

LA-UR-22-32639

Invasive Plant Species Management Plan for Los Alamos National Laboratory



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Cover photo: Large Siberian elm (Ulmus pumila) source tree with a blanket of young Siberian elm trees beneath.



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Introduction

Native species are plants and animals that continually occupy a natural range without direct or indirect introduction and/or care by humans. They are adapted to the environmental conditions and processes of the ecosystem in which they reside. A species introduced into a *novel ecosystem* can either exploit that ecosystem and thrive or be unable to survive in that ecosystem (Hobbs et al. 2006). *Alien or non-native species* are species that are intentionally or accidentally introduced into a novel ecosystem and are capable of living and propagating within the physical parameters of that ecosystem. *Invasive species* is a species that is non-native (or alien) to the ecosystem under consideration and a *noxious species* are those whose introduction causes or is likely to cause economic or environmental harm. The term *invasive species* is applicable to plants and animals alike; however, this invasive species management plan currently focuses on invasive vegetation. Invasive plant species are usually capable of rapid colonization of disturbed ground, such as after a change in wildfire regime intensity and frequency (Reilly et al. 2020) or anthropogenic ground disturbance (Burke and Grime 1996; Hobbs and Huenneke 1992). Climate change facilitates the spread and establishment of many alien species and creates new opportunities for them to become invasive (Turbelin and Catford 2021). As climate change impacts increase in the coming decades, we may see in an increase in invasive species establishment. See a list of definitions of terms pertinent to this document in Appendix A: Definitions.

Los Alamos National Laboratory (LANL) hosts populations of non-native and invasive species all typical of the northern New Mexico region (Martin 2004; NMDA 2020). By implementing an invasive species management plan, LANL will have readily accessible management strategies for invasive species that are found on-site. The benefits of managing invasive species include a decrease in wildland fire risks, an increase in soil productivity, an increase in (productive or beneficial) wildlife habitat, an increase in water quantity and quality, and the restoration of impacted areas (Burke and Grime 1996; Hobbs and Huenneke 1992; D'Antonio and Hobbie 2005; MacDougall et al. 2013; Reilly et al. 2020). The aforementioned benefits from invasive species management directly enable the LANL mission by ensuring compliance requirements are met and site-wide programs, such as the Vulnerability Assessment and Resilience Plan, are supported for a mutually beneficial outcome. An example for the LANL site specifically, controlling non-native annual plant species, for example, could reduce the costs associated with stabilizing soils during the stormwater pollution prevention compliance process. Roadway and utility right-of-way areas are another place where an integrated vegetation management strategy would promote low growing perennial plants in a way that is mutually beneficial to habitat and the institution through lowered maintenance costs. There is also an economic benefit to managing invasive species. In one nationwide study, invasive plants had an estimated impact cost of \$190.45 billion (Fantel-Lepczyk et al. 2022). Investing in preventative measures and surveillance could help to offset future control and management costs of invasive species that have the potential to become established.

The State of New Mexico has developed plant species lists and recommendations through the New Mexico Department of Agriculture's Noxious Weeds Management Act, Article 7D (NM Statute § 76-7D-4 2021); however, effective invasive species management must rely on local knowledge of the site and region. Los Alamos County (LAC) has already compiled a target invasive plant species list and species-specific management objectives (Martin 2004). Therefore, the New Mexico Noxious Weed List and the LAC invasive plant species list, as well as management objectives from those documents, are integrated into LANL's invasive plant species management plan.

Purpose

The purpose of controlling invasive plants at LANL is to maintain and improve the diversity, function, and sustainability of native plant communities and habitats. Non-native plant species are aggressive and outcompete native plants for resources (Vila and Weiner 2004; Golivets and Wallin 2018). Without effective control, invasive plants can result in adverse impacts including

- Degradation of *ecosystem services* and processes by increasing erosion and reducing water quality;
- increase in fuel load, allowing wildland fires to burn more intensely and severely in areas where non-native invasive species occur;
- decrease in wildlife habitat quality and quantity, especially in riparian areas where Siberian elm and Russian olive take over native riparian ecosystems; and
- negatively impact visual resources and recreation.

Drivers

The 1999 Executive Order 13112, “Invasive species” (Volume 64 Federal Register [FR] 6183–6186), called on executive departments and agencies to take steps to prevent the introduction and spread of invasive species and to support efforts to eradicate and control invasive species that are already established. Executive Order 13112 also created a coordinating body—the National Invasive Species Council (NISC)—to oversee implementation of the order, encourage proactive planning and action, develop recommendations for cooperation, and take other steps to improve the federal response to invasive species. In 2016, Executive Order 13751, “Safeguarding the nation from the impacts of invasive species,” sought to continue coordinated federal prevention and control efforts related to invasive species (Volume 81 Federal Register [FR] 88609–88614). The NISC prepared the National Invasive Species Management Plan (2016–2018), which provided a strategic framework for federal agencies to follow to address the national problem of invasive species impacts to natural and human systems as directed by Executive Order 13112 and 13751 (NISC 2016). The framework of the National Invasive Species Management Plan is adaptable to the local level for federal facilities. This plan discusses recommendations and approaches to invasive plant species control measures for the LANL site, adapted from the 2016–2018 National Invasive Species Management Plan, as well as additional works from the NISC.

