INTEGRATED PEST MANAGEMENT PLAN FOR THE

SEVILLETA NATIONAL WILDLIFE REFUGE

by

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ACRONYMS

Term	Description
ACE	American Conservation Experience
AGOL	ArcGIS Online
CRI	Conservation Reserve Initiative
EDRR	Early Detection / Rapid Response
FWS / US FWS	United States Fish and Wildlife Service
HMP	Habitat Management Plan
IMP	Inventory and Monitoring Plan
IPIEDT	Invasive Plant Inventory and Early Detection Tool
IPM	Integrated Pest Management
IPMP	Integrated Pest Management Plan
IPMPT	Invasive Plant Management and Prioritization Tool
NM ISST	New Mexico Invasive Species Strike Team
NMMJM	New Mexico Meadow Jumping Mouse
NWR	National Wildlife Refuge
NWRS	National Wildlife Refuge System
PUPS	Pesticide Use Proposal System
RGSM	Rio Grande Silvery Minnow
SMART	Specific, Measurable, Attainable, Results-oriented, Time-bound
SWFL	Southwestern Willow Flycatcher
T & E	Threatened and Endangered
USDA	United States Department of Agriculture

ACRONYMS CONTINUED

UTV	Utility Terrain Vehicle
YBCU	Yellow-billed Cuckoo

ACKNOWLEDGMENTS

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ABSTRACT

Each National Wildlife Refuge (NWR) within the U.S. Fish and Wildlife Service (FWS) National Wildlife Refuge System provides landscapes that contribute to conservation of wildlife and the habitats they depend on at local, regional, and national levels. I am the New Mexico Invasive Species Strike Team Lead and am responsible for planning and management of invasive species on eight National Wildlife Refuges across the state. Part of my responsibilities included writing Integrated Pest Management Plans. My Professional Paper, the Integrated Pest Management Plan (IPMP) for Sevilleta National Wildlife Refuges presents the goals, objectives, strategies, and guidance for managing non-native invasive species, as well addresses the long-term vision, continuity, and consistency for the target species on Sevilleta NWR. My IPMP identifies the highest priority non-native invasive plant species found on the Refuge as well as prioritizes areas for treatment. I selected areas based on the conservation assets of Sevilleta NWR and then identified the invasive species that occur in these areas. I combined two tools produced by the FWS for prioritizing target areas and species. The Invasive Plant Inventory and Early Detection Tool (IPIEDT) focuses on Early Detection Rapid Response and the Invasive Plant Management and Prioritization Tool (IPMPT) prioritizes based on response to management actions. By combining the tools, I added the management aspect from the IPMPT to the inventory and rapid response portion of the IPIEDT to encourage more active management of early detection rapid response species. Without prioritization, management objectives can be subjected to personal bias and lack long term success. I established management objectives and yearly actions to meet these objectives. Regular monitoring is required to ensure management is effective and moving towards achieving the objectives. A specific monitoring protocol was not developed as a part of my plan. Ideally, this would have been included, but Refuge staff are unlikely to enact any formal monitoring due to low staffing. My plan will also guide priority work for the New Mexico Invasive Species Strike Team and its funds and is intended to be adaptable to changing circumstances and remain in effect until the objectives are met.

INTRODUCTION

Sevilleta National Wildlife Refuge (NWR; the Refuge) encompasses 92,945 hectares in central New Mexico protecting a diversity of unique resources in a landscape where the Colorado Plateau Shrub Steppe, the Chihuahuan Desert, the Great Plains Short Grassland Prairie, and the Rocky Mountain Woodland biomes all converge. In addition, the Rio Grande River flows through the center of the Refuge, providing a riparian oasis that plays a vital role for wildlife in these diverse ecological systems. These ecosystems are affected by numerous invasive plant species; currently managed species include *Ailanthus altissima* (Tree of Heaven), *Elaeagnus angustifolia* (Russian olive), *Lepidium latifolium* (perennial pepperweed), *Rhaponticum repens* (Russian knapweed), *Tamarix ramosissima* (salt cedar), and *Ulmus pumila* (Siberian Elm). Detailed species accounts can be found in Section 3.1 Priority Species Ecology. Sustaining and protecting these resources requires planning, active on-the-ground management and partnerships with the surrounding communities and land management agencies of the Middle Rio Grande.

Each NWR within the U.S. FWS National Wildlife Refuge System (NWRS) provides landscapes that contribute to conservation of wildlife and the habitats they depend on at local, regional, and national levels. The Integrated Pest Management Plan (IPMP) for a given refuge is a guide to how (strategic management actions) and why (SMART objectives) the U.S. Fish and Wildlife Service manages the priority invasive species occurring on a particular refuge. My IPMP presents the goals, objectives, strategies, and guidance for managing invasive species, as well as the long-term vision, continuity, and consistency for the target species on Sevilleta NWR. This Plan is intended to remain in effect until the objectives are met.

1.1 Plan Purpose and Need

Sevilleta NWR was established by the U.S. Fish and Wildlife Service in 1973 as a result of a land donation by the Nature Conservancy. The purpose of the Refuge is "to preserve and enhance the integrity and character of its ecosystems as closely as possible to their natural state." (U.S. Fish and Wildlife Service 2015). The Rio Grande River flows through the Refuge providing a riparian oasis that plays a vital role for wildlife. Due to the rareness of this ecosystem and the federally listed threatened or endangered species (*Empidonax traillii extimus* [SWFL; Southwestern willow flycatcher], *Coccyzus americanus* [YBCU; western yellow-billed cuckoo], *Hybognathus amarus* [RGSM; Rio Grande silvery minnow], *Zapus hudsonius luteus* [NMMJM; New Mexico meadow jumping mouse]) that depend on riparian areas, monitoring of this plant community is the top priority identified in Sevilleta's Inventory and Monitoring Plan (ServCat - Plan - (Code: 114242) (fws.gov)).

Of particular concern in riparian areas is maintaining a canopy comprised primarily, although not exclusively, of native tree and shrub species. Invasive plants threaten the biodiversity of the Refuge and limit space available for natural vegetation and for the wildlife that depend on native species. Parker et al. (1999) found that plant invasions initially increase arthropod species richness due to the increase in plant diversity followed by a sharp decline as a reaction to the decrease in plant diversity as the introduced species becomes invasive. Decreasing the abundance of invasive species in the riparian areas of the Refuge will substantially benefit the Refuge’s species of concern.

For the upland plant communities that exist on most of the Refuge, the goal is to “perpetuate the biological integrity and diversity of the uplands to sustain native wildlife and plant communities, including species of concern” (USFWS, 2015). In pursuit of this goal, the Refuge staff selected monitoring of invasives as the third priority in the Inventory and Monitoring Plan. Early detection of new invasives along likely routes of entry will maximize the chances of eradication. Part of this plan focuses on Early Detection Rapid Response (EDRR, Reaser 2020) to prevent new species from becoming established “maintenance” populations. Monitoring of known invasive populations will help determine when additional efforts are needed and when treatments are successful. This plan will serve to ensure invasive species management addresses the conservation priorities specific to Sevilleta NWR. This plan will also guide priority work for the New Mexico Invasive Species Strike Team and its funds.

1.2 Spatial Scope and Setting

Sevilleta NWR is situated in central New Mexico (Figure 1) with elevations on the Refuge ranging from 1350 m at the Rio Grande to 2729 m in the Sierra Ladrones. Climate data for the Refuge have been monitored since 1989. Data from seven weather stations have been analyzed for a 23-yr period from 1989 - 2011. The average daily temperature was 14° C, and the average annual precipitation was 250 mm. The monthly average daytime temperature (daily maximum + daily minimum divided by 2) ranges for the Refuge were 2° C in December to 25° C in July, while average monthly precipitation ranged from 10 mm in January to 45 mm in both July and August (U.S. Fish and Wildlife Service 2015).

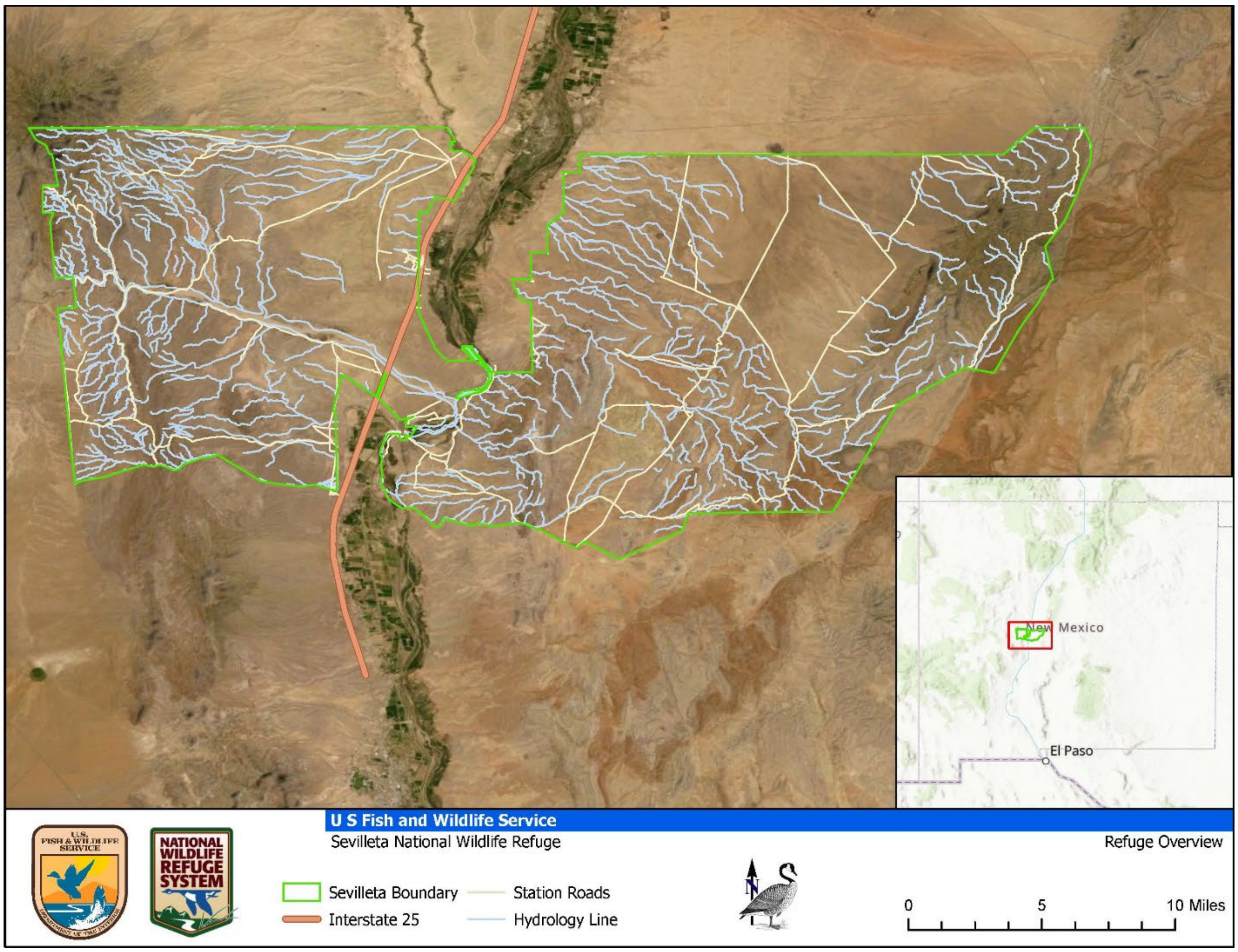

Figure 1: Overview map of Sevilleta National Wildlife Refuge depicting roads and hydrology features.

Water is a precious resource at Sevilleta NWR. There are an estimated 20 springs or seeps on the Refuge, approximately 19 km of the Rio Grande, and two medium-sized ephemeral desert rivers (Rio Salado and Rio Puerco) that run through Sevilleta NWR and subsequently into the Rio Grande. In addition to these two seasonally dry rivers, there are several smaller drainages that typically run during winter rain events or the monsoon season,

when summer thunderstorms can produce flows in the thousands of cubic feet per second for very short periods. These drainages and rivers plus the wetland units along the Rio Grande make up the primary areas of interest in the invasive species management at Sevilleta NWR.

1.3 Conservation Assets

Sevilleta NWR is approximately 80 km south of Albuquerque in Socorro County, encompassing and protecting a unique set of resources and ecological diversity. The Rio Grande provides a riparian oasis that plays a vital role for wildlife in these diverse ecological systems. The biological priorities that govern the direction of management at the Refuge were established in 2015 as a result of regional leadership mandating all National Wildlife Refuges in Legacy Region 2 (Texas, Oklahoma, New Mexico, Arizona) identify their priorities for management. These priorities were drafted to answer the questions "Why are we doing this work or gathering this information? Why is the work important and what is the objective? How will this work or information help our management? Do we have clear goals and objectives, and is the work we are doing answering our questions?" Sevilleta NWR's biological priorities are as follows (USFWS 2016):

1) Perpetuate the biological integrity and diversity of the Western Great Plains short-grass prairie biome by reintroducing *Cynomys gunnisoni* (GPD, Gunnison's prairie dogs), a keystone species, on the Refuge where GPDs were historically abundant.
2) Perpetuate the biological integrity and diversity of the Rio Grande riparian ecosystem by conserving and restoring suitable habitat for the Southwestern willow flycatcher, yellow-billed cuckoo, Rio Grande silvery minnow, and other riparian species within the 100-year floodplain along the Rio Grande.
3) Maintain and manage the native plant diversity, physiographic characteristics, and natural functions of the Refuge's ecosystems by controlling invasive species.
4) Maintain and manage the native plant diversity, physiographic characteristics, and natural functions of the Refuge's ecosystems by allowing fire on the landscape.
5) Preserve and enhance the integrity and the natural character of the ecosystems of the Refuge by monitoring select species and their habitats and evaluating data to gain understanding for future management.

The second biological priority to "perpetuate the biological integrity and diversity of the Rio Grande ecosystem by conserving and restoring suitable habitat for the federally endangered Southwestern willow flycatcher and Rio Grande silvery minnow, federally threatened yellow-billed cuckoo, and other riparian species within the 100 year floodplain along the Rio Grande (USFWS 2016) has been the guiding principle for invasive species management in the wetland units along the Rio Grande since 2016. Additionally, the top objective for both the Inventory and Monitoring Plan and Habitat Management Plan address SWFL and YBCU habitat enhancement and monitoring. A riparian restoration project (Cooperative Recovery Initiative) at Sevilleta began in 2016 to enhance habitat for the SWFL, YBCU, and RGSM as well as other native species dependent on riparian habitat. Sevilleta NWR protects unique resources that have a high level of irreplaceability (Ecoregional Conservation Analysis AZ/NM Mountains, 1999). The majority of the surrounding lands have been farmed or ranched since Spanish settlement. As urbanization continues and as the landscapes protected on the Refuge become increasingly scarce elsewhere, protection of these lands within the Refuge becomes exceedingly important.

1.4 Conservation Goals

Preserving the conservation assets of the Refuge guide management decisions, but equally as important as the Refuge conservation goals is early detection rapid response. If a new species were to arrive on the Refuge outside of target areas, it has the potential to impact resources once established. By detecting new species early on and responding quickly, management effort and negative repercussions of the species can be kept to a minimum.

Objectives laid out in the HMP for the SWFL and YBCU are to preserve and restore suitable habitat within the 100-yr floodplain along 11 km of the Middle Rio Grande corridor, and for the RGSM to preserve and restore habitat on 5 km of the Rio Grande. Specifics of these goals include:

- By 2018, establish at least 12 ha of suitable SWFL nesting habitat, with dense native riparian foliage from the ground level to at least 4 m and canopy closure of at least 50% in Unit A Prime.

- By 2022, establish 8 to 14 ha of SWFL nesting habitat in Unit A with dense, native riparian foliage from the ground level to at least 4 m and canopy closure of at least 50%.
- In Units A and A Prime, designate and enhance at least 8 ha of contiguous riparian forest to be managed for YBCU nesting habitat, with native willow and cottonwood dominated forests with canopy closure of at least 70% by 2022.
- Annually, maintain 20 ha of seasonally flooded wetlands within Units A and A Prime with at least 8 ha as open wetland habitat and less than 15% overall cover of invasive plants. This will enhance available habitat for wintering waterfowl and wading birds from at least November to January, while providing habitat for other riparian species during the spring and summer, including shorebirds.

Additional objectives specific to upland areas laid out in the HMP are as follows:

- Remove the invasive *Tamarix ramosissima* in arroyos and drainages on the Refuge.
- Maintain and manage the native plant diversity, physiographic characteristics, and natural functions of approximately 10,120 ha (McKenzie Flats) of exemplary short-grass prairie by minimizing human impact, controlling invasive species, and allowing fire on the landscape.
- Maintain and manage the native plant diversity, physiographic characteristics, and natural functions of Chihuahuan Semi-Desert Lowland Grassland (Lowland Grassland) along the Cibola arroyo by minimizing human impact, controlling invasive species and allowing fire on the landscape.

The Refuge HMP goes into great detail establishing the steps to achieve these goals along with appropriate timelines. The HMP establishes several other objectives that could have been included in my IPMP but were left out because their deliverable date was 2025 or later. This plan is intended to remain in effect until the objectives are met.

The first objective for this Integrated Pest Management Plan at Sevilleta NWR is to eradicate known infestations of *Rhaponticum repens* from the Refuge. This is not directly related to the above goals but is EDRR. As of 2021, there are two known locations with multiple small, isolated populations. One of the known locations is along the Rio Puerco from I-25 to just upstream of the new bridge on Old Highway 60 (106.8539115° W, 34.4098281° N). The second known location is on the East Side of the Refuge along the Rio Grande fence line from the San Acacia diversion weir south (106.8932884° W, 34.2251169° N). *Rhaponticum repens* forms dense monocultures with extremely long-lived, deep, extensive root systems thus making it difficult to control (Zouhar 2001). Although *R. repens* does not currently have direct influence on conservation priorities, it has a high potential to spread and negatively impact areas designated as SWFL and YBCU habitat.

The second purpose of my IPMP targets several objectives of the HMP; to contain invasive trees (*Tamarix ramosissima*, *Elaeagnus angustifolia*, *Ulmus pumila*) to less than 5% of their initial survey numbers. Maintaining invasive trees below this metric serves to conserve native plant diversity, physiographic characteristics, and natural functions of these landforms. The invasive trees disrupt natural processes by altering flood and fire regimes, stabilizing streambanks increasing silt deposition and channel incision, and by displacing native vegetation (Zouhar 2003, 2005).

Finally, the third objective will be containment of *Lepidium latifolium*. This persistent, difficult-to-control plant alters species diversity, structure, function, and succession in wetland and riparian areas decreasing food and habitat for wildlife species (Zouhar 2004). Litt et al. (2014) conducted a meta-analysis on the effects of invasive plants on arthropods and found that most insects were negatively impacted by invasive plants. Since SWFL and YBCU are both primarily insectivores, management of *L. latifolium* is a critical component to ensure suitable habitat is preserved.

1.5 Invasive Plant Management History

Invasive plants have been extensively managed on Sevilleta NWR, particularly in the riparian and wetland areas. Historically, *E. angustifolia* and *L. latifolium* have been treated in the wetland units, although efforts have been inconsistent over time in response to variations in funding and personnel. Future restoration efforts may be necessary to meet habitat requirements for the species of concern and limit the extent of non-native trees and shrubs. Invasive species management will be planned and implemented in coordination with any new restoration projects.

The CRI project began in 2016 at Sevilleta NWR to improve riparian habitat for SWFL, YBCU, and RGSM in addition to enhancing wetland habitat. The project began with extensive clearing of dense *T. ramosissima* patches to meet SMART objectives laid out in the Refuge's HMP. Components of the CRI project have included invasive species management and revegetation of native plants including *Distichlis spicata*, *Salix exigua*, *Salix gooddingii*, and *Populus deltoides wislizenii*.

For the upland areas, historical data available to the New Mexico Invasive Species Strike Team (NM ISST) goes back to 2009 and primarily relates to treatments of *T. ramosissima*. Most *T. ramosissima* removal has been confined to arroyos on both the East and West sides of the Refuge. A few other projects have occurred but have not been maintained and have reverted to a *T. ramosissima* dominated community. Increasing consistency of treatments will further enhance the integrity of native plant communities. Figure 2 provides an overview of historical *T. ramosissima* treatments on the Refuge.

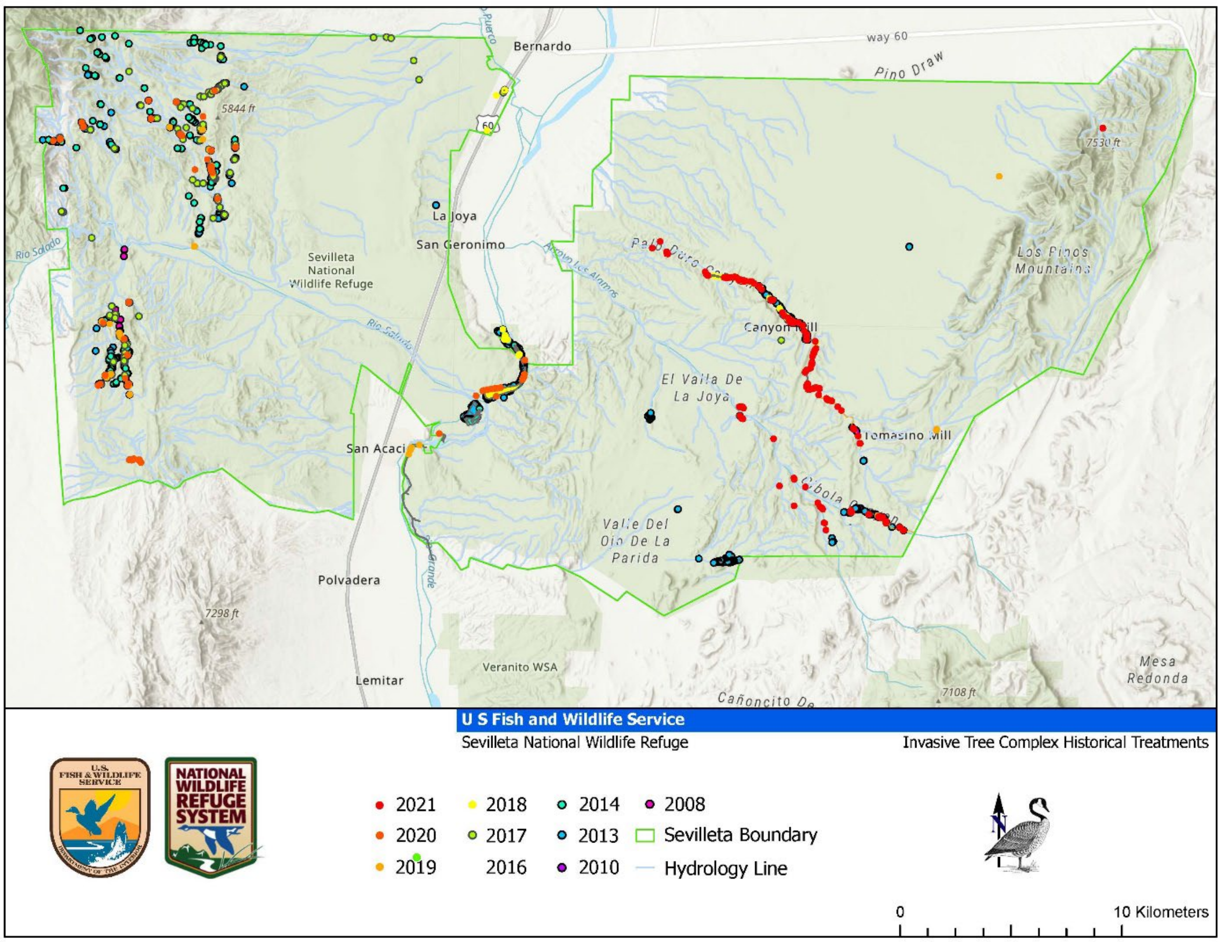

Figure 2: Overview of historical chemical and mechanical invasive tree species treatments at Sevilleta National Wildlife Refuge.

