds to disperse.

Treatment Prioritization

Given limited resources and an abundance of invasive plant problems in an area, weed managers must institute some form of prioritization.

The process is similar to the triage procedure in an overworked battleground hospital. The threat that a plant places to ecological, economic, or aesthetic values must be balanced against the likelihood of treatment success. It would be counterproductive to continue to pour resources into an effort that is doomed to fail while smaller, more manageable populations grow and disperse. Plant populations can recover lost ground quickly if they are substantially reduced but not completely eliminated.

A worksheet to aid managers in prioritizing weed infestations is included in Appendix B.

Prevention, early detection, and rapid response for new infestations are

more likely to succeed than a major assault on a well-established or widespread population. Methodology also needs to be tailored to the scale of an infestation. Hand pulling can work well for small, isolated populations, while herbicides work well on the scale of a few square yards up to a few acres and infestations of thousands of acres can only be reasonably managed with the use of biocontrol agents.

One of the most important criteria for treatment prioritization is the degree of threat posed by a particular species in a given area. This element has been addressed separately by the Alaska Invasive Plant Ranking Project; for more information, refer to the website listed among additional sources of information in Appendix D.

Control Options

Manual Methods

Hand pulling, either directly, using hand tools, or in association with digging, can be a very effective means of eliminating small populations of invasive plants. The amount of below-ground material that must be removed for successful control, however, varies by species. Some plants may be controlled by removing only the above-ground material, while below-ground material must be removed for others, especially perennial plants and those that reproduce vegetatively. For certain species or large infestations, manual control may not be effective at all. For species-specific information, see the accounts provided in the "Management" section of each species description.

Manual control is the most selective control method and is especially useful when a target plant species is interspersed with non-target species. Leaving the non-target species untouched minimizes the need for site restoration and the likelihood that the target species will return. Workers require minimal training for manual control, and most people have had some experience pulling weeds. Hand pulling "parties" are a great way to involve the community in invasive plant management.

Hand pulling forces us to get up close and personal with the infestation, and by getting down on our hands and knees, we can gain insights about the plant's habits that otherwise may escape us. If volunteer pullers can be recruited on a regular basis, hand pulling is very economical and can help pay back a weed control program if volunteer time can be leveraged as cost-sharing for grant money.

The main disadvantage of manual control is the time and effort involved. Tackling an infestation larger than a few acres by hand pulling is generally not worthwhile, and the cost of paying workers to hand pull weeds can add up quickly. However, a motivated group can often exceed expectations. If in doubt about the potential effectiveness of manual control for a given infestation, perform a pilot project by pulling for a few hours with a small crew in an area that is representative of the overall infestation in terms of weed density, terrain, and vegetation. Return soon thereafter and evaluate the results.

Barriers

On a small scale, barriers such as black polyethylene and landscape fabric may be used either alone or in conjunction with other methods. Barriers may be used as a means of killing plants or to aid restoration by preventing regrowth of weeds. Use of these materials is more practical in landscaped areas than in wildlands, particularly because synthetic barriers would be remain as litter in a natural setting. Some workers have experimented with using clear plastic to heat up soil to kill plants, which would be worth trying in interior parts of Alaska during hot weather. Burying plants under several feet of soil may have some use, as noted above, either as a means of killing weeds or disposing of them after removal from a site.

Herbicides

A wide variety of herbicides are available today, and new ones regularly become available. Newer chemicals and formulations are improving worker safety, environmental safety, selectivity, and effectiveness. Generally, they are the recommended control option for large infestations of tenacious species. But herbicides are not a simple solution, with many considerations needed to ensure safety and effectiveness.

Herbicides have traditionally been developed in an agricultural context where target and non-target species are arranged in an orderly pattern in a highly managed landscape. In natural areas, off-target effects result from lack of selectivity in application. If weeds are interspersed with desirable native vegetation, steps must be taken to avoid killing the desirable plants or the desirable vegetation must be written off as necessary collateral damage and replanted later.

Herbicide application may result in a variety of unintended consequences. If an herbicide is ineffective against the target plant, it may actually encourage the target plant by removing competing vegetation. Applications performed during the wrong stage in the plant's life cycle are ineffective. As a rule

of thumb, applications performed while the plant is translocating photosynthetic products from the foliage to the roots are most effective. Many chemicals are only effective if applied when the plant is actively growing rather than in a dormant state as can occur in extremely cool, hot, or dry weather.

Foliar sprays are the quickest, easiest, and often most effective way to apply herbicides, but a variety of other methods exist. Herbicides may be applied by wiping a plant with a wick, roller, or brush or by injection directly into a plant. Non-target plants may be shielded from spray with some kind of barrier. Small trees may be protected by use of tube shelters that are often employed to prevent wildlife browsing. Spray applications should be done when winds are calm, using tanks, pumps, and nozzles designed specifically for herbicide application that dispense the product at low pressure with a large droplet size to minimize drift.