The Dingell Act was passed in 2019. The act stated under Title VII language for the development of a “strategic plan and implementation of an invasive species program to achieve, to the maximum extent practicable, a substantive annual net reduction of invasive species populations or infested acreage on land managed by any federal agency.” As part of the Dingell Act, the same language was incorporated into Section 10 of the Fish and Wildlife Coordination Act, which called for agencies to not only develop a strategic plan but to also take into consideration the economic and ecological costs of action or inaction and coordinate with adjacent landowners while also considering priorities implemented by the State of New Mexico.

Additionally, multiple internal LANL drivers exist for invasive species management. The mitigation action plan (MAP) for LANL associated with the National Environmental Policy Act process (LANL 2020) includes a mitigation commitment to develop a LANL invasive species best management practices document. The Pollinator Protection Plan for LANL (Stanek and Hathcock 2021), the LANL Landscape Management Plan (UI-PLAN-017-R0), the LANL Engineering Standards (ISD 341-2), and the LANL Storm Water Best Management Practices Manual (Lemke 2011) require using native perennial seed mixes for revegetation. The LANL Pollinator Protection Plan and the LANL

Landscape Management Plan further emphasize the removal of non-native vegetation onsite, when possible. All LANL work is governed by the principles of LANL SD400, *Environmental Management System*, which has institutional environmental objectives and targets, including Objective 3: Create a Sustainable Future. As part of this goal, the Laboratory's Long-Term Strategy for Environmental Stewardship and Sustainability is being updated for Enduring Site Environmental Stewardship, which is expected to contain drivers for actively managing for native species and limiting the spread of invasive species. Additionally, one of the environmental aspects tracked in SD400 is how work interacts with wildlife and/or habitat, which includes removing weeds and limiting the spread of invasives.

Goals and Implementation

This plan was developed by the Environmental Stewardship Group within the Environmental Protection and Compliance Division. Implementation of the plan will be coordinated primarily by Biological Resources and Forest Health Programs in coordination with the Wildland Fire and Forest Management Program and facilitated by the Integrated Review Tool (IRT). The IRT is comprised of the Permits and Requirements Identification (PRID) tool, the Excavation/Fill/Soil Disturbance (EXID) permit tool, and the Site Selection tool.

The goals of the LANL Invasive Plant Species Management Plan are as follows:

- Describe current and future initiatives that address best management practices to identify, reduce, control, or eradicate invasive species onsite and to prevent spread offsite when applicable.
- Establish long-term and continuous strategic goals for invasive species management onsite.
- Coordinate with the Department of Energy (DOE) headquarters invasive species working group to implement the most recent best management practices and invasive species management.
- Identify opportunities to collaborate with multiple programs within LANL and other neighboring entities such as LAC, Bandelier National Monument, the Santa Fe National Forest, and other surrounding landowners or interested parties.

Non-Native Invasive Plant Species in Los Alamos County

The LANL Biological Resources Program and the Wildland Fire and Forest Health Program have identified non-native invasive focal plant species for the site (Table 1) to be targeted for control, eradication, or management. The focal plant species list was created by cross referencing the LAC Invasive Species Management Plan priority species list (Martin 2004), the New Mexico Noxious Weed List (NMDA 2020; updated June 2020), as well as incorporating on-site knowledge of non-native invasive plant species occurrence at LANL.

Class lists defined by the state of New Mexico are as follows:

- Class A species are currently not present in New Mexico or have limited distribution. Preventing new infestations of these species and eradicating existing infestations are the highest priorities.
- Class B species are limited to portions of the state. In areas with severe infestations, management should be designed to contain the infestation and stop any further spread.
- Class C species are widespread in the state. Management decisions for these species should be determined at the local level, based on feasibility of control and level of infestation.

- Watch List species are of concern in the state and have the potential to become problematic. More data are needed to determine if these species should be added. If a Watch List species is encountered, please document the location and contact LANL Biological Resources Program subject matter experts (SMEs) so they can report the species and location to the New Mexico Department of Agriculture.

Our priority ratings are designated based on the NM Class designations, if the invasive species occurs in LAC and on LANL property, and the feasibility of control and eradication (Table 1). For example, if a species is Class A, found on LANL property, and can be feasibly controlled or eradicated, it is listed in Table 1 as a high-priority species. If a species is Class C, found in LAC and on LANL property, and cannot be feasibly eradicated, it is a low-priority species. Additionally, if a species is Class A and found in LAC but has not yet been documented on LANL property, we will target that species to gather more on-site location information. Species that are known to occur in LAC or in nearby counties but have not yet been documented onsite need more information before their priority rating designation.