Lepidium latifolium has been periodically managed in the wetland units (Figure 3). This species has tremendous potential to negatively impact the integrity of these wetland units. The 2018 and 2019 polygons represent a 1-10% density of *L. latifolium*, whereas 2013 data show specific patches that were treated. Future data management will be more consistent and map specific patches that received treatment, not the entire survey area.

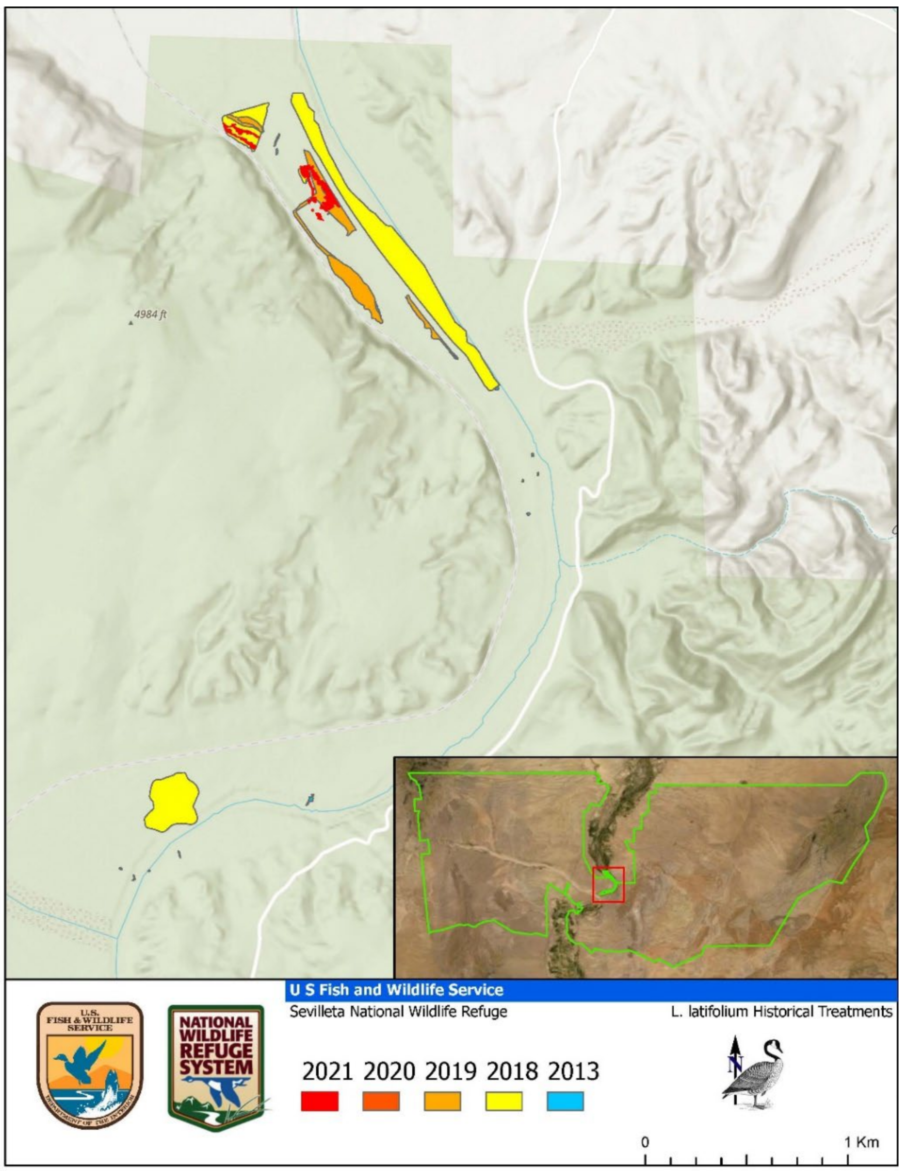

Figure 3: Historical treatments of *Lepidium latifolium* at Sevilleta National Wildlife Refuge. Treatments began in 2013, but did not occur again until 2018, and now occur every year.

Two areas with multiple populations of *R. repens* were identified recently; one in 2017 (1.72 ha) another in 2019 (0.15 ha) (Figure 4). Management began as soon as appropriate to prevent this aggressive non-native plant from spreading further. Allelopathy and a high reproductive potential facilitate its growth and spread, consequently reducing native biodiversity (Zouhar 2001). Allowing *R. repens* to proliferate threatens the Refuge's ability to effectively manage for species of concern.

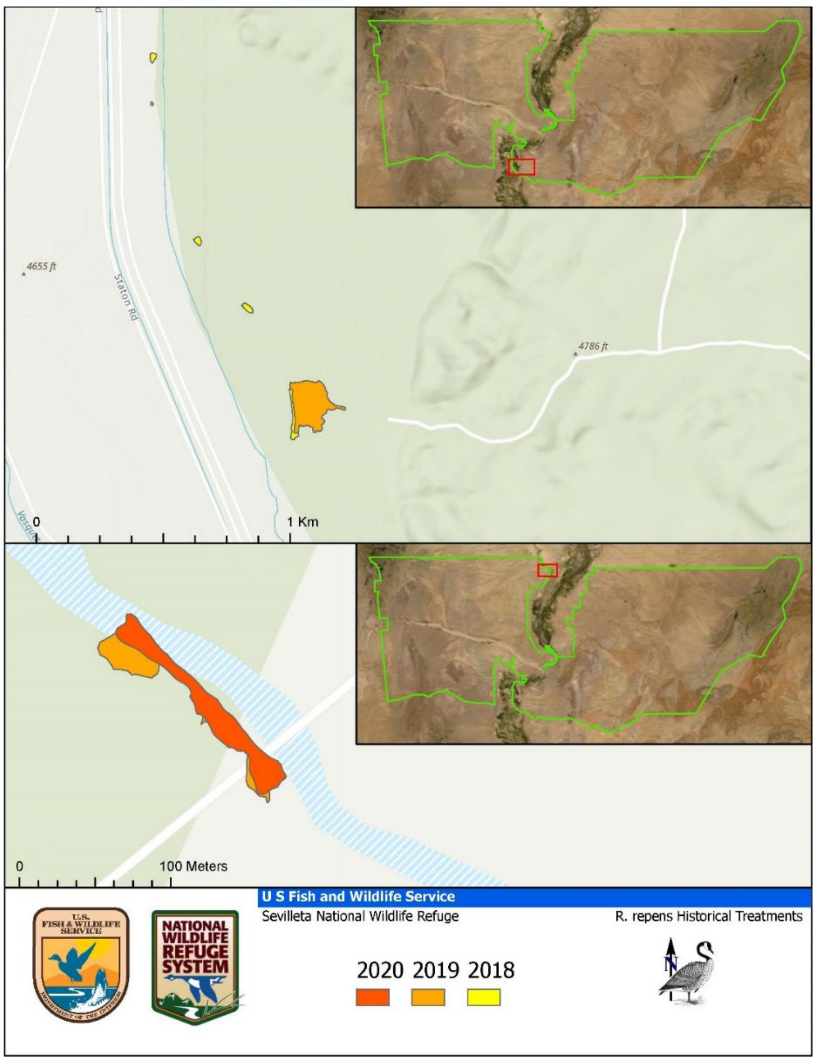

Figure 4: Historical treatments of *Rhaponticum repens* at Sevilleta National Wildlife Refuge. The southern population was first detected in 2018 and the northern population in 2019. Early Detection Rapid Response began the year of detection and has continued every year since.

1.6 Relevant Invasive Species Laws and Policies

Invasive species are the most commonly mentioned impendence in the threats and conflicts database of the National Wildlife Refuge System (NWRS). Recognizing this, the NWRS created a National Strategy for the Management of Invasive Species in 2003. This strategy promotes innovation in addressing invasive species issues throughout the system and publishes an annual report to promote information sharing. In 2013, it was reported that more than 970,000 ha of the NWRS were impacted by invasive plant species. Policy and legislation regarding invasive species, like the Lacey Act (1900) and Plant Protection Act (2000), tend to focus on preventing or limiting spread or movement of invasive species. The New Mexico Noxious Weed Management Act of 1998 called for the creation of a noxious weed list for the state. Plants are listed in one of four categories; Class A Species are not present in NM or have limited distribution throughout the state. Prevention and eradication are the primary management strategies. Class B Species have limited, localized distribution in NM and management should focus on containment. Class C Species are widespread across the state and management is based on feasibility of control. Watch List Species are not present in NM, but present potential to become established. Of the species targeted in this Plan, *E. angustifolia*, *R. repens, T. ramosissima,* and *U. pumila* are Class C Species, and *L. latifolium* is a Class B Species (NMDA 2020).

The Comprehensive Conservation Plan (CCP, 2000), Habitat Management Plan (HMP, 2015), Biological Priorities document, and Inventory and Monitoring Plan (IMP, 2019) for Sevilleta NWR have several objectives linked to the management of invasive species. The IMP lists invasive species monitoring as the number three priority for the Refuge, and the HMP addresses restoration of warm southwest riparian forest and woodland habitats to benefit SWFL, YBCU, and other avian species that use these areas. *Tamarix ramosissima* is the only invasive species specifically addressed in these documents, however *E. angustifolia*, *L. latifolium*, *R. repens*, and *U. pumila* have significant potential to disrupt native vegetation communities preventing the Refuge from meeting its goals for the SWFL and YBCU.

As these habitat management actions may affect listed species under the Endangered Species Act, additional legislation and policy apply. To meet the requirements of the National Environmental Policy Act (1970), actions proposed in this Plan were reviewed under an Environmental Assessment as part of the Refuge’s CCP. In addition, a Categorical Exclusion and Section 7 consultation was completed to address potential impacts to threatened and endangered species.

METHODS

This chapter identifies who was involved in developing this IPMP; information resources and processes used to inform its design; the people (public, leadership, others) or organizations who were informed of its development or engaged in the planning process; and how decisions were made. This Plan’s contents were developed using the best available information and processes. This chapter describes processes that were used to make decisions such as which areas to focus on and what strategies and activities to employ.

2.1 Project Team

The Project Team was comprised of NWRS members who worked on developing the Plan (Edward Sprigg, Sarah Lehnen, Heather Whitlaw, Jon Erz, Nancy Spencer-Morris), members who were decision makers (Edward Sprigg, Kathy Granillo, Renee Robichaud, Sarah Lehnen, Heather Whitlaw), and members who will be implementing the Plan (NM ISST, Sevilleta NWR staff and volunteers).

2.2 Internal and External Communication, Outreach and Engagement

Internal communication occurred throughout the planning process, which helped build consensus, limited redundant work, and ensured that the team was connected and supportive of the final Plan. Prior communication between external partners (Save Our Bosque Task Force, American Conservation Experience) enabled building the ideas and vision for this IPMP. Formal communication with internal partners will occur upon IPMP completion. To assist with understanding the Refuge vision, implementation schedule, and biological justification for invasive species removal, a meeting will be held with the NM ISST Lead, Refuge manager, and Refuge biologist before the NM ISST request for proposals in February 2022. Further communication may be necessary if current staff leave, and new staff are hired.

2.3 Prioritization of Management Areas and Species

One key aspect of invasive plant management planning is prioritization: which species to work on, where, when, and how (Stone and Andreu 2017). Managing for all non-native species everywhere within the defined action area is not practical. In this section, I address the methods used to prioritize species and areas. The Invasive Plant Inventory and Early Detection Prioritization Tool (IPIEDT) combined with a modified version of the Invasive Plant Management Prioritization Tool (version 1.0) (IPMPT) was used to rank the known invasive species on the Refuge. I used a combined version because each tool is designed to rank for different purposes. The IPIEDT was built for prioritizing Early Detection species, whereas the

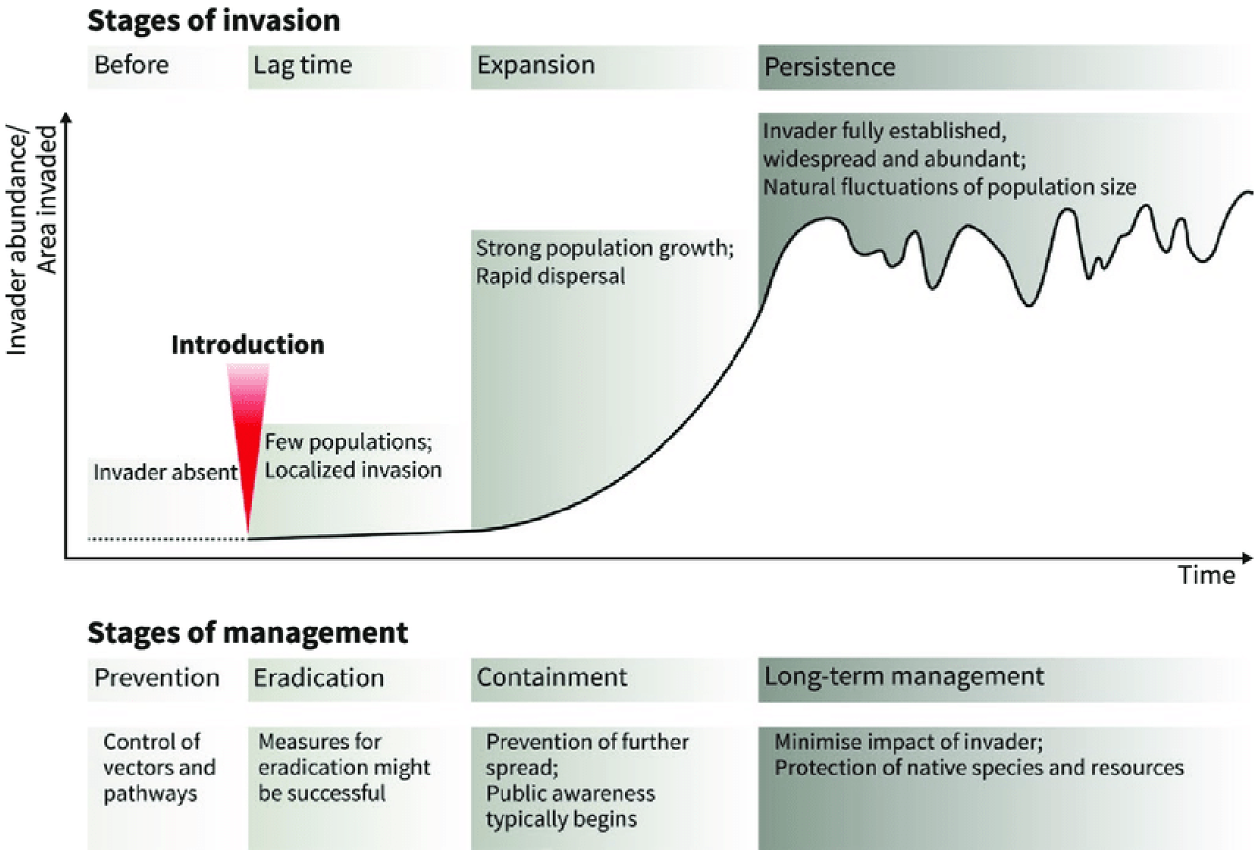

Figure 5: Theoretical invasion curve (black line), stages of the invasion process and according stages of invasive species management (after Boudouresque et al. 2005; State of Victoria 2010; Gothland et al. 2014).

IPMPT focuses on prioritizing species for management. Prevention and EDRR are the most cost-effective management strategies (Reaser et al. 2020) and should take precedence over species further along the invasive curve (Figure 5). However, while many refuge managers acknowledge the benefits of focusing on prevention and EDRR, they continue to work on species in the Containment or Long-term management stages. By incorporating the management aspect into prioritization using the IPMPT we can account for the Rapid Response portion of EDRR and hopefully encourage more active management of EDRR species.

Species prioritization was completed with the combined version of the IPMPT and IPIEDT mentioned above. To begin, species and areas are ranked in both tools using the criteria respective of each. Then, results from the IPIEDT were brought into the IPMPT and averaged with IPMPT. A higher score indicates a higher priority. Results and explanations of each criterion are available in Appendix D.

For specific information on categories used in ranking, see the respective tools. Further discussion of priority species ecology and characteristics, and priority area characteristics are in Chapter 3.

Methods for Area Prioritization

Selected areas for prioritization are the management units at Sevilleta NWR. These are: Unit A, Unit A prime, Unit B, Unit C, Unit D, the East River Corridor, East Side Arroyos, and West Side Arroyos. Areas were prioritized based on five factors: ecological integrity, threatened and endangered (T&E) species, natural pathways (water, hitchhikers on animals, wind), anthropogenic transport (vehicles and equipment, shoes, clothes), and disturbance. Definitions for these and the scoring criteria may be found in Appendix C.

Sevilleta NWR's conservation goals and objectives, past treatment, and EDRR needs influenced the ranking using the tools addressed above (Table 1). These scores for each category range from 0 to 10. Unknown scores are for situations where baseline data are unavailable. For example, Unknown Ecological Integrity is used when there are insufficient data to categorize the current state of the ecosystem and Unknown T&E Species should be used when the habitat conditions exist to support any particular T&E species, but it has not yet been detected in the area. Areas with relatively high ecological integrity frequently have high conservation value and are a priority for prevention and management of invasive species (De Leo and Levin 1997). Presence/absence of T&E species is also considered. When T&E species are present, or the correct habitat exists, the importance of areas where they may be found or are found increases. Ecological Integrity and T&E Species make up 80% of the Weighted Score (Table 1). The remaining 20% consists of spread vectors and disturbance. By weighting the scores, the importance of ecological integrity and presence of T&E species is increased relative to spread vectors and disturbance. This weighting is to ensure resources are funneled to higher quality habitats that are more resistant to invasion as well as those that support T&E Species. The ranking in Table 2 Hybrid Score column will be used to guide prioritization of invasive species management on Sevilleta NWR.

Methods for Species Prioritization

Early in the planning process, project team consensus determined that *Rhaponticum repens* due to its EDRR status, *Tamarix ramosissima* and *Lepidium latifolium* are the primary target invasive plants at Sevilleta NWR. *Elaeagnus angustifolia* and *Ulmus pumila* occur in similar areas as *Tamarix ramosissima* and will be referenced as “invasive tree complex” where all three species are known to occur together.

Species are ranked on seven categories: Rate of Invasiveness, Level of Threat to Resource, Level of Effort to Control, Number of Treatments for Control, Response to Control Method, Costs, and Ease of Logistics. Definitions can be found in Appendix D. These categories are also weighted based on their relative importance to the Refuge. Level of Establishment receives 30% of the total score and Threat to Biological Priorities receives 25%. These two categories make up 55% of the Weighted Score demonstrating the importance of prevention and EDRR and the biological priorities of the Refuge. When ranking species, the area in which it occurs must be considered. Environmental conditions in one area X may be different than another, area Y where a species occurs. In this case, it may be a greater threat to resources in area X than Y, and must be ranked accordingly. Level of Effort to Control, Number of Treatments for Control, Response to Control Method, Costs, and Ease of Logistics may also vary with respect to environmental conditions of each area.

Ailanthus altissima and *Saccharum ravennae* are included in the prioritization but are outside the scope of this Plan. The *Ailanthus altissima* on the Refuge are resprouts from previous treatments adjacent to a camera trap and are periodically monitored and treated as needed. *Saccharum ravennae* is considered a high priority EDRR species as there are known populations both north and south of the Refuge, however, it is not included in this Plan as there are no active management activities that can be done, but rather only periodic monitoring. There are other non-native plants at Sevilleta NWR, however those addressed here are the most impactful. *Rhaponicum repens* carries EDRR status, and the invasive tree complex and *L. latifolium* are the most relevant to Sevilleta NWR's conservation goals and objectives. *Tamarix ramosissima* priorities are dictated in the Refuge's IMP, HMP, and Biological Priorities documents, therefore the "invasive tree complex," which includes *T. ramosissima*, was moved up in priority to reflect the SMART objectives already laid out in the HMP. Thus, priorities will be *R. repens*, Invasive Tree Complex, and *L. latifolium*, respectively.

Table 1: Invasive Plant Management and Prioritization Tool ranking of priority areas at Sevilleta National Wildlife Refuge. The top row, "Sevilleta" is an average of the Units listed below to represent the Refuge as a whole and serves only as a reference. Each category is ranked based on criteria found in Appendix D. The "Score" is an average of scores across each Unit row, also primarily a reference. The "Weighted Score" weights values based on importance to the Refuge. Ecological Integrity and T/E Species make up 80% of the Weighted Score and Natural Pathways, Anthropogenic Transport Vectors, and Disturbance contribute 20% to the Weighted Score.

	Ecological Integrity	**T/E Species**	**Natural Pathways**	**Anthropogenic Transport Vectors**	**Disturbance**	**Score**	**Weighted Score**
Area	V. Good: 10 Good: 7 Fair: 3 Poor: 1 Unk: 3	High: 10 Med: 5 Low: 0 Unk: 5	No: 0 Low: 3 Med: 7 High: 10	No: 1 Low: 3 Med: 5 High: 10	High: 10 Med: 5 Low: 1		
Weighted Values -->	0.8		0.2				
Sevilleta	4.50	2.50	9.25	3.50	4.63	**4.88**	**3.96**
Unit A Prime	5	5	10	5	10	**7.00**	**5.67**
East River Corridor	5	5	10	5	5	**6.00**	**5.33**
Unit A	5	5	10	5	5	**6.00**	**5.33**
Unit B	3	5	10	5	5	**5.60**	**4.53**
East Side Arroyos	8	0	10	1	1	**4.00**	**4.00**
West Side Arroyos	8	0	10	1	1	**4.00**	**4.00**
Unit C	1	0	7	3	5	**3.20**	**1.40**
Unit D	1	0	7	3	5	**3.20**	**1.40**

Table 2: Scores from the IPMPT for area and species combined for an Area/Species rank. Higher scores indicate a higher priority.

