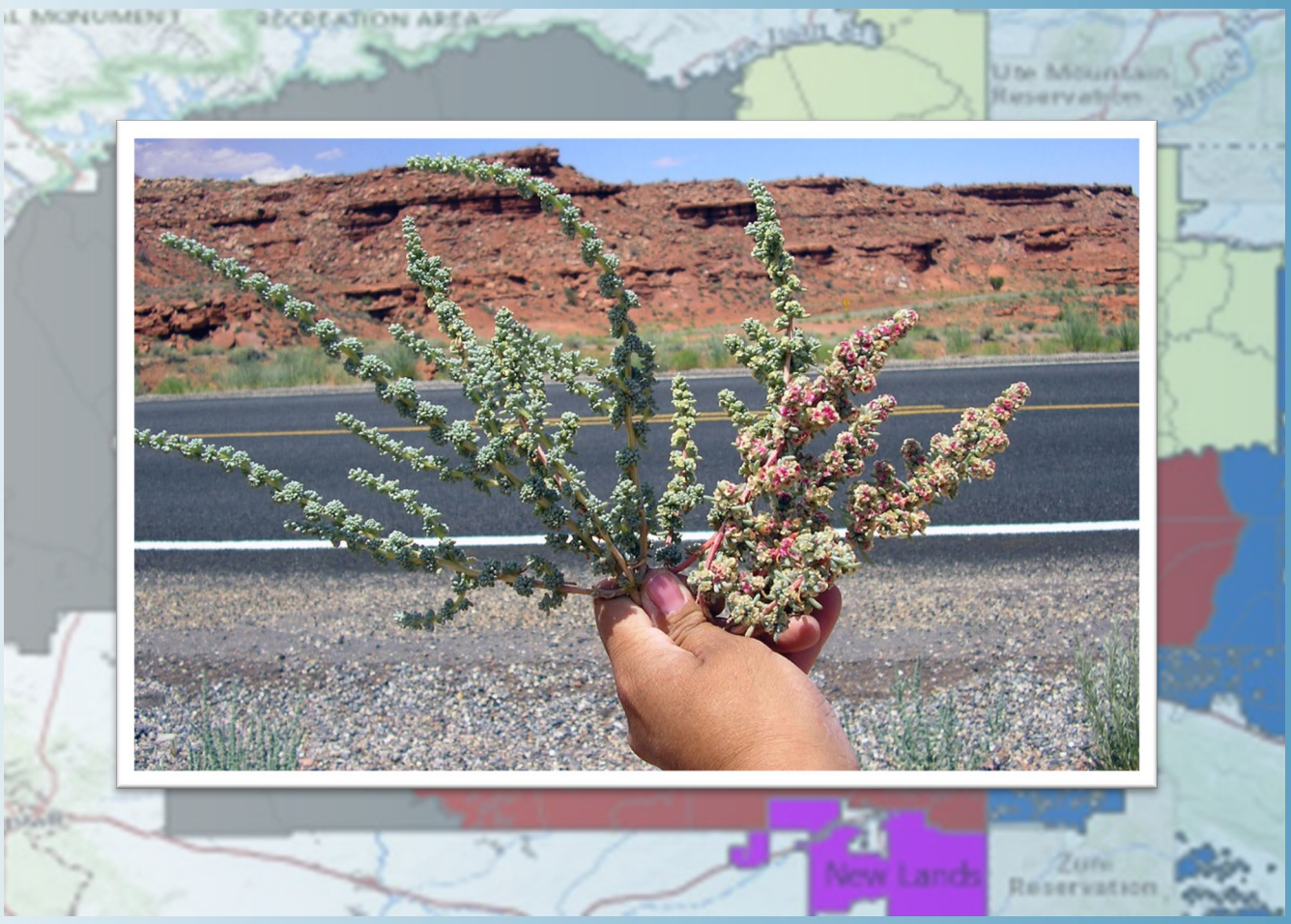

Navajo Nation Integrated Weed Management Plan

FINAL

August 2022

FOR MANAGEMENT OF LANDS ON:
THE NAVAJO NATION

UNITED STATE DEPARTMENT OF THE INTERIOR
BUREAU OF INDIAN AFFAIRS NAVAJO REGION

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NAVAJO NATION INTEGRATED WEED MANAGEMENT PLAN

August 2022

U.S. Department of the Interior
Bureau of Indian Affairs
Navajo Region

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Cover photo by Renee Benally, Bureau of Indian Affairs Western Navajo Agency Natural Resource Specialist, of a halogeton sample collected along Highway 163.

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1.0 Introduction

Controlling noxious/invasive weeds, or more appropriately, undesirable non-native vegetation, has long been a serious concern for land users. According to the Federal Noxious Weed Act of 1974 (P.L. 93-629), noxious or invasive weed species are plants "classified as undesirable, noxious, harmful, exotic, injurious, or poisonous" and does "not include plants indigenous to an area where control measures are to be taken." Noxious weeds have little value and often have negative impacts on desired native plants and wildlife. Noxious weeds occupy space across the landscape, absorb sunlight, and utilize soil moisture that would otherwise be available for native plants. Many noxious weeds can directly change a site, making it difficult to re-establish desired native plants. In addition, noxious weeds can harm livestock, wildlife, and humans; thereby, resulting in economic, cultural, and social impacts.

On the Navajo Nation, the number and cover of noxious weed species has increased in recent years. Noxious plants were introduced through various activities, including:

- Road construction & maintenance,
- Use of hay and feed with weeds,
- Transportation of weed seeds by livestock and wildlife to remote locations,
- Infrastructure development (i.e., waterline, gas lines, powerlines, and fiber optics),
- Flowing streams, wildlife and the wind which contribute to seed dispersal, and
- A lack of grazing limits, which can put additional pressure on native vegetation, allowing noxious weeds to outcompete native plants.

Disturbed habitats facilitate the establishment of noxious weeds. Disturbance can introduce weeds along roads and rights-of-way from vehicles that carry seeds and plant materials, construction material, or garbage. These linear corridors provide a thoroughfare for rapid weed expansion to adjacent wild, agricultural or range lands. Rights-of-way also provide access points for weeds to spread to riparian corridors from runoff or road crossings.

The expansion of noxious weeds on the Navajo Nation contributes to the decline of forage production, native grassland community quality, wildlife habitat quality, and overall ecological health of the region. Noxious weeds impact every habitat on the Navajo Nation, which affects the economic, historic, and cultural livelihood of the Navajo people. Control of these weeds will improve rangeland and agricultural land quality by improving growth of native forbs and grasses that benefit subsistence ranching and farming, increase native plant diversity in riparian corridors, protect water resources and water quality, prevent the spread of additional weeds to unaffected land and property, and maintain and improve wildlife habitat.

1.1 Background

The Bureau of Indian Affairs (BIA) Noxious Weed program was initiated in December 1988 in response to Congressional directives to improve management on Indian lands. A task force and 10-Year Management Plan were developed and included in the BIA Range and Agriculture Handbook. The Acting Deputy Commissioner of Indian Affairs issued an Interim Policy in 1991 for the Noxious Weed Control Program. This policy directed on-the-ground work and allocated funds directly for weed control projects. Program standards and oversight are provided by BIA Branch of Agriculture and Rangeland Development based on input from BIA Regional Noxious Weed Coordinators.

The BIA Navajo Region has initiated various projects to control specific target noxious weeds on the Navajo Nation using various methods. The target noxious weeds treated to date on the Navajo Nation include:

- Tamarisk (*Tamarix* spp.)
- Russian olive (*Elaeagnus angustifolia*)
- Russian knapweed (*Acroptilon repens*)
- Camelthorn (*Alhagi camelorum*)
- Halogeton (*Halogeton glomeratus*)
- Musk thistle (*Carduus nutans*)

While these efforts support the goals of the Noxious Weed Control Program, the Navajo Regional Office (NRO) determined the need for an integrated and coordinated management plan which used methodical, science-based strategies to actively monitor and control noxious weeds. In conjunction with developing a weed management plan, NRO determined that compliance with the National Environmental Policy Act (NEPA) was necessary to facilitate discussions with the public regarding potential impacts of a weed management plan. By completing one wholesale environmental compliance effort for integrated weed control, the BIA can streamline planning and compliance processes and encourage large-scale cooperative projects.

To address the need for a more balanced approach to weed management, NRO initiated development of a weed management plan. This Navajo Nation Integrated Weed Management Plan (NNIWMP) identifies weed species of concern; details weed removal strategies; and consolidates the best management practices available for weed control. Best management practices that were limited in the past are now an integral component of the Region's weed management efforts, such as early detection and eradication, prevention, and education. This plan will encompass a 10-year period but will be reviewed after five years. After 10 years, the BIA may opt to keep the NNIWMP in place or update the plan based on updated data and project planning needs. The NNIWMP, however, will remain in place if no plans are developed to replace it. Repeated treatments will be necessary until the desired control objective is reached for most species as seeds can be viable for 10 or more years.

1.2 Project Goals

1. Develop the best control techniques described for the target weed species in a planned, coordinated, and economically feasible program to limit the impact and spread of noxious weeds.
2. Use adaptive management strategies to incorporate successful projects from completed weed projects when developing new initiatives.
3. Identify and prevent the expansion of existing target weed species, and quickly prevent the spread of new high priority weed species.
4. Coordinate weed removal efforts with adjacent landowners, land managers, and/or federal agencies to prevent the further spread of weeds.
5. Provide and promote economic opportunities for the Navajo people to improve rangeland and farmland productivity and to remove noxious weeds.
6. Develop a public education program focused on weed identification, prevention, and removal techniques for local communities and non-profit organizations.

2.0 Project Area

The Navajo Nation covers approximately 16.3 million acres across northeastern Arizona, southeastern Utah, and northwestern New Mexico and (**Figure 2-1**). The BIA Navajo Region is divided into five BIA agencies including (acres indicate total size of areas managed by each agency):

- Western Navajo Agency (Tuba City, Arizona, 5.2 million acres)
- Eastern Navajo Agency (Crownpoint, New Mexico, 2.3 million acres)
- Fort Defiance Agency (3.3 million acres)
- Shiprock / Northern Navajo Agency (2.7 million acres)
- Chinle / Central Navajo Agency (1.4 million acres)

The Navajo Partitioned Lands (Pinon, Arizona, 910,000 acres) and the New Lands Area (310,000 acres) contain an additional 1.2 million acres. At the date of this writing, New Lands is managed by the Office of Hopi and Navajo Indian Relocation but may come under the BIA in the foreseeable future. Thus, the New Lands Area is included in the project area. Additionally, there are approximately a million acres of land that may be in transition to allotment or trust lands on the Navajo Nation as part of land buy backs. For this document, the project area refers to the entire Navajo Nation as defined above with project sites referring to individual weed project locations.

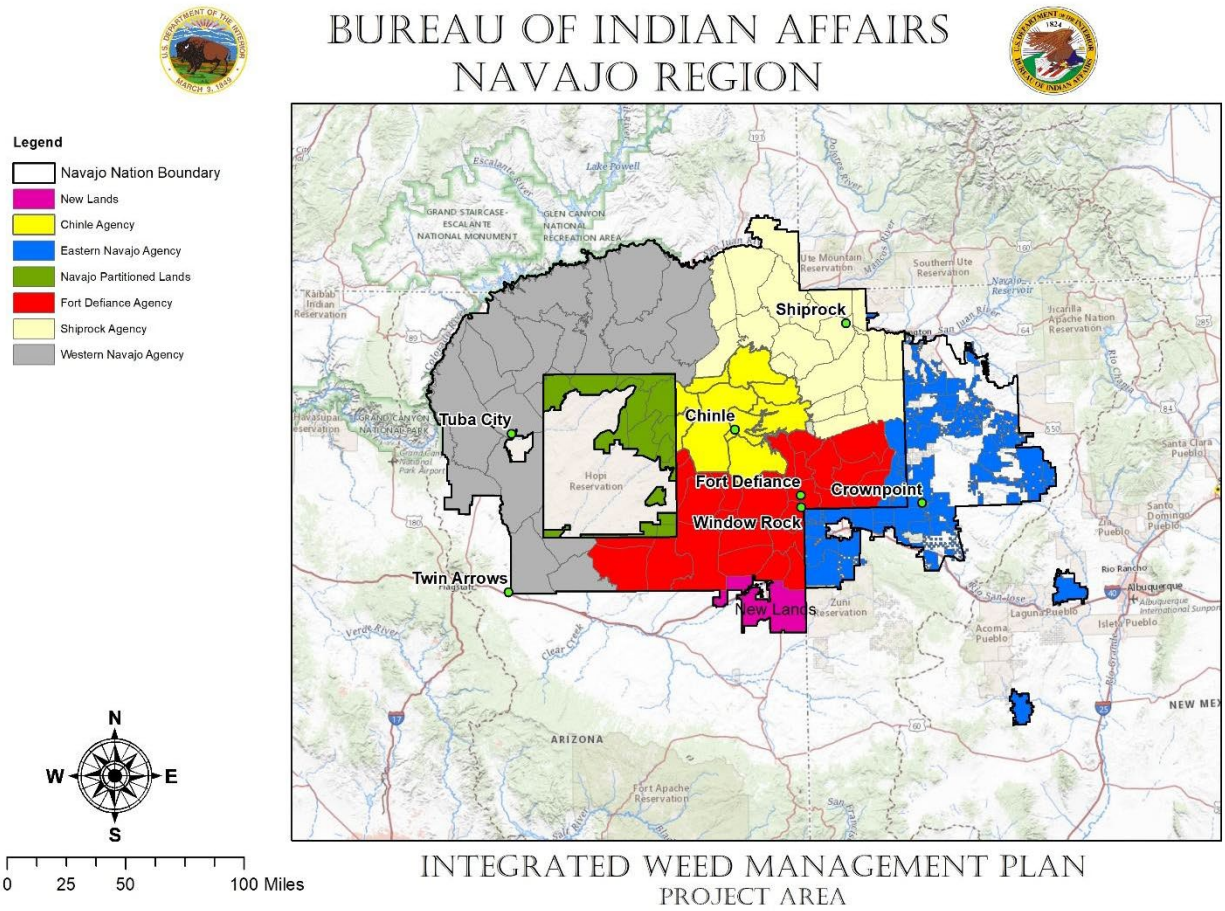

Figure 2-1. Project area of the Navajo Nation divided by BIA Navajo Regional Agencies.

This plan addresses lands under the direct administration of the NRO, which includes all Navajo Indian Allotments and Navajo trust land. Priority areas were identified to direct weed treatments where noxious weeds cause significant issues for land users and land managers (Appendix B). These areas were selected based on general land use types where a majority of weed management projects have been planned or coordinated. Priority areas include:

- Navajo Nation, BIA, federal, state, and county roads
- Riparian areas
- Navajo Nation-designated Community Development Areas
- Rights-of-way
- Designated rangeland
- Designated farmlands
- Navajo Agricultural Products Industry (NAPI) lands

All weed treatment projects shall be conducted in close coordination with local communities, Chapter Houses, and the Navajo Nation.