Table 1: Non-Native Invasive Plants in Los Alamos County and Confirmed on Los Alamos National Laboratory Property. Priority ratings are based on New Mexico Class List, occurrence in LAC and on-site, and feasibility of management or removal.

Common Name	Scientific Name	Plant Type	Confirmed in LAC	Confirmed on LANL	NM Class List*	Priority Rating
Bull thistle	<i>Cirsium vulgare</i>	biennial forb	Y	Y	B	Moderate
Canada thistle	<i>Cirsium arvense</i>	perennial forb	Y	Y	A	High
Cheatgrass	<i>Bromus tectorum</i>	annual grass	Y	Y	C	Low
Common mullein	<i>Verbascum thapsus</i>	biennial forb	Y	Y	C	Low
Dalmatian toadflax	<i>Linaria dalmatica</i>	perennial forb	Y	NMI	A	NMI
Diffuse knapweed	<i>Centaurea diffusa</i>	biennial forb	N	NMI	A	NMI
Field bindweed	<i>Convolvulus arvensis</i>	perennial forb	Y	Y	C	Low
Flixweed, tansy mustard	<i>Descurainia sophia</i>	annual forb	Y	NMI	C	NMI
Giant reed	<i>Arundo donax</i>	perennial grass	NMI	NMI	C	NMI
Jointed goatgrass	<i>Aegilops cylindrica</i>	annual grass	Y	Y	C	Low
Leafy spurge	<i>Euphorbia esula</i>	perennial forb	NMI	NMI	A	NMI
Musk thistle	<i>Carduus nutans</i>	biennial forb	Y	NMI	A	NMI
Myrtle spurge	<i>Euphorbia myrsinites</i>	perennial forb	NMI	NMI	WL	NMI
Oxeye daisy	<i>Leucanthemum vulgare</i>	perennial forb	Y	NMI	A	NMI
Red brome	<i>Bromus rubens</i>	annual grass	NMI	NMI	NA	NMI
Russian knapweed	<i>Acroptilon repens</i>	Perennial	Y	Y	B	Moderate
Russian olive	<i>Elaeagnus angustifolia</i>	shrub/tree	Y	Y	C	Low
Russian thistle	<i>Salsola tragus</i>	annual forb	Y	Y	C	Low
Saltcedar	<i>Tamarix ramosissima</i>	shrub/tree	Y	Y	A	High
Siberian elm	<i>Ulmus pumila</i>	Tree	Y	Y	C	Low
Skeletonleaf bursage	<i>Ambrosia tomentosa</i>	perennial forb	Y	NMI	B	NMI
Smooth brome	<i>Bromus inermis</i>	perennial grass	Y	Y	NA	Low

Common Name	Scientific Name	Plant Type	Confirmed in LAC	Confirmed on LANL	NM Class List*	Priority Rating
Spotted knapweed	<i>Centaurea biebersteinii</i>	perennial forb	Y	NMI	A	NMI
Teasel	<i>Dipsacus fullonum L.</i>	biennial forb	Y	Y	B	Moderate
Tree of heaven	<i>Ailanthus altissima</i>	Tree	Y	NMI	B	NMI
Whitetop/hoary cress	<i>Lepidium draba</i>	perennial forb	Y	Y	NA	NMI
Yellow star thistle	<i>Centaurea solstitialis</i>	annual forb	Y	Y	A	High
Yellow salsify	<i>Tragopogon dubius</i>	biennial forb	Y	Y	A	High
Yellow toadflax	<i>Linaria vulgaris</i>	perennial forb	Y	NMI	A	NMI

*Class list designations are from the New Mexico Noxious Weed List (NMDA 2020).

Y = Yes; NMI = Needs more information; N = No.

Current Initiatives

Current initiatives that opportunistically document and manage invasive plant species are as follows:

- The creation and use of ArcGIS Survey 123 Invasive Species application (app) for use on LANL iPhones and iPads to document where and what invasive species are located onsite.
- The support of any projects that have the potential to integrate the removal of invasive species and opportunistically identify and remove invasive species on a project-by-project basis through recommendations made in the project review process using IRT.
- Updating engineering standards for requirements on native plants and seed mixes for use in landscaping or revegetation activities onsite.

Best Management Practices for Non-Native Invasive Plants

This section contains a concise description of actions that projects and field personnel can take, followed by a detailed description of how the institution will address prevention, early detection, and control of invasive species at LANL.

Best Management Practices for Projects and Field Personnel

- Use native species in landscaping, restoration, and forest management; consult with Forest Health and Biological Resources subject matter experts (SMEs) in the Environmental Stewardship Group to assess for existing invasive species and for planning restoration.
- Projects that are subject to a Construction General Permit (CGP), must adhere to all measures for stabilization, sediment and erosion control, and storm water management. Projects not covered by a CGP must follow project-specific comments provided by EPC-CP personnel in the IRT.
- Remove mud from boots, gear, and vehicles before entering and leaving the work site. This action is especially important when changing fieldwork locations. Mud can harbor high densities of seeds, including those of invasive species.
- Field personnel should take care not to get seeds on clothing. Burs, cockleburs, burdock found attached to personal articles of clothing or other items should be removed close to the source or disposed of in an appropriate municipal waste receptacle if in an open area.