Weighting --->	Level of Establishment	Rate of Invasiveness	Threat to Bio Priorities	Level of Effort to Control	# of Treatments for Control	Response to Control Method	Costs	Ease of Logistics	Sum of Weights
	0.3	0.15	0.25	0.1	0.05	0.05	0.05	0.05	1

Scope	Species	Level of Establishment	Rate of Invasiveness	Level of Threat to Resource	Level of Effort to Control	# of Treatments for Control	Response to Control Method	Costs	Ease of Logistics	Priority Score for Treatment	Area Score (Weighted)	Hybrid Score	Rank
Sevilleta	Rhaponticum repens	9	5	10	10	7	7	10	10	8.65	3.91	3.38	1
	Lepidium latifolium	7	7	10	10	5	5	10	10	8.15	3.91	3.19	2
	Saccharum ravennae	10	3	5	10	5	7	10	10	7.30	3.91	2.85	3
	Tamarix ramosissima	5	5	10	7	3	7	10	10	6.95	3.91	2.72	4
	Elaeagnus angustifolia	7	10	5	7	3	3	10	10	6.85	3.91	2.68	5
	Ulmus pumila	7	3	5	7	5	7	10	10	6.10	3.91	2.39	6
East Arroyos	Elaeagnus angustifolia	9	10	5	7	3	3	10	10	7.45	4.00	2.98	1
East Arroyos	Tamarix ramosissima	5	5	10	7	3	3	10	10	6.75	4.00	2.70	2
East Arroyos	Ulmus pumila	7	3	5	7	5	5	10	10	6.00	4.00	2.40	3
Rio Grande San Acacia	Elaeagnus angustifolia	5	10	5	7	3	3	10	10	6.25	5.33	3.33	4
Rio Grande San Acacia	Lepidium latifolium	10	7	3	10	5	5	10	10	7.30	5.33	3.89	2
Rio Grande San Acacia	Rhaponticum repens	9	5	10	10	7	7	10	10	8.65	5.33	4.61	1
Rio Grande San Acacia	Saccharum revennae	10	3	5	10	5	5	10	10	7.20	5.33	3.84	3
Rio Grande San Acacia	Tamarix ramosissima	1	5	10	7	3	3	10	10	5.55	5.33	2.96	6
Rio Grande San Acacia	Ulmus pumila	7	3	5	7	5	5	10	10	6.00	5.33	3.20	5
Unit A	Elaeagnus angustifolia	5	10	5	7	3	3	10	10	6.25	5.47	3.42	3
Unit A	Lepidium latifolium	5	7	10	10	5	5	10	10	7.55	5.47	4.13	1
Unit A	Saccharum ravennae	10	3	5	10	5	5	10	10	7.20	5.47	3.94	2
Unit A	Tamarix ramosissima	1	5	10	7	3	3	10	10	5.55	5.47	3.03	5
Unit A	Ulmus pumila	7	3	5	7	5	5	10	10	6.00	5.47	3.28	4
Unit A'	Elaeagnus angustifolia	5	10	5	7	3	3	10	10	6.25	5.67	3.54	3
Unit A'	Lepidium latifolium	5	7	10	10	5	5	10	10	7.55	5.67	4.28	2
Unit A'	Saccharum ravennae	9	5	10	10	5	5	10	10	8.45	5.67	4.79	1
Unit A'	Tamarix ramosissima	1	5	10	7	3	3	10	10	5.55	5.67	3.15	5
Unit A'	Ulmus pumila	7	3	5	7	5	5	10	10	6.00	5.67	3.40	4
Unit B	Elaeagnus angustifolia	5	10	5	7	3	3	10	10	6.25	4.87	3.04	4
Unit B	Lepidium latifolium	7	7	10	10	5	5	10	10	8.15	4.87	3.97	2
Unit B	Saccharum ravennae	10	5	10	10	5	5	10	10	8.75	4.87	4.26	1
Unit B	Tamarix ramosissima	5	5	10	7	3	3	10	10	6.75	4.87	3.29	3
Unit B	Ulmus pumila	7	3	5	7	5	5	10	10	6.00	4.87	2.92	5
West Arroyos	Elaeagnus angustifolia	7	10	5	7	3	3	10	10	6.85	4.00	2.74	2
West Arroyos	Rhaponticum repens	8	5	10	10	7	7	10	10	8.35	4.00	3.34	1
West Arroyos	Tamarix ramosissima	1	5	10	7	3	3	10	10	5.55	4.00	2.22	4
West Arroyos	Ulmus pumila	7	3	5	7	5	5	10	10	6.00	4.00	2.40	3
Rio Puerco Bridge	Rhaponticum repens	9	5	10	10	7	7	10	10	8.65	2.07	1.79	1
Rio Puerco Bridge	Tamarix ramosissima	1	5	10	7	3	3	8	10	5.45	2.07	1.13	2

2.4 Identifying Management Strategies

I identified management strategies primarily through evaluations of historical treatment effectiveness on Sevilleta NWR, US Forest Service species guides and other publications. The appropriate control options for each of the target species within any given area of the Refuge will vary in time and space as a result of variable site conditions and species susceptibility to treatment methods.

SPECIES AND AREAS PRIORITIES

3.1 Priority Species Ecology

Lepidium latifolium

Introduced to the US in the early 1900s, *L. latifolium* has established populations in at least half of US states, most of which are west of the Mississippi River. It is native to southern Europe and western Asia and initially spread as a seed contaminant of sugar beets. It was not until the 1980s that it was recognized as an invasive species, first in California then in neighboring states. At Sevilleta NWR, a 2019 visual estimate (Edward Sprigg, personal observation) in Unit A indicated *L. latifolium* was probably the third most dominant plant behind salt grass and coyote willow.

Lepidium latifolium prefers wet environments such as stream sides, marshes, roadsides, railways, and ditches. A perennial herb, it has a semi woody crown that can extend three m deep with a creeping root system capable of producing new ramets from adventitious buds (Renz et al. 2012). A newly established colony may expand as much as three m per year (Zouhar 2004), whereas older colonies were found to expand less than one meter per year (Renz et al. 2012). Reproduction occurs both by seed and vegetatively. Zouhar (2004) states that "seed production is potentially very high" but environmental conditions generally limit what is actually produced, and seeds are only viable up to two years with limited germination. However, Carpinelli et al. (2005) claimed that seed viability is enhanced after 96 hours in the gut of ruminants. Additionally, Zouhar (2004) suggests the majority of local spread is limited to vegetative reproduction either through adventitious buds or severed root fragments, and risk of long-distance dispersal is relatively low. Basal rosettes appear in May followed by the flowering shoots late May through June. Shortly after seed production, above ground portions die back. When conditions are favorable, fall rosettes may sprout and overwinter.

Influences of infestation are numerous. Zouhar (2004) summarized impacts as “altered species diversity, structure, and function; displaced native species; decreased food and habitat for several wildlife species; changes in biogeochemical cycles; and increased streamside soil erosion.” More specifically, *L. latifolium* has an extensive root system that allows the plant to pull salts from deep within the soil and deposit them on the soil surface, altering plant composition and diversity (Blank and Young 1997). The NRCS Web Soil Survey classifies the soils in the Sevilleta NWR Wetland Units A, A prime, and B, where most of the *L. latifolium* can be found, as moderately to strongly saline. These are inherently saline soils, but if salts are drawn from within the soil and concentrated on the surface, this could impact germination of native plant species and negatively impact restoration efforts in these Units.

Lepidium latifolium management at Sevilleta seems to have occurred in 2009, 2013, 2018, 2019, and 2021. These gaps in management and non-targeted efforts, combined with its extremely competitive nature and tendency to develop large, dense monocultures, gave the plant the opportunity to rapidly expand. Management efforts may be enhanced by using integrated pest management techniques. Renz (2000) found that *L. latifolium* is susceptible to inundation of more than 50 days over two seasons. Mechanical control is generally ineffective, as plants can establish from root fragments. For example, disking has been shown to significantly increase its spread (Renz 2000). However, mowing before flooding or chemical treatments may increase effectiveness of management.

<u>*Rhaponticum repens*</u>

Rhaponticum repens was introduced to the US about 1910 from Eurasia as a seed contaminant that spread rapidly across the country. Twenty years ago, it was estimated to infest more than 485,623 ha in the contiguous USA (Duncan 2001).

Wherever it has been introduced, *R. repens* has become a major pest species. Commonly infested sites include roadsides, railways, riverbanks, irrigation ditches, pastures, and any other areas with past or current soil disturbance and sufficient soil moisture (Zouhar 2001). This long-lived perennial has a deep taproot combined with creeping horizontal roots that form dense stands that can outcompete native vegetation (Watson 1980). Plants are monoecious with pollination occurring by insects. A single plant will produce anywhere from 100 to 1200 seeds in a growing season depending on the quality of its environment (Harrod and Taylor 1995). These seeds remain viable for 2-3 years (Zouhar 2001). Ballistic dispersal has been observed to launch seeds roughly the height of the plant as they are brushed by animals or as the plant moves in the wind (Zouhar 2001). Long-distance dispersal is typically attributed to livestock and wildlife transporting seeds in their gut as well as vehicles and machinery (Roche et al. 1986). At Sevilleta NWR, the Rio Grande riverbank is frequented by trespassing cattle that are suspected to be spreading *R. repens* seeds as they traverse the area. Minimizing livestock presence on the Refuge is imperative to the successful eradication of *R. repens*. Vegetative reproduction through shoots produced along adventitious buds makes up the bulk of the reproductive potential of *R. repens* (Zouhar 2001). Additionally, new ramets may sprout from severed root fragments, thus mechanical control methods that damage roots are not recommended (Watson 1980). Plants emerge in May, bolt late May into June and flower June through October. Additional shoots may appear after rainfall later in the season.

Rhaponticum repens is highly adaptable, tolerating a wide range of soil moisture and is most competitive in drier conditions. Allelopathic chemicals produced by the plant suppress the growth of neighboring plants, degrade landscape quality, and encourage development of monocultures (Alford et al. 2007, Zouhar 2001). Horses that consume *R. repens* develop brain lesions causing "chewing disease." However, sheep and goats appear to be immune to this toxicity and are effective for targeted grazing (Lacey and Olsen 1991).

Primary impacts of *R. repens* to Sevilleta NWR are its tendency to form dense monocultures and release of allelopathic chemicals (Watson 1980). Callaway et al. (2012) also discovered that *R. repens* is more competitive and affects its environment far more in its invaded range than its natural range. Both factors can reduce native biodiversity if the plant is left unmanaged.

An integrated management approach for *R. repens* is ideal. Classical biocontrol agents are available, but due to the limited distribution of *R. repens* at Sevilleta NWR, they will not be considered for use. Repeated mowing to prevent seed production followed by a winter herbicide application combined with sowing native grasses has potential to restore infested sites. The limited distribution of the current infestation at Sevilleta NWR is ideal for herbicide application and passive restoration as the primary means of management. There are enough native plants adjacent to the *R. repens* patches, and patches are small enough that passive revegetation should be sufficient.

Elaeagnus angustifolia

Elaeagnus angustifolia quickly escaped cultivation after it was introduced to the US in the early 1900's. It was listed as the fifth most dominant tree in the Western US in 2005 (Friedman et al., 2005) and can be found in a variety of habitats where soil moisture remains relatively high throughout the year. In central NM it has not yet established vast stands such as can be found in some more northern states.

It is a small, fast growing tree that is primarily invasive in riverine areas in the Western US but also colonizes marshes and irrigation ditches. It faces little threat from herbivores. These trees can reach 15 m tall and have deep taproots with a well-developed lateral root system (Field Guide 2014). The average age at which trees begin to produce seed is ten years, and these seeds can remain viable up to three years (Zouhar 2005). Reproduction is predominantly by seed, but annual precipitation over 400 mm reduces seed production (Brock 2003). Adventitious buds along lateral roots send up ramets, especially after injury to the parent plant. Fruits overwinter on stems providing a valuable winter food source that is readily consumed by animals, thus facilitating its spread. This is thought to be the primary means of dispersal, although fruits can spread via water as they float for up to 36 hours. Invasion of *E. angustifolia* is relatively slow compared to other invasive species because of its long maturation time and low recruitment. In contrast, *T. ramosissima* can flower in its first year of growth but year three is most common (Stevens 1989). Native cottonwoods reach maturity slightly earlier than *E. angustifolia* at five to 10 years, but seeds are only viable for one to five weeks and must find suitable germination sites created by spring floods within that timeframe (Braatne et al. 1996).

Although *E. angustifolia* is an important food source for wildlife, it alters hydrological processes by stabilizing stream banks and increasing floodplain roughness (Zouhar 2005).

Beavers avoid felling *E. angustifolia* and prefer native cottonwoods. As cottonwoods are removed, they are replaced by *E. angustifolia* which then become the dominant species (Lesica and Miles 2001). Additionally, leaf litter is high in nitrogen which can upset the balance of nutrients in soil and water, furthering the invasion of other non-native species (Zouhar 2005).

Control of *E. angustifolia* is difficult and expensive. Eradication is highly unlikely. Zouhar (2005) suggests that the best strategy for controlling *E. angustifolia* is through native species management such as properly timed flooding to mimic natural processes to encourage native species growth. This combined with cut stump applications can help restore a riparian site to a more “natural” condition.

<u>*Tamarix ramosissima*</u>

Tamarix ramosissima has been present in the US since the early 1800s, and its introduction has been well documented (Zouhar 2003). Robinson (1965) estimated that in 1920 the entire US contained about 4000 ha of *T. ramosissima*. By the mid-1960s more than 500,000 ha had been documented, primarily because of extensive planting and water control projects that altered natural processes. More recent estimates suggest there are between 600,000 and 1.2 million hectares of *T. ramosissima* in the US (NASA, Tamarisk Tree 2018).

Tamarix ramosissima grows along riparian corridors and reservoir shorelines where groundwater is readily available in arid and semiarid regions (Everitt 1980, Brock 1994, Shafroth et al. 2005). Large quantities of seed produced from April to October are disseminated by wind or water and remain viable for several weeks. The seeds will germinate on saturated soils or while afloat. Slowly receding water levels along river banks or wetland shoreline create optimum seed beds, but survival requires several months without subsequent flooding (Horton et al. 1960). *Tamarix ramosissima* can range from extensive, dense, monospecific stands to small patches within a vegetation mosaic (Shafroth et al. 2005).

By changing the structure and function of riparian corridors, *T. ramosissima* impacts the survival of species including the endangered NMMJM, SWFL, and YBCU. Most dense, extensive *T. ramosissima* invasions are the result of altered natural hydrologic and geomorphic processes or by land uses such as livestock grazing, land clearing, and groundwater pumping (Everitt 1980, 1998; Shafroth et al. 2002; Stromberg and Chew 2002).

Once established, *T. ramosissima* is difficult to kill. Mature plants are tolerant of heat, cold, drought, flood, and high concentrations of dissolved solids (Everitt 1980). By dropping its leaves and halting growth, *T. ramosissima* can withstand lengthy droughts (Horton and Campbell 1974). A mature tree can survive inundation for as long as 70 days (Warren and Turner 1975). Under saline conditions, *T. ramosissima* absorbs dissolved solids and releases excess salts through glands in its leaves (Decker 1961) that are eventually deposited on the soil surface under the plant, sometimes forming a hard crust (McQueen and Miller 1972). These saline deposits continue to degrade the site and impede establishment of other vegetation. *Tamarix ramosissima* recovers quickly and sprouts vigorously after burning or cutting at or above ground level. Severed stems and shoots readily root in moist soil and produce new plants. Adventitious roots sprout from submerged or buried stems, and buried branches may also reproduce vegetatively (Kerpez and Smith 1987).

<u>*Ulmus pumila*</u>

Ulmus pumila is a deciduous tree native to Asia that can reach heights of 21 m. It was introduced to the US in 1905 for its rapid growth, use as a windbreak, and for shade (Leopold 1980). Dirr (1975) describes it as "one of the worst ornamental trees that does not deserve to be planted anywhere." Yet, Oklahoma and Texas still sell *U. pumila* commercially. Preferred environments include disturbed areas, streambanks, rangelands, and rights of way with moist soils and full sun (Field Guide 2017). This description fits the target areas at Sevilleta, but for now distribution has been very limited and management is more opportunistic as *T. ramosissima* and *E. angustifolia* are targeted.

Ulmus pumila is a prolific seed producer, and under the right conditions, seeds readily germinate and grow quickly, outcompeting native vegetation. Seed is the primary form of reproduction, dispersed mainly by wind but also by water and animals (Kennay 2017). Hybridization occurs in the central US with *U. rubra*, which has led to conservation concerns (Zalapa 2008). Perez-Corona (2013) found that leaves dropped in the fall exhibit some allelopathic effects stunting growth of radicals or inhibiting germination in other species. This allelopathy combined with prolific seed production can lead to dense thickets which shade out native vegetation. In some cases, this will create the right environment for other invasive species to populate (*Ulmus pumila* 2021).

If top growth is damaged, the root crown will resprout aggressively. Infested plant communities are very difficult to restore, and integrated control methods can take 10 years or more to effectively control populations (Field Guide 2017). Destroying the root system is the only means of killing the entire tree. Digging using heavy equipment, cut stump, and girdling combined with herbicide are the most effective treatment options (*Ulmus pumila* 2021).

3.2 History of Management

Rhaponticum repens is a relatively new discovery at Sevilleta NWR putting it in the realm of EDRR. In a 2009 New Mexico Invasive Species Strike Team report there is mention of *R. repens* being interspersed in patches of *L. latifolium*, but there are no spatial data or any other information provided. The Rio Grande populations (1.9 ha total) were identified in 2018 while removing *T. ramosissima*, and the Rio Puerco populations (0.18 ha) were found in 2019 during the construction of a bridge (Figure 4). The extent of the Rio Puerco *R. repens* indicates it was present long before the new bridge was installed, but the increased activity allowed for these areas to be identified and subsequently mapped along the south side of the Rio Puerco in summer 2019. Initial herbicide treatments with aminopyralid followed in October 2019. Effectiveness of this initial treatment was not evident until spring 2020. The Rio Grande populations have received two late fall (2018 and 2019) treatments using aminopyralid with excellent results. In October 2020 only 1.5 square meters were treated along the Rio Grande. One challenge of *R. repens* management in this area are trespassing cattle. Cattle will occasionally graze *R. repens* and can spread seeds through their gut, fur, or in mud stuck in their hooves. In fall 2019 significant grazing of *R. repens* was seen (personal observation), thus there is potential for it to have spread outside the identified areas.

Lepidium latifolium has been under management sporadically for several years at Sevilleta NWR. The first mention of ISST management of *L. latifolium* is 2009, but spatial data are not available until 2013. It can be reasonably assumed that *L. latifolium* management has been confined to the wetland units along the Rio Grande. Currently, the wetland units A, A Prime, and B are the primary infested areas, although it can be found along roadsides and ditches in some areas adjacent to these units. The status of *L. latifolium* of Units C and D is unknown, however these are more upland units and likely too dry to support the plant. Across all river corridor units, it appears 2013 was the last year *L. latifolium* was treated until the most recent management began in 2018, continuing every May/June until present. A variety of herbicides have been used including imazapyr, glyphosate, and triclopyr. All three herbicides were applied late spring into early summer and seem to have provided adequate control by reducing densities in treated areas. Some activities such as the CRI project in unit B and mastication by a skid steer with a mulcher attachment in unit A have facilitated the colonization of *L. latifolium*. Between the lack of management for five years and the disturbance associated with the CRI project, the ideal environment for establishment and spread was created. Removing *L. latifolium* alone is not enough for effective management. Native plant communities must be encouraged to out compete *L. latifolium*. It will likely never be eradicated from these units, but it is possible to reduce populations to levels manageable by Refuge staff to mitigate impacts to native plant and animal communities that utilize these wetland units.

Tamarix ramosissima has seen the most consistent and thorough management at Sevilleta NWR. Its management in arroyos is a biological priority for the Refuge. The earliest mention of *T. ramosissima* management at Sevilleta in available data is 2009. However, there is no location or treatment information, only that *T. ramosissima* was surveyed for and subsequently removed. From data that is available, as of June 2021 it appears that surveys or treatments were conducted in 2010, 2011, 2013, 2014, 2017, 2018, and 2019. Survey data have been found for 2011 and 2013 with spatial data for treatments in 2010 and 2014. Up until 2017 most of the invasive trees removed were isolated patches and did not extend the full length of the arroyos. Since 2017 Palo Duro Canyon has received at least one cut stump treatment from the pipeline road east to

Tomasino road. In the future this section should only require basal spraying of trees if visited every other year. These retreatments can easily be accomplished in a single day either on foot or by Utility Terrain Vehicle (UTV). Known treatments in Cibola Canyon began in 2010, and then in 2018 when NM ISST returned for surveying from the boundary at La Joya to the eastern boundary of the Refuge. From Cibola Spring east to the Refuge boundary, *T. ramosissima* and *U.* pumila were cleared by cut stump in 2018 and 2019. Cibola Canyon from Cibola Spring west to La Joya and adjacent drainages have not received any treatments to date and will require extensive cut stump efforts, the bulk of the infestation is west of Palo Duro Road. If management actions are maintained it is entirely possible to have the invasive trees eradicated from most, if not all, of Palo Duro and Cibola Canyons and their associated minor drainages.

The NM Fire District assisted in removing *T. ramosissima* from Unit C in 2011 and 2012. Following this, the NM ISST conducted basal bark applications of xx in 2013 and 2014. Unit D was masticated by a skid steer with mulcher attachment in 2019. Data on how *T. ramosissima* responded to treatments in Units C and are lacking, though some spatial data and a few reports have been found.

3.3 Current Status

Invasive trees, primarily *T. ramosissima* are found along the majority of riparian corridors on the Refuge including arroyos. *Lepidium latifoilum* appears to be contained to the Rio Grande corridor, but proper conditions for range expansion exist elsewhere on the Refuge. All target species in this Plan are widespread across the state and well established on the Refuge.

We are working on containment and asset protection by aiming to keep these plants out of ecologically valuable areas on the Refuge. The known distribution of *R. repens* (2.08 ha at initial surveys, < 0.8 ha as of 2020) at Sevilleta is miniscule compared to other invasive species (*L. latifolium,* 4.8 ha treated between 2019 and 2020, though more is known to occur). Aggressive management of these isolated populations is essential to preventing further spread.

3.4 Impacts

Both *L. latifolium* and *R. repens* are aggressive competitors with a high tendency to form dense monocultures that outcompete native vegetation. Monocultures of plant species reduce the quality and availability of wildlife habitat as a reduction in both plant and animal diversity (Zouhar 2001). *Lepidium latifolium* acts as a salt pump drawing salts from deep within the soil up to the surface, and *R. repens* may be allelopathic. Both species significantly alter soil chemistry impacting long term recovery (Zouhar 2001, 2004). Direct influences to the T&E species at Sevilleta NWR have not been observed. It must be inferred that the reduced native plant diversity noted by Zouhar (2001) will elicit a negative response with respect to these T&E species.

All invasive trees addressed in this Plan can have negative ecological and economic effects. The most commonly reported negative impacts are depletion of water flows within streams resulting from high evapotranspiration rates, displacement of native vegetation, degradation of wildlife habitat, increased soil salinization, stream channel narrowing, increased potential for flood damage, and increased frequency and magnitude of riparian forest fires (Graf

1978, 1981; Brock 1994; Di-Tomasso 1998; Lovich and DeGouvenain 1998; Zavaleta 2000). Conservation concerns at the Refuge are tied to altering the structure and function of Rio Grande silvery minnow, Southwester willow flycatcher , and Western yellow billed cuckoo habitats. When invasive trees, particularly *T. ramosissima* move into RGSM habitat, shallow areas can dry up and become silted in converting a shallow backwater channel to a riparian area (Everitt 1998). Additionally, *Diorhabda* beetles released for biological control of *T. ramosissima* can defoliate trees during peak SWFL nesting season leading to nest failure (McLeod 2015).

3.5 Priority Areas

Rhaponticum repens

Priority one for *R. repens* is the infestation along the Rio Puerco (Figure 6). Adjacent to the Rio Puerco population is a recently disturbed area resulting from a 2018 bridge construction and intermittent flooding primarily during the summer monsoon season. The Rio Puerco site is the smaller of the two infestations at 0.12 ha. Patches are densely populated, but eradication is very possible based on the success since control efforts began (2018, 0.12 ha; 2019, 0.04 ha, 2020, 0.002 ha). It is a degraded, low quality site but is also a source population for *R. repens* to enter other areas of the Refuge.