Roads are a primary contributor of noxious weed populations on the Navajo Nation and are a priority area for weed treatment. In 2018, the Navajo Nation DOT assumed full responsibility for the administration and management of the Tribal Transportation Program (TTP), including the BIA Navajo Region Branch of Transportation (NRBOT) Force Account Program. There are numerous paved and unpaved public roads managed under the TTP. For roads managed by state transportation agencies, vegetation is treated approximately 300 ft from the center of the road for interstates and between 50-100 ft from the center of the road or to the right-of-way fence on state highways. Agencies responsible for management of public roads include Navajo Nation Department of Transportation (Navajo DOT, 5,174 miles); Bureau of Indian Affairs Branch of Transportation (6,086 miles); County Roads (1,512 miles); and state and federal routes managed by Arizona Department of Transportation (ADOT), Utah Department of Transportation (UDOT) and New Mexico Department of Transportation (NMDOT). Treatments may also occur along tribal forest roads, which will require coordination with Navajo Forestry Department and the BIA Branch of Forestry.

Riparian areas are distinct ecosystems surrounding perennial and intermittent surface water bodies, such as lakes, rivers, and streams. These areas are hotspots of biodiversity in the region and cover approximately 1.3 million acres on the Navajo Nation. Water bodies are classified based on the major watershed basin they are located in. Five sub-regional watershed basins occur on the Navajo Nation and include the Rio Grande (710,367 acres), Upper Colorado (980,449 acres), San Juan (8.54 million acres), Lower Colorado (723,528 acres), and Little Colorado (6.67 million acres). These major watersheds are divided into 32 drainage basins on the Navajo Nation. Noxious weeds have been identified in all drainage basins on the Navajo Nation. Riparian habitats in these watersheds have been most impacted by noxious trees, such as Russian olive (*Elaeagnus angustifolia*) and tamarisk (*Tamarix spp.*). Weed populations in these habitats often serve as seed sources to downstream habitats and degrade valuable habitat for wildlife populations, including federally and tribally listed species.

Community Development Areas (CDAs) are defined by the Navajo Nation Department of Fish and Wildlife as "areas in and around towns with few or no restrictions on development." Planning for these areas is done through the Navajo Nation Department of Community Development with local Navajo Chapters. These areas are deemed unsupportive for Navajo species of concern with few restrictions on development. CDAs can be hotspots for weeds as construction, road work, and development activities spread seeds and plant parts to neighboring communities and natural areas.

Rights-of-way (ROWs) occur along all utility transmission lines, homesite leases, and roads on the Navajo Nation. Utility ROWs on the Navajo Nation are Indian Trust Land and maintained by utility companies who manage the lines. These include transmission lines for electricity, water, sewage, internet, phone, and natural gas. Most lines are managed by the NTUA, who provide utility service to residents on the Navajo Nation. BIA Realty currently estimates over 14,000

acres of approved rights-of-way across the Navajo Nation.[1] In addition to NTUA and a few local service providers, Arizona Public Service, Public Service Company of New Mexico, and the Salt River Project also maintain transmission lines on the Navajo Nation but may not provide direct service to trust lands. Federal law requires grantees to control and prevent weeds as part of their right-of-way (25 CFR §169.5). Land disturbance from installation or repair of utility lines can encourage the growth and introduction of many of noxious weed species.

Designated rangeland are areas managed for livestock grazing. These areas are administered by the Navajo Nation either through the Department of Agriculture (NNDA) or the BIA. There are currently around 11,000 active grazing permits on the Navajo Nation. All range permits and range units are managed by the BIA, while NNDA manages enforcement and oversight. These lands encompass roughly 2.6 million acres. The highly disturbed nature of designated rangelands has promoted the growth of many noxious weeds.

Designated farmlands are set aside either through land lease agreements or permits by the Navajo Nation (3 N.N.C. 1) and the BIA (25 CFR § 162 and 167). Designated farmlands comprise approximately 57,900 acres of the Navajo Nation under an estimated 5,000 customary land use permits. Farmlands are categorized as either dryland farms or irrigated farms. Irrigated farms are located near open water used to irrigate fields. Dryland farms are located further away from open water and receive water through irrigation, pumping, and seasonal precipitation.

Commercial farmlands cover areas managed by the Navajo Agricultural Products, Inc. (NAPI) and the Navajo Indian Irrigation Project (NIIP), which provide irrigation and agricultural products for the Navajo Nation. The BIA is responsible for NAPI and NIIP project oversight and ensures they remain in compliance with environmental concerns. The Navajo Nation is responsible for overall management and operations. NAPI lands comprise approximately 110,000 acres along the border between Shiprock / Northern Navajo Agency and Eastern Navajo Agency south of Farmington, New Mexico. In 2019, 66,490 acres were in active production, and 7,000 acres were inactive or fallow. The remaining 36,510 acres are inactive due to delays in the construction of the NIIP irrigation delivery system to the site.

Although the BIA will focus on weed treatments in these priority areas, weed treatments may occur in non-priority areas based on ecological and economic impacts and need. If a site matches the site prioritization criteria outlined in Section 5.0, and serious concern exists for the ecological and economic impacts of existing weed populations, efforts should be made to treat and manage weeds in those areas.

Weed inventory and mapping will be conducted concurrently as part of this plan to identify weed populations in the project area and to prioritize control efforts. Recent efforts in the past 5 years

[1] Based on BIA TAMS data compiled on January 15, 2021 recently transferred and requires additional clean up and categorization to determine road vs. right of way data. Estimate is likely higher due to undigitized records.

have documented over 70,000 acres of noxious weeds. All areas with identified weed infestations should be ranked and prioritized based on criteria outlined in Section 4.0.

3.0 Priority Weed Species

Forty-five noxious weed species are prioritized for control in this plan. The priority weed species were identified through previous weed mapping efforts by the BIA and the Southwest Exotic Plant Information Clearinghouse (SWEPIC) managed by the U.S. Geological Survey (USGS) Colorado Plateau Research Station (**Table 3-1**). These weeds were selected and ranked based on variety of factors, such as weed occurrence data and priority status in nearby states. The BIA also proposes implementing a weed mapping program as part of the Plan to assess and monitor weeds cover and impacts on the Navajo Nation. Weed inventory and mapping is discussed further in Section 6.0. Information, including photos, names, and management concerns for each species can be found in Appendix L of the PEIS associated with this plan.

These 45 weed species were categorizing into Category A, B, or C with help from the San Francisco Peaks Weed Management Area Working Group (**Table 3-1**, Morse, et al. 2004). Category A noxious weeds are not currently present or have limited distribution on the Navajo Nation but may occur in neighboring areas. The management goal for Category A weeds is to prevent new infestations and eradicate existing ones. For Category A species, the BIA will emphasize eradication, prevention, education, awareness, identification, monitoring, and treatment. Category B noxious weeds are limited in range across the Navajo Nation and the management goal is to contain existing infestations and stop further spread. For Category B species, the BIA will emphasize immediate control, prevention of seed spread, and eradication. Category C noxious weeds are widespread and well established on the Navajo Nation, and the management goal is to locally contain infestations and monitor populations. Management of Category C species is determined at the local level and is based on the feasibility of control and level of infestation. For Category C species, the BIA will emphasize management, education, awareness, and identification/monitoring.

Under this plan:

- **Prevention** means minimizing introductions of a weed species in the project area and is usually combined with eradication to allow the elimination of small populations as they arise.
- **Eradication** means to eliminate a species from the project area.
- **Contain** means preventing seed production in a target patch and reducing the area covered by a species.

  Long-term eradication means an attempt to eliminate a species from the project area over several years. The “contain” and “long-term eradication” strategies are combined as

different sized populations may be found in different areas. Some populations may be controlled in a manner to eventually achieve eradication within the project area.

- **Local contain** means local weed management teams will identify the species to contain in localized sites and implement monitoring.

- **Monitoring** means making observations to detect changes in a population using qualitative or quantitative techniques. Monitoring can help prioritize noxious weed removal activities by identifying increases in existing populations, presence of new infestations, and invasion from new noxious weed species.
    - Qualitative techniques involve monitoring methods that do not include measurements or statistics (i.e. photo monitoring and general ocular observations).
    - Quantitative techniques involve using a systematic empirical investigation of plant community characteristics via statistical, mathematical, or computational methods.

Table 3-1. Noxious weeds of concern and proposed management strategy goals.

CATEGORY A - HIGH		
COMMON NAME	**SPECIES**	**MANAGEMENT GOAL**
African rue	Peganum harmala	Prevent
Blue mustard	Chorispora tenella (Pall.) DC.	Eradicate
Bull thistle	Cirsium vulgare	Eradicate
Canada thistle	Cirsium arvense	Eradicate
Common Mediterranean grass	Schismus barbatus	Eradicate
Dalmatian toadflax	Linaria dalmatica	Eradicate
Fountaingrass	Pennisetum setaceum	Prevent
Leafy spurge	Euphorbia esula	Prevent
Musk thistle	Carduus nutans	Eradicate
Perennial pepperweed	Lepidum latifolium	Eradicate
Ravenna grass	Saccharum ravennae	Eradicate
Sahara mustard	Brassica tournefortii	Eradicate
Scotch thistle	Onopordum acanthium	Eradicate
Spotted knapweed	Centaurea maculosa, C. stoebe	Eradicate
Squarrose knapweed	Centaurea virgata	Prevent
Sulphur cinquefoil	Potentilla rect L.	Eradicate
Tall Whitetop	Cardaria draba	Eradicate
Tamarisk (other species)	Tamarix spp., including hybrids	Eradicate
Tree of Heaven	Ailantus altissima	Prevent
Uruguyan pampas grass	Cortaderia sellonana	Eradicate
Yellow nutsedge	Cyperus esculentus	Eradicate
Yellow starthistle	Centaurea solstitialis	Eradicate
CATEGORY B - MEDIUM		
COMMON NAME	**SPECIES**	**MANAGEMENT GOAL**
Camelthorn	Alhagi camelorum	Eradicate
Diffuse knapweed	Centaurea diffusa	Contain & Long term eradicate
Halogeton	Halogeton glomeratus	Contain & Long term eradicate
Johnsongrass	Sorghum halepense	Contain & Long term eradicate
Russian knapweed	Acroptilon repens	Contain & Long term eradicate
Russian Olive	Elaeagnus angustifolia	Contain & Long term eradicate
Siberian elm	Ulmus pumila	Contain & Long term eradicate
Tamarisk, Saltcedar	Tamarix ramosissima	Contain & Long term eradicate
CATEGORY C - LOW		
COMMON NAME	**SPECIES**	**MANAGEMENT GOAL**
Bald brome	Bromus racemosus	Local Contain & Monitor
California burclover	Medicago polymorpha	Local Contain & Monitor
Cheatgrass	Bromus tectorum	Local Contain & Monitor
Field bindweed	Convolvulus arvensis	Local Contain & Monitor
Field brome	Bromus arvensis	Local Contain & Monitor
Horehound	Marrubium vulgare	Local Contain & Monitor
Jointed goatgrass	Aegilops cylindrica	Local Contain & Monitor
Kochia	Bassia scoparia	Local Contain & Monitor
Puncturevine	Tribulus terrestris	Local Contain & Monitor
Red brome	Bromus rubens	Local Contain & Monitor
Rescuegrass	Bromus catharticus	Local Contain & Monitor
Ripgut brome	Bromus diandrus	Local Contain & Monitor
Russian thistle	Salsola kali, S. collina, S. paulsenii, S. tragus	Local Contain & Monitor
Smooth brome	Bromus inermis	Local Contain & Monitor
Spreading wallflower	Erysimum repandum	Local Contain & Monitor

4.0 Implementation Strategy

The BIA proposes completing up to 50,000 acres of weed treatments across the Navajo Nation annually. Noxious weed treatments will be prioritized for the priority areas described above including roads; riparian areas; Navajo Nation Designated Community Development Areas; utility rights-of-way; designated rangeland; designated farmlands; and Navajo Agricultural Products Industry (NAPI) lands. BIA has identified priority Demonstration Projects in these areas (see Section 12.0) based on completed weed mapping efforts and on-going projects, which will be initiated upon approval of this plan. To assist BIA in selecting and ranking new noxious weed projects, the following implementation prioritization strategy was developed. Since funding is limited, the number of projects and acres treated per year will likely vary.

The tasks outlined below provide the essential steps for implementing successful weed removal projects. For the long-term sustainability of weed removal efforts, a Weed-Free Policy should be developed and enforced by the Navajo Nation and BIA to prevent the further spread of noxious weeds. The Weed-Free Policy should require use of certified-weed free hay, seed, ballast, and road material on the Navajo Nation to prevent further spread and establishment of noxious weed species. A checklist is provided in Appendix C, which outlines all steps necessary for weed projects.

Task 1. Initiate demonstration projects near communities. These projects are shovel ready projects that will provide public outreach and educational opportunities, obtain public support for the broader goals of the Plan, and engage the local community in weed removal efforts. The demonstration projects provide information about the distribution of noxious weeds, effective removal methods, project costs, and effective monitoring and maintenance. Proposed demonstration projects are listed in Section 12.0 Demonstration Projects.

Task 2. Meet with local communities and nearby federal agencies. Engagement with the public should determine potential concerns or issues that may affect local communities, such as public health concerns, treatment preferences, or treatment conflicts. Meeting with local residents, community leaders, and agencies will determine the scope of the weed treatment project, identify concerns and challenges, and inform each project's goals and objectives. These concerns can include but are not limited to identifying culturally important plants and/or collection sites, health concerns, and access issues.

Task 3. Map and inventory noxious weeds. A regular workshop will be conducted with the BIA Weed Coordinators to establish a standardized approach to consolidate and coordinate mapping efforts. Mapping provides information on the species present, the size of the infestation, and location.

Task 4. **Apply the site and species approaches.** Actions are prioritized using the site and species approaches to select the best sites to initiate weed management (see Section 5.0). This applies to all new weed management projects.

Task 5. Develop a site-specific plan to implement weed removal efforts for projects. The plan will provide information on weed species present; a map of the treatment area; the removal efforts selected, including detailed information on equipment; native plant restoration; and proposed project costs. If the treatment is located within forestlands a silvicultural prescription may be required.

Task 6. Obtain required permits, clearances, and funding. Acquire permits and support from the tribe and BIA, develop landowner access agreements, obtain funding, and build capacity. Required permits and clearances may include but are not limited to: Forest product harvest permit or contract, burn permit, consent of the majority Indian interest of the beneficial Indian owner(s), Biological Resource Compliance Form from NNDFW, the Cultural Resource Compliance Form from Navajo Nation Historic Preservation Department (NNHPD), and a tribal resolution from the local Chapter House(s) and/or Grazing Committee(s) affected by the project. Finally, all projects should complete a project-specific EA based on the analysis provided in the Programmatic EIS prepared for this plan. See Appendix C for more details on these processes.

This plan can be incorporated into other Navajo nation land management projects or plans by citing either the BIA NEPA reference number or by an in-text citation (i.e., BIA 2022). By incorporating this plan, it is agreed that the subsequent plans or projects will abide by the methods, planning requirements, and mitigation measures outlined in this document.

5.0 Approach for Prioritizing Actions and Sites

To successfully work toward the Plan's goals, an organized approach is essential to prioritize weed removal actions and sites. While the Navajo Nation is a large land base, focused weed removal efforts in targeted areas will help prevent the spread of noxious weeds. A two-pronged approach was developed to prioritize noxious weed removal actions: Site Approach (**Table 5-1**) and Species Approach (**Figure 5-1**).