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- Contact Environmental Stewardship personnel if you would like to participate in documenting new populations of invasives with the Survey 123 invasive species mobile application (See Appendix B: Species Specific Identification).

Prevention

One of the main long-term goals is to prevent introduction, establishment, and proliferation of invasive species to reduce impact. Prevention is the most cost-effective approach because once a species becomes widespread, controlling it could require significant and sustained expenditures. Therefore, investment in prevention tools, resources, and infrastructure is indispensable in protecting agriculture and natural resources. Long-term success in prevention will reduce the rate of introduction, the rate of establishment, and the damage from invasive species, which is less costly in the long-term.

To focus on prevention, LANL Resources Management SMEs will

- Maintain a list of invasive species present in or around LANL (Table 1) in order to document the existing invasive species onsite and document any emerging invasive species onsite. The invasive species list will be re-evaluated as new information, such as potential range expansion, becomes available.
- Promote the use of locally native species in landscaping, restoration, and forest management. For example, LANL Resources Management SMEs will work with internal partners, such as Utilities and Infrastructure, to create an approved native species plant list and options for non-natives that would be approved only for plants contained in planter beds for subcontractors who are tasked with landscaping decisions.

Early Detection and Response

It is critical to quickly control an infestation before it becomes more widely established. By developing and enhancing the capacity to identify, report, and effectively respond to newly discovered/localized invasive species, we can minimize the potential cost associated with removing them in the future. To conduct early detection and rapid response, invasive species populations must first be found. These early detection efforts are essential for control.

To focus on early detection and rapid response, LANL Resources Management SMEs will

- Review projects in the IRT and include invasive species assessment and control recommendations as part of all new construction projects and other projects that involve vegetation removal. Assess for the presence of invasive species before and after project implementation.
- Develop and implement a site-wide forest and ecosystem health-monitoring plan that includes projects identified in the IRT to focus on early detection of invasive species including invasive plants and forest pests and pathogens. This plan is in preparation as identified in the FY22 Annual Operating Plan for Wildland Fire and Forest Health.
- New invasive species vegetation infestations will be submitted to the IRT for review as a treatment by LANL pest control and documented as Forest and Watershed Health Initiatives proposed in the next fiscal year's annual operating plan.
- Track and submit data to the LANL ArcGIS Survey 123 invasive species mobile application; submit verified new invasive species location data to the national database on invasive species (Early Detection and Distribution Mapping System: <https://www.eddmaps.org/report/>) (EDDMapS 2022).

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- Continue to pursue regional coordination of invasive species management through the East Jemez Resource Council and look into the formation of a [Cooperative Weed Management Area](#).
 - Attend U.S. Department of Energy Headquarters (DOE-HQ) Invasive Species Working Group meetings to stay informed about current and ongoing information and resources for newly introduced species.

Control and Management

A lack of financial and human resources often limits the capacity to control and manage invasive species; therefore, priority will be given to those species that are ranked as high priority and are already known to occur onsite. Table 2 identifies the effectiveness of potential controls for selected invasive plant species found in LAC and at LANL. Table 2 will help target species that are known to occur onsite and that have potential for opportunities available to manage those species; we need more information on some species listed in Table 2 regarding whether they are located onsite. In the project review process on a project-by-project basis, LANL Resources Management SMEs will opportunistically offer suggestions to develop species-specific invasive species management objectives and implementation procedures depending on project goals.

To further focus on control and management of invasive species, LANL Resources Management SMEs will

- Use Table 1 and Table 2 to prioritize species by class list, infestation, and feasibility of removal. Other considerations for prioritization will include small, isolated infestations; patches of high-priority species that are likely to spread; and infestations within project areas or along roads, trails, or parking areas. Choice of individual methods for control depend on the degree and density of the infestation, current land use, and site conditions (accessibility, terrain, microclimate, other flora and fauna present, etc.).
- Stand up a chainsaw use protocol wherein LANL Resources Management SMEs are trained and certified to operate electric-powered chainsaws to remove invasive trees of less than 6 inches diameter-at-breast height.
- Recommend, when possible during collaboration and project review, managing invasive species by mechanical means, including
 - Mowing. Cut when plants are in flower to remove before seeds are mature, mow close to the ground, and repeat as needed.
 - Seed-head clipping. Clip seed heads off invasive forbs, and dispose of seed heads in trash bags. Best done before seed emergence. Primarily done in wetland areas to minimize ground disturbance by heavy equipment use.
 - Digging. Any mechanical or physical method that severs the root below the soil surface.
 - Girdling. Severs the bark (cambium) in a ring that extends entirely around the trunk of the tree. The ring needs to be wide and deep enough to kill the tree.
 - Fire. Slash-pile burning is a routinely used fuels reduction treatment that is cost-effective in reducing unwanted vegetation in a practical manner.
- If mechanical means are not effective, use trained and qualified personnel to apply approved herbicides to eliminate high-priority target populations.