The second priority is the Rio Grande *R. repens* population that contains the larger infestations at 1.7 ha. This area has been under management since 2017 and as of Spring 2021 the Rio Grande population has been reduced to three isolated low-density patches totaling about 1.2 square meters. These populations are likely the result of installing a fence several years ago. The largest patch is in what was the equipment staging area for the project. This x is also a relatively low-quality site with *T. ramosissima* dominating the adjacent floodplain. Native vegetation is well established in the right of way where access is maintained. The biggest challenge with the Rio Grande population is that trespassing cattle frequent the area. This continued disturbance and vector has the potential to negatively impact management and has likely facilitated its spread. With the significant reduction (17,000 sq m in 2017 to 1.2 sq m 2020) seen since 2017, eradication at this location is possible as well. Due to the scale of the map in Figure 5, the entire projected survey areas for *R. repens* are depicted so they are visible. Ideally, the 172 ha along the Rio Grande fence line and 37 ha along the Rio Puerco will be surveyed for additional *R. repens* populations.

Lepidium latifolium

Management of *L. latifolium* has been ongoing and inconsistent. It is abundant along the middle Rio Grande and associated wetland areas (Units A, A Prime, and B). However, the goal will be to contain it to small source populations. Prioritizing areas will ensure that densities are reduced and maintained long term. Unit B (~29 ha), a recent restoration area, will be the first priority for *L. latifolium* management. Removal of the *T. ramosissima* monoculture and restoration began in 2016. Following this removal, willow and cottonwood poles were planted during 2017, 2018, and 2019 in select areas throughout the unit. As of summer 2019, *L. latifolium* densities remain low and patches scattered. Targeted control in Unit B will facilitate revegetation with native plants. Unit A Prime (~30 acres) is the second priority for *L. latifolium* and has some recently disturbed areas but is mostly left unmanaged. *Lepidium latifolium* in Unit A Prime is roughly equal to that in Unit B. The third priority area for *L. latifolium* is Unit A (~29 acres). This unit contains the densest infestation of *L. latifolium* in the three wetland units.

Tamarix ramosissima

The prioritization of *T. ramosissima* management was set forth in the Refuge's IMP, HMP, and Biological Priorities documents and does not match the IPMPT results. *Tamarix ramosissima* found in the arroyos reduces native plant and animal diversity and alters the structure and function of the arroyos. Removal will begin at the first priority site for invasive trees in the West Side Arroyos (~1000 ha) where native communities are very well intact; *T. ramosissima* is the only state listed invasive species documented in these arroyos, and 2019 estimates indicate about 90% of the *T. ramosissima* has been removed in treated areas. The East Side Arroyos (~330 ha) will follow as priority two for invasive trees. Here, all three trees of the invasive tree complex are present, but these are the only state listed invasive species known to occur in the East Side Arroyos. Past management has been less intense than the West side, but current estimates indicate about 80% of *T. ramosissima* has been removed in treated areas.

3.6 Early Detection and Rapid Response

Many non-native species exist in the US and are spreading through human activities. The New Mexico Noxious Weed List (2020) includes 47 plant species, many of which are known to occur in and around Socorro County, NM. Due to the variety of ecosystems at Sevilleta NWR, Table 3 is by no means an exhaustive list of potential invaders. The species listed in Table 3 have been documented in Socorro County but are not yet known to occur at Sevilleta NWR or occur in extremely small, isolated pockets. Staff and volunteers working on the Refuge should be familiar with these species in order to identify any new occurrences.

Early detection is likely going to be passive; a new species is noticed while conducting other work. Specific treatment recommendations for these 13 EDRR species are outside the scope of this Plan. To effectively manage an EDRR species should it be found, Figure 6 recommends collecting a plant specimen for identification, though a true herbarium specimen may not be necessary, and a picture could be sufficient to confirm identification.

Table 3: Species targeted for Early Detection Rapid Response at Sevilleta National Wildlife Refuge. *Species documented at Sevilleta. Early Detection Rapid Response has been initiated, and population is so small it does not warrant IPM planning. ǂSpecies has been documented both north and south of the Refuge, likely present in the Rio Grande corridor.

Aegilops cylindrical, jointed goatgrass	*Ailanthus altissima**, Tree of Heaven
Alhagi maurorum, camelthorn	*Arundo donax*, giant cane
Bromus tectorum, cheatgrass	*Carduus nutans*, musk thistle
Cirsium arvense, Canada thistle	*Cirsium vulgare*, bull thistle
Lepidium draba, hoary cress	*Onopordum acanthium*, Scotch thistle
Peganum harmala, African rue	*Saccharum ravennae*ǂ, ravennagrass
Xanthium spinosum, spiny cocklebur	

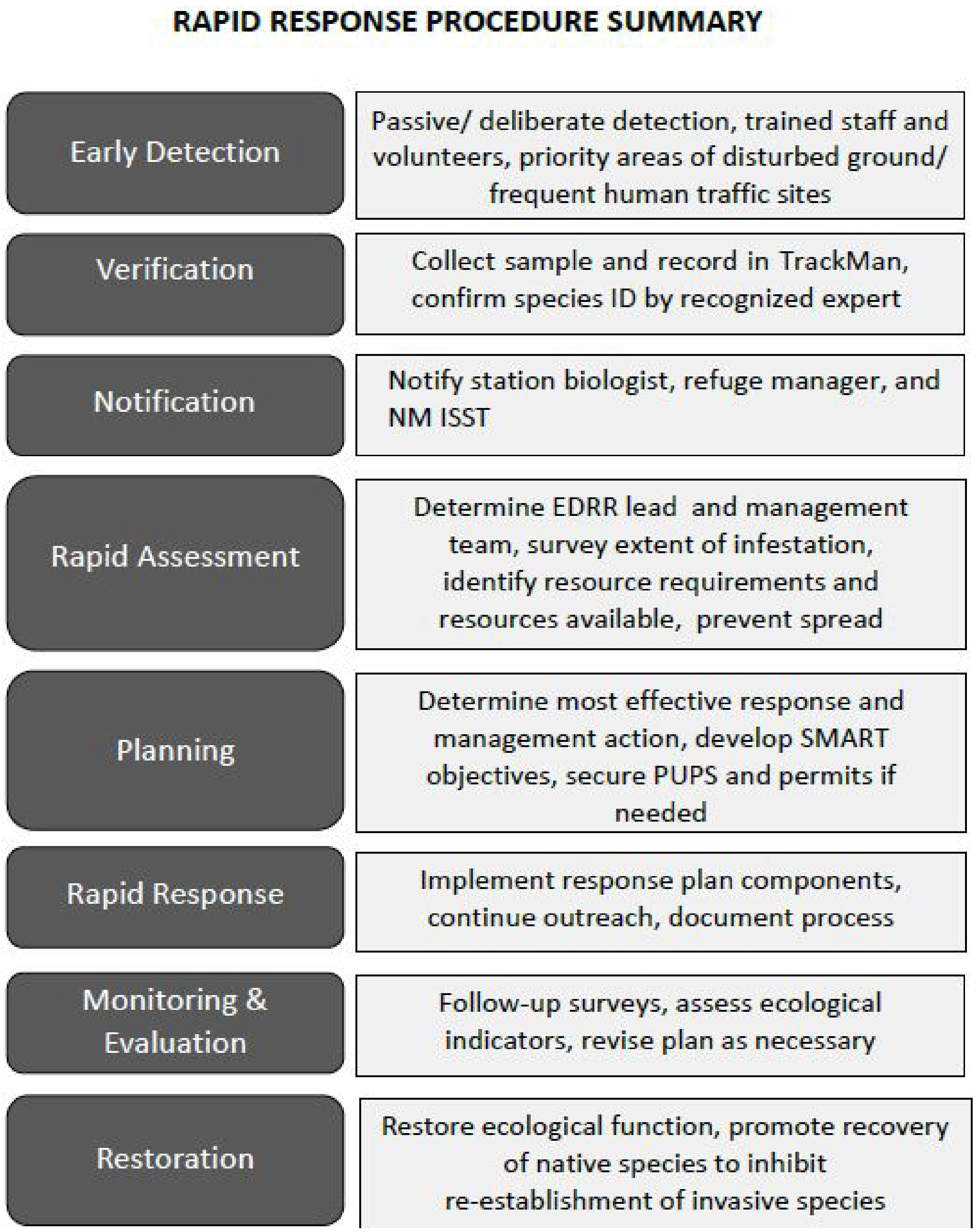

Figure 6: Rapid response procedure for early detection of invasive species. (Adapted from NYDEC 2016)

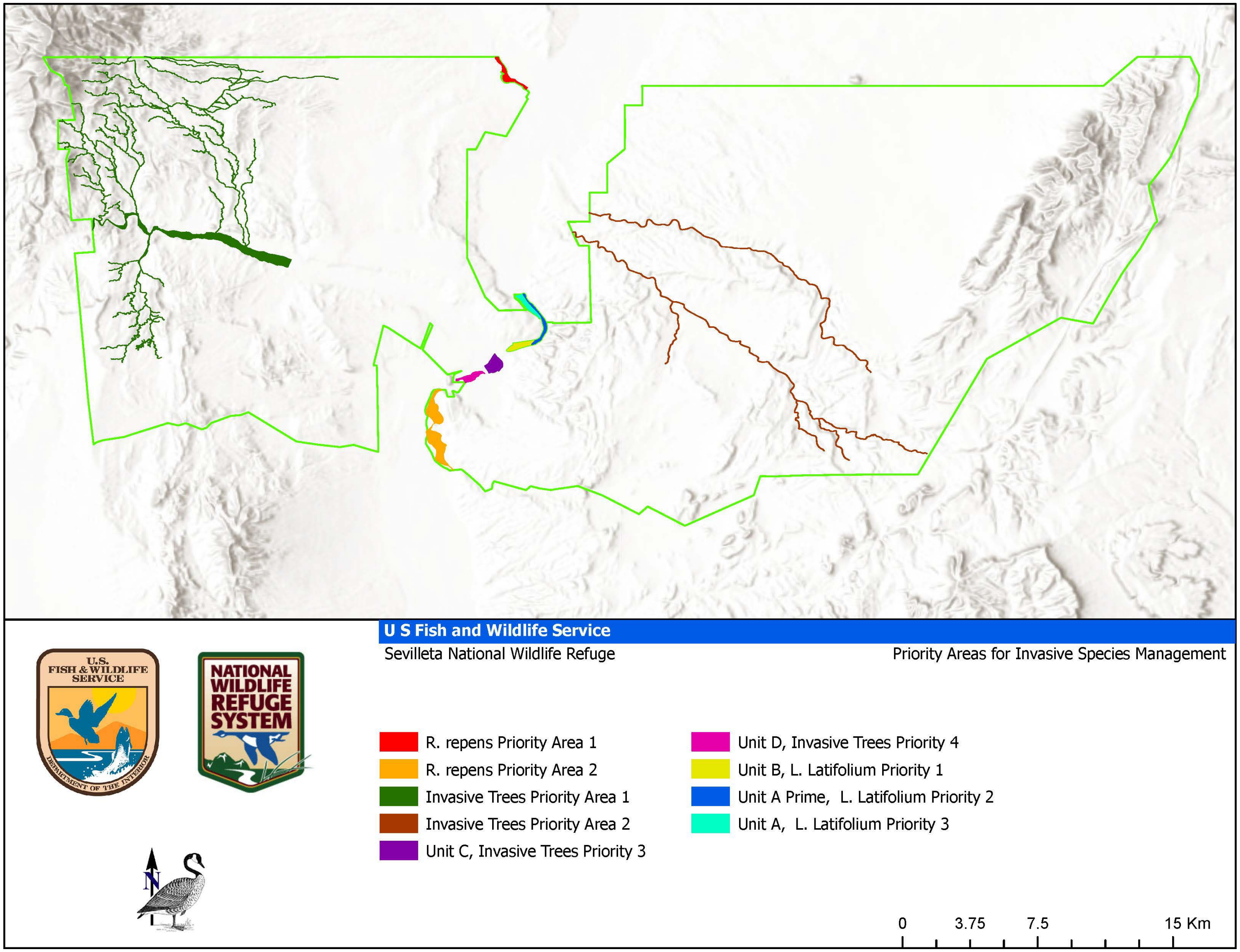

Figure 7: Priority areas at Sevilleta National Wildlife Refuge. These are the ideal survey areas; known infestations will be indicated on subsequent maps.

WORK PLAN

4.1 Invasive Plant Management Objectives

Areas were prioritized using the IPMPT (Table 2). *Rhaponticum repens* was not included in the area prioritization since it is an EDRR species. Management will begin on the outer edge of patches and move inward. Using this technique, invasive species patch expansion will be stymied as work continues to reduce densities to achieve the goals listed below. The Project Team developed the following SMART objectives:

Rhaponticum repens

A. Survey the entire 37 ha (Figure 5) for additional patches by 2022 and eradicate the currently (2019) mapped *R. repens* along the Rio Puerco by 2024. If any additional areas are found, they will be mapped and assessed for treatment. Monitoring of treated areas will continue for three years after the last individual is treated to confirm eradication.

B. Eradicate the currently (2019) mapped *R. repens* from the Rio Grande fence line by 2023 and survey the entire 172 ha (Figure 5) for additional patches by 2023. If additional patches are found, they will be mapped and assessed for treatment. Monitoring of treated areas will continue for three years after the last individual is treated to confirm eradication

Invasive Trees, Arroyos

A. Survey every other year from 2020-2026 and re-treat at least 60% of the previously treated *T. ramosissima* infested arroyos and drainages (Figure 5) on the West Side (excluding the main channels of the Rio Salado and San Lorenzo Canyon) with the goal of maintaining *T. ramosissima* at less than 5% of the 2014 survey.
B. Survey every other year from 2021-2031 and re-treat, as necessary, at least 60% previously treated *T. ramosissima* invaded arroyos and drainages (Figure 5) on the East Side of the Refuge with the goal of maintaining *T. ramosissima* at less than 5% of the 2018 survey.
C. Survey at least 90% of the arroyos and drainages on the West Side of the Refuge for new or undocumented invasive species by 2026.
D. Treat at least 20% of previously untreated *T. ramosissima* infested arroyos and drainages on the East Side, using mechanical and/or chemical treatments, by 2028.

Invasive Trees, Units C and D

A. Conduct a baseline inventory of *T. ramosissima* in Units C and D (Figure 5) by Fall of 2022.
B. Establish tamarisk beetle research plots in Unit D (Figure 5) by end of 2022.
C. Remove the remaining 2.8 ha of old growth *T. ramosissima* in Unit C (Figure 5) using heavy equipment in 2022.
D. Begin basal bark treatment in both units by the end of 2022 (Figure 5). Reduce the abundance of *T. ramosissima* in Units C and D to less than 5% of the 2021 baseline inventory by December 2028.

Lepidium latifolium

A. Reduce the amount of *L. latifolium* in Unit B (Figure 5) to less than 5% of 2020 treatment areas by 2024. In 2024 distribution and treatments should be reassessed to determine if eradication is possible or if maintenance will be required by Refuge staff indefinitely.

B. Reduce the amount of *L. latifolium* in Unit A Prime (Figure 5) to less than 5% of baseline data by 2025. Baseline distribution will be mapped by end of 2022. In 2025 distribution and treatments will be reassessed to determine if eradication is possible or if maintenance will be required by Refuge staff indefinitely.

C. Reduce the amount of *L. latifolium* in Unit A (Figure 5) to less than 5% of baseline data by 2026. Baseline distribution will be mapped by end of 2023. In 2026 distribution and treatments should be reassessed to determine if eradication is possible or if maintenance will be required by Refuge staff indefinitely.

4.2 Management Activities

Rhaponticum repens

Due to the limited extent of infestations (Figure 8), chemical control will be the primary method used for *R. repens* management. Completing treatments, monitoring, and surveys of both areas should only take one to two 40-hour weeks per year of a two-person Strike Team. Chemical applications at both areas can be completed in two 10-hour days, surveys of the entire potentially infested site will likely require one to two 10-hour days per priority location.

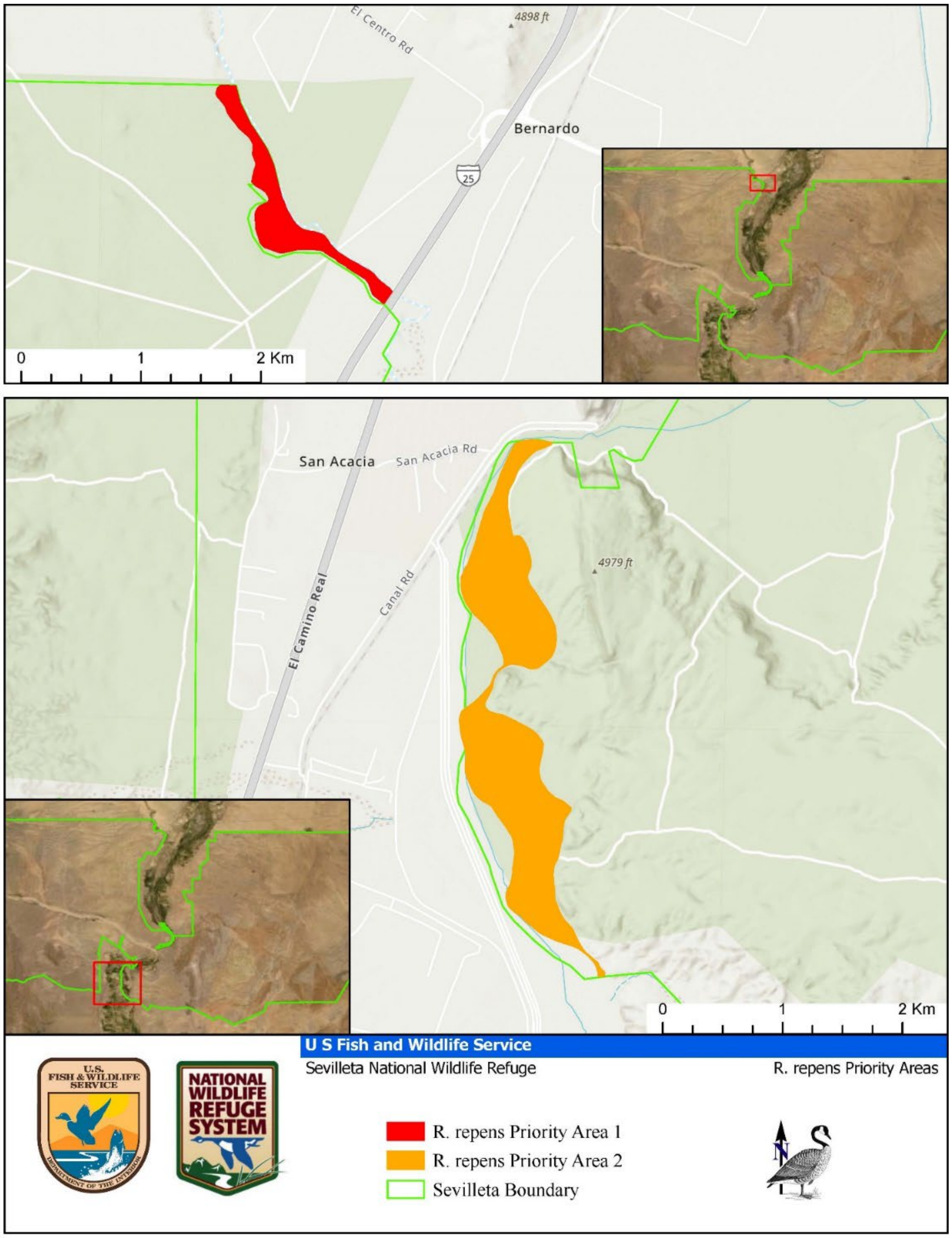

Figure 8: *Rhaponticum repens* priority areas at Sevilleta National Wildlife Refuge. These polygons depict ideal survey areas based on appropriate environmental conditions for *R. repens* to grow.

Priority Area One, Rio Puerco Population. Small, isolated treatment polygons along the north refuge boundary on the banks of the Rio Puerco will be treated by backpack foliar spraying aminopyralid (preferred) or imazapyr-based herbicides. Ideal timing for aminopyralid applications is in the fall after the first frost when mature plants are dormant and basal rosettes may be present (DiTomaso 2013).

Follow-up chemical treatments will continue until *R. repens* plants are no longer found. Eradication of *R. repens* is expected to be completed by 2024 (initial treatment October 2019) but will continue until the last plant has been removed. At this point surveys should be conducted once a year for three years to confirm eradication. These surveys will occur during the growing season June - August, whenever convenient.

<u>Priority Area Two, Rio Grande Population</u>. Small, isolated treatment polygons along the north/ south refuge boundary that follows the Rio Grande east of San Acacia will be treated by backpack foliar spraying aminopyralid (preferred) or imazapyr-based herbicides. Ideal timing for aminopyralid applications is in the fall after the first frost when mature plants are dormant, and basal rosettes may be present.

Follow-up chemical treatments will continue until *R. repens* plants are no longer found. This is expected to be completed by 2023 (initial treatment October 2018) but will continue until the last plant has been removed. At this point surveys should be conducted once a year for three years to confirm eradication. These surveys will occur during the growing season, June - August, whenever convenient.

Lepidium latifolium

Management activities such as mowing and masticating periodically occur in wetland units A, A Prime, and B (Figure 9). Reducing the density of *L. latifolium* will lower the risk of transferring propagules between units and to other areas. Control will largely rely on chemical applications, as fire and physical removal are ineffective and biocontrol options are unavailable. Completing *L. latifolium* treatments and monitoring of all three wetland units can be accomplished in two 40-hour weeks, preferably late May or early June. If practical, mowing in late May will stress *L. latifolium* making it more susceptible to herbicide application three to four weeks later. Grubbing using hand tools or hand pulling may be utilized in select areas within willow planting sites. However, careful application of herbicide will be more effective. If time is available, fall herbicide treatments to basal rosettes can further reduce *L. latifolium* density. This work will require a two-person Strike Team to treat all three units in a season. Baseline data will need to be obtained for all three units by 2022 in order to have data to measure success by.

Priority Area One, Unit B. Unit B has seen a considerable amount of disturbance due to restoration activities from 2016 - 2018 which have encouraged both native and non-native plant growth. *Lepidium latifolium* has widespread distribution throughout Unit B, but populations remain small and isolated and are mostly contained proximate to or within willow planting sites. Herbicides will be applied using backpack sprayers or by UTV spot application depending on the amount of precision required.

If physical removal is to be attempted, a garden hoe or hand pulling will be utilized. Regular removal throughout the growing season will be necessary to make any impact in reducing the population. Mowing *L. latifolium* is not recommended in this area as the disturbance could hinder native revegetation.