The Site and Species Approaches are tools used to first prioritize sites and then prioritize the species for removal within a given site. In some cases, all noxious weeds occurring at a site could be removed. This should be determined on a case-by-case basis.

There are five fundamental requirements that dictate the feasibility of a successful weed removal project at any given site. The characteristics listed below must be met for weed removal to proceed:

1. Funding is available to complete the project, including for monitoring and maintenance.
2. The land user/manager is interested and willing. The land user(s)/manager(s) should agree to the removal project and cooperate with weed removal activities, goals, monitoring, and long-term maintenance.

3. Permits are obtained. Noxious weed removal work cannot start without all required permits and environmental clearances. Any projects implemented under this plan will require compliance with the National Environmental Policy Act (NEPA), Section 106 of the National Historic Preservation Act (NHPA), and Section 7 of the Endangered Species Act (ESA) coverage. Additional permits and clearance may be necessary to comply with Navajo Nation regulations as managed by the Navajo Nation Environmental Protection Agency (NNEPA), Navajo Forestry Department, and the U.S. Army Corps of Engineers, as well as coordination with local communities, Navajo Nation Programs, and neighboring land management agencies. Permits and additional compliance are explained further in Section 7.0 Permitting.

4. There is capacity to conduct work at project sites. A trained work force and a logistic plan are necessary to implement a successful and timely noxious weed removal project.

5. The site is accessible. Site accessibility will affect the cost of the noxious weed removal efforts. Difficulty employing certain removal techniques, monitoring, and long-term maintenance should be considered based on the accessibility of the site.

5.1 Site Approach

The site prioritization criteria listed in **Table 5-1** is used to select sites where weed treatments will be most effective at preventing the spread of noxious weed infestations.

Table 5-1. Criteria for site prioritization.

Criteria	Criteria Objective
A. Sites upwind of prevailing wind direction or higher in elevation	Prevent seed or vegetative source from infesting sites downwind of the prevailing wind direction.
B. Sites upstream in the watershed	Prevent seed or vegetative source from infesting downstream sites.
C. Sites with high economic value	Removal efforts can be focused in areas of economic value (i.e. range and farmland) if noxious weed species compromise their functionality.
D. Sites with potential for high mobility (i.e. roads, rights-of-way)	Prevent the spread of noxious weeds along roads or other developed linear corridors that have high mobility potential.
E. Presence of Category A species	These species occupy minimal habitat and are feasible to remove. These species should be prevented from further spread.
F. Coordinated project efforts	Removal efforts can be focused in areas where adjacent land management agencies (e.g., Bureau of Land Management, Forest Service, Hopi Tribe, National Park Service, etc.) have similar noxious weed removal projects.

Criteria	Criteria Objective
G. Greater than 10% total canopy cover of noxious trees.	Maintain noxious trees cover below 10 percent.
H. Greater than 20% total canopy cover of herbaceous and grass invasive species	Maintain herbaceous and grass noxious weed cover below 20 percent.
I. Presence of isolated small populations of Class A or B species	Isolated populations of Class A or B weeds are feasible to remove to prevent further infestation. Priority Class A or B weeds should be identified using the Species Prioritization Flow Chart (**Figure 5-1**).
J. Potential for wildfire	Reduce wildfire risk for damage to property, human safety and wildlife habitat.
K. Herbaceous weed control where plants interfere with passive or active revegetation	Control noxious herbaceous species if they have the potential to serve as secondary weeds when woody noxious weed species have been removed.
L. Sites with high wildlife value	Removal efforts can be focused in areas with high wildlife value if noxious weeds are compromising their habitat.

5.2 Species Approach

The species prioritization approach is adapted from the U.S. Forest Service (USFS) Region 3 Invasive Weed Classification System and the Coconino National Forest (**Figure 5-1**). A species prioritization approach provides a plan for treating and managing different target weed species on a site based by species category, infestation size, risk, or potential of spread, and available resources.

5.2.1 Risk Assessment

An essential consideration when prioritizing species is to determine factors that may facilitate the spread of noxious weeds to other areas, such as the species' mechanism of establishment or colonization (seed, vegetatively, spread via flood events, wind, water, etc.), its location at a site, and site characteristics. Weeds classified as Category A (**Table 3-1**) are highly aggressive but may be a lower priority than a Category B species because the site factors are not conducive to spread, whereas the Category B species may have the appropriate site conditions to spread. For example, a patch of saltcedar (A) located on flat or isolated area off the river corridor may be less of a priority than camelthorn (B) located on the riverbank. While saltcedar is a highly aggressive species, the camelthorn may have a higher risk of spreading through flood events. Risk assessments should be conducted in the field by qualified professionals.

5.2.2 Pre-Field Review

The species prioritization process should begin with a review of existing weed data for each area of interest. Areas of interest include those that may serve as a noxious weed seed source to downstream or downwind areas, developed linear corridors (roads, fences, utility easements), areas with high quality range, agricultural lands, or riparian habitat (dominated by >90% native species), and areas with high fire risk. The following is a list of considerations when preparing existing data.

1. Review geographic information system (GIS) maps of all existing information for an area, weed data, hydrology, roads and travel corridors, vegetation type, and primary use of the land.
2. Check with local BIA weed coordinators, county/state weed specialist, and the Southwest Exotic Mapping Program at Northern Arizona University to determine if noxious weed species are present on or adjacent to the area. For noxious weeds along non-forest roads and highways, contact ADOT, NMDOT, and/or UDOT. For tribal forest roads contact the Navajo Forestry Department (NFD) and BIA Branch of Forestry. Develop a list of possible species present.
3. Compare the habitat requirements for noxious weeds to the project area to determine if potential habitat for noxious weeds exists.
4. Determine the accessibility of the site and complete a habitat evaluation if necessary.
5. Determine if plant gathering sites could be affected by treatments based on input from the community.

Figure 5-1. Flow Chart Species Prioritization

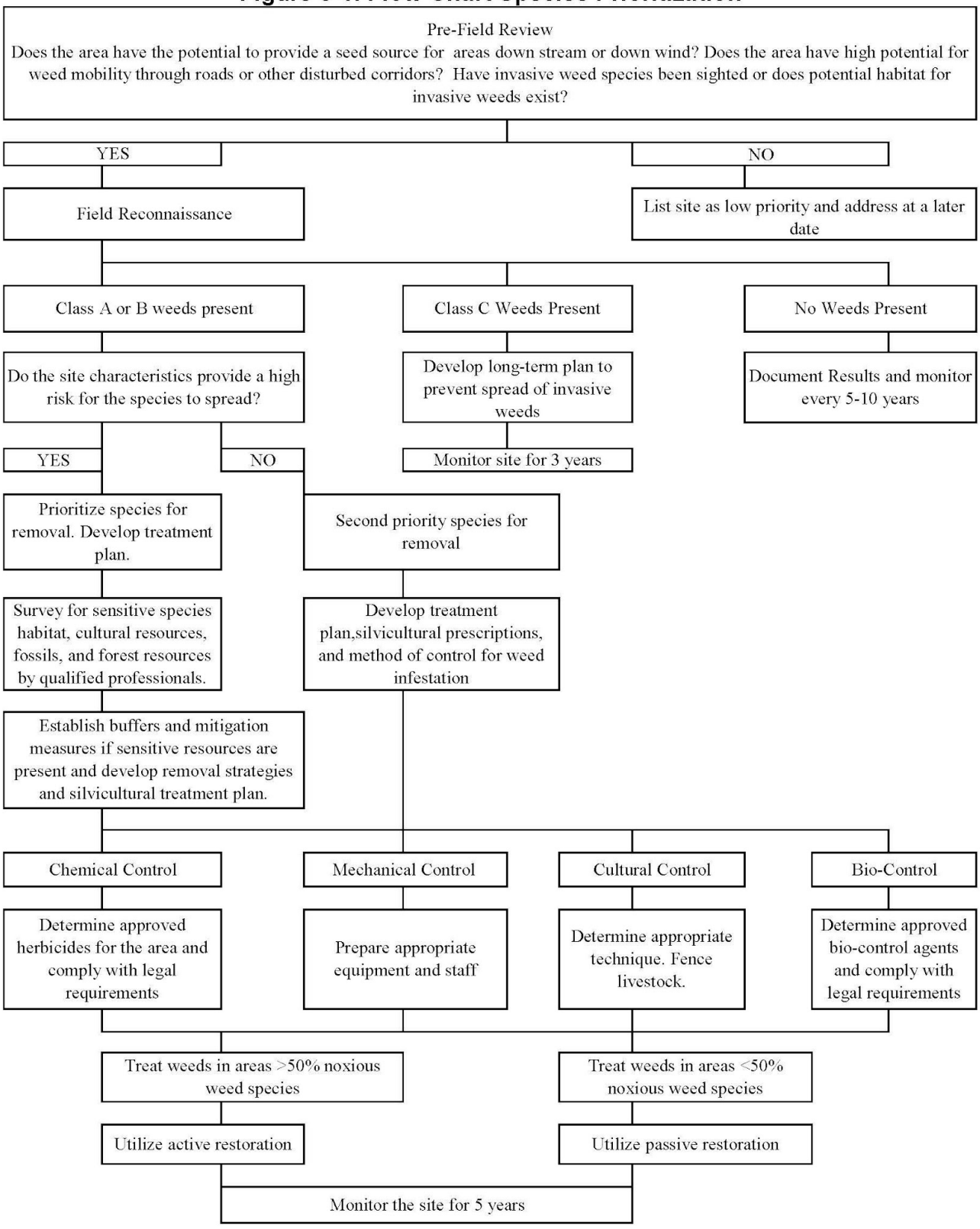

Figure 5-1. Flow chart for prioritizing noxious weeds identified at a project area.

6. Conduct a field reconnaissance to determine the presence of noxious weeds and their habitats in the area are indicated by the pre-field review (See 5.2.3 Field Reconnaissance).

7. Summarize results, including a list of the species considered and sources used to identify habitat in area.

5.2.3 Field Reconnaissance

Field reconnaissance should be conducted to determine the presence and distribution of noxious weed infestations and to evaluate spread risk if a weed inventory has not already been completed. If an inventory involves any of the listed invasive tree species (i.e. tamarisk, Russian olive, Siberian elm, or tree of heaven), a forest stand exam is required. Stand exams will provide an estimate on trees per acre of all trees species identified. They should also provide volume estimates for any native tree species that occur. Stand exams can evaluate the entire project area or provide an estimate based on at least 10% of the proposed project area. Consultation with BIA Forestry should be conducted to determine specific inventory requirements, especially if a silvicultural prescription is required.

A reliable sampling design should be used, such as a systematic search using transects or plots to cover as much of the area as possible. If the area is large, a sub-sample of the area using transects can be used. The surveyor should walk the distance of the transects and map all noxious weeds with a Global Positioning System (GPS) handheld unit. Infestation data should include the name of the species encountered, a unique population identifier, and the species spread risk. Surveys should be conducted during the growing season for proper plant identification. When conducting field reconnaissance, note changes in weather conditions that may affect noxious weed growth at the site. Some noxious weeds may not be obvious or may not occur at certain times of the year (i.e. delayed monsoon season, early spring emergence). Site characteristics should also be noted, such as landform type, existing hydrology, and land use history.

The results from the field reconnaissance can be used to develop a removal strategy (e.g. silvicultural prescription) and include control methods, re-planting of native species, and monitoring. These inventories provide baseline information on the species present and size and location of the infestation.

The field reconnaissance should guide the following weed management actions based on noxious weed class and the risk of spread:

Category A or B weeds are present:

1. Develop and implement treatment measures to eliminate weeds, based on the following:
    a. Most effective removal techniques: chemical, mechanical, and biological control (Appendix E).
    b. Approved herbicides for the area.

c. Legal requirements for herbicides.
d. Active restoration in areas with >50% noxious weeds.
e. Obtain applicable permits and coverage based on federal, tribal, and state requirements (Appendix C).
f. Develop fire and safety plans.

8. Monitor management measures (qualitative and quantitative) for 5 years.

Category C weeds are present:

9. Develop and implement treatment measures to prevent spread or eliminate weeds.
10. Monitoring treatment area for 3 years.

No weeds are present

1. Document results.
2. Monitor every 5 – 10 years.

6.0 Weed Inventory and Mapping

Of the 17 million acres across the Navajo Nation, 3,600,015 acres (or 21% of the land area) have been inventoried for noxious weeds. Weed inventory and mapping can identify and monitor weed populations in project areas. Weeds in each project site should be mapped starting with field reconnaissance to assess the size and scale of existing infestations and to provide valuable information for developing weed control projects. After treatments, populations should be monitored annually to determine the effectiveness of weed control efforts. Weed mapping should be conducted in priority weed areas at least every 5 - 10 years to inform project planning and to document changes to previously treated areas. Data should be no older than 5 years old when planning projects. The BIA Navajo Region plans to develop a website for the Navajo Region's Noxious Weed Program to inform the public on the location of current weed populations, planned projects, and post-project monitoring and updates. The GIS features on the site will also streamline the data collection process for future weed inventory projects and provide updates on the status of existing populations. The public can use the site for information on planned, current, and past projects, to see the extent of existing mapping efforts, or to report new weed populations as part of the BIA's early detection efforts.

Figure 6-1. A field infested with musk thistle on the Navajo Nation. Photo courtesy of R. Benally.

Weed mapping is an important tool for land managers to effectively manage weeds on the Navajo Nation. While it is impossible to map every single weed, mapping is a critical tool for identifying and monitoring problem populations. Regular weed mapping should be done in areas identified for treatment and management and should provide information on weed cover in project areas. Site-specific mapping, as described above in Field Reconnaissance, should be conducted at least every 5 to 10 years to identify new populations for treatment by weed coordinators, range managers, or members of the community. While field reconnaissance will provide initial information to develop treatment plans, weed mapping focuses on documenting the size, severity, and diversity of weeds in an area.

In addition to mapping, processing the collected data is necessary to provide agency and region-wide assessments of recurring and emerging weed issues on the Navajo Nation. There are a wide array of methods and tools used to map weeds, the following section explains the necessary information to document in a basic weed inventory protocol to assist in prioritizing weed control projects and assessing the effectiveness of control measures. A basic weed mapping protocol is provided in Appendix D.

6.1 Field Mapping

Weed mapping requires field surveys of new and established weed infestations. Field surveys should be conducted annually or semi-annually to determine the presence and distribution of weed infestations and to evaluate spread risk. A reliable sampling design should be developed, such as a systematic search using grid cells or transects to cover as much of the area as possible. If the area is large, define a sub-sample of the area to estimate the coverage and size of observed weed populations. The parameters for defining a sub-sample and its size should be documented. The surveyor should walk the area of the grid cell or the distance of the transect and map all noxious weeds observed. All documented infestations should record the geographic location of the spread, noxious weed species observed, and the size and the density of the population. Weed map data can use point, line, or polygon data depending on the techniques used and the size of infestations. However, it is preferred to document infestations as polygons to make it easier to estimate acres and to assist in project planning. However, if infestations are documented using point or line data, it is recommended that acreage and coverage estimates be included to estimate the overall size of the population.

When conducting field mapping, surveyors should be briefed on the following:

- The size of the property being surveyed including property boundaries or areas to avoid (i.e. private property).
- How to clean off equipment and clothing after a survey is done to avoid inadvertently spreading weeds to other mapping locations.
- How to identify and avoid sensitive plant species (i.e. federally and tribally listed species).
- How to identify priority weed species.