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- A cut-stump herbicide treatment is preferred; therefore, the herbicide application should be applied directly to the cut stump immediately after cutting and not as a broadcast application.
 - Injection treatment method of herbicide would be applied during the active growing season. This method would be employed if vegetation was cut during the non-growing season because it accomplishes killing the root while minimizing potential “off-target” damage. The method consists of drilling holes into the sapwood and applying herbicide into holes.
 - Update the list of approved herbicides in the Pesticide Discharge Management Plan (PDMP). Herbicides approved under the current PDMP are non-selective and broad-spectrum herbicides. Including low-toxicity and broadleaf selective herbicides can reduce off-target damage to desired plant species.

Restoration

Restoration treatments are an integral part of control and management efforts to help guard against future re-infestations of invasive species. Section 2(a) (2) of Executive Order 13112 charges federal agencies to “provide for restoration of native species and habitat conditions in ecosystems that have been invaded.” Additionally, Section 4 (d) of Executive Order 13112 calls on NISC to develop guidance, in coordination with the Council on Environmental Quality (CEQ), “. . . including the procurement, use, and maintenance of native species.” Ideally, species used in restoration efforts will match existing or historical native vegetation and current habitat conditions. In the absence of occupation by desirable native vegetation, re-invasion by non-native invasive species is likely to occur.

To focus on restoration, LANL Resources Management SMEs will recommend when possible during collaboration and project review:

- Restoring areas that contain invasive species by using native seed mixes of treated areas immediately after treatment and removal of invasive species
- Opportunistic plantings of native trees and shrub species in targeted areas in consultation with the Biological Resources and Forest Health Programs

Table 2: Ranked Control Options for Non-Native Invasive Plants (USFS 2017a) on Los Alamos National Laboratory Property and/or in Los Alamos County with Priority Ratings Considered for Management Purposes

Common Name (Priority Rating ¹)	Control Options Ranked: 1 = Most Effective; 2 = Conditionally Effective; 3 = Not Effective							Notes
	Mowing/ Cutting	Mastication	Seed-Head Clipping	Digging	Girdling	Fire	Chemical	
Bull thistle (M)	2	2	1	2	NA	3	3	Needs to be accurately identified before treatment
Canada thistle (H)	2	2	1	2	NA	3	3	Needs to be accurately identified before treatment
Cheatgrass (L)	1	NA	2	2	NA	2	3	Focus on preventing seed production with spring (April) and summer mowing every 3 weeks
Common mullein (L)	1	1	2	1	NA	3	2	Focus on preventing seed production (June–September)
Dalmatian toadflax (NMI)	3	NA	3	2	NA	3	1	Need more location data
Musk thistle (NMI)	2	2	1	2	NA	3	2	Need more location data
Oxeye daisy (NMI)	3	NA	3	1	NA	3	2	Need more location data
Russian knapweed (NMI)	2	2	2	1	NA	3	2	Need more location data
Russian olive (L)	1*	1*	3	1	1*	3	2	*Use in combination with herbicide/ best done in winter
Saltcedar (H)	2*	2*	3	1	1*	3	2	*Use in combination with herbicide/ best done in winter
Siberian elm (L)	1*	1*	3	1	1*	3	2	*Use in combination with herbicide/ best done in winter
Skeletonleaf bursage (NMI)	2	NA	2	1	NA	3	2	Need more location data
Spotted knapweed (NMI)	2	NA	2	1	NA	3	2	Need more location data
Teasel (M)	2	2	2	1	NA	3	2	Focus on preventing seed production
Yellow toadflax (NMI)	3	NA	3	2	NA	3	1	Need more location data
Yellow star thistle (H)	1	NA	1	1	NA	2	2	Focus on preventing seed production
Tree of heaven (NMI)	1*	1*	3	2	1*	3	1	*Use in combination with herbicide
Yellow salsify (H)	2	NA	2	1*	NA	3	2	*Small rosettes, older plants more difficult

¹Priority Ratings are based on New Mexico Class List, occurrence in LAC and on-site, and feasibility of management or removal.

L = Low, M = Moderate, H = High, NMI = Need more information.

Collaboration

Invasive species can span geographic and jurisdictional boundaries. Their control and management require inter-agency communication and regionally coordinated action. Information on the distribution, abundance, rates of spread, and impacts of invasive species are critical to their control. There is opportunity to collaborate with neighbors and other agencies to maximize organizational effectiveness and collaboration on invasive species issues among federal, state, county, local and tribal governments, private organizations, and individuals. Notwithstanding any agency's limitations, research, information sharing and data management, education and outreach, and best practices are some means to collaborate and maximize existing resources for prevention, early detection and rapid response, control and management, and restoration. Where federal facilities border large areas under state, local, or non-government jurisdiction, invasive species may be impossible to manage in the absence of cooperation.