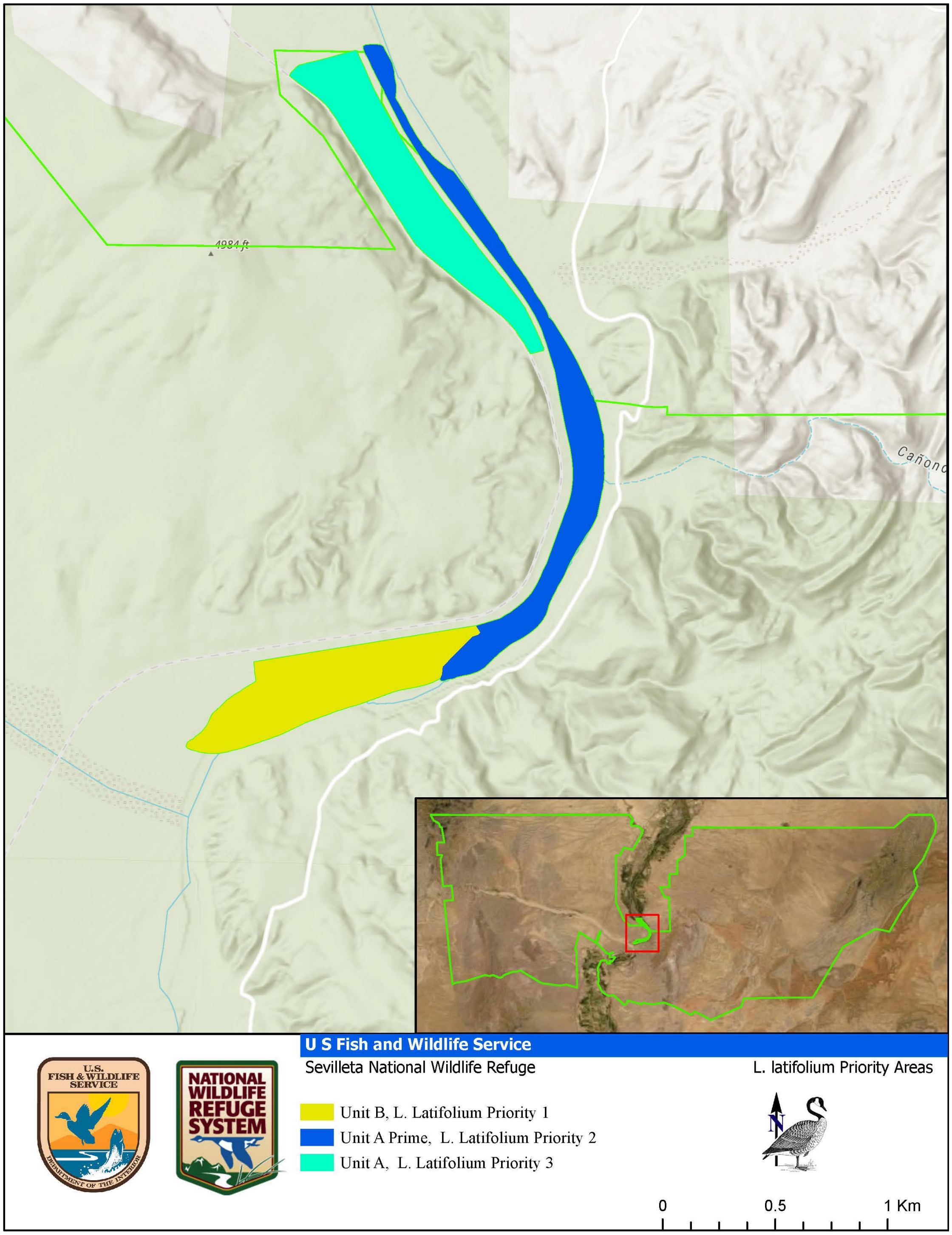

Figure 9: *Lepidium latifolium* priority areas for management at Sevilleta National Wildlife Refuge. Entire Units possess ideal environmental conditions for *L. latifolium*.

Due to its proximity to RGSM habitat, care must be taken to keep herbicides from surface water. Aquatic formulations of glyphosate, imazapyr, and triclopyr (triethylamine salt) must be used to minimize potential impacts. See the "Recommended Protection Measures for Pesticide Applications in Region 2 of the U.S. Fish and Wildlife Service" document for more information.

Follow-up chemical treatments have occurred every year since the initial treatment year (2018) and will continue until *L. latifolium* has been deemed to be less than 5% of the baseline population data. The target of 5% of the baseline population is expected to be completed by 2024 but will continue until this action threshold has been reached. At this point monitoring should continue at least every other year to confirm *L. latifolium* does not exceed the action threshold of 5% of vegetation within the unit. These surveys will occur during the growing season May - July, whenever convenient.

Priority Area Two, Unit A Prime. Unit A Prime is due north of Unit B, and as such, it is the second priority for *L. latifolium*. Reducing *L. latifolium* densities in A Prime will lower the risk of new infestations in Unit B. *Lepidium latifolium* is largely concentrated on the north end of A Prime in the salt grass terrace along the Rio Grande. There are a few small patches in the disturbed area of the south end. Herbicides will be applied using backpack sprayers or by UTV spot application depending on the amount of precision required.

If physical removal is to be attempted, a garden hoe or hand pulling will be utilized. Regular removal throughout the growing season will be necessary to make any impact in reducing the population. Mowing or cutting *L. latifolium* with a sting trimmer could be useful in A Prime if circumstances allow.

Due to its proximity to RGSM habitat, care must be taken to keep herbicides from surface water. Aquatic formulations of glyphosate, imazapyr, and triclopyr (triethylamine salt, choline, or acid formulations) must be used to minimize potential impacts. See the "Recommended Protection Measures for Pesticide Applications in Region 2 of the U.S. Fish and Wildlife Service" document for more information.

Follow-up chemical treatments have occurred every year since the initial treatment year (2018) and will continue until *L. latifolium* has been deemed to be less than 5% of the baseline population data. This x is expected to be completed by 2025 but will continue until the target has been reached. At this point monitoring should continue at least every other year to confirm *L. latifolium* does not exceed the action threshold of 5% of vegetation within the unit. These surveys will occur during the growing season May - July, whenever convenient.

Priority Area Three, Unit A. Unit A is due west of Unit A Prime. *Lepidium latifolium* is largely concentrated on the north end of A and along roadsides. There are a few small patches in the disturbed area of the south end. Herbicides will be applied using backpack sprayers or by UTV spot application depending on the amount of precision required.

If physical removal is to be attempted, a garden hoe or hand pulling will be utilized. Regular removal throughout the growing season will be necessary to make any impact in reducing the population. Mowing *L. latifolium* could be useful in Unit A if circumstances allow.

Follow-up chemical treatments have occurred every year since the initial treatment year (2018) and will continue until *L. latifolium* has been deemed to be less than 5% of the baseline population data. This x is expected to be completed by 2026 but will continue until the target has been reached. At that time monitoring should continue at least every other year to confirm *L. latifolium* does not exceed the action threshold of 5% of vegetation within the unit. These surveys will occur during the growing season May - July, whenever convenient.

Invasive Tree Complex.

Control will include mechanical, chemical, and biological methods described in Appendix A. Mechanical treatments will include large and small equipment utilized in areas determined by accessibility and need. Chemical treatments will include cut-stump, basal bark, and spot foliar application. Chemical applications are most effective through the fall and winter as plants are drawing nutrients into their roots. Monsoon season should be avoided as access to arroyos may be limited due to surface water and quicksand. Mechanical removal can occur year-round, with retreatments following two years later to allow sufficient time for regrowth.

Semi-regular monitoring should occur every 3-5 years. Regular monitoring is imperative to the long-term success of this project.

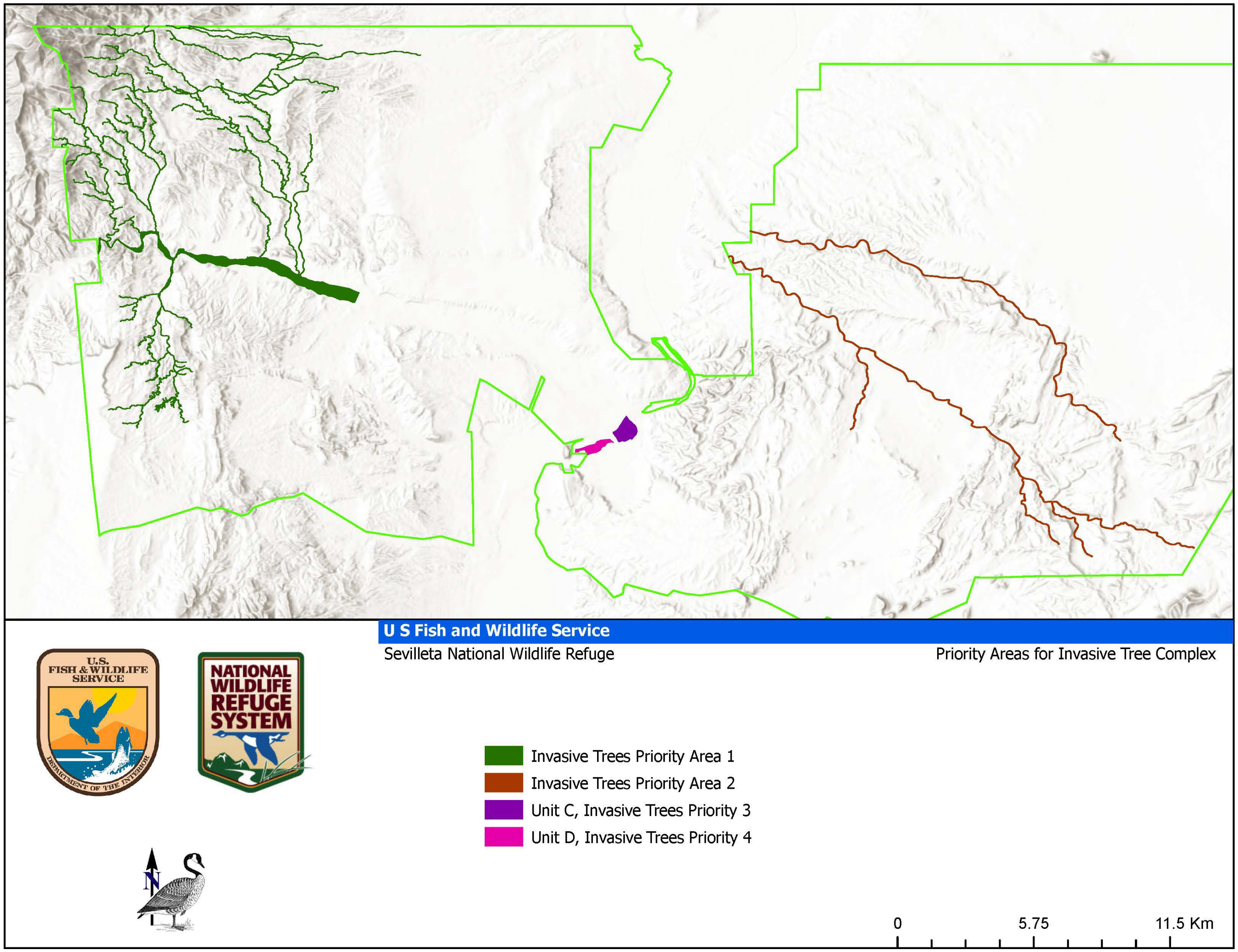

Figure 10: Invasive tree complex priority areas at Sevilleta National Wildlife Refuge.

Priority Area One, West Side Arroyos. The West Side arroyos have been extensively surveyed and treated over the last 10 years. Target areas (Figure 10) have been reduced to regrowth of individual trees. Basal spraying of these resprouts using 20-30% triclopyr butoxyethyl ester in oil will provide the desired level of control. Chemical follow-up treatments will continue every other year through 2026 or until less than 5% of the 2014 survey numbers are detected. In the event a larger tree is found, the cut stump technique using a chainsaw will be implemented where the cut stump will be sprayed with 20-30% triclopyr butoxyethyl ester as soon as possible.

Physical removal using a Pulaski or heavy equipment may occur if the need arises. Saplings can easily be removed with a Pulaski, but care must be taken to ensure the stem is severed below the root crown. If heavy equipment is found to be the best option, a backhoe or skid steer with masticator is sufficient for the small, densely populated patches found in these arroyos.

Access to the West Side arroyos will be by UTV. Travel by UTV will speed up the process and allow for extra chemical, gear, and safety equipment to be carried and used as necessary.

Priority Area Two, East Side Arroyos. The East Side arroyos have received spotty surveys and treatments over the last 10 years. About 70% of Palo Duro and about 50% of Cibola Canyons have received initial treatments. Basal spraying of resprouts using 20-30% triclopyr butoxyethyl ester in oil will provide the desired level of control. In new treatment areas, the cut stump technique using a chainsaw will be implemented where the cut stump will be sprayed with

20-30% triclopyr butoxyethyl ester within 15 minutes of cutting. Chemical follow-up treatments will continue every other year through 2027 or until less than 5% of the 2018 survey numbers are detected.

Physical removal using a Pulaski or heavy equipment may occur if the need arises. Saplings can easily be removed with a Pulaski, but care must be taken to ensure the stem is severed below the root crown. Where heavy equipment is found to be the best option, a backhoe or skid steer with masticator is sufficient for the densely populated patches found in these arroyos.

Palo Duro and Cibola Canyons both have relatively large dense patches that will require the use of heavy equipment or multiple stints of American Conservation Experience (ACE) saw crews for initial treatments. Without one or both of these methods, the project goals for the East Side arroyos will not be met.

Access to the East Side arroyos will be by truck or UTV. This will speed up the process and allows for extra chemical, gear, and safety equipment to be carried and used as necessary.

Priority Area Three, Unit C. Unit C received an initial treatment several years ago by the NM Fire District but needs successive treatments to ensure the long-term success of this project. ACE crews will be used for basal spraying of resprouts using 20-30% triclopyr butoxyethyl ester diluted in oil which will provide the desired level of control. In a 2.8 ha area of *T. ramosissima* that has not received initial treatment, a backhoe or skidsteer with masticator will be used for these larger trees. Removing the tree from below the root crown or follow up using a root rake will significantly reduce the number of resprouts. Biomass may be piled and burned or chipped on site.

Follow-up chemical treatments will continue after the initial ACE/ heavy equipment treatment year (2021) until *T. ramosissima* has been deemed to be less than 5% of the baseline population data. This is expected to be completed by 2028 but will continue until the target has been reached. At this time monitoring should continue at least every 3-5 years through 2040 to confirm *T. ramosissima* remains below 5% of the baseline population data. These surveys will occur during June - September, whenever convenient.

Priority Area Four, Unit D. Unit D received an initial treatment in April 2019 with a masticator but needs successive treatments to ensure the long-term success of this project. ACE crews under the direction of Sevilleta NWR staff will complete the proposed work. In addition to the work provided by ACE crews, a small portion of the unit will remain untreated to study the impacts of the tamarisk beetles as Unit D has been heavily infested with the tamarisk beetle over the last several years. Understanding the impacts of the beetle along the middle Rio Grande will provide valuable information for planning future projects.

Chemical treatments will continue after the initial ACE treatment year (2022) until *T. ramosissima* is less than 5% of the baseline population data (action threshold). The action threshold is expected to be reached by 2028. At this time monitoring should continue at least every 3-5 years through 2040 to confirm *T. ramosissima* remains below 5% of the baseline population data. These surveys will occur during June - September, whenever convenient.

4.3 Best Management Practices for Avoiding Non-Target Effects

Lepidium latifolium is chemically treated during the growing season, whereas *T. ramosissima* and *R. repens* typically fall at the end of the growing season in autumn through winter. Herbicides will be applied using low-volume hand-held applicators, i.e., backpack sprayers or from a UTV mounted spray tank. Best management practices include application at wind speeds between 3.2 - 16 kph (but not inversion conditions), calibration of application equipment, field scouting/monitoring before pesticide application, pesticide application buffers around sensitive areas, and following all label instructions. Mechanical work can be done any time of the year as long as site conditions allow. Management actions will be performed during times of the year to minimize impacts to nesting migratory birds.

4.4 Biosecurity and Reinvasion

The above management actions will require a significant investment. Ensuring that proper biosecurity protocols are implemented is imperative to prevent reinvasion. The Refuge has little control over spread vectors in some areas, such as the Rio Puerco *R. repens* population, while spread vectors in other areas can be more effectively controlled. It is better to prevent an invasion rather than attempt to eradicate or contain one once it is established.

The Refuge is bordered by ranch land, and cattle frequently trespass on Refuge lands, having been seen in every target area addressed in this Plan. Cattle can be important vectors for many undesirable species as well as being destructive of the landscape. Cattle often enter the Refuge through down fences in arroyos. When a storm of sufficient intensity occurs within the Refuge's drainage, fence inspections should immediately follow. It is better to take a few hours for fence inspections than risk a new invasive plant population establishing. Due to the size of the Refuge and cattle's tendency to roam, by the time a new invasive plant is detected it could be too late to eradicate.

Vehicles and equipment are another vector over which the Refuge has some level of control. Public roads that go through or adjacent to the Refuge, such as I-25 and County Road 12, will be problematic as vehicles traversing these roads could be carrying potential invaders. All vehicles and equipment, including those of researchers, should be properly cleaned before entering the Refuge. The most susceptible location will be the wetland areas open to public hunting. Placing signs around these areas and informing the public will help prevent unwanted seed from being transported onto the Refuge by dogs, boots, waders, or vehicles. Boot brush stations, such as those recommended by PlayCleanGo (Boot Brush Stations 2021) and the North American Invasive Species Management Association (NAISMA), are an excellent investment for prevention and biosecurity. Boot brush stations as well as other prevention and education materials may be purchased wholly or in part using NM ISST funds.

Even after SMART objectives have been met in target areas, it is still necessary to perform semi-regular surveys. Once every three to five years, Refuge staff, NM ISST, or volunteers should spend a couple of weeks to a month monitoring and mapping target areas to determine if they remain below their action thresholds. It is imperative that long-term monitoring occurs, without which reinvasion or secondary invasion could go undetected for many years.

MONITORING AND EVALUATION

5.1 Priority Species Distribution

Rhaponticum repens

Baseline data for *R. repens* was recorded for the Rio Puerco population in 2019 and the Rio Grande population in 2017. These data will be used to assess treatment effectiveness throughout the implementation of this Plan and subsequent monitoring activities.

Lepidium latifolium

Useful baseline data for *L. latifolium* at Sevilleta does not currently exist. Moving forward, treatments need to be recorded in great detail following the NM ISST TrackMan Data Collection Guidelines (2020) in order to produce useful baseline information by which to measure success.

Invasive Tree Complex

Invasive trees in the arroyos were assessed in 2011, 2013, 2014, and 2018 with handheld global positioning systems (GPS) to map the extent of invasive trees in the East and West Side arroyos. The products produced during this assessment were geospatial feature classes. The 2014 data will be used as a baseline for the West Side arroyos and the 2018 data for the East Side arroyos. Units C and D will have baseline inventories by 2022 to guide treatment decisions.

5.2 Individual Treatment Area Effectiveness

Geospatial information (e.g., polygon of treated area) and attributes [e.g., % infestation of polygon (<1% - Scarce, 1-10% - Poorly Represented, 10 - 25% - Well Represented, 25 - 60% - Abundant, >60% - Luxuriant)] for treatment areas will be collected in the field using TrackMan, a FWS-Southwest Region developed map for the mobile application "ArcGIS Field Maps" immediately following management activities. Field information will be collected using iOS or Android devices (cell phones or tablets). As soon as possible after collection (preferably same day), data are synced to FWS-Southwest Region's ArcGIS Online (AGOL) TrackMan Treatment map. ArcGIS Field Maps allows data to be collected in any vector (i.e., point, line, or polygon). Attributes collected include treatment date, chemical applied, application rate, etc. FWS Region 2 information collected through TrackMan is backed up annually, for permanent archiving, on ServCat.

After syncing with AGOL, geospatial features specific to these treatments at Sevilleta NWR may be downloaded and added to a local geodatabase. This will allow for all geospatial features associated with invasive species management actions at Sevilleta NWR to be: (1) housed and archived on a local system for analysis, (2) further attributed with information on follow up treatments and effectiveness, and (3) available to all individuals working on the project (Refuge staff and ISST).

Each treatment area will be monitored to determine success of control efforts. After initial treatment, sites will be revisited as prescribed above to monitor for live plants and/or resprouts. There is no specific protocol in place for monitoring, but guidelines are laid out in Section 5.3 Adaptive Monitoring and Management. In general, individuals revisiting treatment sites will estimate percent cover of live target plants and/or resprouts within the original treatment area to fit within the Percent Cover TrackMan categories. This estimate will be added to the attribute file (table) for associated treatment polygon or related geospatial feature. Subsequently, the attribute table will also be updated with follow up treatment methods, chemical applied, application rate and date. Only target invasive species will be monitored.

5.3 Adaptive Monitoring and Management

Monitoring is an essential part of invasive species management that is often neglected. To minimize the chances of not monitoring, the management actions recorded in TrackMan will be used as the monitoring data. A treatment will be seen as a plant detection for that year. If nothing is detected at that location in following treatment cycles, it will be deemed 100% control at that particular location. Both spatial information and chemical use can be used to assess effectiveness of management actions.

<u>*Rhaponticum repens*</u>

Baseline data exists for the *R. repens* populations. As management progresses subsequent treatments will be compared to this baseline data. For example, consider a baseline patch of *R. repens* of 465 sq m that was treated and recorded in 2017. This area was then retreated in 2018 and 2019 and recoded as 450 sq m and 110 sq m consecutively. We will then compare the areas recorded in treatment years to the baseline data taken in 2017. This yields a reduction of 3% the first year (2018) and a 76% reduction by 2019. With these results we know that our management has been effective. Monitoring should occur yearly for 5 years after the last plant is removed. Eradication is the goal for *R. repens* on the Refuge, thus a single plant will trigger management. If the treated areas result in bare ground or a secondary invasion occurs, our efforts will still be considered a success if *R. repens* has been eradicated from the site. This is because *R. repens* is the target. This Plan cannot specify management actions for an invasion that has yet to occur aside from prevention measure. If a secondary invader is detected, and is a state listed invasive species, EDRR will begin immediately and if necessary, this Plan modified to include said species.

<u>*Lepidium latifolium*</u>

Monitoring of *L. latifolium* will follow the same procedure as described for *R. repens*. However, baseline data does not currently exist for all areas. Future *L. latifolium* treatments need to be recorded in detail following the NM ISST TrackMan Data Collection Guidelines (2020) in order to produce useful baseline information by which to measure success. The action threshold for *L. latifolium* is 5% of total cover in the target area. Areas should be monitored indefinitely every other year to ensure the *L. latifolium* remains below the action threshold.

Invasive Tree Complex

The invasive trees will also follow the protocol described above but only where polygons are recorded, such as in the first year or two of treatments in Units C and D. For most of the East and West Side Arroyos, individual points will be recorded for each tree treated. In this situation a count of the current year's treated points divided by the baseline points will yield the percent of trees controlled. For example, if the 2014 survey of the West Side has 214 recorded points in target areas and in the same areas 37 points were recorded in 2019, that would indicate 83% of trees recorded in 2014 have been removed. This method does not account for new recruitment, but it is sufficient to determine effectiveness of management. The goal is to remove 95% of known trees, thus when individuals exceed 5% of baseline numbers, management is warranted.

5.4 TrackMan/ ArcGIS Field Maps

Field data, including maps and attributes, will be gathered using the mobile device application "ArcGIS Field Maps" using the FWS TrackMan map. The FWS-Southwest Region has a standardized mapping process and set of attributes collected though the mobile application "ArcGIS Field Maps". This is information is housed in a central AGOL server and backed up annually on ServCat, along with invasive species data from throughout the Southwest Region.

