

Multiple Habitats

27. Invasive and Nuisance Plant Species Removal

DEFINITION

An *invasive* or *nuisance pest* is a species that causes harm to humans or the environment (USGS n.d.). Unlike invasive species, *nonnative species* are organisms that do not occur naturally in an area but do not necessarily cause harm. Nonnative species are typically introduced to areas by humans (NPS 2020). *Nuisance species* can either be native or nonnative, but they always cause ecological or economic harm (Gwise 2021). This summary focuses on invasive plant species. In 2012, there were an estimated 5,000 nonnative plant species within the United States. While not all are invasive, there is still potential for these plants to spread and cause harm (Kerns and Guo, 2012). Management of invasive and nuisance plant species can benefit both the ecosystem and the economy (Gwise 2021).

TECHNICAL APPROACH

The most effective management practice for invasive and nuisance plants is to prevent species introduction in the first place. Beyond preventing the introduction, many different removal techniques are employed throughout the United States, and early management is crucial to eradicate or control invasive plant species (Bethke et al. 2018). Integrated pest management is the current approach recommended by the US Environmental Protection Agency to manage all invasive and nuisance pests. This approach is an effective and environmentally sensitive method that prioritizes tactics with the least economic costs and harm to humans and the environment, focusing on nonchemical treatments first and using chemical control as a last resort (EPA 2023, University of California 2016). The technical approaches to controlling invasive plants vary depending on the stage of invasion. Across all stages, it is crucial to create interagency partnerships along with collaborations with private landowners because of the cross-boundary nature of invasive and nuisance plants (Kurth 2017).

The steps for combating invasive and nuisance plants are as follows:

1. **Prevention:** With the increase in globalization, the potential for the introduction of invasive species increases. Prevention is the most cost-effective management strategy, and many methods exist to prevent invasive and nuisance plant species invasions (Kurth 2017). Some important prevention methods include effective education on firewood use, ornamental plants, invasive species removal from public and private property, and how not to transport invasive species when traveling (Bethke et al. 2018). Methods specifically for land managers include reducing soil disturbance and revegetating the soil with native species, cleaning equipment when changing watersheds, and preventing the introduction of invasives after prescribed burns (Moorehead et al. 2011). Modeling the risk of invasion that various species pose, especially considering climate change, helps to inform rapid risk screening reports that can help determine the best course of action for managing a particular species (Kurth 2017).

2. **Early detection:** While prevention is the most important containment method, early detection is the next-best strategy (Kurth 2017). One method used to detect invasive and nuisance species is sampling vegetation along roads, trails, power line corridors, and other highly trafficked areas. Maintaining a priority list for species with the highest spread potential or with the most devastating impacts is essential to manage effectively (NPS n.d.).
3. **Eradication:** To eradicate invasive and nuisance plant species before they are not containable, early detection and rapid response is crucial (DOI 2021). Removal methods include the following:
 - **Manual/mechanical removal:** Mechanical removal, including pulling and digging, is often the first method used for invasive species removal (Figure 1). Mechanical methods typically do not require specific licensing but may require permits. Although mechanical removal can be effective if the invasion is early and in small quantities, it is extremely labor-intensive and can cause site disturbance, which can lead to reinvasion. It is important to remove the entirety of the root, and this method is easiest in the spring or early summer because of soil saturation. Cutting or mowing can also be effective, but because it does not destroy the roots of the plants, it will take years to be successful and requires a commitment to the process (DOEE 2023).
 - **Cultural control:** *Cultural invasive species management* refers to the manipulations of habitats to increase invasive species mortality and limit its rate of damage. Cultural methods tend to change human behavior through education to effectively prevent, remove, or manage invasive species. Prescribed grazing with farm animals and prescribed burning are both examples of cultural control methods (USDA n.d.).
 - **Farm animals:** There are examples of agencies using farm animals to help control invasive plant species (Figure 2). For instance, at the Travis Air Force Base, goats, and sheep are used to reduce invasive species populations instead of mowing because of the size and accessibility of the area (Schilter-Lowe, 2018). Because animals have different eating preferences, it is essential to know what species will be most effective for grazing the invasive plants in question; the animals may potentially need training on which plants to eat (Bell 2014).
 - **Prescribed burns:** Humans have used fire to manage vegetation for centuries. Prescribed fire can reduce invasive species populations, but the effectiveness of fire on plants varies considerably based on region, species, and growth forms. For example, in the western United States, prescribed fire is most effective on annual species prior to seed maturation or dispersal. Biennial and perennial species, on the other hand, are more challenging to control and cannot be controlled by a single prescribed burn. However, in the eastern United States, management agencies have been successful in managing perennial grasses with prescribed burning. Woody invasive species are often the most difficult to control with prescribed burning because they tend to resprout after burns (DiTomaso et al. 2006).