- The best routes for accessing mapping locations and where to park to avoid damage to sensitive areas.

6.1.1 GPS Units

Global Positioning System (GPS) units are commonly used to collect geographic data. GPS units provide real-time data collection and navigation, allowing users to systematically collect data as they survey a project area. GPS units can provide the most accurate geographic location data that can be used to create detailed maps and a variety of spatial analyses. Using GPS units requires training on how to set them up and use them accurately and efficiently. For surveying, it is important that users know how to set up the projection system, navigate to specific locations, and input relevant information and unique identifiers for individual data points or populations.

Some GPS units may save geographic data in different file formats, which may make it difficult to use with GIS mapping software or between different GPS units. The State of Minnesota Department of Natural Resources has developed open-source software called DNRGPS that converts several popular GPS file formats compatible with different GPS models and GIS software (Available online here: http://www.dnr.state.mn.us/mis/gis/DNRGPS/DNRGPS.html).

GPS units can be limited by satellite reception. While widespread use of GPS units has increased their accuracy, it may be hard to get accurate location data in some locations, such as slot canyons or under dense canopy cover, where features can interfere with the unit's reception. It may be necessary to note data points where accuracy is limited or questionable.

6.1.2 Smart Phone Mapping Apps

An array of GPS apps allows surveyors to use their personal phones as GPS devices. These apps use the phone's GPS technology to provide real-time location information and allow data collection. Smart phone apps may reduce the costs for survey equipment and can allow volunteer groups to assist with weed mapping. Apps such as Esri Field Maps, iNaturalist, LandPKS, Fulcrum, and MapIt allow users to collect field data and create custom reports for mapping projects. Esri applications allow easy integration with ArcGIS Online to update data in real-time, reducing the time needed to process and convert data. This method, however, depends on whether field surveyors have access to smart phones. In some instances, the GPS signal on the smart phone may not provide the level of accuracy needed to document individual weed populations and a signal booster or GPS antenna may be needed.

6.1.3 GIS Remote Mapping

GIS, or a Geographic Information System, is a powerful tool for creating geographic data for mapping and project planning. GIS software can compile and analyze data collected in the field. GIS software can identify potential populations through remote sensing or by documenting visible problem areas on aerial imagery. This method works well for noxious weed tree species, such as tamarisk or Russian olive, which can grow in dense stands and have distinctive foliage. For example, dense stands of tamarisk can be delineated when using high resolution aerial

imagery based on differences in infrared signals. Remote sensing is recommended where field mapping may not be feasible, such as in canyons or rivers, but may be expensive due to the costs for obtaining high resolution multi-spectral images needed for such analysis. While currently in development, remote sensing for smaller, less dense weed species such as thistles, grasses, or other herbaceous or annual weeds is limited due to their visual similarities to other native populations and the size of individual plants. However, new methods and imagery technology may provide some guidance on how to use remote sensing for large-scale weed mapping projects.

6.2 Data Collection

Whether in digital or paper form, the information below represents the basic required information collected during all weed mapping surveys and will allow the BIA to share weed data with other agencies and weed management groups. This list can be updated as weed mapping efforts develop and evolve. A sample data sheet is provided in Appendix D.

- Agency - As weed mapping is done, field surveys should identify the BIA Agency collecting the data and the weed coordinator managing the mapping effort.
- Date - Mapping surveys should document the month, day, and year the survey was conducted. This information can determine if certain weeds may have been missed due to the timing of the survey. For example, species that emerge in the fall may not be documented if surveys are conducted in the spring.
- Surveyor Information - Record the names and contact information of individuals conducting the survey. Follow-up may be needed to clarify recorded data or fill in missing information.
- Unique ID Code - Each infestation or area should have a unique identifier. It can be a unique combination of letters and numbers that correspond to specific geographic features, agency, date, or sequential numbers. However, they should be unique to each infestation to avoid confusion. The identifiers can be used to track projects over time.
- Information Source - Information source documents how the BIA became aware of the infestation. It can identify previous survey dates, weed coordinators, specific land users, other federal, state, or tribal agencies, community groups, or other BIA Navajo Regional agencies. During the first years implementing the Integrated Weed Management Plan, knowledge of who identified each weed infestation may be incomplete but collecting this information over time can identify community members who can assist with weed management.
- Location Data - All weed inventories should identify where infestations are located. Location information includes the geographic coordinates used to pinpoint the exact location of the infestation. Location data should be recorded for

each infestation during the survey. An infestation represents a distinct population of noxious weeds in a given area. While infestations of solitary plants may be collected, mapping efforts should focus on sites where infestations represent sizeable clusters of noxious weeds. Often this information is automatically collected with the data points.

All GIS data should comply with the Navajo Region's GIS Strategic Plan. They should also meet the FGDC metadata standards. Metadata should include descriptions of the data, an agency point of contact, and when data was collected.

If using GPS, **the geographic projection system on the unit should be set to either NAD1983 UTM Zone 12N (Arizona) or 13N (New Mexico)**, depending on where the survey is conducted. If this projection is not available on the device, coordinates can be recorded in Latitude and Longitude (Degrees, Minutes, Seconds, or Decimal Degrees), which can be converted into UTM coordinates later. To convert coordinates, the following website provides some limited coordinate conversion tools: https://www.earthpoint.us/Convert.aspx

Other location data may include the USGS quad map identifier (if used), state, county, watershed HUC codes, and range, township, and section information. However, such data is not required for basic weed mapping inventories.

- Size of the Survey Area. While weed mapping may focus on a specific area, such as a Land Management District or Range Unit, it is important to document the actual size of the area surveyed, especially of surveys do not cover the entire area. Defining the size of the survey area will allow the BIA to estimate weed cover.
- Weed Species- Weed species should be identified using the U.S. Department of Agriculture (USDA) PLANTS database symbol (http://plants.usda.gov). Individuals conducting field surveys should be trained to identify priority weed species and local vegetation. This training should teach field surveyors to identify sensitive species to avoid collection or damage. If a species is not easily identifiable in the field, a sample may be collected for identification later. A collected plant specimen should include the entire plant, if possible, including flower, roots, stems, and leaves. Collected samples should note the date, location, the unique ID code for the population, and any other pertinent information about where the sample was taken. A data point should be recorded on the GPS unit to denote where the plant was collected.

USDA PLANTS database symbols for the target weed species are provided in Appendix D. The table and symbols should be updated annually so the proper codes are used in the field to identify problem weeds.

- Native Species (for forest land projects) – Projects requiring a silvicultural permit should include an inventory of native tree species at the project site. Consult with

a professional forester to determine the level of detail needed to develop weed treatments in forestlands. The distribution of a timber and woodland tree species will determine the appropriate silvicultural system needed to ecologically restore an area or accomplish specific project goals and objectives in line with the current forest management plan. Baseline data collected during a forest inventory include but is not limited to species, diameter at breast height/diameter at root collar, percent canopy cover, height, and basal area, and understory species occupancy.

- Size and Extent- The size of the infestations should be documented in either square feet (for small sites) or an estimated acreage (for large sites). Size estimates for each documented infestation are used to assess the severity and spread of identified weed species. Polygon data is the most accurate way to document the size of the infestation. If point data is collected, surveyors should record a rough estimate of the population's size (e.g. >0.1 acres, 5-10 ft^2, etc.). If line data is collected, surveyors should set a buffer distance for the width of the infestation.

Size and extent should record the size of the infestation for **each species identified** at a recorded site. The size estimate should be an estimate for each weed population found in an area, not an estimate of the size of individual plants. This information can determine which control method to use, how to set up post-treatment monitoring, and how to assess the overall cover of priority weed species on the Navajo Nation.

- Vegetation Cover- Vegetation cover is an estimated percentage of the ground covered by the specified species. Cover is a measure of how densely the plants grow in an area. Some weeds may grow in a large area, but they may be widely spaced, allowing other vegetation to grow in the same area. Other weeds, such as tamarisk, can grow in dense stands or patches, which crowd out other plant species. Cover is best estimated by looking at how much foliage or canopy crown covers the view of the ground. For more detailed information on how to estimate vegetation cover refer to Elzinga et al. 1998 (https://digitalcommons.unl.edu/usblmpub/17/; pp. 178-186).

- Other Information

Additional information to record:

- Nearby water sources or barriers that may limit the size of the infestation
- Locations of wells or wellheads at the site.
- Travel routes to project sites and roads within the site
- Other dominant vegetation
- If unique, sensitive, or protected plants were present
- Problems encountered while collecting the data
- Other sources that may document the infestation (e.g. maps, notes, etc.)
- Photos of infestations along with photo file information

6.2.1 Stand Exams

If the project treats a noxious tree species (i.e. Russian olive, tamarisk, tree of heaven, or Siberian elm), then a stand exam is required to estimate and evaluate stand dynamics of the site. This should include an inventory of all the tree species at the site, including native trees, and an estimate of trees per acre. The stand exam information is used to estimate volume for a harvest document through either the Navajo Nation Forestry Department (if on tribal land) or BIA Forestry (if on allotted land). Stand exams are done by establishing plots within the proposed treatment so that the size and number of plots equates to at least 10% of the total stand area. The stand exam will be used to develop silvicultural prescriptions if the removal project takes place on a Navajo Nation forestland (i.e. timberland or woodland). Stand exams should be updated for each permit to detail the number of trees removed with each phase of treatment.

For any stand exam, a survey plan should be developed before field data collection starts. Project sites should follow the Navajo Forestry Compartment Exam Handbook, especially for establishing the exam layout. See the Navajo Forestry Compartment Exam Handbook (2012) for more details on exam design and terms.

In the field, the following are parameters should be collected for stand exams.

- Plot number – Create a unique identifier for each plot.
- Plot size – Record the size of the plots to ensure proper sampling design.
- Location Information – Provide the tract number, Township, Section, and Range information, if available, or latitude and longitude for the center of each plot.
- Tree species – use scientific name or USDA PLANTS code.
- Native Tree Species – Seedlings, saplings, and trees with a DBH/DRC greater than 6" should be inventoried by species per the Navajo Forestry Department Compartment Exam Handbook (2012).

6.3 Data Processing

Once data is collected in the field, it will be compiled and analyzed using GIS software. The software can organize inventory data and use it to assess weed cover and treatment effectiveness. The BIA uses ArcGIS Online to display, collect, and manage weed mapping data for the Noxious Weed Program. The data is managed by each BIA Agency weed coordinator, including management and development of relevant metadata.

Spatial data in the form of vector data should be used to assess and summarize mapping efforts. All field surveys are compiled into a central geodatabase to provide a comprehensive view of all documented weed infestations. Spatial data should include attributes that describe when individual populations were first documents, when they were last updated, if they are part of a specific weed management project, and if they represent an expansion or reduction of weed coverage from previous years (if applicable).

Weed data should be assessed at the agency and regional level on an annual basis. Analyses should look at the size and extent of infestations for all priority species, the effectiveness of treatment methods to reduce the size and cover of target species, and locations where weed projects can make the best use of limited funds. Implementation of a basic weed mapping program will aid planning and long-term management of priority weed species on the Navajo Nation.

7.0 Permitting

The PEIS, Biological Assessment (BA), and Biological Opinion (BO) associated with this plan will provide federal coverage to implement weed management activities on the Navajo Nation. However, some permitting is needed on a project-by-project basis. Prior to implementing a project, the following agencies should be contacted to ensure project compliance and to obtain necessary permits and approvals. Additional information on how to apply or fulfill additional permitting and compliance requirements are outlined in the Weed Project Checklist (Appendix C)**.** Contact information for the agencies is available in Appendix I.

Navajo Nation Department of Fish and Wildlife (NNDFW)

Project sponsors conducting weed projects under this plan shall complete and submit a Data Request Form for the project area to NNDFW Natural Heritage Program, including weed treatment methods proposed and maps of the project area. NNDFW will determine if habitat for Federal or Navajo Listed Endangered, Threatened, or Proposed species or migratory birds exists through the Biological Resource Compliance Form (BRCF). If habitat exists a qualified biologist will conduct species specific surveys during the appropriate season to determine if the species is present or have a qualified biologist on site during construction to identify species locations. To conduct species surveys on the Navajo Nation, a biological research permit must be acquired from the NNDFW. If species are detected on the site, the agency shall implement the species conservation measures outlined in the BA, BO, and PEIS (see Appendix F). Any positive results from the habitat evaluation and species surveys (i.e., occurrences of listed species) should be reported to the NNDFW. If any projects affect wetland or riparian habitats, NNDFW will require a review and approval of the project.

Navajo Nation Historic Preservation Department (NNHPD)

Cultural surveys for individual weed projects will be conducted using the standard Section 106 process established between BIA and NNHPD (see Appendix G). The project sponsor, primarily BIA, will be responsible for obtaining all necessary cultural resource clearances for individual projects. Cultural surveys should be conducted by a qualified cultural resource specialist with an NNHPD approved permit. Prior to conducting surveys, the consultant shall obtain a Class B project-specific permit from NNHPD at least 10 days prior to the start of field work. Surveys will include records searches, ethnographic interviews, and field surveys for cultural resources,

including traditional cultural properties (TCPs), for all projects. After a survey is complete the consultant must complete an Archeological Inventory Report based on the NNHPD standards (Appendix G). NNHPD will recommend specific cultural resource mitigations to the BIA NRO Regional Director through a Cultural Resource Compliance Form (CRCF) and as part of the NEPA decision document to avoid adverse effects to historic properties or TCPs. Upon approval by the BIA NRO Regional Director, the project sponsor will distribute the CRCF to all project partners for their records, excluding the cultural resource consultant and the SHPO, who will receive their approved CRCF forms from NNHPD.

Navajo Nation Environmental Protection Agency (NNEPA)

Projects must comply with the Navajo Nation Clean Water Act, Navajo Nation Safe Drinking Water Act, Navajo Clean Air Act, Navajo Environmental Policy Act, and the Navajo Nation Pesticide Act. The following reports may be required to comply with the Navajo Nation EPA:

- Any project using herbicide must submit a Pesticide Use Permit (PUP) for the Navajo Nation EPA Pesticide Program. A weed treatment flyer should be posted to the nearby Chapter House and to the project site to notify the public about the project.
- Due to the size of the Navajo Nation, projects using herbicides near open water must submit an electronic Notice of Intent (eNOI) to the U.S. Environmental Protection Agency (U.S. EPA). Each BIA Navajo Agency will serve as the Decision-Maker and Operator for the eNOI on the U.S. EPA's Region 9 Pesticide General Permit (PGP). The eNOI will provide the U.S. EPA with the project details (herbicides proposed, size of area, weeds managed, potential endangered species and watershed impacted, etc.). Copies of the Notice of Intent must be sent to the NNEPA Surface & Ground Water Protection Department and the NNEPA Pesticide Enforcement and Development Program. Information on the Pesticide General Permit requirements and eNOI submission requirements can be found in Appendix C**.**
    - Any projects using restricted use pesticides must have certified pesticide applicators who are certified through NNEPA. Project records must record where, when, amount applied, and for whom herbicide was applied. These records will be subject to review by NNEPA to ensure compliance with the Navajo Nation Pesticide Act.
    - Any projects that implement prescribed burns must be planned in coordination with NNEPA and BIA Branch of Fire Management to address air quality concerns when developing the project Burn Plan. An air quality report may be necessary to document the effects of burning on regional air quality for specific communities on the Navajo Nation.
    - Any actions that require a federal permit, license or approval to discharge into federal waters will require a Section 401 permit from the NNEPA Water Quality

Program (not including herbicides which are covered under the PGP). These include projects that excavate or place materials in some waterways and wetlands (i.e. weed removal in a stream or wetland); consultation with the U.S. Army Corps will help determine which wetlands and waterways are subject to this requirement. If necessary, an application for the Section 401 permit should be done at the same time as the Section 404 permit (see below) since these permits are done in conjunction with each other for all projects in riparian or wetland areas.