CONCLUSION

Sevilleta National Wildlife Refuge (NWR; the Refuge) encompasses 92,945 hectares in central New Mexico with ecosystems affected by numerous invasive plant species. Currently managed species include *Ailanthus altissima* (Tree of Heaven), *Elaeagnus angustifolia* (Russian olive), *Lepidium latifolium* (perennial pepperweed), *Rhaponticum repens* (Russian knapweed), *Tamarix ramosissima* (salt cedar), and *Ulmus pumila* (Siberian Elm). Sustaining and protecting NWR resources requires planning, on-the-ground active management, and partnerships with the surrounding communities and land management agencies of the Middle Rio Grande.

Each NWR in the U.S. FWS National Wildlife Refuge System provides landscapes that contribute to conservation of wildlife and their habitats. The Integrated Pest Management Plan (IPMP) is a guide to how (strategic management actions) and why (SMART objectives) the U.S. Fish and Wildlife Service manages the priority invasive species occurring on a particular refuge. My IPMP presents the goals, objectives, strategies, and guidance for managing invasive species, as well as the long-term vision, continuity, and consistency for the target species on Sevilleta NWR.

One key aspect of invasive plant management planning is prioritization: which species to work on, where, when, and how (Stone and Andreu 2017). Managing all non-native species within the defined action area is unfeasible. The Invasive Plant Inventory and Early Detection Prioritization Tool (IPIEDT) combined with a modified version of the Invasive Plant Management Prioritization Tool (version 1.0) (IPMPT) was used to rank the known invasive species on the Refuge. I used a combined version as each tool is designed to rank for different purposes. By incorporating the management aspect into prioritization using the IPMPT, I can account for the Rapid Response portion of EDRR and hopefully encourage more active management of EDRR species.

Species prioritization was completed with the combined version of the IPMPT and IPIEDT mentioned above. Results from the IPIEDT were brought into and averaged with IPMPT. Results and explanations of each criterion are available in Appendix D.

Selected areas for prioritization are Unit A, Unit A prime, Unit B, Unit C, Unit D, the East River Corridor, East Side Arroyos, and West Side Arroyos. Areas were prioritized based on five factors: ecological integrity, threatened and endangered species, natural pathways (water, hitchhikers on animals, wind), anthropogenic transport (vehicles and equipment, shoes, clothes), and disturbance. Definitions for these and the scoring criteria may be found in Appendix C.

Sevilleta NWR's conservation goals, objectives, past treatment, and EDRR requirements influenced ranking. Areas with relatively high ecological integrity frequently have high conservation value and are a priority for prevention and management of invasive species (De Leo and Levin 1997). I will use the Hybrid Score column to guide prioritization of invasive species management as this plan is implemented on Sevilleta NWR.

With the completion of prioritization and extensive research on the ecology and management of the target species, I was able to develop this IPMP for Sevilleta NWR. Without this prioritization work and assessment of target species and conservation assets, future management would lack direction and may not fully contribute to the protection of Sevilleta NWR's resources.

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APPENDICES

Appendix A

MANAGEMENT STRATEGIES

Rhaponticum repens

Rhaponticum repens can be very difficult to control once it is established. The best management tools are prevention, early detection, and eradication. Small stands should be eradicated first followed by the perimeter of larger stands to initiate containment. Tables 4 and 5 provide treatment recommendations for different areas of the Refuge.

Prescribed Fire

Prescribed fire is not an effective control method for *R. repens* as it tends to increase dominance of the plant. However, when the infestation is dense it may make it easier to manage with other methods by removing above ground plant matter. After burning plants will be easier to access for spot or broadcast treatments.

Physical

Most methods of physical removal show limited effectiveness. If used, these techniques are best applied in conjunction with herbicide. Spring rosettes of small, newly established populations may be hand pulled or hoed. Care must be taken to remove as much root as possible. Shallow cultivation or tillage can encourage growth, but deep cultivation (300+ mm) repeated over three or more years can be effective in reducing densities. Mowing two to three times through the growing season will suppress shoots and flower production but not affect densities. Such repeated mowing can increase the effectiveness of a fall herbicide application.

Chemical

Chemical control is the single most effective management tool for *R. repens*. The herbicides listed in Table 4 are known to significantly reduce populations but repeat applications should be expected. Table 4 is not an exhaustive list of available herbicides, rather only the most commonly used for *R. repens* on Refuge lands. The best time to apply herbicide on *R. repens* is in the fall after the first hard frost when rosettes appear and mature plants are dormant. Spraying too soon will only provide short term control and will likely not kill root systems. Backpack applications using aminopyralid at 5-10% should only be used over sparsely populated areas. Spraying dense patches of *R. repens* at 5-10% will result in quickly exceeding the legal application amount per year. Always consult the herbicide label prior to use for proper timing, application rate, environmental conditions, safety precautions, and resistance management recommendations.

Biological

Several biological control options exist for *R. repens*. Due to the small size of both of the known populations on Seviletta NWR, biological control is not a recommended strategy. Livestock can be used for targeted grazing, however the plant is bitter and animals tend to avoid it. The USDA has approved three biocontrol agents for use in the US: the gall wasp *Aulacidea acroptilonica*, a gall midge (*Jaapiella ivannikovi*), and a nematode (*Subanguina picridis*). Seed production and aboveground growth can be reduced by both the midge and the nematode, while the wasp has shown a reduction in competitive ability under controlled conditions (Gaskin and

Littlefield 2017). The nematode will form galls on stems, leaves, and root crowns, but is generally seen as ineffective. Recent research has indicated over the long-term *S. picardis* and *J. ivannikovi* will significantly limit the spread of *R. repens* by reducing seed set and length of fruit bearing branches, but it is suspected they will not reduce overall population levels since the primary mode of reproduction is by shoots arising from rhizomes (Story 2008, Marini et al. 2021, Gaskin and Littlefield 2017). For large, dense populations, *S. picardis* or *J. ivannikovi* could be viable options to combine with other control methods to maintain lower densities. The gall nematode *S. picridis* has been released in northwestern New Mexico to control *R. repens* with results similar to those seen in the studies referenced above.

<u>Cultural</u>

Prevention and early detection are essential to hindering *R. repens* establishment. Vehicles, staff, and equipment need to be checked for seeds and plant material and cleaned prior to entering uninfested areas. Additionally, livestock are known vectors; removing trespassing cattle as quickly as possible will limit their ability to spread seeds. Seeding following cultivation or herbicide treatment can help promote a healthy native plant community to compete with *R. repens* plants. Stressing root reserves and maintaining healthy native plant communities are essential to effective management of this species.

Table 4: Herbicide recommendations for *Rhaponticum repens*; adapted from "Field Guide to Managing Russian Knapweed in the Southwest" (2015).

Common Chemical Name (active ingredient)	Product Example	Product Example Rate per Acre (broadcast)	Backpack Sprayer Treatment Using Product Example	Timing of Application	Remarks
Aminopyralid	Milestone	4-6 fluid ounces	5-10%	Spring and summer at bud to flowering growth; or in late fall on dormant plants.	May be used in combination with 2,4-D. Use higher rate on older stands; late fall treatment of dormant plants can be very effective. Add 0.25-0.5 percent nonionic surfactant for mature plants or for adverse conditions. Labeled for use up to water's edge. No grazing restrictions.
Glyphosate	RoundUp, many products	4-4.8 quarts	2%	Late bud to early flower; late summer or fall.	Use primarily as follow up spot treatment. Direct spray or use a wipe method when desirable plants are present.
Imazapyr	Arsenal	2 pints	1%	Anytime plants are growing or in the fall after frost.	Use primarily as follow up spot treatment. Direct spray or use a wipe method when desirable plants are present. In addition to overspray, nontarget plants may also be killed or injured by root transfer of imazapyr between intertwined root systems.

Table 5: Management options for *Rhaponticum repens* as printed in the USDA "Field Guide to Managing Russian Knapweed in the Southwest (2015).

Site	Physical Methods	Cultural Methods	Biological Methods	Chemical Methods
Large Infestations on Roadsides, fence lines, or noncrop areas	Mow at 2 to 3 week intervals during growing season but before seed set. Follow up with an herbicide application in the fall.	Avoid driving vehicles and equipment through infested areas; wash if travel through these areas is unavoidable. Educate road crews and others to identify and report infestations.	A gall-forming nematode (Subanguina picridis) may be available in some western states including New Mexico.	Use truck or tractor mounted Spraying equipment to broadcast treat. Wash underneath vehicle after application to prevent spread.
Large Infestations on Rangeland, pasture, or riparian corridors	Deep cultivation (>12 inches) repeated over 3 years can be effective. Shallow cultivation/tillage is not recommended as severed root fragments may regrow. Burning is ineffective and may contribute to further knapweed dominance.	Use certified weed-free seed and hay. Use pellets for horses in backcountry areas. Check animals, clothing, and vehicles for seeds. Always evaluate the need to reseed with native perennial grass when considering knapweed control.	Graze heavily infested sites in late summer or early fall. Maintain litter cover to reduce knapweed germination. A gall-forming nematode (Subanguina picridis) is available in New Mexico.	In areas difficult to access, an ATV-mounted sprayer or backpack unit may be the most practical application methods. Wash underneath vehicle after application to prevent spread.
Wilderness, other natural areas, and/ or small infestations	Hand pulling, hoeing, or digging must remove all root stock to be effective; wear gloves for pulling; pull when soil is moist; most effective on newly established plants.	Use certified weed-free seed and hay. Use pellets for horses in backcountry areas. Check animals and clothing for seeds. Post signs warning visitors to remove seeds after passing through infested areas. Always evaluate the need to reseed with native perennial grass when considering knapweed control.	Same as above.	Use backpack or handheld sprayers. Broadcast spraying with ground methods may be used on thicker stands if allowed. Remove seed from clothing to prevent spread.

Lepidium latifolium

Well-established stands of *L. latifolium* are difficult to control, but that does not mean they cannot be eradicated. Early detection and aggressive management are the keys to management success when dealing with *L. latifolium*. Small, isolated populations should be targeted first followed by patches along waterways or other areas with a high likelihood of spreading. Expect eradication to take 3-10 years. If eradication is to be achieved in priority management areas at Sevilleta NWR, it will likely take closer to 10 years. Table 8 summarizes various control methods for different locations.

Prescribed Fire

Fire is not a recommended method as it can encourage growth. It may be useful to remove old growth prior to enacting other treatment methods.

Physical

Repeated physical control can be moderately effective, even more so if combined with herbicide application. Haphazard mowing can spread and increase the density of existing populations, however properly timed mowing can increase the effectiveness of herbicides. Mowing prior to flowering serves to deplete root reserves as the plant responds by resprouting. Applying herbicide to these resprouts at the early bud stage enhances the effectiveness of herbicides. Cultivation alone is not recommended but combined with mowing and herbicide it has been shown to yield up to 95% reduction in *L. latifolium* (Renz and Tomaso 2012). The process begins with disking in the fall followed by mowing in the spring/ early summer when plants begin to bud. Once the *L. latifolium* resprouts and buds again, apply herbicide. With both methods, multiple treatments should be expected.

Flooding is an effective management tool if sufficient water is available. Populations in California were nearly eradicated after inundation for 2 years. Other research indicates 70 days is sufficient to kill *L. latifolium* root systems (Renz 2000). Either way, flood margins will likely become populated and require management.

Chemical

Herbicides are a very effective tool for controlling *L. latifolium*, especially when combined with other techniques. Applications should be timed to coincide with the lowest root reserves, which is bud to early flowering growth stage in *L. latifolium*. Newly established plants should be sprayed immediately, as they have had insufficient time to develop large taproots to store carbohydrates. The high-water table and surface water limits herbicide options for Sevilleta NWR. Chemicals listed in Table 6 were used at the Refuge to control *L. latifolium* in 2019. Anecdotally, all three have reduced densities in the short term. Scientifically robust monitoring activities have not occurred. *Lepidium latifolium* has not been managed long enough or consistent enough to determine long term success of these chemicals. Glyphosate and triclopyr seem to have little to no effect on desired salt grass and may be the best option when boom spraying is required. Imazapyr is very effective, but due to its non-selective control it is recommended for spot spraying only. Always consult the herbicide label for proper timing, application rate, environmental conditions, safety precautions, and resistance management recommendations.

Table 6: Herbicide recommendations for *Lepidium latifolium* at Sevilleta NWR. Adapted from the USDA "Field Guide to Managing Perennial Pepperweed in the Southwest" (2014).

Common Chemical Name (active ingredient)	**Product Example**	**Product Example Rate per Acre (broadcast)**	**Backpack Sprayer Treatment Using Product Example[2]**	**Time of Application**	**Remarks**
Glyphosate	Rodeo, RoundUp, others	Depends upon formulation: 3 quarts Rodeo 1 gallon RoundUp	Rodeo: 0.75-2% + NIS RoundUp: 2%	Flower bud stage.	Nonselective; if infestation is dense, mow, then apply glyphosate when regrowth reaches flower bud stage. Rodeo is labeled for use in or near aquatic areas. Good treatment if reseeding is planned.
Triclopyr (amine, acid, or choline formulation)	Garlon 3A, Trycera, Vastlan, others	3 quarts	5%	Flower bud stage in spring or in the fall to rosettes.	Selective; safe for most perennial grasses; add 0.25% v/v NIS[3]; labeled for riparian areas and use near water bodies; chemically mow second application: 2 quarts/ac is effective.
Imazapyr	Arsenal, Habitat, others Polaris AC Complete	2-3 pints 1-1.5 pints	3-5% 2.5%	Same as above.	Nonselective; total vegetation control. Labeled for fence lines, rights-of-way, railways, and aquatic situations. Add 0.25% v/v NIS[3] for postemergent use. In addition to overspray, death or injury of nontarget plants may occur from root transfer of imazapyr between intertwined root systems.

Biological

Grazing can suppress spring growth, but *L. latifolium* quickly recovers once animals are removed. Once the plant begins to bud, livestock generally avoid it. Classical biocontrols are not available for *L. latifolium*. Closely related native plants and crops have limited research into identifying viable biocontrol options. A native rust and several herbivorous insects have been found to use *L. latifolium* as a host plant, but neither seem to have much impact (Zouhar 2004).

Cultural

Prevention and early detection are paramount to preventing *L. latifoilum* establishment. Vehicles, staff, and equipment need to be checked for seeds and plant material and cleaned prior to entering uninfested areas. Additionally, livestock are potential vectors; removing escaped cattle as quickly as possible will limit their ability to spread propagules. Seeding following management activities can help promote a healthy native plant community to compete with *L. latifolium* plants. Stressing root reserves and maintaining healthy native plant communities are essential to effective management of this species.

Table 7: *Lepidium latifolium* management options as reported in the USDA "Field Guide to Managing Perennial Pepperweed in the Southwest (2014).

Site	Physical Methods	Cultural Methods	Biological Methods	Chemical Methods
Large Infestations on Roadsides, fence lines, or noncrop areas	Mow at flower bud stage; apply herbicide to resprouts. Hand pull or grub small patches.	Clean machinery following activity in infested areas. Train road crews and the public to identify and report infestations; map reported populations.	Biological control agents are unavailable.	Spray at flower bud stage. For ground application, use truck-mounted or tractor-pulled spraying equipment. Wash under vehicle after application to prevent spread.
Large Infestations on Rangeland, pasture, or riparian corridors	Disking alone can spread the weed; combine any cultivation with herbicide control. Use of prescribed fire is not recommended except to remove dead material.	Use certified weed-free seed and hay. Monitor areas where soil was imported or hay bales were used for erosion control. Reseed with plants that are desirable and will provide competition.	Use prescribed grazing strategy with sheep or goats in the spring followed by herbicide control at flower bud stage. Closely manage grazing to prevent overuse. Biological control agents are unavailable.	Spray at flower bud stage. For extensive and dense infestations, use ground or aerial broadcast spraying. For sparse infestations, use backpack or hand-held sprayer. Wash under vehicle after application to prevent spread.
Wilderness, other natural areas, and/ or small infestations	Hand pull or grub small patches; remove as much of the root as possible; bag and dispose of debris appropriately.	Educate the public to identify and report infestations. After passing through infested areas, inspect and remove any seed or root fragments from animals, clothing, and vehicles.	Same as above.	Spray at flower bud stage. Use backpack or hand- held sprayers or use wick method for individual plant treatment (IPT). Broadcast spraying by aerial or ground methods may be used on thicker stands, if allowed.

Invasive Tree Complex (*T. ramosissima*, *E. angustifolia*, *U. pumila*)

Managing *T. ramosissima*, *E. angustifolia*, and *U. pumila* infested areas is most effective using an integrated approach. Control methods for all three species must target and destroy root systems to obtain complete control. Techniques that only remove above ground portions will suppress trees, but regrowth is almost guaranteed. Expect 5-10 years of control efforts to achieve effective management. In areas of dense infestations, heavy equipment and restoration activities may be required.

Prescribed Fire

Fire is not a recommended management tool. It can be used to suppress growth, but trees will vigorously resprout post fire. Fire is useful for removing brush piles or standing dead after herbicide applications.

Physical

Small individual plants may be removed with a shovel, weed wrench, or Pulaski, but care must be taken to ensure as much root material as possible is removed. Plants should be stacked and dried prior to disposal.

Heavy equipment is commonly used for both individual plant treatments and clearing of large stands. All methods utilizing heavy equipment will be very destructive, and how destructive depends on size and density of infestation, size of equipment used, specific technique used, and how accessible the location is. The following techniques described by Taylor and McDaniel (1998) are commonly used when removing individuals and large stands. Grubbing is useful for low density areas of relatively small trees. A grubbing blade is attached to the front of a tractor and drug below the soil surface to sever root systems below the root crown and bring the roots to the surface to be piled and dried. For larger individual trees, excavation is implemented. The bucket is placed beneath the root crown with an opposing arm gripping the tree; the operator pulls upward plucking the tree from the soil. Denser infestations may require the use of a masticator to remove above ground portions first, then resprouts are excavated or chemically treated 2-3 years later. Biomass from mastication should be piled, dried, and burned. In extensive monocultures, root plowing and raking may be the best option. Above ground trees are cut at the soil surface with a D-7/8 class dozer with a front mounted brush blade. Biomass is then piled to dry for later burning. Following above ground removal, a large root plow is pulled behind a D-7/8 class dozer to sever root crowns from the remaining root system. This material will be brought to the surface and piled with other biomass to dry and burn. None of these methods will provide 100% control, and chemical treatments should follow mechanical removal after 2 years of growth has been established.

Chemical

Herbicides are the most common control method for these trees. Which herbicide to use and how to apply is influenced by the time of year to be sprayed, the plants' growth form, site accessibly, and threatened and endangered (T&E) species restrictions. The density of populations and proximity to desirable plants and T&E species complicates how best to proceed with herbicide control. Herbicide application is rarely 100% successful on the first attempt. It is important to expect that treated areas will need to be monitored and retreated for several years. Most chemical applications will be limited to either basal spraying in retreatments areas or cut stump in newly treated areas. See Table 9 for specific herbicide recommendations. Always consult the herbicide label for proper timing, application rate, environmental conditions, safety precautions, and resistance management recommendations.

Table 8: Herbicide recommendations for the invasive tree complex at Sevilleta NWR. Adapted from the USDA "Field Guide to Managing Russian Olive in the Southwest" (2014), "Field Guide to Managing Salt Cedar in the Southwest" (2014), and "Field Guide to Managing Siberian Elm in the Southwest" (2014).

Common Chemical Name (active ingredient)	Product Example	Product Example Rate per Acre (broadcast)	Backpack Sprayer Treatment Using Product Example	Time of Application	Remarks
Glyphosate	Rodeo, RoundUp Pro, others	Rodeo: 3-7.5 pints Roundup: 1.5-3.3 quarts	**Foliar** Rodeo: 1.5 - 3.5% RoundUp: 5% **Frill, girdle, or cut stump**: 50-100%	Foliar spot treatment: spring (April to May). Frill or injection: winter Cut Stump: Anytime	Nonselective herbicide; can injure surrounding plants and open more area for weeds. Frill, girdle, or cut stump: 50-100% concentration. Follow label for mixing instructions.
Imazapyr	Habitat, Arsenal, others	2-4 pints	**Foliar:** 1 - 5%	Summer to fall (Aug. to Sept.); when actively growing and fully leafed.	Use foliar spray for seedlings and saplings. Frill or girdle: use undiluted. Cut-stump: use 10% imazapyr with 90% methylated seed oil. Habitat okay for riparian use. Nontarget plants may be killed or injured by root transfer of imazapyr between intertwined root systems.
Triclopyr ester	Garlon 4, Trycera, others	NA	**Low volume foliar:** 1.5 % **High volume foliar:** 1.0% **Cut stump/ basal bark:** 20 - 30%	Basal bark: winter to early spring; Foliar: After full leaf (late spring to early summer). Cut Stump: Anytime	Selective, systemic broadleaf herbicide; low soil activity. For basal bark or cut stump, use 20-30% triclopyr with 70-80% carrier oil. Garlon 4 volatilizes above 86 °F.

Biological

Biological control agents have only been approved for *T. ramosissima*, however goats may be used for a short term intense grazing regimen on *U. pumila* and *E. angustifolia*. Grazing will only suppress trees, and the best results will come from an integrated approach. The tamarisk beetles (*Diorhabda* spp.) were released in several states across the Southwest from 2001 - 2009, after which the USDA issued a moratorium on their release due to concerns over affects to the Southwestern Willow Flycatcher. Despite this, *Diorhabda* beetles have spread extensively over the last 10-20 years. The beetles will not eradicate *T. ramosissima* but provide additional pressure to suppress growth.

Cultural

Education and monitoring are important components of any IPM program. Some nurseries still stock *E. angustifolia* and *U. pumila* as ornamentals for commercial and residential use. Educating the public on the environmental impacts of these trees can increase private landowner control efforts and prevent future planting. Monitoring is essential to evaluate treatment effectiveness and progress.

APPENDIX B

WORK SCHEDULE

Unless otherwise noted, all work will be completed by the NM ISST.

Rhaponticum repens

Fall treatments should occur shortly after the first hard frost.

Fall/ Winter 2021 - 2 Weeks

- NM ISST will treat both Rio Puerco and Rio Grande populations with aminopyralid at 7 oz/ac in densely infested sites or with a 4% solution at sparsely populated areas. An MSO surfactant should be used at 1%.
- The remainder of the 172 ha of potential habitat along the Rio Grande will be surveyed. Any additional infestations will be mapped. If any new populations are identified, the NM ISST will assess the extent and determine if these populations can be rolled into the current treatment plan or if the Plan for *R. repens* will need restructuring for Rio Grande sites.

Fall/ Winter 2022 - 2 Weeks

- NM ISST will monitor and treat *R. repens* populations at both Rio Puerco and Rio Grande locations with aminopyralid at 7 oz/ac in densely infested sites or with a 4% solution at sparsely populated areas. An MSO surfactant should be used at 1%.

<u>Fall 2023 - 1 Week</u>

- NM ISST will monitor the Rio Grande site. At this point no detections of *R. repens* are expected. If this is not the case treatment options and schedule of work will be reassessed. Originally mapped populations (2018) will have been eradicated when no detections have been made for 5 years.
- NM ISST will monitor and treat the Rio Puerco populations with aminopyralid at 7 oz/ac in densely infested sites or with a 4% solution at sparsely populated areas. An MSO surfactant should be used at 1%.

<u>Fall 2024 - 1 Week</u>

- NM ISST will monitor the Rio Puerco site. At this point no detections of R. repens are expected. If this is not the case treatment options and schedule of work will be reassessed. Originally mapped populations (2019) will have been eradicated when no detections have been made for 5 years.