Figure 27.1 Russian olive removal on a US Air Force base in North Dakota



Photo courtesy USFWS Mountain-Prairie

- **Mulching:** Mulching can be used to block light from invasive and nuisance plant species and is typically done with a combination of mulch and cardboard to fully cover the invasive or nuisance ground cover. Blocking the light prevents germination and growth (Manning and Miller, 2011).
- **Biological control:** *Biological control methods* refer to the use of native or natural enemies to weaken, kill, or stop seed production of invasive and nuisance plant species. It is important to do extensive research on the species and method

Figure 27.2 Releasing goats at the Bozeman Fish Technology Center to control noxious weeds



Photo courtesy USFWS Mountain-Prairie

intended prior to releasing large numbers of the native species. Species used are typically insects, pathogens, nematodes, and mites that feed upon plants (Miller et al. 2015).

- **Chemical control:** Using herbicides is a very common control method for invasive and nuisance plant management, but it can adversely affect the surrounding ecosystem. Selective herbicide spraying typically has the least impact on the ecosystem due to the ability to target individual plants; it is important to avoid broad-spectrum herbicides as much as possible (DOEE 2023, Miller et al. 2015) When working in wetland zones, there are specific aquatic herbicides that should be used (DOEE 2023).
4. **Containment/long-term management:** If the invasion is beyond the point of eradication, the last management method is containment and long-term management. Containment can include practices such as the removal of above-ground plant parts or restricting the species spread (Miller et al. 2015). Long-term management and containment can be incredibly costly and labor-intensive (DOI 2021).

OPERATIONS AND MAINTENANCE

The process of detection and prevention will need to continue over time to prevent reinvasions or reintroductions of invasive and nuisance plants. As described previously, long-term management will be required to contain and prevent the spread of these plants in some cases.

FACTORS INFLUENCING SITE SUITABILITY

Because invasive and nuisance species plague most of the land in the United States to some extent, the most crucial aspect of site suitability is prioritization to help decide which sites are at the highest risk.

- ✓ **Heavily trafficked areas:** Invasive and nuisance species are typically unintentionally spread by humans, so heavily trafficked sites are often at higher risk of introductions (NWF n.d.).
- ✓ **High-risk invasive species detected:** Using species distribution models is a standard method of determining the invasion risk of particular species in specific regions (Adhikari et al. 2022).
- ✓ **Area at risk of invasion:** Prevention is the most cost-effective management strategy, so it is essential to implement projects in areas at high risk of invasive plant species invasion (Bethke et al. 2018).
- ✓ **Riparian areas:** Riparian areas are often disturbed by humans, which puts them at higher risk for species invasions (Hammer 2019).
- ✓ **High biodiversity:** It is important to preserve biodiversity when possible; this is often the goal of invasive species management projects. Determining high-biodiversity areas is crucial in prioritizing project implementation (Tu 2009).
- ✓ **Stage of the plant life cycle:** It is important to know the life cycle of the plant that is being managed or eradicated. According to research, annual plants should be pulled and cut at the soil and chemically treated before flowering. Biennial plants should be pulled and dug out in the first year, repeated cutting should be implemented in the second year. Biennial plants should be chemically treated before emergence in the first year and during the rosette stage; in the second year, they should be treated before flowering. Noncreeping herbaceous perennials should be dug, cut, pulled, and treated with herbicide at full canopy but before the seed is set. Creeping herbaceous perennials should be cut and chemically treated in the late season. Nonsuckering woody species should be cut and chemically treated when at full canopy (May/June) to fall. Suckering woody species should be chemically treated between July to fall. Woody vines should be cut any time of the year and chemically treated eight weeks after cutting (Rojik 2023).