- If any projects are proposed in wetland or riparian areas, a wetland delineation is required. NNEPA must review and approve all projects that may impact federal or tribal waters along with the NNDFW.
- Projects must survey for wellheads and coordinate activities with NNEPA Public Water Systems Supervision Program (PWSSP) to incorporate wellhead protection measures.

United States Army Corps of Engineers (Corps)

The Corps regulates activities on federal waters and is charged with protecting harbors and navigation channels from destruction and encroachment, and with restoring and maintaining environmental quality. Pursuant to Section 404 of the Clean Water Act, projects along riparian and wetland areas that impact jurisdictional waters require Corps permits. The Corps has an obligation to ensure that permitted projects comply with NEPA, ESA, and NHPA. Weed projects that require mechanized removal of vegetation along riparian corridors or wetlands will require a Section 404 permit. The application for the permit should be submitted to the representative State Corps office (i.e., Arizona, New Mexico, or Utah).

Navajo Nation Forestry Department

The Navajo Nation Forestry Department should issue a forest harvest permit (Appendix K) for any projects that remove noxious trees. Forest permits require a stand exam (Section 6.2.1 Stand Exams) to evaluate current stand composition and an estimate on the number of trees removed. A stand exam will be used to estimate how much volume will be removed during the project. If the project takes place in a Navajo Nation forestland (e.g., riparian woodland, ponderosa pine timberland, etc.), a silvicultural prescription prepared and/or reviewed by a certified silviculturist is required. The prescription should outline the following information:

- Project Location and Property Identification (same as BIA Form 5-5331)
- Name of certified silviculturist
- Date of Preparation
- Stand exam methods
- Woodland type or stand designation number

- Silvicultural system applied
- Cutting method or treatment
- Stand description and forest history
- Management constraints from each project's BRCF, CRCF, and EA.
- Landowner goals and objectives
- Map of the project area
- Detailed description of the prescribed treatment (as outlined in the treatment plan)
- Monitoring needs
- Signature of the certifying silviculturist

This applies to all woodland management areas, which include riparian habitats and commercial forests as described in 53 IAM Handbooks (i.e. where native species are present). Additional planning may be needed to ensure that forest management BMPs and permit special provisions for weed removal projects are followed and existing 638 contracts are enforced. BIA Branch of Forestry can help develop the treatment plans to ensure they include the prescription and permit requirements.

BIA Branch of Forestry

Projects planned and proposed on allotted lands that remove noxious trees should be developed in consultation with the BIA Navajo Region Branch of Forestry. Noxious tree treatments within allotment lands require consent of the majority Indian interest of the beneficial Indian owner(s), documented by their signature(s) on a Power of Attorney for the Sale of Allotment Timber, contract or permit. Stand exams should also be completed to document the estimated number of trees being removed. If the projects take place in timberlands and woodlands, a silvicultural prescription is required with the same elements as above (a certified silviculturist is not required, however). Refer to 25 CFR Part 163, IAM Part 53 Chapter 3 – Harvest of Forest Products, IAM Part 53 Chapter 9 – Silviculture, and other IAM's and handbooks for forestland management activities on Indian lands for additional guidance.

BIA Branch of Fire Management

Projects that used prescribed or pile burning to remove invasive weeds should be developed in consultation with the BIA Navajo Region Branch of Fire Management. The Branch of Fire Management will assist in developing the required burn plans, including required fire modeling and smoke management mitigations. The Branch can ensure that all fires and burn plans align with the BIA's Wildlife Prevention Plan for the Navajo Region. They can also assist with public notifications and additional coordination with Navajo Nation Programs, local fire departments, tribal forestry programs, and other local fire management programs.

8.0 Mitigation Measures

The following measures are required when implementing weed management projects. These measures should be printed and checked off when implementing projects.

8.1 General Measures

Project Planning

- Complete all necessary permits and authorizations prior to implementing a project (see Section 7.0 and Appendix C).
- If treatments are planned for allotment lands, the project sponsor must obtain consent from the Indian owner(s) as the law requires.
- Noxious tree treatments require consent of the majority Indian interest of the beneficial Indian owner(s), documented by their signature(s) on a Power of Attorney for the Sale of Allotment Timber, contract, or permit.
- Surveys and clearance for paleontological resources are required before any surface disturbing activities, mechanical treatments, or chemical treatments in coordination with the Navajo Nation Minerals Department.
- Conduct surveys for cultural resources by a qualified cultural resource specialist before treatments in coordination with the Navajo Nation Historic Preservation Department (NNHPD).
- Conduct ethnographic inquiries with local community members to identify plant gathering sites and other traditional cultural properties (TCPs) that may be affected by weed treatments. If TCPs and gathering sites are identified, the project sponsor will work with the community to identify alternative sites, treatment options, or other mitigation measures.
- Complete and submit two copies of the Archaeological Inventory Report and all site forms to the NNHPD Cultural Resource Compliance Section for review. The BIA NRO Regional Director will approve the CRCF to provide Section 106.
- Avoidance of all cultural resources is the preferred mitigation measure to avoid adverse effects, as well as identifying alternative plant gathering areas. All work must be coordinated with NNHPD to ensure compliance with Section 106 and NHPA.
- Complete and submit a Data Request Form for the project area to NNDFW (https://www.nndfw.org/nnhp/drs2012.pdf) and obtain a Biological Resource Compliance Form (BRCF).
- If potential habitat for endangered or threatened species is present, conduct a habitat assessment by a qualified biologist. If potential habitat is found, protection measures, including species buffers will be applied to the habitat or additional surveys for species presence will be conducted by a qualified biologist. If the species is present at the site,

species protection measures will be employed, NNDFW will be notified, and a biological monitor will be present during all phases of project implementation (Appendix F).

- Develop a Safety and Communications Plan that identifies specific safety measures for all treatment methods used in the project, including equipment handling, required Personal Protection Equipment (PPE), and emergency response communication protocols.
- Removal of noxious trees requires a forest product harvesting permit or contract and may require a silvicultural prescription to authorize a treatment in forestlands, including woodlands. Special provisions associated with the harvest document(s) should be reviewed and modified when appropriate to address unforeseen resource issues associated with the harvesting activities.
- All project personnel will be trained on the use of Personal Protection Equipment (PPE), equipment handling, and safety protocols. Personnel will be required to use PPEs during herbicide and mechanical (chainsaw, control burn, etc.) applications.

Prior to Project Implementation

- Designate staging areas and/or equipment wash stations for cleaning and prep work before and after treatments. These sites will be used to mix herbicides, refuel equipment and vehicles, and store materials for the duration of the treatment. Equipment wash stations may be temporary and will have a filter system, for example at least 6 inches of large cinder or gravel spread over an area 10 feet x 30 feet. Filter cloth may be used for temporary stations. The area will be a perched drainage to allow excess moisture to drain after being filtered and will be located at least 300 feet away from surface water, natural drainages or wellheads.
- Notify adjacent landowners, authorized land users, local authorities, and/or the public of treatments, treatment duration, and post-treatment measures before implementation to prevent exposure and limit re-infestations through education and outreach with the local grazing official, posting public notices, radio announcements, and/or chapter meeting announcements. Weed treatment flyer and/or forest harvest sales permit should be posted locally before projects start.
- To reduce the risk of weed spread, access routes will avoid heavy infestation areas. Access routes will be closed when the project is completed.
- Clearly mark boundaries of treatment sites (such as posting visible flags or signs) before and during treatments.
- Sites will be inspected, and potential hazards removed, to ensure safety prior to treatments.

During Project Implementation

- Vehicles will use only established roads for accessing project sites. Vehicles will be parked at designated parking spots near established roadways during treatments.

- If camping, project personnel will use designated and established campsites with approval from NNHPD or a qualified archeologist.
- On-site safety briefings will be given prior to any treatments to review required PPE, safety, and emergency response measures, and what to do in the case of an injury or emergency.
- Inspect and clean equipment, heavy machinery, and clothing after treatments for mud, dirt, and plant parts to prevent spread to other project sites by the field crew.
- Minimize soil disturbance to the extent practical.
- No mechanical treatments or use of heavy mechanized equipment will be used in archeological sites or traditional cultural property boundaries.
- If potential habitat for an endangered or threatened species is present, a qualified biological monitor will be on site during all phases of project implementation.
- Vehicles and equipment should be turned off if periods between use are longer than 15 minutes.

Post Project Implementation

- Post-treatment monitoring will evaluate treatment effectiveness, potential re-infestations or new introductions, and impacts to resources (Section 11.0)
- Limit the number of people and trips to sensitive areas for follow-up treatments and/or monitoring.

8.2 Chemical Treatments

Project Planning

- The on-site Pesticide Applicator will develop a Spill Contingency Plan that meets the minimum requirements specified by the BIA to eliminate contamination of water or soil resources in the case of accidental spills.
- If using herbicide, notify NNEPA Pesticide Enforcement of project, including location, herbicides used, and treatment dates. Submit a Pesticide Use Proposal (PUP) for approval.
- If wellheads or source water areas are identified within the project area, notify NNEPA Public Water System Safety Program to determine protection zones for herbicide applications and alternative treatment methods to be used in the protection area.
- For aerial herbicide treatments, native vegetation communities in or near treatment sites should be documented with GPS, especially cottonwood-willow woodlands and native sagebrush communities.

Prior to Project Implementation

- All herbicides must be U.S. EPA approved and mixed and applied according to label instructions.
- Treatment sites will be closed according to label specifications when limiting exposure to humans, livestock, and pets is recommended.

During Project Implementation

- All herbicides will be used according to the U.S. EPA approved label.
- Certified Pesticide Applicators must be on site to supervise projects during herbicide treatments. Pesticide Applicators must be certified by the U.S. EPA for the Navajo Nation.
- Use dye markers with herbicides to identify the physical spray location on weeds.
- When herbicides are used, an emergency spill kit must be available to contain, absorb, and dispose of spill materials.
- Material Safety Data Sheets (MSDS) for herbicides and adjuvants must be accessible in the event of accidental exposure or spill.
- Avoid applying chemicals during times of high wind speeds, high temperature, and low humidity to prevent chemical drift to areas off site. Read the herbicide label for specific conditions.
- Use Water Quality Protection Zones (WQPZ) set by the NNEPA for mechanical treatments and broadcast herbicide treatments when using a vehicle in or near riparian and wetland areas. The WQPZ is at least 200 feet unless a greater buffer is needed for a listed species or if indicated on the herbicide label. Refer to the Water Quality Protection Guidelines for the Navajo Nation Forest (2000) and the Navajo Nation Aquatic Resource Protection Program Guidance (1994) on distance guidelines. Wells and wellheads will also require a 100-foot buffer based on the NNEPA PWSSP's Source Water-Wellhead Protection Guidance.
- *Near riparian areas,* only aquatic formulations of 2,4-D, glyphosate, triclopyr, and imazapyr will be used within 25 ft of the daily high-water mark. They must be applied using spot treatment methods in this zone.
- Herbicides that are practically non-toxic to fish and mollusks (White 2007) require a 25-foot (7.6 m) buffer from the daily high-water mark, including: aminopyralid, chlorsulfuron methyl, clopyralid, imazapic, and thifensulfuron-methyl. They must be applied using spot treatment methods in this zone.
- Native plant communities, such as cottonwood-willow woodlands and native sagebrush, require a 300-foot buffer during aerial herbicide treatments.
- Aerial herbicide treatments should use GPS monitoring to track their position, provide a record of where herbicide was applied, and ensure all applicable avoidance buffers are enforced.

- Non-aquatic approved and moderate to high aquatic toxicity herbicides (White 2007) require a 300-foot (91 m) buffer from the daily high-water mark.
- Only aquatic approved herbicides will be used for aerial applications by either fixed wing or rotary aircraft applications.
- Water for mixing herbicide and cleaning herbicide equipment will be potable water obtained off-site or through a Water Use Permit. For remote sites, there is a possibility of a Water Use Permit with the local water code. An anti-siphon and back flow preventer device are required to prevent contamination of the water source.
- Store equipment and materials away from riparian areas in safe and secure upland sites in close proximity of the project site. Herbicide containers and equipment must be stabilized with straw bales, filter cloth, or other appropriate means to prevent release into waterways or wetlands.
- Herbicides will be stored in a secondary containment storage unit with impermeable materials such as concrete or metal so leaks, and spills do not reach soils. Storage containers will be coordinated with BIA Safety Officer and Environmental Services.

Post Project Implementation

- Herbicide containers and application equipment will be triple rinsed at designated washing stations to minimize chemical residues left as per the MSDS and herbicide labels. Do not pour rinse water from empty containers or sprayer cleaning onto ground or any drainage system. Dispose as hazardous waste.
- Properly dispose of pesticide waste and containers according to federal, state, and tribal regulations.

8.3 Mechanical

Prior to Project Implementation

- If mechanical treatments increase the risk of erosion near waterways, erosion control measures will be implemented to stabilize and limit erosion.
- Establish and implement a burn plan if prescribed burning is used as a control method.
- Prescribed burning will not be conducted during migratory bird breeding season.

During Project Implementation

- Keep areas without vegetation wet to prevent fugitive dust. This can be accomplished with a sprayer mounted to a water truck.
- Use lightest/smallest off-road vehicle, utility vehicle, or tractors will be a priority for treatments. No such equipment will be used on wet soils or cryptobiotic soil crusts.
- No mechanical treatments within 200 feet of open water sources.

8.4 Cultural

During Project Implementation

- Projects using targeted grazing treatments will develop a grazing treatment plan for review by NNHP.
- Targeted grazing must use fencing around the perimeter of the treatment area to contain livestock.
- Use targeted grazing only in sites where weeds are palatable and non-toxic and where desired native species will not be damaged.
- After targeted grazing is implemented, livestock will be placed in a separate fenced location for 48 hours to collect animal waste. Animal waste will be burned to destroy plant parts and seeds.
- Targeted grazing will not exceed more than 10 days on a range and/or wildland project site or 365 days on a cropland site.
- Targeted grazing will not be used in areas where weed comprise less than 50% of total vegetative cover.
- Passive restoration is preferred when native vegetation comprises >75% of the treated area. If natural re-vegetation fails, then active restoration is necessary. Active restoration includes planting of native species poles, root stocks, and seeds.
- Reseeding will be timed with precipitation events and at least 7 days after herbicide treatments are completed. Reseed disturbed areas with native vegetation to minimize opportunities for weed establishment and soil erosion.
- Only native vegetation, certified weed-free and preferably locally sourced, will be used for restoration activities.

Post Project Implementation

- Livestock grazing will be deferred during the growing season or until seeding has established.