<u>Invasive Tree Complex</u>

Late summer into fall, post-monsoon season is the ideal treatment window. As surveys and monitoring occur for invasive trees, other invasive species will be marked as they are observed.

East and West Side Arroyos

Fall 2021. 6 Weeks. NM ISST will continue monitoring and treatments in the east arroyos.

- Management will begin with retreatments in Palo Duro Canyon followed by retreatments in Cibola Canyon.
- Once monitoring and retreatments have been concluded, the NM ISST will begin initial surveys of Palo Duro Canyon where it continues to the east and crosses Tomasino Road splitting into Aqua de los Torres and Salas Arroyo.
- If the above tasks are complete and time remains, the NM ISST will begin initial treatments from Palo Duro Road east to Cibola spring.

Fall 2022. 6 Weeks

- Monitor and retreat invasive trees in arroyos on the West Side of the Refuge.
- The NM ISST will survey the remaining arroyos on the West Side focusing on those occurring on the southern end. If time remains after surveys have been completed, NM ISST will initiate treatments in the newly surveyed areas.

<u>Fall 2023.</u> 6-8 Weeks

- ACE crews should be requested for 6-8 weeks of work conducting cut stump applications in the most densely populated areas beginning with Palo Duro Canyon from the pipeline road west to the boundary. If this is completed, they will move to Cibola Canyon at Palo Duro Road and work west.
- NM ISST will continue monitoring and retreatments in the east arroyos while ACE is working through Palo Duro Canyon.
    - Once monitoring and retreatments are complete, work will resume from Palo Duro Road east to Cibola Spring.
    - NM ISST will then focus on clearing Cottonwood Tank, survey the unnamed tank at 34.283737, -106.619103, and retreat Hidden Tank.
    - Should the above be completed, surveys will begin at Arroyo Rosa de Castillo, Arroyo Varrido, Arroyo Milagro, Arroyo los Alamos, Pascual Arroyo, and Maes Arroyo.

<u>Fall 2024.</u> 6 Weeks

- By 2024 invasive trees in most arroyos on the West Side should be below the action threshold of 5% of 2014 survey numbers. NM ISST will monitor and retreat these areas beginning with the southernmost arroyos that have received fewer treatment cycles.

- Should this be completed in less than 6 weeks, surveying of new areas on the West Side will occur.

Fall 2025. 6 Weeks

- ACE crews should be requested for 8 weeks of work conducting cut stump applications in the most densely populated areas in Cibola Canyon from Palo Duro Road west to the boundary. If this is completed, they will move to any untreated areas that remain.
    - If sufficient staff and equipment are available, mechanical removal by skid steer, backhoe, or both should be strongly considered. This could be combined with ACE crew time to quickly move through the dense areas found in Cibola Canyon.
- NM ISST will continue monitoring and retreatments in the east arroyos while ACE is working through Cibola Canyon.
    - Surveys of Arroyo Rosa de Castillo, Arroyo Varrido, Arroyo Milargro, Arroyo los Alamos, Pascual Arroyo, and Maes Arroyo will continue. Once Surveys have been completed, these areas will be assessed and prioritized for treatment.
    - NM ISST will join removal in Cibola Canyon conducting cut stump operations. If they have the appropriate certifications, they may also assist with mechanical removal.

Fall 2026. 3 Weeks

- By 2026 invasive trees in most arroyos on the West side should be below the action threshold of 5% of 2014 survey numbers. NM ISST will monitor and retreat these areas beginning with the southernmost arroyos that have received fewer treatment cycles.
- Should this be completed in less than 3 weeks, the remaining time will be spent on initial treatments on the east side. If none remain, then surveying of any areas that have been missed will occur.

Fall 2027. 6 Weeks

- If any densely populated areas remain in Cibola Canyon, an ACE crew will be requested for the appropriate time frame to complete. If ACE is deemed unnecessary but initial treatments are still required, NM ISST will conduct these treatments.
- NM ISST will monitor and retreat all arroyos on the east side that have received initial treatments prior to 2027.

Fall 2029. 3 Weeks

- Initial treatments should have been completed through both Palo Duro and Cibola Canyons. If not, a new timeline and work plan should be developed.
- NM ISST will monitor and retreat all of Palo Duro and Cibola Canyons including any adjacent tanks or drainages that have received initial treatments since 2019.

Fall 2031. 5 Weeks

- NM ISST will monitor and retreat all of Palo Duro and Cibola Canyons including any adjacent tanks or drainages that have received initial treatments since 2019.
- West Side arroyos will be monitored and receive treatments as necessary by NM ISST. Should the 5% threshold be exceeded, future treatment strategies will be developed to ensure integrity of cleared areas.

Units C and D

Both units will be managed using Sevilleta NWR personnel and funding.

2021. 2 Weeks

- Sevilleta NWR staff will conduct initial surveys to obtain baseline data.
- Refuge staff or partners will remove the remaining 2.8 ha of *T. ramosissima* from Unit C using heavy equipment.

Fall 2022. 4 Weeks (2 Stints) of ACE crews

- ACE crews will conduct basal bark treatments in Unit D.

Fall 2023. 4 Weeks (2 Stints) of ACE crews

- ACE crews will conduct basal bark treatments in Unit C.

Fall 2024. 4 Weeks (2 Stints) of ACE crews

- ACE crews will conduct basal bark treatments in Unit D.

Fall 2025. 4 Weeks (2 Stints) of ACE crews

- ACE crews will conduct basal bark treatments in Unit C.

Fall 2026. 4 Weeks (2 Stints) of ACE crews

- ACE crews will conduct basal bark treatments in both Units C and D.

Fall 2027. 2 Weeks (1 Stint) of ACE crews

- ACE crews will conduct basal bark treatments in both Units C and D.

Fall 2028. 2 Weeks (1 Stint) of ACE crews

- ACE crews will conduct basal bark treatments in both Units C and D.

2029 - 2034. Monitor Units C and D to ensure *T. ramosissima* remains below the action threshold.

Lepidium latifolium

The ideal treatment window is mid-May through mid-June. All applications should fall into this window.

2022. 3 weeks

- NM ISST will spend three weeks in May - June treating *L. latifolium* across the wetland units beginning in Unit B moving to Unit A Prime, then Unit A.

2023. 3 weeks

- NM ISST will spend three weeks in May - June treating *L. latifolium* across the wetland units beginning in Unit B moving to Unit A Prime, then Unit A.
- Treatment effectiveness will be assessed in 2023. If expected progress has not been made, methods and work plan will be revised.
- Seeding of native plants should be strongly considered at this point. A healthy native plant community will help prevent the spread and reinvasion of *L. latifolium*.

2024. 3 weeks

- NM ISST will spend three weeks in May - June treating *L. latifolium* across the wetland units beginning in Unit B moving to Unit A Prime, then Unit A..
    - It is expected that the wetland units should be approaching or below the action threshold of 5% of baseline levels.

2025. 3 weeks

- NM ISST will spend three weeks in May - June treating *L. latifolium* across the wetland units beginning in Unit B moving to Unit A Prime, then Unit A.
    - It is expected that the wetland units should be approaching or below the action threshold of 5% of baseline levels.

2026. 2 weeks

- NM ISST will spend two weeks in May - June treating *L. latifolium* across the wetland units beginning in Unit B moving to Unit A Prime, then Unit A.
    - It is expected that the wetland units B, A Prime, and A will be below the action threshold of 5% of baseline levels.
- Progress will be assessed again to determine if local eradication is a possibility or if *L. latifolium* management will be a long-term objective.

- Additional seeding of native plants should be strongly considered at this point. A healthy native plant community will help prevent the spread and reinvasion of *L. latifolium*.

APPENDIX C

NM ISST DATA COLLECTION GUIDELINES

Please follow these guidelines when collecting data on NM National Wildlife Refuges with the TrackMan application in ArcCollector. It is imperative for land managers that the data collected paints an accurate picture of the infestation in the field. Precise data collection will assist in planning (ex. initial and follow up treatments), analysis (ex. determining distribution and habitat preferences), reporting, and the monitoring of treatment efficacy. The scale of data collection is very important. These guidelines seek to maximize efficiency in the field while supporting informative data collection for programmatic analysis. Failing to complete as many fields as possible in the attribute table renders the data far less useful than it could be.

Treatment Type:

Chemical = herbicide application.

Mechanical = manual treatment of the plant, includes mechanized tools such as heavy equipment.

Invasive Plant Detection = infestation mapped, no treatment.

If only a portion of an infestation is treated, map just the treated portion and record the rest of the infestation separately as a Ping-a-Poly. If the untreated plants are part of a larger infestation that has been previously mapped or treated, record a new feature of the area to track progress. For example, say a 1 ha patch was treated in 2018 and retreated in 2019 but in 2019 only 0.5 ha was able to be retreated and a portion remained untreated that year. Map the retreatment as a Chemical Polygon and the untreated area as a Ping-a-Poly in order to have a record of the entire patch size in 2019.

Figure 11: Examples of how invasive species patches should be recorded. If only a portion of an infestation is treated, map just the treated portion and record the rest of the infestation separately as a Ping-a-Poly. If the untreated plants are part of a larger infestation that has been previously mapped or treated, record a new feature of the area to track progress. For example, say a 1 ha patch was treated in 2018 and retreated in 2019 but in 2019 only 0.5 ha was able to be retreated and a portion remained untreated that year. Map the retreatment as a Chemical Polygon and the untreated area as a Ping-a-Poly in order to have a record of the entire patch size in 2019.

Feature Type:

Point (PT) = a small, discontinuous patch (<2.5 sq m)

1. Record one GPS point in the center of the patch.
2. If plants are separated by more than 3 m, they should be recorded as separate points.
3. Area Treated At this Point = Estimate the length and width of the infestation being mapped and generate the area of the patch in square feet (Length x Width). A 1.5 m by 1.5 m (or .75 m radius) patch is the largest size to be recorded as a point.

Line (LN) = a linear patch; most often a road, trail, or arroyo

1. Line Treatment Type = Indicate which side of the line the treatment occurred.
2. Total Treatment Width in Feet = Estimate the width of the infestation being mapped

in feet. This will be used to generate total area treated (Length x Width) during data post-processing.

Polygon (Poly) = A large patch (>2.5 sq m) that is non-linear

1. Map the perimeter of the treatment area as accurately as possible.
2. Be sure to map the entire survey area separately from the treatment area using the Ping a Poly layer and make a note in the Comments that this area was surveyed. For example, if you sprayed three 465 sq m patches over 2 ha, you would record the 3 small patches as a Chemical Poly and the 2 ha survey area as a Ping-a-Poly.

For all feature types, fill in Application Rate_Value, Application Rate_Units, Application Method, Amount Applied_Value, Amount Applied_Units, Application Equipment, Applicator Operator Affiliation, and Treatment Location Type.

Percent Cover is the aerial cover of invasive plants covering the ground surface. Visualize the feature you are recording (Area Treated) and estimate the percentage of that area that is covered by the infestation. The tendency is to overestimate! Be aware of this.

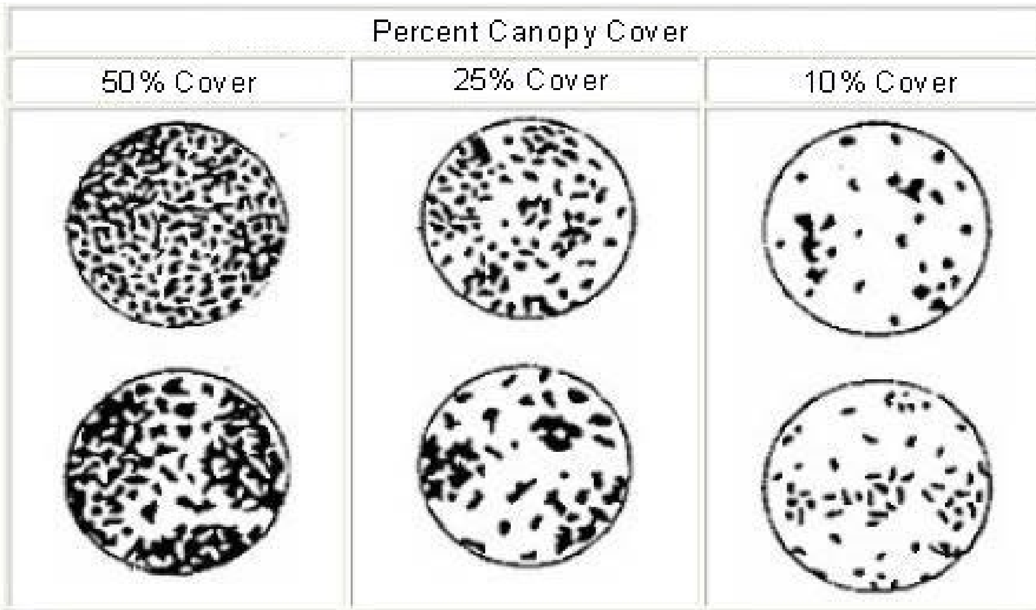

Figure 12: Examples of percent canopy cover to help visualize cover of infestation.

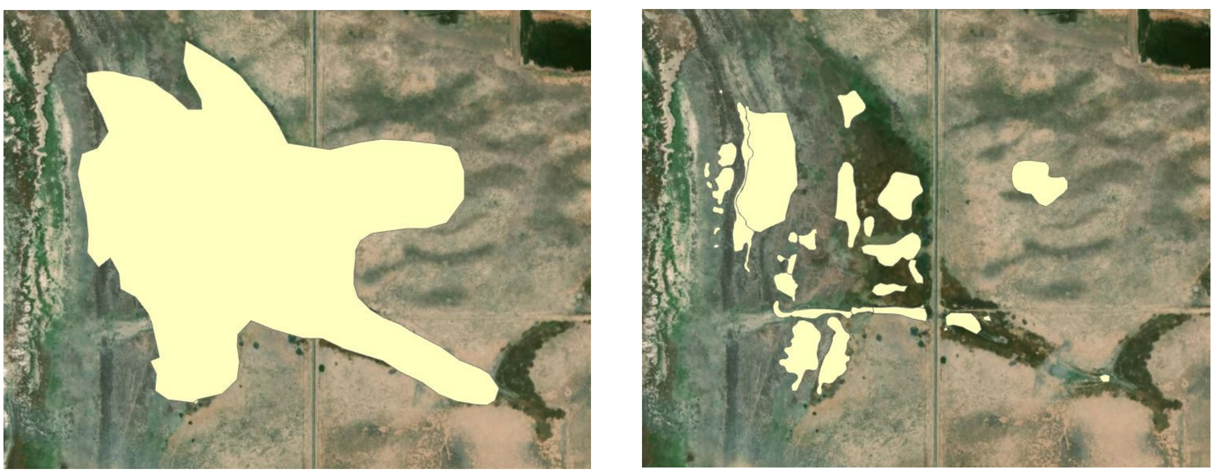

Figure 13: Preferred mapping techniques to use at Sevilleta National Wildlife Refuge. These are the same areas mapped two different ways. The image on the left depicts the overall survey area where the right image shows the specific patches that were treated. The right image provides more useful data and is the preferred method.

APPENDIX D

RESULTS OF THE INVASIVE PLANT MANAGEMENT PRIORITIZATION TOOL

The prioritization tool can be overwhelming. Each tab steps you through the individual phases of the process. The “Spp. Classification” tab identifies each species found on the Refuge and which Units it is known to be present in. This section also lays out which IPM techniques are available and known to be effective as well as the general objective for each species.

The “Area Data Wt” tab ranks each area of the Refuge based on 5 criteria. The weighted values applied to each criteria are subjective and may be changed to reflect the specific Refuge addressed. The *Weighted Score* is used in the final ranking. It is important to revise these weights before any areas are added into the table to reduce any bias. Areas are ranked from highest priority to lowest. The Scores for the entire Refuge are the average values for each category.

The “Spp Data x Area Wt” tab ranks each species on 8 different criteria and combines the data from with the “Area Data Wt”. These 8 Criteria weights are also subjective and may be changed to reflect the Refuge being assessed. It is important to revise these weights before any species are added into the table to reduce any bias.

The “IPIEDT Results” tab takes the results from the IPIEDT Tool and brings them into the spreadsheet. This provides a second ranking criteria that assesses both Areas and Species. By bringing in these additional results we further limit any personal bias that may exist in the ranking system.

The “Spp x Area + IPIEDT” tab contains the final results of the ranking assessment for the Refuge as a whole and each of the individual units. This is the data that should be used to inform management decisions. The *Species Data x Area Wt Priority Score* is scaled to match the *IPIEDT Scores* so each are weighted similarly.

Spp Obectives are the SMART objectives for each individual species. Not every species needs a SMART objective. You may only plan to initially manage one or two species. As such, you will only need SMART objectives for those species you plan to actively manage. The examples included are for the entire Refuge; SMART objective should also be established for each unit where management will occur. The *Combined Rank* column contains script to pull the value in, all you need to do is enter the *Species* and *Unit*.

The *Area Maps* provide cumulative data for each species. Unless indicated otherwise, all points, lines, or polygons represent past management actions. Extent of infestation is a rough estimate based on this incomplete data. Since every population likely has not received treatment, it should be assumed that the extent of each species is greater than represented in these maps.

The “Spp Definitions” and “Area Definitions” tabs provide explanations of the ranking criteria used on the “Area Data Wt” tab and the “Spp Data x Area Wt” tab.

Species Classification

Table 9: Classification of species with respect to areas of occurrence. The Objectives Formations represents the target objective of each priority species in that area. The Treatment Strategies group depicts the available treatment options for each species in each area.

		Objectives Formation					Treatment Strategies			
Area (Scope)	Species	Area EDRR (Prevention)	Eradication	Containment (Reduce small populations)	Long-term Management (widspread throughout area)	Isolated Exclusion (T&E, target plant comm)	Mechanical	Chemical	Bio	Cultural (Competition) - Natural restoration/ reforestation
Sevilleta	Ailanthus altissima	x						x		
	Elaeagnus angustifolia				x		x	x		
	Lepidium latifolium				x			x		
	Rhaponticum repens		x					x		
	Saccharum ravennae	x					x	x		
	Tamarix ramosissima				x		x	x		
	Ulmus pumila				x		x	x		
The following are rough estimates based on past data. For better prioritization a thorough inventory is needed.										
East Arroyos	Elaeagnus angustifolia		x				x	x		
	Tamarix ramosissima			x			x	x		
	Ulmus pumila		x				x	x		
East River Corridor	Elaeagnus angustifolia			x			x	x		
	Lepidium latifolium	x						x		
	Rhaponticum repens		x					x		
	Saccharum ravennae	x					x			
	Tamarix ramosissima				x		x	x		
	Ulmus pumila			x			x	x		
Unit A	Elaeagnus angustifolia			x			x	x		
	Lepidium latifolium			x				x		
	Saccharum ravennae	x					x	x		
	Tamarix ramosissima				x		x	x		
	Ulmus pumila			x			x	x		
Unit A'	Elaeagnus angustifolia			x			x	x		
	Lepidium latifolium			x				x		
	Saccharum ravennae	x					x	x		
	Tamarix ramosissima				x		x	x		
	Ulmus pumila			x			x	x		
Unit B	Elaeagnus angustifolia			x			x	x		
	Lepidium latifolium			x				x		
	Saccharum ravennae	x					x	x		
	Tamarix ramosissima				x			x		
	Ulmus pumila			x				x		
Unit C	Elaeagnus angustifolia			x			x	x		
	Tamarix ramosissima				x		x	x		
	Ulmus pumila			x			x	x		
Unit D	Elaeagnus angustifolia			x			x	x		
	Tamarix ramosissima				x		x	x		
	Ulmus pumila			x			x	x		
West Arroyos	Elaeagnus angustifolia		x				x	x		
	Rhaponticum repens		x					x		
	Tamarix ramosissima			x			x	x		
	Ulmus pumila		x				x	x		

Area Data Weight

Table 10: IPMPT ranking of priority areas at Sevilleta National Wildlife Refuge. The top row, "Sevilleta" is an average of the Units listed below to represent the Refuge as a whole. Each category is ranked based on criteria found in Appendix D. The "Score" is an average of scores across each Unit row. The "Weighted Score" weights values based on importance to the Refuge. Ecological Integrity and T/E Species make up 80% of the Weighted Score and Natural Pathways, Anthropogenic Transport Vectors, and Disturbance contribute 20% to the Weighted Score.

Area	Ecological Integrity	T/E Species	Natural Pathways	Anthropogenic Transport Vectors	Disturbance	Score	Weighted Score
	V. Good: 10 Good: 7 Fair: 3 Poor: 1 Unk: 3	High: 10 Med: 5 Low: 0 Unk: 5	No: 0 Low: 3 Med: 7 High: 10	No: 1 Low: 3 Med: 5 High: 10	High: 10 Med: 5 Low: 1		
Weighted Values -->	0.8		0.2				
Sevilleta	4.50	2.50	9.25	3.50	4.63	**4.88**	**3.96**
Unit A Prime	5	5	10	5	10	**7.00**	**5.67**
East River Corridor	5	5	10	5	5	**6.00**	**5.33**
Unit A	5	5	10	5	5	**6.00**	**5.33**
Unit B	3	5	10	5	5	**5.60**	**4.53**
East Arroyos	8	0	10	1	1	**4.00**	**4.00**
West Arroyos	8	0	10	1	1	**4.00**	**4.00**
Unit C	1	0	7	3	5	**3.20**	**1.40**
Unit D	1	0	7	3	5	**3.20**	**1.40**

Species Data x Area Weight

Table 11: Scores from the IPMPT for area and species combined for an Area/Species rank. Higher scores indicate a higher priority.