To focus on collaboration and cooperation, LANL Resources Management SMEs will

- Identify opportunities to collaborate and correspond within the Laboratory itself between divisions and with neighboring entities, including LAC, Santa Fe National Forest, Valles Caldera National Preserve, and Bandelier National Monument to stay informed about new and ongoing information and resources for invasive species.
- Attend DOE HQ Invasive Species Working Group meetings to stay informed about current and ongoing information and resources.

Future Actions

Future initiatives supported by this plan that opportunistically document and manage invasive species are as follows:

- Periodically update the ArcGIS Survey 123 Invasive Species application (app) on LANL iPhones and iPads to identify and document invasive species onsite and in the county.
- Internally develop standard response comments in the project review process (IRT/PRID/EXID) to support any projects that have the potential to integrate the removal of invasive species and opportunistically identify and remove invasive species.
- Document invasive species phenology at LANL to develop recommended cutting time periods for control.
- Incorporate invasive species documentation into the trail assessment protocol.
- Look into installing a weed wash station similar to those employed on wildland fire incidents to facilitate integration of vehicle washing protocols.
- Incorporate invasive animals into the LANL invasive species management plan or have a stand-alone invasive species management plan for animals, including insects.
- Develop an outreach and education program for the public and LANL employees to display in all General Access Areas (GAAs) and badge-holder-only trails where foot traffic and bicycle traffic are increased. Displaying information at trailhead parking lots, on or near existing trails kiosks, and near open areas where outdoor foot traffic is high.
- Develop an integrated vegetation management strategy for roadways and utility corridor right of ways.

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Appendix A: Definitions

Native species—plants and animals occupying their natural range without direct or indirect introduction and/or care by humans. They are adapted to the environmental conditions and processes of an ecosystem such as climate, soil characteristics, and fire regime. As a result, they are well-suited for survival within that system. In addition, native plant species provide habitat and food sources for wildlife. Because they do not alter existing ecosystem balance, they are the most desirable species.

Non-native or alien species—species that occur outside of an ecosystem/geographic region but are capable of living and propagating within the physical parameters of that ecosystem/region. A plant introduced with human help (intentionally or accidentally) to a new place or new type of habitat where it did not previously occur. Not all non-native plants are invasive. In fact, most non-native plants cannot reproduce or spread readily after introduction without continued human help (for example, many ornamental plants). Many familiar, common plants found within Los Alamos County are alien species. Some are considered weeds (dandelion, sweet clover, Russian thistle) while others are incorporated into garden beds for their floral displays. Not all of the non-native species found in Los Alamos County are considered invasive and harmful to the local ecosystem.

Novel ecosystem—is a system of abiotic, biotic, and social components (and their interactions) that, by virtue of human influence, differs from those that prevailed historically, tending to self-organize and manifest novel qualities without intensive human management

Invasive species—non-native species whose introduction is likely to cause economic or environmental harm. An invasive species is both non-native and able to establish on many sites, grow quickly, and spread to the point of disrupting ecosystems. They are non-native plants or animals that have the ability to establish self-sustaining, expanding, free-living populations, and may cause economic and environmental harm to an ecosystem. They frequently invade an area, exclude other plants or animals, and can expand their populations to cover acres hundreds or thousands of acres.

Noxious species—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.

Ecosystem services— the benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services, such as nutrient cycling, that maintain the conditions for life on Earth.

Eradicate—to eliminate all individuals of a species. For plant species, this includes live roots, rhizomes, and seeds. Eradicating a species in a management area is very difficult unless it is present in small numbers.

Control—to reduce the abundance of a species. For plant species, this is typically measured or estimated in terms of canopy cover or plant density.

Contain—to confine an infestation so it does not expand, but containment does not usually mean reducing or eliminating the current infestation.



Appendix B: Species Specific Identification

Bull thistle (M)

Bull thistle is a biennial growing 2 to 5 feet tall. It has a short, fleshy taproot. Stems are very pubescent and have dark purple veins. The first year's leaves form a rosette. Second-year leaves are double-toothed ending in a spine; are wavy; have prickles on the surface; and are pubescent on the underside. Stem leaves are similar to rosette leaves, but they are smaller and have longer spines. Flower heads, made up of dark purple flowers, are 1.5 to 2.0 inches wide. Flower heads are shaped like a shaving brush. The stout spines below the flower head are characteristic. Stems of bull thistle have spines but not wings formed by extended leaves. Lobes of the leaves of bull thistle are nearly perpendicular to the central leaf vein. (USFS 2017b)



Canada thistle (H)

Canada thistle is a creeping perennial forming dense populations as a result of extensive horizontal, branching roots. Stems are up to 5 feet tall, branched at the top, ridged, and hollow. Leaves are alternate and lack petioles; margins are either wavy or lobed, both with a spine. Flower heads are usually 0.5 inch in diameter, are surrounded by spineless bracts, and have purple to lavender flowers. White flowers are not uncommon. (USFS 2017c)



Cheatgrass (L)