TOOLS, TRAINING, AND RESOURCES FOR PLANNING AND IMPLEMENTATION

Name and Link	Resource Type	Year	Authors/ Authoring Organization	Geography	Description	Resource Includes			
						Design/Construction Guidance?	Site Selection?	Monitoring Guidance?	Example Projects?
Executive Order 13751	Document	2016	Executive Office of the President	National	This order explains the duties to be performed by all federal agencies to limit the impacts of invasive species throughout the United States.	✓	—	—	—
A Management Guide for Invasive Plants in Southern Forests	Guidebook	2013	US Department of Agriculture Forest Service (USFS)	Southern United States	This guidebook provides information on how to prevent invasive species establishment, maintain native forests, and eradicate invasive species in southern forests.	✓	✓	✓	✓
Land Manager's Guide to Developing an Invasive Plant and Management Plan	Guidebook	2018	US Fish and Wildlife Service, California Invasive Plant Council	National	This guide aids land managers in writing an invasive species management plan and monitoring the outcomes and adaptive management strategies.	✓	✓	✓	✓
Best Management Practices (BMPs) to Prevent the Introduction and Spread of Invasive Species	Guidebook	2011	The University of Georgia Center for Invasive Species and Ecosystem Health	National	This document provides best management practices for land managers to prevent the introduction and spread of invasive species.	✓	✓	✓	✓
Field Guide: Invasive Plant Inventory, Monitoring, and Mapping Protocol	Guidebook	2001	USFS	National	This guide provides a protocol for land managers to monitor, map, and inventory invasive species. This guide aids in collaborative management by providing information that can be shared across jurisdictions. Because it is an older resource, the technical mapping data may be outdated.	✓	✓	✓	✓

Name and Link	Resource Type	Year	Authors/ Authoring Organization	Geography	Description	Resource Includes			
						Design/Construction Guidance?	Site Selection?	Monitoring Guidance?	Example Projects?
Cohesive Approach for Invasive Species Management in the Northeastern US	Guidebook	2007	USFS	Northeastern United States (20 states bounded by Minnesota, Maine, West Virginia, and Missouri)	This guide is meant to help facilitate collaboration, create management plans, and conduct targeted actions plan for invasive species in the northeastern United States.	✓	—	✓	✓
Midwest Invasive Plant Network: Invasive Plant Control Database	Website	2018	Midwest Invasive Plant Network	Midwest United States	This database provides information on control techniques, examples of projects, method effectiveness, and handbooks/other resources.	✓	✓	✓	✓
Invasive Species List	Website	2022	US Department of Agriculture National Invasive Species Information Center	National	This website provides a list of registered invasive species within each state and the regulations accompanying them.	✓	✓	—	—
Invasive Species: Alaska	Website	n.d.	Alaska Department of Fish and Game	Alaska	This website provides information on invasive species within Alaska and how to manage, prevent, and report them.	✓	—	✓	✓
Invasive Species Strategic Plan 2021-2025	Document	2021	US Department of the Interior (DOI)	National	This document provides information on DOI's plans for invasive species management throughout the different bureaus and agencies.	✓	✓	✓	✓
Bureau of Land Management's (BLM's) National Invasive Species Information Management System (NISIMS)	Website	2023	US Geological Survey (USGS)	Mostly western states (anywhere with BLM land)	This dataset provides standardized information on invasive species (currently only weeds, but will expand to all invasive taxa).	✓	✓	✓	—

Name and Link	Resource Type	Year	Authors/ Authoring Organization	Geography	Description	Resource Includes			
						Design/Construction Guidance?	Site Selection?	Monitoring Guidance?	Example Projects?
The Use of Fire as a Tool for Controlling Invasive Plants	Book	2006	California Invasive Plant Council, Joint Fire Science Program, USGS	National	This book describes methods for using prescribed fire as a control method for invasive plant species.	✓	✓	✓	✓
Field Guide for Managing Cheatgrass in the Southwest	Guidebook	2017	USFS	Southwest United States	This guide gives actionable information on how to manage invasive cheatgrass.	✓	✓	✓	✓
EDDMapS	Website	2005	University of Georgia	National	This webpage allows people to report invasive species, monitor current distribution, learn about management methods, and get species information.	✓	✓	✓	✓
Assessing and Managing Invasive Species within Protected Areas	Document	2009	The Nature Conservancy	National	This guide provides information on managing invasive species for biodiversity within protected areas. This guide is meant for practitioners.	✓	✓	✓	✓
Invasive Aquatic Plant Control and Management Guide	Guidebook	2015	Michigan Lake and Stream Associations	Midwest	This guide provides information on invasive aquatic plant management.	✓	✓	—	—

LIKELY BENEFITS AND OUTCOMES

Primary objectives for each strategy are **highlighted**.