9.0 Weed Management Techniques

An integrated weed management approach uses a combination of treatment methods to control aggressive and adaptable weed species. No single control method or any 1-year treatment program will achieve effective control of any weed-infested area. The fast growth, extensive root system and high reproductive capacity of weeds requires long-term cooperative and integrated management programs and planning to contain and reduce weed populations on the Navajo Nation. Weed removal efforts should coordinate resources with adjacent agencies (e.g., NTUA, ADOT, BLM) who conduct weed treatments to maximize cost effectiveness of weed treatments.

Additionally, use of multiple, appropriately timed methods will increase the effectiveness of weed management projects while reducing the risk of harmful impacts. Mechanical and/or manual treatments followed by a chemical treatment is more effective than implementing each treatment by itself. Chemical treatments followed by seeding or planting native understory species, such as grasses, will help restore native plant diversity. Prior to noxious weed seed set, hand pulling is effective for small infestations followed with a mechanical or chemical treatment to ensure no target weeds germinate that year. Appropriate timing of weed control techniques is the most important factor to improve effectiveness. Most annual and biennial plants should be treated early in the season before the plants bolt and flowering occurs. In contrast, many perennials are effectively treated with systemic herbicides in the fall when plants actively transport nutrients to their root system. The methods described below are recommendations for treating noxious weeds based on techniques used in areas outside the Navajo Nation. Appendix E outlines the best option for control for each priority weed species.

Biological control agents will not eliminate an infestation; however, they will enhance control and reduce the rate of expansion of large existing infestations. Biological control is most effective on large populations where other control methods are limited due to the size and scale of the infestation. The use of herbicides in combination with biological control is successful on large populations of several weed species. A more detailed discussion of the proposed weed treatments for the Navajo Nation is discussed below. Comprehensive weed management methods for each target weed species can be found in USDA Forest Service Southwest Region Weed Field Guides (https://www.fs.usda.gov/detail/r3/forest-grasslandhealth/invasivespecies/?cid=stelprd3813522) and in the University of California, Davis Cooperative Extension and Agricultural Experiment Station (https://wric.ucdavis.edu/information/info_spec_weed.htm)

Treatment method selection should consider several factors. Local community engagement should identify public health concerns, economic impacts, cultural resources (such as plant collection areas), and community-based goals for removing the infestations. Impacts to natural resources such as sensitive plant and animal populations, soil erosion, and water quality, should also be evaluated. Projects should determine, based on the size, density, and the specific weed species, a reasonable level of treatment needed to reduce the population while minimizing impacts. For example, widespread but patchy clusters of yellow starthistle may be controlled with less intense treatments such as biological control or targeted grazing while dense isolated populations of Canada thistle may require more intensive mechanical removal followed by chemical treatments. Treatments should also prioritize the least harmful methods by selecting non-herbicide techniques where feasible and using the least toxic herbicide available for treating the targeted weed species (Appendix E) paired with other control methods to reduce the amount of herbicide needed to effectively reduce and minimize regrowth. These considerations ensure that projects address a wide array of concerns while maintaining treatment effectiveness through a multi-faceted and integrated management approach.

9.1 Prevention

Prevention is the most effective and least expensive method of control. Establishing a "weed-free" policy to include, but not limited to hay, grain, seed, and ballast, is crucial to reduce weed expansion and to prevent new weed introductions. A "weed-free" policy will require action by the Navajo Nation Tribal Council. Maintenance of a vigorous, competitive native plant community will also reduce noxious weed establishment.

Cleaning tires, boots, hooves, and equipment when leaving infested areas will prevent weed introductions and limit the spread of existing infestations. Extensive disturbance gives noxious weeds an advantage over native plants as most weeds are well adapted to disturbed areas. Revegetating large, disturbed sites with vigorous, hardy, native grass and perennial plants will prevent establishment of new noxious weed populations.

9.2 Early Detection/Rapid Response

The key to preventing new noxious weed introductions involves early detection and rapid response. The longer a species goes undetected during the early, non-invasive stage, the less opportunity there is to intervene. Once weeds are established, control or eradication methods become more expensive and limited in their effectiveness. Education programs on how to recognize noxious weeds may help community members detect infestations when they are still small. Community members can also use the BIA's planned weed program website to report new populations and assist with early detection efforts. Repeated surveys can detect new weed infestations in high priority areas, such as wildlife habitat, areas for collecting traditional plants, or riparian areas. After detecting a new noxious weed on the Navajo Nation, a treatment plan should be developed based on the growth characteristics of each species, size of the infestation, and the personnel and equipment capacity of the BIA. Early detection and rapid response is most successful when new infestations are less than 1 acre in size. Early detection and rapid response to new noxious weed infestations is a high priority.

Since roads and rights-of-way corridors are primary vectors for introducing and spreading weeds, early detection and rapid response in these areas is important. Surveys along roads and rights-of-way and adjacent land can identify new weed populations with the potential to spread. Once these populations are identified, early treatment to maintain linear corridors will prevent or reduce the potential for large scale infestations on adjacent lands.

Early detection and rapid response techniques will follow those established by the U.S. Forest Service in 2005 and the Arizona Invasive Species Advisory Council in the Arizona Invasive Species Management Plan in 2008. Scattered plants and spot infestations around the perimeter of the infestation should be treated first to contain the spread of the infestation. To limit seed dispersal, treatment of infestations along roads should be done at the same time as treatment around the infestation perimeter. Treatments should then move inward toward the core of the infestation. Treatments should be repeated until the seed bank is depleted. Treatments along

linear corridors (roads and rights-of way) will be treated in a linear fashion in right-of-way easements. Linear corridors serve as both the core and/or the perimeter of the infestation and weed removal activities on adjacent infested areas should be done at the same time.

9.3 Manual Control

Photo courtesy of Fred Phillips Consulting.

Manual control techniques include the use of hand tools to cut, clear, or prune herbaceous or woody species. A maximum of 30 people (typically between 7-20 people) will conduct manual treatments. Manual treatments involve cutting undesirable plants above ground level; pulling, grubbing, or digging out root systems to prevent sprouting and regrowth; and removing competing plants around desired species. Manual control is conducted with hand tools, including handsaws, loppers, axes, shovels, rakes, machetes, grubbing hoes, mattocks (combination of cutting edge and grubbing hoe), Pulaskis (combination of axe and grubbing hoe), brush hooks, weed whackers, and hand clippers. Manual treatments, such as hand pulling and hoeing, are most effective where weeds are limited and soils allow for complete removal of the plant material, including the root system (Rees et al. 1996).

Annual and biennial plants with shallow root systems that do not re-sprout and plants growing in sandy or gravelly soils will be hand pulled. Vegetation removed manually will be bagged and sent to a certified incinerator to prevent reinfestation from seeds or other plant materials. Repeated treatments will be necessary as seeds remain in the ground for multiple years. Manual techniques are most effective for small areas (<1 acre), areas where burning or herbicide treatments are not appropriate, areas that may be inaccessible to ground vehicles, and in areas where species of concern exist. For the most effective control, manual techniques will be used in combination with chemical techniques.

9.4 Mechanical Control

Mechanical control involves the use of power tools and heavy machinery to remove noxious weeds. The techniques described are adapted from the Bureau of Land Management (BLM)'s Vegetation Treatments for 17 Western States (BLM 2007). These techniques are utilized when clearing large areas where weeds are widespread and provide dense coverage, often limiting the growth of native vegetation to very confined areas (**Figure 9-1**). Mechanical equipment should be cleaned before treatments and before leaving the treatment area in designated facilities or equipment wash stations (see 8.0 Mitigation Measures for specifications).

Figure 9-1. Examples of mechanical treatments. *Left*: Tractors grubbing root systems for large tamarisk stands. *Right*: A site cleared of invasive tamarisk using mechanical treatments. Photos courtesy of Fred Phillips Consulting, LLC.

- **Grubbing** - Grubbing removes a plant by digging out its root system. If a species has a shallow root system, a shovel or mower is used to remove the plant. Noxious weeds with deep root systems require the use of a crawler-type tractor and a brush or root rake attachment. Brush is uprooted and roots are combed from the soil by placing the base of the blade below the soil surface. Grubbing disturbs perennial grasses, so grubbed areas will be reseeded to prevent extensive runoff and erosion, if possible. This removal technique requires a maximum of 5 people to drive the heavy machinery and prepare the site. Grubbing will not be used in areas with active prairie dog colonies or in habitats with other burrowing animals.

- **Tillage** - Tilling involves the use of angled disks (disk tilling) or pointed metal-toothed implements (chisel plowing) to uproot, chop, and mulch vegetation. Tilling is done with either a brushland plow, a single axle with an arrangement of angle disks that covers about 10-foot swaths, or an offset disk plow, which consists of multiple rows of disk sets at different angles to each other. These plows are pulled by a crawler-type tractor or a large rubber tire tractor. This technique is best used where complete removal of vegetation or thinning is desired and is followed with seeding. Tilling leaves mulched vegetation near the soil surface, which encourages the growth of newly planted native seeds. This method is also used for removal of sagebrush and similar shrubs and works best on areas with smooth terrain, and deep, rock-free soils. Chisel plowing is used to break up compact soils. This removal technique requires a maximum of 5 people to drive the heavy machinery and prepare the site. Tillage will not be used in areas with active prairie dog colonies or in habitats with other burrowing animals.

- **Mowing -** Mowing tools, such as rotary mowers or straight-edged cutter bar mowers are used to cut herbaceous and woody vegetation, and is most effective on annual and biennial plants, above the ground surface. Power tools such as chainsaws and power

brush saws are used for thick-stemmed plants. Mowing is done along highway ROWs to reduce fire hazards, improve visibility, prevent snow buildup, and/or improve the appearance of an area. Weeds are rarely killed by mowing, and an area often needs to be mowed repeatedly for treatments to be effective (Colorado Natural Area Programs 2000). The use of a "wet blade," in which an herbicide flows along the mower blade and is applied directly to the cut surface of the plant, has greatly improved the control of some species. Chipping equipment is used to cut and chip vegetation. This removal technique requires a maximum of 2 - 5 people to operate the chainsaws, power brush saws or Bobcat and to prepare the site. Heavy machinery (Bobcats) with a mowing attachment may require off-road use and have medium ground disturbance (**Figure 9-2**).

Figure 9-2. A Bobcat with a brush hog mower attachment removing noxious weeds. Photo courtesy of Fred Phillips Consulting, LLC.

- **Prescribed Fire** - The use of controlled burns, or prescribed fire, to treat noxious weeds is the intentional application of fire under specified conditions. Controlled burns can provide many benefits to an area by controlling vegetation, enhancing growth, reproduction, and vigor of desired vegetation, reducing fuel loads, and maintaining some vegetation communities. Pile burning is an effective method to reduce fuel loads after mechanical treatments. A Burn Plan must be developed for each project prior to implementing this technique. The Burn Plan may include but will not be limited to 1) project objectives; 2) prescription; 3) scheduling; 4) pre-burn considerations and weather; 5) site assessment and topography considerations; 6) organization and equipment; 7) communication; 8) public and personnel safety and medical information 9) smoke management plan; 10) ignition and holding plans; 11) contingency plan; 12) mop up plan, and 13) restoration plan. Prescribed fire will be followed by habitat restoration.

Photo courtesy of Fred Phillips Consult LLC

Prescribed fires will be used in areas where there is no threat to human life or property to maintain ecosystems that are functioning within a normal fire regime. Prescribed fires are evaluated for potential risks and implemented with adequate fire management personnel and equipment. Prescribed fires will follow the guidelines outlined in the BIA NRO Programmatic Pile Burn Agreement with the Navajo Nation and all permits and authorizations will be obtained prior to implementing this technique. Prescribed fires minimize soil disturbance and will not be conducted during the migratory bird breeding season.

- **Heavy Machinery**- Heavy machinery includes large chipping equipment or masticators, roller chopping tools, feller-bunchers, bulldozers, and extracting equipment and requires special training for operation. Bulldozers or extracting equipment is used to uproot dense woody vegetation or tree species. Large chippers, or "tub-grinders" and masticators, are used to chip the limbs, bark, and trunks of trees to generate mulch or biomass. Feller-bunchers are used to cut trees at the base, pick them up, and move them into a pile or onto the bed of a truck (Bonneville Power Administration [BPA] 2000). Rolling chopping tools are heavy bladed drums that cut and crush vegetation up to 5 inches in diameter with a rolling action. The drums are pulled by crawler-type tractors, farm tractors, or a special type of self-propelled vehicle designed for forest or range improvement projects. Blading uses a crawler-type tractor with a blade shear attachment to cut small brush at ground level and scrape topsoil with the brush to pile into windrows. Blading is only employed in areas where the degradation of the soil is acceptable, such as along ROWs or in borrow ditches. Heavy machinery highly disturbs soils. This technique requires a maximum of 5 people to operate the heavy machinery and prepare the site.

9.5 Cultural Control

Cultural treatments include targeted grazing, replanting native species (see Chapter 10), cultivation and crop rotation, using weed-free hay, and mulching around desired vegetation to limit competition with undesired plants. Targeted grazing uses specific livestock species at a determined season, duration, and intensity to accomplish defined vegetation or landscape goals (Daines 2006). Targeted grazing can be used around Community Development Areas, in agricultural fields, in riparian habitats, and in Highly Sensitive and Moderately Sensitive RCP Areas. However, it may not be used where sensitive species do occur because of the high degree of ground disturbance. All targeted grazing treatments conducted outside of Community Development Areas require a grazing treatment plan that must be reviewed by the Navajo Nation

Heritage Program (NNHP). Targeted grazing alone will not eradicate a weed population and must be used in combination with other methods as a long-term land management strategy (Daines 2006). Targeted grazing should aim to reduce growth and vigor of established weed populations, increasing the effectiveness of more direct removal and control methods. To successfully implement target grazing at a local level, public outreach and education, workshops, and training on identification, reporting, and monitoring weeds is necessary.

The key to success with targeted grazing is selecting the most appropriate animal to browse or graze the target weed species (**Table 9-1,** Daines 2006). Additionally, weeds must be consumed at the most appropriate life stage to be palatable to livestock and livestock should be specifically trained to consume weed species. Livestock will avoid plants that are novel, low in nutrients, or high in toxins (Daines 2006). Timing and intensity of targeted grazing should be designed to maximize damage to the target weed while minimizing impacts to native vegetation. Targeted grazing requires containing livestock in an isolated area with fencing for up to 24 hours after grazing treatments to isolate and collect defecated seed. Feces will be collected, bagged, and destroyed by incineration. A robust monitoring program is also required to understand the effectiveness of the targeted grazing treatment and should include the following metrics: livestock type, performance, and/or weight gain, consumption of vegetation (utilization and residue), and changes in vegetation structure (biomass, canopy cover or basal area, and plant density) (see11.1. Treatment Effectiveness Monitoring). Targeted grazing has limited effects on field brome, common Mediterranean grass, camelthorn, several annual brome grasses, and jointed goatgrass and is not recommended to control these species. The Society for Range Management maintains a website with research, management recommendations, and training on updated information (https://targetedgrazing.org/).

Table 9-1. Targeted grazing by weed species, livestock class, grazing objective, plant growth stage, and potential effectiveness (Daines 2006). Only the weed species listed in the table were reduced by targeted grazing treatments. Weeds not listed are not recommended for target grazing.