Weighting --->	Level of Establishment	Rate of Invasiveness	Threat to Bio Priorities	Level of Effort to Control	# of Treatments for Control	Response to Control Method	Costs	Ease of Logistics	Sum of Weights
	0.3	0.15	0.25	0.1	0.05	0.05	0.05	0.05	1

Scope	Species	Level of Establishment	Rate of Invasiveness	Level of Threat to Resource	Level of Effort to Control	# of Treatments for Control	Response to Control Method	Costs	Ease of Logistics	Priority Score for Treatment	Area Score (Weighted)	Hybrid Score	Rank
Sevilleta	Ailanthus altissima	10	10	10	7	3	7	10	10	9.20	3.96	3.64	1
	Elaeagnus angustifolia	7	10	5	7	3	3	10	10	6.85	3.96	2.71	2
	Lepidium latifolium	7	7	10	10	5	5	10	10	8.15	3.96	3.23	3
	Rhaponticum repens	9	5	10	10	7	7	10	10	8.65	3.96	3.42	4
	Saccharum ravennae	10	3	5	10	5	7	10	10	7.30	3.96	2.89	5
	Tamarix ramosissima	5	5	10	7	3	7	10	10	6.95	3.96	2.75	6
	Ulmus pumila	7	3	5	7	5	7	10	10	6.10	3.96	2.41	7
East Arroyos	Elaeagnus angustifolia	9	10	5	7	3	3	10	10	7.45	4.00	2.98	1
East Arroyos	Tamarix ramosissima	5	5	10	7	3	3	10	10	6.75	4.00	2.70	2
East Arroyos	Ulmus pumila	7	3	5	7	5	5	10	10	6.00	4.00	2.40	3
East River Corridor	Elaeagnus angustifolia	7	10	5	7	3	3	10	10	6.85	5.33	3.65	4
East River Corridor	Lepidium latifolium	8	7	10	10	5	5	10	10	8.45	5.33	4.51	2
East River Corridor	Rhaponticum repens	9	5	10	10	7	7	10	10	8.65	5.33	4.61	1
East River Corridor	Saccharum revennae	10	3	5	10	5	5	10	10	7.20	5.33	3.84	3
East River Corridor	Tamarix ramosissima	1	5	10	7	3	3	10	10	5.55	5.33	2.96	6
East River Corridor	Ulmus pumila	7	3	5	7	5	5	10	10	6.00	5.33	3.20	5
Unit A	Elaeagnus angustifolia	5	10	5	7	3	3	10	10	6.25	5.33	3.33	3
Unit A	Lepidium latifolium	5	7	10	10	5	5	10	10	7.55	5.33	4.03	1
Unit A	Saccharum ravennae	10	3	5	10	5	5	10	10	7.20	5.33	3.84	2
Unit A	Tamarix ramosissima	1	5	10	7	3	3	10	10	5.55	5.33	2.96	5
Unit A	Ulmus pumila	7	3	5	7	5	5	10	10	6.00	5.33	3.20	4
Unit A'	Elaeagnus angustifolia	5	10	5	7	3	3	10	10	6.25	5.67	3.54	3
Unit A'	Lepidium latifolium	5	7	10	10	5	5	10	10	7.55	5.67	4.28	1
Unit A'	Saccharum ravennae	10	3	5	10	5	5	10	10	7.20	5.67	4.08	2
Unit A'	Tamarix ramosissima	1	5	10	7	3	3	10	10	5.55	5.67	3.15	5
Unit A'	Ulmus pumila	7	3	5	7	5	5	10	10	6.00	5.67	3.40	4
Unit B	Elaeagnus angustifolia	5	10	5	7	3	3	10	10	6.25	4.53	2.83	4
Unit B	Lepidium latifolium	7	7	10	10	5	5	10	10	8.15	4.53	3.69	1
Unit B	Saccharum ravennae	10	3	5	10	5	5	10	10	7.20	4.53	3.26	2
Unit B	Tamarix ramosissima	5	5	10	7	3	3	10	10	6.75	4.53	3.06	3
Unit B	Ulmus pumila	7	3	5	7	5	5	10	10	6.00	4.53	2.72	5
Unit C	Elaeagnus angustifolia	7	10	5	7	3	3	10	10	6.85	1.40	0.96	1
Unit C	Tamarix ramosissima	1	5	10	7	3	3	10	10	5.55	1.40	0.78	3
Unit C	Ulmus pumila	7	3	5	7	5	5	10	10	6.00	1.40	0.84	2
Unit D	Elaeagnus angustifolia	7	10	5	7	3	3	10	10	6.85	1.40	0.96	1
Unit D	Tamarix ramosissima	1	5	10	7	3	3	10	10	5.55	1.40	0.78	3
Unit D	Ulmus pumila	7	3	5	7	5	5	10	10	6.00	1.40	0.84	2
West Arroyos	Elaeagnus angustifolia	7	10	5	7	3	3	10	10	6.85	4.00	2.74	2
West Arroyos	Rhaponticum repens	8	5	10	10	7	7	10	10	8.35	4.00	3.34	1
West Arroyos	Tamarix ramosissima	1	5	10	7	3	3	10	10	5.55	4.00	2.22	4
West Arroyos	Ulmus pumila	7	3	5	7	5	5	10	10	6.00	4.00	2.40	3

IPIEDT Results by Unit

Table 12: Invasive Plant Inventory and Early Detection Tool (IPIEDT) results. This tool is an Access database that focuses solely on Early Detection Rapid Response and is included to account for factors that the Invasive Plant Management Tool (IPMT) does not account for. For example, the IPMT priority rank for *Rhaponticum repens* is lower when the IPIEDT results are left out. Since this R. repens is an EDRR species, the IPIEDT results should be included.

Area	Scientific Name ITIS	Presence Score	Status Score	Habitat Score	Total Score	Species Score	Overall Score
East River Corridor	Rhaponticum repens	10	10	10	30	8.1	38.1
Unit A	Ulmus pumila	10	10	10	30	6.5	36.5
West Arroyos	Ulmus pumila	10	10	10	30	6.5	36.5
Unit A'	Saccharum ravennae	0	10	10	10	5.3	35.3
Unit A	Saccharum ravennae	0	10	10	10	5.3	35.3
West Arroyos	Tamarix ramosissima	10	7	10	27	8.17	35.17
West Arroyos	Elaeagnus angustifolia	10	10	10	30	5.1	35.1
Unit A'	Lepidium latifolium	10	5	10	25	8.7	33.7
Unit B	Lepidium latifolium	10	5	10	25	8.7	33.7
Unit A	Lepidium latifolium	10	5	10	25	8.7	33.7
Unit B	Ulmus pumila	10	7	10	27	6.5	33.5
East Arroyos	Ulmus pumila	10	7	10	27	6.5	33.5
Unit B	Tamarix ramosissima	10	5	10	25	8.17	33.17
Unit A	Tamarix ramosissima	10	5	10	25	8.17	33.17
East Arroyos	Tamarix ramosissima	10	5	10	25	8.17	33.17
East Arroyos	Elaeagnus angustifolia	10	7	10	27	5.1	32.1
Unit C	Lepidium latifolium	10	7	5	22	8.7	30.7
Unit D	Lepidium latifolium	10	7	5	22	8.7	30.7
East River Corridor	Elaeagnus angustifolia	10	5	10	25	5.1	30.1
Unit A'	Elaeagnus angustifolia	10	5	10	25	5.1	30.1
Unit A	Elaeagnus angustifolia	10	5	10	25	5.1	30.1
Unit C	Elaeagnus angustifolia	10	5	10	25	5.1	30.1
Unit D	Elaeagnus angustifolia	10	5	10	25	5.1	30.1
East River Corridor	Tamarix ramosissima	10	1	10	21	8.17	29.17
Unit A'	Tamarix ramosissima	10	1	10	21	8.17	29.17
Unit C	Tamarix ramosissima	10	1	10	21	8.17	29.17
Unit D	Tamarix ramosissima	10	1	10	21	8.17	29.17
Unit A	Rhaponticum repens	10	0	10	20	8.1	28.1
West Arroyos	Rhaponticum repens	10	0	10	20	8.1	28.1
Unit C	Rhaponticum repens	10	0	10	20	8.1	28.1
Unit D	Rhaponticum repens	10	0	10	20	8.1	28.1
East River Corridor	Ulmus pumila	10	0	10	20	6.5	26.5
Unit A'	Ulmus pumila	10	0	10	20	6.5	26.5
Unit C	Ulmus pumila	10	0	10	20	6.5	26.5
Unit D	Ulmus pumila	10	0	10	20	6.5	26.5
East River Corridor	Saccharum ravennae	0	10	5	5	5.3	25.3
Unit B	Saccharum ravennae	0	10	5	5	5.3	25.3
Unit D	Saccharum ravennae	0	10	5	5	5.3	25.3
East River Corridor	Lepidium latifolium	10	0	5	15	8.7	23.7
Unit B	Rhaponticum repens	5	0	10	15	8.1	23.1
East Arroyos	Rhaponticum repens	10	0	5	15	8.1	23.1
East River Corridor	Ailanthus altissima	5	0	10	15	7.7	22.7
West Arroyos	Ailanthus altissima	5	0	10	15	7.7	22.7
Unit C	Ailanthus altissima	5	0	10	15	7.7	22.7
Unit B	Elaeagnus angustifolia	10	5	0	15	5.1	20.1
Unit A'	Rhaponticum repens	5	0	5	10	8.1	18.1
Unit A'	Ailanthus altissima	5	0	5	10	7.7	17.7
Unit B	Ailanthus altissima	5	0	5	10	7.7	17.7
Unit A	Ailanthus altissima	5	0	5	10	7.7	17.7
East Arroyos	Ailanthus altissima	5	0	5	10	7.7	17.7
Unit D	Ailanthus altissima	5	0	5	10	7.7	17.7
Unit C	Saccharum ravennae	0	10	1	1	5.3	17.3
East Arroyos	Saccharum ravennae	0	10	0	0	5.3	15.3
West Arroyos	Saccharum ravennae	0	10	0	0	5.3	15.3
East Arroyos	Lepidium latifolium	5	0	1	6	8.7	14.7
West Arroyos	Lepidium latifolium	5	0	1	6	8.7	14.7

IPIEDT Results for Whole Refuge

Table 13: Species ranking for the Sevilleta National Wildlife Refuge using the Invasive Plant Inventory and Early Detection Tool.

Scientific Name ITIS	Invasiveness Score	Status Score	Impacts Score	Legal Score	Total Score	Rank
Lepidium latifolium	2	3.6	2.1	1	8.7	1
Tamarix ramosissima	2	3.07	2.1	1	8.17	2
Rhaponticum repens	1.4	3.6	2.1	1	8.1	3
Ailanthus altissima	1	3.6	2.1	1	7.7	4
Ulmus pumila	1	3.6	0.9	1	6.5	5
Saccharum ravennae	0.6	2.8	0.9	1	5.3	6
Elaeagnus angustifolia	0.2	3.6	0.3	1	5.1	7

Species x Area + IPIEDT

Table 14: Final results of the Invasive Plant Management Tool. The Combined Score column is the average of the Species Data x Area Wt Hybrid Score and IPIEDT Score column. This Combined Score is the number used for prioritization ranking throughout the Plan.

Scope	Species	Species Data x Area Wt Hybrid Score	IPIEDT Score	Combined Score	Rank
Sevilleta	Lepidium latifolium	6.45	8.70	7.58	1
	Ailanthus altissima	7.28	7.70	7.49	2
	Rhaponticum repens	6.85	8.10	7.47	3
	Tamarix ramosissima	5.50	8.17	6.84	4
	Ulmus pumila	4.83	6.50	5.66	5
	Saccharum ravennae	5.78	5.30	5.54	6
	Elaeagnus angustifolia	5.42	5.10	5.26	7
	Area weights are included in the scoring below. The higher the score, the higher the priority of management. A value of "0" indicates that species is not present in that area.				
East River Corridor	Rhaponticum repens	36.91	38.10	37.50	1
Unit A'	Saccharum ravennae	32.64	35.30	33.97	2
Unit A'	Lepidium latifolium	34.23	33.70	33.96	3
Unit A	Saccharum ravennae	30.72	35.30	33.01	4
Unit A	Lepidium latifolium	32.21	33.70	32.96	5
Unit B	Lepidium latifolium	29.56	33.70	31.63	6
Unit A	Ulmus pumila	25.60	36.50	31.05	7
East River Corridor	Lepidium latifolium	36.05	23.70	29.88	8
East River Corridor	Elaeagnus angustifolia	29.23	30.10	29.66	9
Unit A'	Elaeagnus angustifolia	28.33	30.10	29.22	10
Unit B	Tamarix ramosissima	24.48	33.17	28.83	11
West Arroyos	Elaeagnus angustifolia	21.92	35.10	28.51	12
Unit A	Tamarix ramosissima	23.68	33.17	28.43	13
Unit A	Elaeagnus angustifolia	26.67	30.10	28.38	14
East River Corridor	Saccharum ravennae	30.72	25.30	28.01	15
East Arroyos	Elaeagnus angustifolia	23.84	32.10	27.97	16
West Arroyos	Ulmus pumila	19.20	36.50	27.85	17
Unit B	Ulmus pumila	21.76	33.50	27.63	18
West Arroyos	Rhaponticum repens	26.72	28.10	27.41	19
East Arroyos	Tamarix ramosissima	21.60	33.17	27.39	20
Unit A'	Tamarix ramosissima	25.16	29.17	27.17	21
Unit A'	Ulmus pumila	27.20	26.50	26.85	22
West Arroyos	Tamarix ramosissima	17.76	35.17	26.47	23
East River Corridor	Tamarix ramosissima	23.68	29.17	26.43	24
East Arroyos	Ulmus pumila	19.20	33.50	26.35	25
East River Corridor	Ulmus pumila	25.60	26.50	26.05	26
Unit B	Saccharum ravennae	26.11	25.30	25.71	27
Unit B	Elaeagnus angustifolia	22.67	20.10	21.38	28
Unit C	Elaeagnus angustifolia	7.67	30.10	18.89	29
Unit D	Elaeagnus angustifolia	7.67	30.10	18.89	30
Unit C	Tamarix ramosissima	6.22	29.17	17.69	31
Unit D	Tamarix ramosissima	6.22	29.17	17.69	32
Unit C	Ulmus pumila	6.72	26.50	16.61	33
Unit D	Ulmus pumila	6.72	26.50	16.61	34

<u>Species Definitions</u>

Elements	Definitions:	Score Definitions	Score
1 - Level of Establishment	The level of infestation (distribution) within the zone. Refuge zone (e.g., Hakalau Mesic Native Forest), for EDRR not level of distrbution, but presence or absence.	Peripheral, not in zone yet	10
		Low % established =< 10%	7
		Established, limited distribution, >10% to 70%	5
		Well established, widespread >70%	1
		custom score & definition for Refuge	
2 - Rate of Invasiveness	The rate at which an infestion spreads, how aggressively a species spreads or does not spread.	Not Spreading: infestation is contained and not expanding	1
		Slow: expands over a course of many years	3
		Medium: expands over a few years (2-3)	7
		Fast: expands quickly, within one season or 1-2 years	10
		custom score & definition for Refuge	
3 - Level of Threat to Resource	The level of threat the species poses to the ecological integrity of the ecosystem or to a resource of concern (focal species and its habitat). How damaging, or innocuous is the invasive species. Assume the zone is in ideal condition, i.e., a restored native ecosystem.	Low: threat of altering <10% of native plant community	1
		Medium: threat of altering 10 - 45% of native plant community; some impact to Refuge resources of concern (focal species)	5

	Prevents future recruitment of all species, understory and canopy.	High: threat of altering >50% of native plant community; impacts to Refuge resources of concern (focal species)	10
		custom score & definition for Refuge	
4 - Level of Effort to Control	The amount of effort needed to implement the control method. For Hakalau the range of techniques from least intensive to most intensive are: helicopter drop (isolated gorse), boom sprayer, cut stump, hack and squirt, backpack sprayer, cut/treat/dig (holly).	Easy: method is quick and simple	10
		Moderate: method is more involved than being quick and easy. Single method required (chemical).	5
		Moderately Difficult: method is more involved than being quick and easy, multiple treatment methods required (Mechanical + chemical) for maximum effectiveness.	3
		Difficult: method is intensive	1
		custom score & definition for Refuge	
5 - Number of Treatments for Control	The number of applications that are needed to obtain complete control and removal of the plant, or at least partial control and/or containment of the infestation to prevent it from spreading into adjacent areas. Does it persist do to a presence of a seed bank or root sprouts.	One treatment year for complete/ maximum control	10
		A few treatment years (2-3) for maximum control or containment of infestation	7
		Multiple treatment years (4-6) for eradication, maximum control, or containment of infestation	3
		Many treatment years (>6) for eradication, maximum control, or containment of infestation	1

		Custom: 3 - 5 years for eradication, maximum control, or containment of infestation	5
6 - Response to Control Method	The ability of the selected control method to effectively reduce the presence of the invasive species (i.e., the species responds well to the method; the plants are eliminated). The method reduces the infestation to zero or very low numbers vs. the species shows resistance and only partial control can be achieved. Assumes we attack the plant at the optimal time when it is most susceptible. Factor in biocontrol when available.	Quick: effective response, plants die	10
		Moderate: spotty response, most plants die (photinia)	7
		Slow: inconsistant response, some plants die (blackberry)	3
		Unknown or Ineffective: response unknown or no known effective control method (i.e., uncontrollable, Clidemia)	1
		custom score & definition for Refuge	
7 - Costs	The general level of cost involved with the control method, including the cost of materials (type and quantity), staff time (treatment method and search effort), contracting, equipment (hatchet vs helicopter).	Low: low effort (labor); already have equipment; low material costs	10
		Moderate: requires more effort; purchase of equipment; moderate cost of materials	5
		High: requires high effort; expensive equipment; high cost of materials; many people; long treatment period	1
		custom score & definition for Refuge	
8 - Ease of Logistics	The level of effort that is required to reach and treat the infested area. An infestation located near a road	Easy: infestation location is accessible to people and equipment	10

	with easy terrain (i.e., grassland field next to a Refuge road) vs. an infestation in an area with no road (i.e. equipment needs to be walked in) or requires other machinery to reach the area (i.e. boats) or is difficult terrain (i.e. steep hills, rocks, wet areas, thick vegetation, etc.). Labor for a plant.	Moderate: infestation location is a short distance from an access point; equipment can be brought in with some effort; terrain is navigable	5
		Difficult: no access point near location; location is on an island; it is difficult to bring in equipment; terrain or habitat is very difficult to move through	1
		custom score & definition for Refuge	

Area Definitions

Ecological Integrity		
Rationale and Assumptions: Areas with high ecological integrity are relatively unimpaired across a range of ecological attributes and spatial and temporal scales (De Leo and Levin 1997). Areas with relatively high ecological integrity often have high conservation value and are a priority for preventing or reducing human-induced threats such as invasive species.		
Scale	**Scale Definition**	**Score**
Very good estimated ecological integrity	Ecosystems of the area are believed to be, on a global or range-wide scale, among the highest quality examples with respect to major ecological attributes functioning within the bounds of natural disturbance regimes. Characteristics include: the landscape contains natural habitats that are essentially unfragmented (reflective of intact ecological processes) and with little to no human-induced threats (e.g., contaminants, invasive species, etc.); vegetation structure and composition, soils, and hydrology are within natural ranges of variation; invasive species are essentially absent or have negligible negative impact; key native plant and animal indicators are present.	10
Good estimated ecological integrity	Ecosystems of the area are not among the highest quality,but exhibit favorable characteristics regarding major ecological attributes functioning within the bounds of natural disturbance regimes. Characteristics include: largely natural habitats with minimal fragmentation and few human induced threats (e.g. contaminants, invasive species, etc.); vegetation structure and composition, soils, and hydrology are within natural ranges of variation; invasive species are uncommon/rare and/or have minimal negative impact; many key plant and animal indicators are present.	7
Fair estimated ecological integrity	Ecosystems of the area contain a number of unfavorable characteristics in terms of major ecological attributes and natural disturbance regimes. Characteristics of this ecosystem would include: moderately fragmented natural habitat with several human-induced threats; biotic and abiotic factors are outside their natural range of variation; a moderate number of human induced threats are present; invasive species are moderately abundant and/or have moderate negative impacts; many of the key plant and animal indicators are absent. Management is needed to maintain or restore major ecological attributes.	3
Unknown	The ecological integrity of the area is unknown.	3

Innate Resistance to Invasion		
Rationale and Assumptions: Factors that can influence resistance include resident native plant diversity, abiotic conditions (e.g., nutrient levels, soil or water quality [e.g., salinity], hydrology) and natural disturbance regimes (e.g., flooding, fire). Human-induced factors that affect resistance, such as human-induced disturbance and invasive propagule transport (e.g., roads, trails, waterways), are addressed in another section of this tool. Areas with low natural (e.g., innate) resistance to invasion are a priority for invasive plant detection and control. Areas where native plants occupy most bare ground or capture almost all light at the soil surface can limit establishment of invasive plants (Hobbs and Huenneke 1992). Areas with greater plant diversity occupy a greater variety of resources and thereby can limit the ability of non-native species to obtain resources that are not already occupied or used (Naeem 2000, Lockwood et. al. 2010). Disturbance, whether natural or human-caused often facilitates or creates opportunities for invasion (Lockwood et. al. 2010). Here, we are focused on natural disturbance regimes (later, we address human-caused disturbance). Areas with relatively extreme abiotic conditions (e.g., highly saline, low nutrient levels) can limit invasive plant establishment.		
Scale	**Scale Definition**	**Score**
Low Resistance	Two or more of the following characteristics are present: low plant species richness, high frequency and intensity of natural disturbance events (e.g., fire, hurricanes, extreme tides), and relatively non-stressful abiotic conditions.	10
Moderate Resistance	Two or more of the following characteristics are present: moderate plant species richness, moderate frequency and intensity of natural disturbance events, moderately stressful abiotic conditions.	5
High Resistance	Two or more of the following characteristics are present: high plant species richness, low frequency and intensity of natural disturbance events, abiotic conditions stressful (e.g., high salinity, low nutrient levels, regular flooding).	1

Importance to Federal- or State-Listed Species		
Rationale and Assumptions: Areas important to listed species are a high priority for detecting and removing threats such as invasive plants.		
Scale	**Scale Definition**	**Score**
High Importance	The value of greatest existing or realistically potential core habitat	10
Medium Importance		5

Low Importance		0

Pathways		
Rationale and Assumptions: Terrestrial pathways provide a means for transport, establishment, and spread of invasive plants. Areas where terrestrial pathways are widely distributed and occur at high density are at high risk for invasion and are therefore a high priority for invasive plant detection and removal.		
Scale	**Scale Definition**	**Score**
No pathways	No occurrence of terrestrial pathways within the area.	0
Low coverage and/or density	Terrestrial pathways spatial coverage and/or density is low relative to other areas within the project scope.	3
Medium coverage and/or density	Terrestrial pathway spatial coverage and/or density is medium relative to other areas within the project scope.	7
High coverage and/or density	Terrestrial pathway spatial coverage and/or density is high relative to other areas within the project scope.	10

Transport Vectors		
Rationale and Assumptions: Transport vectors provide the means for transporting invasive plant propagules along terrestrial and aquatic pathways (Lockwood et. al. 2007). Vectors here include any means of human-mediated transport of invasive plant materials such as vehicles, boats, bicycles, clothing/shoes and construction equipment. Areas that experience frequent or long duration vector events are at high risk to invasive plant introduction and spread and are therefore a high priority for invasive plant detection and removal. Vector events are occurrences where a vector enters the area (e.g., for public use, management, inventory and monitoring).		
Scale	**Scale Definition**	**Score**
No vectors or vector frequency/duration low	All vectors are absent OR vectors operate within the area, but frequency and duration of vector events is low relative to the other areas in the project scope.	1

Vector frequency/duration medium	All vectors operate in the area AND frequency and duration of vector events is moderate relative to the other areas in the project scope.	5
Vector frequency/duration high	All vectors operate in the area AND frequency and duration of vector events is high relative to the other areas in the project scope.	10

Anthropogenic Disturbance		
Rationale and Assumptions: Disturbance facilitates invasive plant invasions and can be described as a "relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment" (Lockwood et. al. 2007, White and Pickett 1985). Here we are focused on anthropogenic disturbances such as restoration/enhancement activities, regular maintenance activities, resource extraction, and toxic spills. Areas that are exposed to intense, frequent, or long-duration disturbance events are at high risk for invasion and therefore should be a priority for invasive plant detection and removal.		
Scale	**Scale Definition**	**Score**
High	The area has experienced high levels of anthropogenic disturbance (e.g., high intensity, duration, or frequency) relative to other areas within the project scope in the last 10 years.	10
Medium	The area has experienced moderate levels of anthropogenic disturbance (e.g., moderate intensity, duration, or frequency) relative to other areas within the project scope in the last 10 years.	5
Low	Anthropogenic disturbance has not occurred in the last 5 years or the area experiences low levels of anthropogenic disturbance (e.g., low intensity, duration, or frequency) relative to other areas within the project scope in the last 10 years.	1