Climate Threat Reduction

- **Reduced wildfire risk:** Invasive and nuisance plant species, especially grasses, increase the severity of wildfires because of their high flammability. Many of these grasses grow and dry out quickly; the species of particular concern within the United States are cheatgrass (*Bromus tectorum*), cogon grass (*Imperata cylindrica*), and buffelgrass (*Cenchrus ciliaris*). Effectively managing these grasses can help reduce catastrophic wildfires (Cornwall 2022).

- **Drought mitigation:** Invasive and nuisance species often require more water than native species; therefore, invasive species management can help reduce drought stress (White House 2022).

Social and Economic

- **Food security:** Invasive and nuisance plant species can affect food security because of their negative impact on crop and animal health (IUCN 2021). Within the United States in 2001, weeds (45% of which were invasive species) caused a \$33 billion loss in revenue from agriculture (Pimental et al. 2001).
- **Agriculture and timber yields:** Invasive and nuisance species such as buckthorn and honeysuckle can reduce tree growth, leading to losses in timber sales. Managing these species can therefore safeguard timber profits (Wisconsin DNR). As noted previously, nuisance and invasive weeds also cost billions of dollars in agriculture revenue (Pimental et al. 2001).

Ecological

- **Enhanced biodiversity:** Invasive and nuisance species are one of the biggest known threats to biodiversity (Hanley and Roberts 2019, Allendorf and Lundquist 2003). Invasive plant species are known to out-compete, hybridize with, or alter the ecological community of native plants, which reduces local biodiversity and can lead to extinction (Morse et al. 2004). Invasive species have contributed to the decline of 42% of endangered or threatened species (Kurth 2017). Biodiversity is crucial in supporting a functioning ecosystem and can lead to a loss of the value of ecosystem services provided by forests (Smith and Webber, 2017).
- **Supports wildlife:** Invasive and nuisance plant species can negatively affect habitat and food supply for native animals and insects (National Wildlife Federation n.d.).

BARRIERS AND SOLUTIONS FOR PRACTITIONERS

Common Barriers

Several barriers are common across many of the nature-based solutions strategies; these are described in more detail in [Section 1 of the Roadmap](#). Additional notes about the barriers specific to invasive and nuisance plant species are included here.

- **Expense:** In 2020, DOI invested \$143 million into invasive species management. Cheatgrass, a species plaguing the western United States, cost \$18 million to remediate from 2015–2019 within lands managed by DOI (2021). Invasive species management does not typically lead to complete eradication, so perpetual management is often needed, which is extremely costly (DOI 2023).
- **Capacity:** Invasive and nuisance species management often requires a lot of human capacity to succeed. Managers often have to put all resources into current invasion management. They are limited in the time and resources to prevent new invasions, which is the most cost-effective management method (Beaury et al. 2020).

- **Public opinion**
- **Conflict with other land uses**
- **Regulation**
- **Lack of effectiveness data**

Community

- **Ornamental plants:** There are still many invasive and nuisance species being sold throughout the country, typically as ornamental plants. This is the primary pathway for invasive species to enter the United States. Advocating for federal regulation and cohesive local policies for preventing invasive species sales is essential to avoid disjointed state rulings (Beaury et al. 2021).