Target Weed	Livestock Class	Grazing Objective	Growth Stage for Treatment	Potential Effectiveness
Bull Thistle (*Cirsium vulgare*)	Sheep, Goats, and Cattle	Prevent seed production, reduce plant size and vigor	Graze heavily during rosette to bolting stage. Repeat grazing at approximately 2-week intervals. May need to graze once a season if in early flowering stage. 3 consecutive years needed.	Cattle will not graze beyond late bud stage. Grazing works best when combined with a fall herbicide treatment. Grazing reduced plant size, density, and reproductive efficiency.
Canada Thistle (*Cirsium arvense*)	Sheep, Goats, and Cattle	Begin grazing when rosettes are green and begin to sprout. Remove animals when grazing shifts to desirable species and re-graze new sprouts	Graze during seedling to late vegetative stage with regular removal of top growth throughout the season. Graze to prevent flowering. Repeat at least 3 years.	Goats will graze all stages. Sheep and cattle prefer when young before spines develop. Most effective with repeated treatments for multiple seasons to prevent seed production and prevent root reserves. Best results when combined with herbicide treatments.

Target Weed	Livestock Class	Grazing Objective	Growth Stage for Treatment	Potential Effectiveness
Cheatgrass (*Bromus tectorum*)	Sheep, Goats, and Cattle	Intense flash grazing to remove biomass, decrease plant density, and suppress flowering.	Graze when green, as early as possible, without harming desirable perennial plants. Repeat to prevent seed production. Minimum of 2 treatments per year for 2 or more years to suppress populations.	Heavy repeated grazing for 2 or more years will reduce plant density, size and seed production. Grazing must be closely monitored to avoid damage to desirable perennial plant species. Can be used in conjunction with mechanical, herbicides, and controlled burn.
Diffuse knapweed (*Centaurea diffusa*)	Sheep, Goats, Cattle	Graze heavily at least twice each year for three or more years.	Sheep - rosette or bolted stage. Goats - all growth stages Cattle - before bolting stage	Reduce plant vigor, size, and flower production. Remove livestock for about 2 weeks and re-graze to prevent seed head formation. Grazing most effective when combined with herbicide treatments.
Leafy Spurge (*Euphorbia esula*)	Sheep and Goats	Remove 95% of top growth; graze regrowth after 1st treatment; prevent flowering and seed production	Graze in vegetative to flowering stage. Sheep - prefer young plants Goats - eat all growth stages	Effective at reducing biomass on an annual basis when grazed moderate to heavy from vegetative to flowering growth stages. Grazing effectiveness can be low 1st year. Suppression of high-density infestations will occur after 4 or more consecutive years of grazing. Used in combination with herbicides and biological control may be an effective strategy for long-term management.
Musk Thistle (*Carduus nutans*)	Sheep, Goats, Cattle	Prevent seed production, reduce plant size and vigor.	Graze heavily during the rosette to bolting stage. Repeat grazing at two-week intervals to prevent flowering and seed production. May need to graze once a season if in early flowering stage and site conditions limit regrowth. Graze at least 3 consecutive years.	Grazing reduces plant size, density, and reproductive efficiency. Cattle will not graze beyond early bud stage. Works best when combined with fall herbicide treatment.
Perennial Pepperweed (*Lepidium latifolium*)	Sheep and Goats	Remove 85% of top growth with repeated grazing (every 3-4 weeks)	Graze until early flowering stage, with preference for early vegetative stages. Repeat grazing for several years is necessary.	Repeat, intensive grazing can reduce biomass, density, and height in single season, but root system replenishes infestation. Grazing must be continued for several years. Can be combined with herbicide spraying.

Target Weed	Livestock Class	Grazing Objective	Growth Stage for Treatment	Potential Effectiveness
Russian Knapweed (*Acroptilon repens*)	Sheep (particularly dry ewes) and goats	Removal of 80% biomass	Early vegetative to flowering. Graze at least 3 times per season, allowing 8-10 in. of regrowth between treatments. 3 or more years necessary.	Graze repeatedly multiple times each season for several years. May result in reduced biomass and density of plants but may return to pre-gazing density when grazing ceases. Long-term management requires integrated program with herbicides and competitive planting.
Saltcedar (*Tamarix ramosissima*) **Russian olive** (*Elaeagnus angustifolia*)	Goats	Severe defoliation to deplete root reserves and prevent establishment of new plants	Prefer young shoots but will browse 4-year-old shoots. Repeated browsing is needed to limit resprouting and remove new seedlings.	Browsing is effective to reduce size and density of trees and eliminate from specific sites. Goats must consume most or all resprouts and seedlings for at least 3-5 years. Maintain native perennial grass understory to prevent seedling establishment for long-term management.
Scotch Thistle (*Onopordum acanthium*)	Sheep, Goats, Cattle	Prevention of flowering and reduction of stem density.	Graze at the rosette to bolting stage. Heavy to severe utilization, using short-duration, high-intensity grazing provides the best results when repeated for several years to deplete seedbank.	Grazing is effective at suppressing flowering and reducing stem density 30 to 50%. Several years may be needed to reduce populations. Native perennial grass competition is essential. Effective when used in combination with follow-up herbicide treatment.
Spotted Knapweed (*Centaurea maculosa*)	Sheep and Goats	Graze to prevent seed production and reduce biomass.	Graze heavily during the rosette or bolting stage. Two grazing periods per year during rosette to bolting and bud stages provide best control.	Grazing can reduce plant vigor, density, size, flower stems, and seed production. Sheep digestive systems may suffer if diets are composed of >70% knapweed. Most effective when combined with herbicide treatments.
Tall Whitetop (*Cardaria draba*)	Sheep and Goats	Prevent flowering and maintain removal of 85% of top growth during growing season.	Graze before flowering. Repeat at least 2 times a year for at least 3 years.	Repeated grazing may reduce plant vigor and flower production.
Yellow Starthistle (*Centaurea solstitialis*)	Sheep, Goats, and Cattle	Graze heavily at least twice a year to prevent flowering and for several years to deplete seedbank and reduce plant density.	Sheep and goats will graze at all growth stages. Cattle will graze in the rosette to bolting stage. 2-3 treatments are needed if grazed in rosette or bolting stage, goats grazing during or after flowering may require 1 year.	Goats are most effective. Grazing reduces plant vigor and plant size and suppresses flower production. Graze twice a year over several years to prevent flower and seed production.

9.6 Biological Control

Biological control agents are U.S. Department of Agriculture (USDA)-approved insects and pathogens that undergo rigorous testing prior to availability for release. Initial testing occurs in quarantined laboratories to determine their effectiveness in controlling the target organism and

host specificity. Testing includes potential effects on economic crops, rare plants, and similar species found in North America. An agent is approved for release only after it is determined that it is unlikely to feed or cause injury to any native or agricultural species. It generally takes between 15-20 years for an agent to be cleared for release. Prior to the release of a new agent, an environmental analysis is prepared by USDA APHIS (Agricultural Plant Health Inspection Service). The analysis assumes that agents will spread throughout North America following release. The BIA is using only those biological agents approved by APHIS as listed in **Table 9-2**.

The BIA will not consider the release of the tamarisk leaf beetle (*Diorhabda carniulata*). This species was released near Moab, Utah in 2004 along the Colorado River with the expectation that it could not migrate below the 38º N latitude. However, the beetles moved and infiltrated sites south of the 38º N latitude, migrating down the Colorado River past Lake Mead. This unexpected migration decimated the nesting habitat of the endangered Southwestern Willow Flycatcher, which has affected the reproductive success of this species. The leaf beetle occurs in riparian areas across the Navajo Nation. The BIA NRO monitors the leaf beetle to document its extent and impact on the Navajo Nation.

Table 9-2. Target noxious weeds and proposed biological control agents.

Target Weed Common Name	Proposed Control Agents by Scientific Name	Proposed Control Agents by Common Name
Dalmatian toadflax	*Brachypterolus pulicarius* *Calophasia lunula* *Eteobalea intermediella* *Eteobalea serratella* *Mecinus janthinus* *Gymnetron antirrhini* *Gymnetron linariae*	Flower feeding beetle Toadflax moth Root-boring moth Root-boring moth Stem-mining weevil Seed capsule weevil Root-galling weevil
Diffuse knapweed	*Bangasternus fausti* *Bangasternus orientalis* *Cyphocleonus achates* *Larinus minutus*	Seed head feeding weevil Seed head feeding weevil Root feeding weevil Seed head feeding weevil
Field bindweed	*Aceria malherbae* *Tyta luctuosa*	Bindweed gall mite Bindweed moth
Leafy spurge	*Aphthona abdominalis* *Aphthona cyparissiae* *Aphthona czwalinae* *Aphthona flava* *Aphthona lacertosa* *Aphthona nigriscutis*	Minute flea beetle Brown dot flea beetle Black flea beetle Copper flea beetle Brown-legged flea beetle Black dot flea beetle
Puncturevine	*Microlarinus lypriformis*	Puncturevine seed feeding weevil
Russian knapweed	*Subanguina picridis* *Jaapiella ivannikovi* *Urophora kasachstanica* *Urophora xanthippe*	Nematode Diptera: Cecidomyiidae Flower gall fly Flower gall fly
Spotted knapweed	*Bangasternus fausti* *Bangasternus orientalis* *Cyphocleonus achates* *Larinus minutus* *Larinus obtusus*	Seed head feeding weevil Seed head feeding weevil Root feeding weevil Seed head feeding weevil Seed head feeding weevil

Target Weed Common Name	Proposed Control Agents by Scientific Name	Proposed Control Agents by Common Name
Yellow starthistle	*Eustenopus villosus* *Bangasternus orientalis* *Chaetorellia australis* *Urophora sirunaseva*	Starthistle hairy weevil Starthistle bud weevil Starthistle peacock fly Starthistle gall fly

The BIA and Cooperating Agencies will consult with Navajo Nation Department of Fish and Wildlife (NNDFW) on a project-by-project basis to approve the use of biological control agents. Also, prior to the release of any biological control agent, the BIA will obtain a permit from APHIS. The Coconino, Kaibab, and Prescott National Forests and the City of Flagstaff have conducted biological control treatments near the Navajo Nation for Dalmatian toadflax, diffuse and spotted knapweed, yellow starthistle, and leafy spurge (Dewey Murray, personal communication 2013). The greatest success has occurred with biological controls released to control diffuse knapweed.

9.7 Chemical Control

Chemical methods include the use of herbicides to control noxious weeds. Herbicides are categorized as selective or non-selective. Selective herbicides kill only a specific type of plant. For example, a selective herbicide for broad-leaved plants will not affect grasses. Non-selective herbicides will kill all vegetation that it contacts. Therefore, it is important not to spray desirable vegetation when using non-selective herbicides. The herbicides for use on the Navajo Nation are listed in **Table 9-3**.

Photo courtesy of Fred Phillips Consulting.

There are several herbicide application methods. The method chosen for a particular project site may depend on the size of the infestation, the species present, accessibility to the site, topography, resources and equipment available, and finances. All herbicides will be used according to their labels and a Navajo Nation Certified Pesticide Applicator must be on site. Water for mixing herbicide and cleaning herbicide equipment will be potable water obtained off-site or through a Water Use Permit. For remote sites, a Water Use Permit may be obtained with the local water code. An anti-siphon and back flow preventer device are required to prevent contamination of the water source. Up to 30 people are needed to implement chemical treatments. Some herbicide application methods are described below.

- **Cut Stump** - This method uses both chemical and mechanical/manual techniques and is effective on tree species that sparsely populate an area or in areas where heavy machinery is not an option. The plant is cut as close to the ground as possible using a chainsaw or loppers. The cut stump is then immediately (within 15 minutes) sprayed or painted with a systemic herbicide to prevent vigorous re-

sprouting. It is important to cover the entire cut stump with herbicide. For the most effective and safe treatment, skilled sawyers are recommended.

- **Basal Bark** - Basal bark spraying is most effective on dormant and leafless woody plants with less than a 6-inch stem diameter. This method involves spraying the bottom 12-18 inches of a stem with herbicide. Care is taken to apply herbicide around the entire stem. The herbicide is mixed with a penetrating oil that allows it to pass through the bark. This method results in a dead standing snag.
- **Frill or "Hack and Squirt"**- This method involves making spaced cuts around the entire tree trunk with an ax, machete, or hatchet. It is important that the cut penetrates to the cambium layer. Herbicide is then applied to the cuts using a spray bottle or similar tool.
- **Foliar spray** – Foliar sprays are most effective when plants are in full leaf. Foliar spray is applied using a backpack sprayer, spray bottle, a boom or boomless sprayer mounted on an ATV or truck, fixed-wing airplane or helicopter to distribute over a large area.
- **Pelletized Treatment**- Herbicides made into small pellets can be buried around the plant's base.
- **Pre-Emergent Treatment**- This treatment method involves applying herbicide to the soil before the target noxious weed species germinates or emerges.

Herbicide applications require certain precautions and protocols. U.S. Environmental Protection Agency (U.S. EPA) categorizes pesticides as either "unclassified" or "restricted use." A pesticide, or some of its uses, can be classified as restricted if it causes harm to humans (pesticide handlers or other persons) or to the environment. Herbicide applications will comply with the Navajo Nation Pesticide Act as enforced by the Navajo Nation Environmental Protection Agency, which includes annual reporting on projects that use herbicide treatments and proper disposal of unused herbicide. Herbicides must be applied by applicators with a state applicators license and a U.S. EPA Certified Pesticide applicator card for the Navajo Nation. The U.S. EPA Certified Pesticide applicator card can be obtained through the U.S. EPA Region 9 Pacific Southwest Office.

Near riparian areas, only aquatic formulations of 2,4-D, glyphosate, triclopyr, and imazapyr can be used within 25 ft of the daily high-water mark. Herbicides that are practically non-toxic to fish and mollusks (White 2007) require a 25 ft (7.6 m) buffer from the daily high-water mark, including: aminopyralid, chlorsulfuron, clopyralid, imazapic, and thifensulfuron-methyl. Imazapic and imazapyr have no risk to aquatic invertebrates and fish even if there is an accidental direct spray or spill to the aquatic habitat (BLM 2007). Non-aquatic approved and moderate to high aquatic toxicity herbicides (White 2007) require a 300 ft (91 m) buffer from the

daily high-water mark. Only aquatic herbicides will be used for aerial applications by either fixed wing or rotary aircraft within riparian areas.

When applying herbicides, weather conditions such as wind speed, wind direction, inversions, humidity, and precipitation should be taken into consideration. Herbicides should always be used as directed on their labels. Caution is required to prevent overspray on non-target species. Extreme caution is used when mixing herbicides. Dermal exposure to a small amount of a concentrated herbicide is equivalent to the exposure received after a full day of working in a treated field. Herbicides are applied using the proper equipment and applicators are required to use personal protective equipment. Application rates for each herbicide are in **Table 9-4.**

Use of herbicides can include concerns about human health, ecological risks, and potential impacts to native plants and animals. Projects using herbicides should always be paired with other treatment methods to (1) improve their effectiveness and (2) reduce the potential for harmful impacts. If more than one herbicide can be used for a project, treatments should prioritize the herbicide with the lowest toxicity. Herbicides are listed by toxicity in Appendix E.

Table 9-3. Herbicides approved for use on the Navajo Nation based on priority treatment areas. * Indicates a Restricted Use Pesticide.