Cheatgrass is an early-growing annual that reproduces by seed. It blooms in the early spring, spreads rapidly, and outcompetes native grasses for late winter and early spring moisture. When it dries in early summer, it is brown and highly flammable. Grows 6 to 24 inches tall, with purplish flowerheads, feathery and drooping from the stalk. (USFS 2017d)



Common mullein (L)

Biennials growing over 6 ft. Stems stout, covered with densely branched, woolly hairs. Stem leaves up to 1.5 ft long, elliptical to elongate, wider near the tip than the basal margins coarsely toothed. Leaves are soft to the touch, yellow-green, surfaces covered with branched, woolly hairs. Leaves of the first year very large, in a rosette at the base of the plant. Yellow flowers in a dense, spike-like inflorescence. Found commonly in disturbed areas in the pinyon-juniper woodland and ponderosa pine forest.



Dalmatian toadflax (NMI)

Dalmatian toadflax, a creeping perennial, grows up to 3 feet tall. It reproduces by seed and aggressive underground rootstocks, which makes it difficult to control. Leaves are alternate, waxy, broad-based, and clasp the stem. The two-lipped flowers, borne in axils of upper leaves, are 0.75 to 1.5 inches long and have a characteristic spur. Flower appears in late May and is yellow with an orange, bearded throat-similar in shape to a snapdragon. (USFS 2017e)



Diffuse knapweed (NMI)

Diffuse knapweed is a many-branched annual or short-lived simple perennial ranging in height from 1 to 2 feet at maturity. Basal leaves are finely divided; stem leaves are entire and smaller than basal leaves. Flower color ranges from white to rose to purple. Characteristic floral bracts are yellowish green with a light brown, comb-like margin. These bracts are tipped with a distinct terminal spine. (USFS 2017f)



Field bindweed (NMI)

Field bindweed is a creeping perennial often forming dense mats. It reproduces by seed and a root system that penetrates to a depth of 10 feet with extensive lateral branching. Stems are prostrate or climbing. Leaves are alternate and arrowhead-shaped, with basal lobes that are blunt. Flowers are white to pinkish, borne in leaf axils, and trumpet-shaped with two small bracts below the flower. Seeds are hard, triangular, and borne in a four-seeded capsule.



Flixweed, tansy mustard (NMI)

Tansy mustard is a cool season annual that grows to 2.5 feet high, usually single stemmed, leafy, covered with fine, gray hairs. Leaves alternate along wavy stems, each divided into small segments. Flowers range from yellow to whitish, in long clusters at stem ends, four petals but oddly shaped.



Giant reed (NMI)

Giant reed is an invasive, bamboo-like grass with stems that grow over 20 feet tall and is found in riparian areas. Robust, hollow, stems up to 2 inches in diameter with knotty nodes. Pale green to blue-green, alternate leaves 1 to 2 inches wide and 1 to 2 feet long that grow at 180 angles from one another. Lower part of leaf is yellow has fine hairs and clasps the stem in a distinctive “S” wave. (USFS 2017g)



Jointed goatgrass (NMI)

Jointed goatgrass is a winter annual, but about 5 percent of a populations may be spring annuals. Leaves are grass like, up to a 1/2-inch wide, and have evenly spaced fine hairs along the leaf edges and down the sheath opening. Stems can grow up to 4 feet tall and are tipped with slender, cylindrical spikes that appear to be a series of joints stacked on top of each other. Reddish to straw-colored spikes emerge in May to June, and uppermost joints are tipped by straight awns. Up to 3 “seeds” are enclosed in each joint.



Leafy spurge (NMI)

Leafy spurge leaves have a characteristic bluish-green color but turn yellow or reddish-orange in the fall. Stems originating from crown buds and roots begin growth in April, making leafy spurge one of the first plants to emerge in the spring.



Musk Thistle (NMI)

Musk thistle is a biennial plant that can act as an annual. It has a thick taproot. The plant is capable of growing up to 8 ft tall. Rosette leaves are dark green with a light green midrib, spiny margin, and deep lobes. Stem leaves extend beyond the stem, moving down and give the appearance of a winged stem. Flower heads-made up of deep rose, violet, purple, or white flowers are 1.5 to 3.0 inches in diameter and borne on stem tips, which often nod. These flower heads are subtended by broad-based bracts that have a short spine at the tip.



Myrtle spurge (NMI)

Myrtle spurge has flowers that are yellow-green in color, cupped inside a yellow bract, growing in clusters. Blooms from mid Spring to early Summer. Each flower produces a seed pod that is bluish-green in color and contains three 0.32-cm-long seeds that are dusty brown in color and resemble a peach pit.