The herbicide label, a document which outlines the use of the product, will give instructions for safe handling, use, and disposal of the chemical. Persons using herbicides or directing others should be aware of state and federal laws governing the use of herbicides before doing so and keep in mind that the **directions on the label are legally binding**. Follow the label!

In Alaska, training and certification by the Department of Natural Resources is required by state law for the commercial use of pesticides (herbicides included) or any use of restricted-use pesticides.

It is important to select herbicides that are safe for non-target organisms and have a short lifespan in the environment. Some chemicals, especially those that are active in the soil, may persist for long periods of time and result in unintended consequences. By following the directions for application on the label, you will minimize the harm to other species. For specific herbicide recommendations contact your nearest Cooperative Extension Service office.

Mechanical Methods

Cutting plants with shears, trimmers, or mowers can be a very cost-effective way to treat large infestations of certain species. Many species, however, will readily resprout after being cut, rendering the treatment ineffective. For species that can be controlled by cutting, these activities should always be timed before the target plants set seed and may need to be repeated multiple times in a given season. Plants should be cut close to the ground.

In some cases, heavy equipment can be used to eliminate an invasive plant infestation and can often be commissioned in conjunction with existing projects. In Washington, for example, land managers were decommissioning a road in a watershed where use of herbicides was precluded. A large patch of Japanese knotweed (*Polygonum cuspidatum*) grew adjacent to the road. By adding a small change to the scope of the project they were able to remove the top two feet of soil containing the knotweed root system and dispose of the soil by burying it in an abandoned gravel pit under several feet of overburden. In Alaska, Japanese knotweed is now removed from state Department of Transportation and Public Facilities projects and buried in a similar way. Advantages of heavy equipment include the ability to easily move tons of contaminated soil in a short period of time and avoidance of herbicides. Disadvantages include high costs and the need for a complete restoration of the area from which all topsoil has been removed.

Cultural Methods

Fire has been successfully used to control populations of invasive plants outside of Alaska. However, there is always a risk that the resulting disturbance will leave an area open to further invasion. In addition, controlled burns require extreme care on the part of land managers to ensure that they do not result in a wide variety of unintended consequences. Nevertheless, burns performed as a part of an overall ecosystem management plan have the ability to help control invasive plant species.

In areas where water levels may be manipulated, it can be possible to kill invasive plants by flooding. As with fire, this may bring into play a number of other consequences that should be considered before instituting this kind of control.

Biocontrol

Biocontrol, short for biological control, involves introducing herbivorous or parasitic organisms from an organism's host environment to control an undesirable species. Biocontrol may be the only viable control option for invasive species that occupy thousands of acres. In order for a biocontrol agent to be effective, the target plant must be well-established already, with a large enough population size to support the pest population. There are very few species in Alaska that would meet this condition at the time of writing, and so biocontrol remains an option for the future.

Biocontrol strategies require thorough investigation of the target plant's biology, genetics, native range, and ecological interactions. The process of

developing a biocontrol agent is lengthy and complicated. Rigorous testing is required before a foreign biocontrol agent can be used, in order to ensure that off-target effects do not occur. Many agents are expensive to develop and to rear in quantities sufficient to be effective against the target plant. Establishing and maintaining a viable population of the biocontrol agent can be difficult.

Monitoring

Controlling plants without monitoring may waste the time, labor, and money used in the control effort. Generally, upon returning to a site that was treated once, there will be at least a few individuals re-establishing. Without monitoring, these plants can swiftly grow in population size to former levels. Monitoring frequency should be at least annual for the first few years after the treatment and several times per season for those species that can flower more than once per year. The duration of monitoring should be tailored to the lifespan of seeds in the soil, which varies by species.

Monitoring is the way to determine which control options are most effective for the infestations and species of concern, information that should be used to update management methods and shared with others. Not only target plants but also native plants colonizing the site after treatment should be monitored to evaluate restoration success.

Restoration

Before beginning any weed control effort, it is important to consider which plant species are likely to colonize an area after management and whether it is necessary to reseed the area with native plants or if it is possible to allow the area to be revegetated through natural processes. Generally, the plant species most likely to successfully establish and resist weeds at a disturbed site are those native species that are commonly found in disturbed areas. These are the vigorous pioneer species that characterize the beginning stages of succession but give way to late-successional species without repeated disturbance. It may be desirable to encourage germination of the invasive plant seed bank in order to more rapidly exhaust the seed reserves.

This summary of management considerations only brushes the surface of existing knowledge about invasive species management. Refer to each species' "Management" section herein for more specific information or contact your local Cooperative Extension Service office for further guidance.