Ecological

- **Climate change:** The influence of climate change on invasive and nuisance species management concerns many land managers. Climate change affects the distribution and abundance of invasive plant species, and more challenges are likely to appear (Beaury et al. 2020). Because invasive and nuisance plant species are resilient because of their high dispersal rates, rapid growth rates, and high tolerance to environmental conditions, they will likely be able to adapt easier to changing conditions as a result of climate change (Finch et al. 2021).
- **Site disturbance:** Manual or mechanical invasive and nuisance species removal can disturb the ecosystem, which can lead to reinvasion if not appropriately managed (DOEE 2023). Soil disturbance, erosion, or loss can also be caused by clearcutting or mowing invasive species, but if managed with root retention in smaller areas, erosion can be minimized (Castillo and Smith-Ramírez 2018).
- **Chemical use:** Herbicides can negatively impact all species, including humans. Broad-spectrum herbicides are often used, which can be toxic to native species and create resistance in some invasive and nuisance plants. Herbicides can also impact the environment by contaminating waterbodies if they infiltrate through runoff or misguided application, changes in soil composition, and killing native predators. Herbicides can negatively impact livestock, fisheries, and wildlife through exposure (EPA 2023). Lastly, herbicides can have adverse effects on human health through direct or indirect exposure, including reproductive, liver, and kidney issues (Myers et al. 2016).
- **Biological controls:** Biological controls can result in attacks on native species when not adequately researched and planned, such as the musk thistle weevil's assault on both invasive and native species. It is crucial to perform thorough research before implementing this approach (Miller et al. 2015)

EXAMPLE PROJECTS

Name and Link	Location	Leading Organizations	Techniques Used	Size	Cost	Duration	Project Description	Climate Threats Targeted	Lessons Learned or Adaptive Management
Invasive Plant Management Support at Minute Man National Historical Park	Minute Man National Historical Park, MA	National Park Service (NPS)	Mechanical treatment, chemical treatment	1,038 acres	\$82,446 (\$15,000 grant plus an additional \$67,446)	1 year (1 field season)	This project focused on the removal of 12 different invasive plant species throughout one field season.	Loss of biodiversity	No
Gunnison Basin Cheatgrass Implementation Project	Gunnison Basin, CO	US Fish and Wildlife Service, Colorado Parks and Wildlife, Partners for Fish and Wildlife, Upper Gunnison River Conservancy District, BLM, Colorado Field Ornithologists, Gunnison County Stockgrowers, USFS, Bird Conservation of the Rockies	Wet meadow restoration, cheatgrass treatments, sagebrush restoration	150 acres (wet meadow restoration), 1000 acres (cheatgrass treatment)	\$793,476 (2023)	Ongoing (began 2022)	This project is designed to remove cheatgrass and restore sagebrush in the Gunnison Basin.	Promote biodiversity	No

Name and Link	Location	Leading Organizations	Techniques Used	Size	Cost	Duration	Project Description	Climate Threats Targeted	Lessons Learned or Adaptive Management
Removing Invasive Plants from the Great Meadow	Acadia National Park, ME	NPS	Manual removal (hand saws and pruners), herbicide	116 acres	Not provided	Ongoing (began 1989)	The invasive plant management program in Acadia National Park aims to remove glossy buckthorn and restore native wetland species to combat climate change and increase biodiversity.	Restore native plant communities	They adapted the project to not completely eradicate glossy buckthorn because of capacity limitations but instead to focus on restoring native species.
Weed Control Along Minnesota Roadsides	Minnesota	Minnesota Department of Transportation	Prevention and early detection through monitoring, cleaning equipment, managing ground disturbance, and maintaining healthy roadside native vegetation; control through mowing, herbicide, biological control, and prescribed fire; containment through containing the spread	175,000 acres	Not provided	Ongoing	This project is an ongoing management strategy that prioritizes prevention, control, and containment.	Maintain native species, limit the further spread of invasive species	This project has asked for public help in monitoring and detection.

Bolding indicates DOI affiliates.

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This strategy is one section of a larger work, the Department of the Interior Nature-Based Solutions Roadmap, written in collaboration between the Nicholas Institute for Energy, Environment & Sustainability at Duke University and the US Department of the Interior. This section and the whole document is a work of the United States Government and is in the public domain (see 17 U.S.C. §105).

Authors and Affiliations

Katie Warnell, Nicholas Institute for Energy, Environment & Sustainability, Duke University **Sara Mason**, Nicholas Institute for Energy, Environment & Sustainability, Duke University

Aaron Siegle, Duke University

Melissa Merritt, Nicholas School of the Environment, Duke University

Lydia Olander, Nicholas Institute for Energy, Environment & Sustainability, Duke University

Contributors

Tamara Wilson, US Department of the Interior

Whitney Boone, US Department of the Interior

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