Oxeye daisy (NMI)

Oxeye daisy resembles a typical daisy. The 1.5- to 2-inch flower heads are borne individually on slender stems from June through August. Their yellow centers are surrounded by 20 to 30 white radiating petals, which are slightly notched at their tip. (USWS 2017h)



Red Brome (NMI)

Red brome is an early emerging annual grass that is short lived and actively grows for only about 4 to 6 weeks. It is a cool-season, tufted, annual bunchgrass; 8 to 20 inches tall. Mature foliage and seed heads have a distinctly reddish color that gives its name. Reproduction is solely by seed with a relatively short-lived seed bank (less than 2 percent are viable into the following year) with germination highest in the fall. (USFS 2017i)



Russian knapweed (NMI)

Creeping perennial forming dense colonies as a result of buds from its black, spreading roots. It can reach a height of 4 feet. Lower leaves range from entire to lobed. Upper leaves are smaller, entire, and attached directly to the stem. Cone-shaped, pink-to-lavender flower heads are borne at the end of leafy branches and bloom in July. Floral bracts are smooth and papery with a rounded or pointed margin. (USFS 2017j)



Russian olive (L)

Tree to 25 ft tall. Leaves narrow, with silver dots on the underside. Flowers pale yellow, bell-shaped, strong-smelling. Fruit short-stemmed, spherical, silvery. Found along watercourses, windbreaks, and at the boundaries of housing areas. Old wood stems thorny. (USFS 2017k)



Russian thistle (L)

Russian thistle is a bushy summer annual with numerous slender ascending stems that become quite woody at maturity. Stems vary from 8 to 36 inches in length and usually have reddish to purplish stripes. Seedlings have very finely dissected leaves that almost look like pine needles.



Saltcedar (H)

Small tree or shrub to 20 feet, with scale-like leaves that fall in the winter. Branches upright, spreading. Leaves blue-green. Clusters of pink flowers at ends of branches in spring and summer. Considered a woody phreatophyte, it competes with and replaces native vegetation along water-holding areas and rivers. (USFS 2017l)



Siberian elm (L)

Tree to 25 ft tall. Leaves are small, oval, and have prominent parallel veins. The tree is often as wide as it is tall. Leaves are dropped in the fall. A prolific seeder with a high seed germination rate. Can form thickets with thousands of trees.(USFS 2017m)



Skeletonleaf bursage (NMI)

Skeletonleaf bursage is a perennial averaging about 6 inches in height. The leaves are much divided, green above and the lower surface covered with white hairs. Flowers are inconspicuous and yellow; flowers come in terminal clusters on a single spike. The fruit is a light brown bur with conical spines. The extensive horizontal root system makes it difficult to eradicate.



Smooth brome (NMI)

Hairless, vertical stem. Open panicle, vertical with ascending branches. Blooms in June and July. Basal and stem leaves are numerous, flat, somewhat firm, glabrous, 3 to 5 inches long, and approximately 1/8 to 1/2 inch wide. Leaves may have a distinctive W-shaped water mark on the leaf blade.



Spotted knapweed (NMI)

The rosettes of spotted knapweed are grayish-green in color with leaves that are up to 6 inches in length. Leaves are oblong and wider at the tip, deeply lobed and in early stages, covered with a layer of fine hairs. Stem leaves are alternate and may be slightly lobed or even without lobes.



Teasel (M)

Basal leaves on the rosette are widest near tip and taper to the base, “wrinkled,” with rounded teeth. Flowering plants reach heights of 7 ft, stems are angled and covered with downward turned prickles. Leaves on bolted plants are opposite, lanceolate, up to 2 ft long with spines on underside of midrib. Flower heads are cylindrical up to 4 in. long and 2 in. wide. Tubular corollas are white to light purple in color. The heads are surrounded by long spine-like bracts. (USFS 2017n)



Tree of heaven (NMI)

Leaves are pinnately compound with a central stem with 10 to 40 lance-shaped leaflets growing in pairs. Leaflets are smooth-edged with a small notch on each side close to the base. (USFS 2017o)



Whitetop/hoary cress (NMI)

Whitetop is a deep-rooted, creeping perennial mustard plant that grows up to 2 feet tall. In general, plants have a gray-green, soft, hairy appearance, hence the name hoary. Leaves are blue-green in color with the lower leaves being stalked and the upper leaves having two lobes clasping the stem.



Yellow salsify (H)

Yellow salsify produces ascending, leafy, and sometimes branched stems that exude a milky latex sap when broken. Alternate leaves are narrow, measure 0.4 to 12 inches long and are tapered from base to tip. Young leaves can be hairy, but mature leaves are waxy.



Yellow star thistle (H)

Yellow starthistle is a gray-green to blue-green plant that ranges from 6 inches to 6-1/2 feet tall. Stems are stiff, wiry, and single in small plants and openly branch near the base or above in larger plants. (USFS 2017p)



Yellow toadflax (NMI)

Yellow toadflax, a creeping perennial, grows 1 to 2 feet tall. It reproduces by seed and underground root systems. Stems are smooth with minimal branching. Leaves are narrow, 2.5 or more inches long, nearly opposite, strap-like, and pointed at both ends. Flowers are 1 inch long with a bearded, orange throat, snapdragon-like flowers. Seed are produced in brown, globe-shaped capsules. (USFS 2017e)