Herbicide	Herbicide Characteristics and Target Vegetation	Riparian	Rangeland	Agricultural Lands	Right-of-Ways	Roadsides	Residence/ Communities
2,4-D	Selective herbicide used to control broadleaf weeds by interfering with plant metabolism. It is moderately to highly mobile in the soil, which restricts its use in and around high ground water tables or open water. Key species include biennial thistles, Canada thistle, diffuse knapweed, leafy spurge, blue mustard, perennial pepperweed, Russian knapweed, squarrose knapweed, sulfur cinquefoil, Dalmatian toadflax, whitetop, halogeton, puncturvine, spreading wallflower, horehound, California burclover, Russian thistle, and yellow starthistles.	X	X	X	X	X	X
Aminopyralid	Selective herbicide used for broadleaf weed control. It is relatively immobile in the soil and remains in upper 12" of soil profile. Target weeds include yellow starthistle, squarrose knapweed, bull thistle, Canada thistle, musk thistle, scotch thistle, spotted knapweed, whitetop, sulfur cinquefoil, diffuse knapweed, Russian knapweed, and Russian olive.	X	X	X	X	X	X
Atrazine*	Selective herbicide that controls pre- and post- emergence broadleaf and grassy weeds. It is mostly absorbed through the roots inhibiting photosynthesis. Atrazine degrades in soil primarily by action of microbes. It is common chemical contaminant in ground and surface water. Key species include red brome and kochia.		X	X			
Chlorsulfuron	Registered for general use to control many broadleaf weeds and some annual grasses. This herbicide inhibits enzyme activity. Chlorsulfuron tends to leach into soils with a textural range from sand to silt loam and degrades more rapidly at higher temperatures with adequate moisture contents. It is broken down to smaller compounds by soil microorganisms. Chlorsulfuron may be used to treat blue mustard, Dalmatian toadflax, perennial pepperweed, puncturevine, Russian thistle, kochia and thistles.		X	X	X	X	X
Clopyralid	Selective post-emergence herbicide controlling broadleaf species. This herbicide affects the target weed by mimicking the plant hormone auxin and causes uncontrolled plant growth and eventual death. Once applied to the ground, it rapidly disassociates, which results in having a high potential to contaminate ground or surface water. It is used to treat biennial thistles, Canada thistle, perennial pepperweed, diffuse knapweed, Russian knapweed, squarrose knapweed, and yellow starthistle.		X	X	X	X	
Dichlobenil	Selective weed control of annual grassy and broad-leafed weeds and certain perennial weeds. It is water soluable and moves slowly in the soil. Can be used to treat leafy spurge, biennial thistles, Canada thistle, perennial pepperweed, Russian knapweed, field bindweed, and kochia.			X	X	X	X
Fluroxypyr	A pyridinoxy acid herbicide used to control annual and perennial broadleaf weeds and woody brush. Potential to leach to groundwater is high and potential for loss on eroded soil is low. Plants take up through leaves and roots and translocated to other plant parts. Target weeds include kochia and knapweeds.		X		X	X	

Herbicide	Herbicide Characteristics and Target Vegetation	Riparian	Rangeland	Agricultural Lands	Right-of-Ways	Roadsides	Residence/ Communities
Fluazifop-P-butyl	Selective herbicide for post-emergence control of annual and perennial grass weeds. Breaks down rapidly in moist soils. It is actively taken up by plants and translocated throughout the plant where it interferes with plant cell's ability to produce energy. Target weeds include: fountaingrass, common Mediterranean grass, and red brome.			X	X	X	
Glyphosate	Broad-spectrum, nonselective herbicide used for control of annual and perennial plants including grasses, sedges, broadleaf weeds, and woody plants. Method of action is to inhibit amino acid and protein synthesis. It is moderately persistent in the soil. Glyphosate is strongly absorbed in most soils and normally does not leach out of the profile. Glyphosate is successful in controlling annual, biennial, and perennial grasses, broadleaf weeds, and woody shrubs and trees.	X	X	X	X	X	X
Imazapic	Selective herbicide for both pre- and post-emergent control of some annual and perennial grasses and broadleaf weeds. It affects plants by inhibiting the production of amino acids that ultimately reduces cell growth. It is considered moderately persistent in soils. Effective in control of biennial thistles, Canada thistle, leafy spurge, Dalmatian toadflax, perennial pepperweed, whitetop, halogeton, jointed goatgrass, red brome, and cheatgrass.		X	X	X	X	X
Imazapyr	Broad-spectrum herbicide that is applied pre- or post-emergence. Absorbed by the leaves and roots and moves rapidly through the plant. It has a strong affinity to bind to soils and rarely moves beyond the top few inches. Low potential for leaching to ground water but may reach surface water during storm events over recently treated land. Imazapyr is effective on African rue, Tree of Heaven, Fountaingrass, yellow starthistle, perennial pepperweed, whitetop, Uruguayan pampas grass, common Mediterranean grass, saltcedar, Siberian elm, camelthorn, Russian knapweed, and Russian olive.		X		X	X	
Indaziflam	Pre-emergent and broad-spectrum control of weed seedlings. It inhibits development and cellulose biosynthesis in roots. It is moderately persistent in soils and does have the potential to contaminate surface water through runoff. Target weed species include: cheatgrass, red brome, bald brome, rescuegrass, ripgut brome, smooth brome, dalmatian toadflax, Halogeton, musk thistle, Canada thistle, Russian thistle, yellow starthistle, puncturevine, jointed goatgrass, California burclover, diffuse knapweed, and kochia.		X		X	X	
Isoxaben	Used for pre-emergence control of broadleaf weeds. It is absorbed through the roots and inhibits cellulose biosynthesis in the cell walls. It is moderately persistent in soil and potential for ground and surface water contamination is low. Target weed species include: kochia, mustards, Russian thistle, and leafy spurge.			X	X	X	

Herbicide	Herbicide Characteristics and Target Vegetation	Riparian	Rangeland	Agricultural Lands	Right-of-Ways	Roadsides	Residence/ Communities
Metsulfuron methyl	Control brush and certain unwanted woody plants, annual and perennial broadleaf weeds, and annual grassy plants. Affects plants by inhibiting cell division in the roots and shoots, thereby stopping growth. It dissolves easily in water and can leach through the soil to contaminate ground water but confined to soils that are either sandy or porous. It can control biennial thistles, Canada thistle, Russian knapweed, African rue, yellow starthistle, blue mustard, perennial pepperweed, halogeton, camelthorn, horehound and whitetop.		X	X	X	X	
Metribuzin	Selective herbicide that inhibits photosynthesis. It controls annual grasses and broadleaf weeds. Highly soluble in water and low tendency to adsorb to most soils. Target weeds include field brome, field sandbur, Johnson grass, puncturevine, bromes, Russian thistle, and kochia.			X			
Paraquat*	Non-selective herbicide that destroys green plant tissue on contact and by translocation within the plant. It is a "Restricted Use" herbicide. Quickly adsorbed by soil particles and is long-lived in soil. Target species include field sandbur.		X	X	X	X	X
Pendimethalin	Selective herbicide used to control most annual grasses and certain broadleaf weeds. It can be used on both pre- and post-emergence weeds. Adsorbs strongly to soil organic matter and clay and does not leach through soil to contaminate ground water. It is used to control puncturevine and kochia.			X	X	X	
Picloram*	A “Restricted Use” herbicide due to its mobility in water combined with the sensitivity of many crops that can be damaged with use. It interferes with the weed’s ability to make proteins and nucleic acids. It dissolves easily in water. This herbicide controls biennial thistles, Canada thistle, knapweeds, Dalmatian toadflax, camelthorn, Russian thistle, leafy spurge, Russian knapweed, Scotch thistle, whitetop, and yellow starthistle.		X	X	X	X	
Prodiamine	A selective, pre-emergent herbicide for the control of broadleaf weeds and grasses by inhibiting plant growth. Used for control of kochia, rescuegrass, and Johnsongrass				X	X	X
Thifensulfuron methyl	This is a broad spectrum, post-emergent herbicide for control of broadleaf weeds. Absorbed through foliage of plants to inhibit growth. This herbicide controls spreading wallflower, kochia, and Russian thistle.		X	X	X	X	
Triclopyr	Works by disrupting plant growth. It is absorbed by green bark, leaves, and roots and moves to the meristem of the plant. It has a moderate to low solubility in water and normally binds to clay and organic matter, so it has a slight potential to contaminate ground water. Triclopyr is effective in treatment of yellow starthistle, squarrose knapweed, perennial pepperweed, spotted knapweed, diffuse knapweed, horehound, tamarisk, tree of Heaven, Russian olive, and Siberian elm.	X	X	X	X	X	X

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Table 9-4. Herbicides and recommended application concentrations per acre for priority weed species. Rates listed are general according to label instructions, the USFS Field Guide for Managing Weed Species in the Southwest; Montana, Utah and Wyoming Cooperative Extension Service Weed Management Handbook; and Lake Mead Exotic Plant Management Plan. Herbicides should be applied according to the label instructions by certified pesticide applicators. *Indicates a restricted use pesticide.

Category A - HIGH																		
Noxious Weed		**2,4-D**					**Aminopyralid**			**Atrazine***	**Chlorsulfuron methyl**		**Clopyralid**		**Dichlobenil**		**Fluroxpyr**	**Fluazifop-P-butyl**
Common Name	**Scientific Name**	Various	Grazon P+D (+picloram)	Curtail: (+clopyralid)	GrazonNext (+aminopyralid)	Crossbow (+triclopyr)	Milestone	Chaparral (+metsulfuron)	Milestone + Garlon 4	Aatrex	Telar XP	Cimmaron Plus (+metasulfuron)	Transline	Reclaim	Redeem (+triclopyr)	Casoron	Vista	Fusilade 2000, Fusilade DX
African rue[1]	*Peganum harmala*																	
Blue mustard[3]	*Chorispora tenella* (Pall.) DC.	½ - ¾ pt for 4 lb/gal product									0.125 oz							
Bull thistle[1]	*Cirsium vulgare*		1 - 2 pt	1 - 2 qt	2 pt		3-5 oz						0.33-1.3 pt	0.33-1.3 pt	1.5 - 2 pt	0.92 - 3.84 qt		
Camelthorn[1]	*Alhagi camelorum*												1- 1/3 pt	1- 1/3 pt				
Canada thistle[1]	*Cirsium arvense*	2 qt (based on 1 qt of 4 lb per gal)		6 pints			5-7 oz						0.67-1.3 pt	0.67-1.3 pt	2.5-4 pt	0.92 - 3.84 qt		
Common Mediterranean grass	*Schismus barbatus*																	1-1.5 pt plants;8 oz for seedlings
Dalmatian toadflax[1]	*Linaria dalmatica*										2-2.6 oz							
Fountain grass[1]	*Pennisetum setaceum*																	1-1.5 pt
Leafy spurge[1]	*Euphorbia esula*		2 qts													0.92 - 3.84 qt		
Musk thistle[1]	*Carduus nutans*		2 - 4 pt	1 - qt	1.5 - 2 pt		3-5 oz						0.33-1.3 pt	0.33-1.3 pt	1.5 - 2 pt	0.92 - 3.84 qt		
Perennial pepperweed[1]	*Lepidum latifolium*	1-2 lbs/ac									1-2 oz					0.92 - 3.84 qt		
Ravenna grass[2]	*Saccharum ravennae*																	
Sahara mustard[4]	*Brassica tournefortii*	3-6 pt					¼ to 1/3 pint	2.5-3.3 oz					2-3 qts					
Squarrose knapweed[1]	*Centaurea virgata*	1-2 qt	2-3 qt	4 pt			5-7 oz						⅔- 1 pt	⅓- 1 ⅓ pt	2 pt		8 oz	
Scotch thistle[1]	*Onopordum acanthium*		2 - 4 pt	1 - 2 qt	2 - 2.6 pt		5-7 oz						0.33-1.3 pt	0.33-1.3 pt	1.5 - 2 pt	0.92 - 3.84 qt		
Spotted knapweed[1]	*Centaurea maculosa*	1 - 2 qt	2 - 3 qt	4 pt			5-7 oz						⅔- 1 pt	⅓- 1 ⅓ pt	2 pt		8 oz	
Sulphur cinquefoil[3]	*Potentilla rect L.*		2-4 pt				4-6 oz											
Tall whitetop[1]	*Cardaria draba*							2.5 - 3.33 oz			1 oz	1.25 oz						
Tamarisk, other	*Tamarix* spp., including hybrids																	
Tree-of-Heaven[1]	*Ailantus altissima*																	
Uruguayan pampas grass[6]	*Cortaderia sellonana*																	
Yellow nutsedge[3]	*Cyperus esculentus*																	
Yellow starthistle[1]	*Centaurea solstitialis*	1 qt	2 qt (1:4 mixture)	0.25 - 1 pt			3-5 oz						0.25-0.67 pt	0.25-0.67 pt				

Category A - HIGH																			
Noxious Weed		**Glyphosate**		**Imazapic**		**Imazapyr**			**Indaziflam**		**Isoxaben**	**Metsulfuron methyl**	**Metribuzin**	**Paraquat***	**Pendimethalin**	**Picloram***	**Prodiamine**	**Thifensulfuron-methyl**	**Triclopyr**
Common Name	**Scientific Name**	Rodeo	Round Up	Plateau	Journey (+ Glyphosate)	Arsenal	Arsenal + Rodeo	Chopper	Rejuvra	Esplanade 200 SC	Gallery	Ally, Allie, Gropper, Escort	Sencor	Gramoxone	Pendulum	Tordon 22K	Evade	Volta	Garlon
African rue[1]	*Peganum harmala*					3 pt						3.2 - 6.4 oz							
Blue mustard[3]	*Chorispora tenella* (Pall.) DC.	1.5 pt	11-12 oz									0.125 oz							
Bull thistle[1]	*Cirsium vulgare*			8-12 oz												0.5-2 pt			
Camelthorn[1]	*Alhagi camelorum*					0.75-1.5 qt						1-3 oz				2 qt			
Canada thistle[1]	*Cirsium arvense*								3.5 – 7 oz	3.5 – 7 oz						1 qt			
Common Mediterranean grass	*Schismus barbatus*	1-3 pt						2-3 pt											
Dalmatian toadflax[1]	*Linaria dalmatica*			8-12 oz + 1 qt MSO					3.5 – 7 oz	3.5 – 7 oz						1-2 qt			
Fountain grass[1]	*Pennisetum setaceum*	0.5-1 pt						2-3 pt											
Leafy spurge[1]	*Euphorbia esula*	1 qt	1 qt	8-12 oz + 1.5-2 pt MSO												1-2 qt			
Musk thistle[1]	*Carduus nutans*			8-12 oz					3.5 – 7 oz	3.5 – 7 oz						0.5-2 pt			
Perennial pepperweed[1]	*Lepidum latifolium*	3 qt	1 gal	12 oz				2-3 pt				0.75-1 oz							3 qts
Ravenna grass[2]	*Saccharum ravennae*	5% soln																	
Sahara mustard[4]	*Brassica tournefortii*											0.5-1.0 oz							3 qts
Scotch thistle[1]	*Onopordum acanthium*			8-12 oz												0.5-2 pt			
Spotted knapweed[1]	*Centaurea maculosa*															1-2 pt			
Squarrose knapweed[1]	*Centaurea virgata*															1-2 pt			
Sulphur cinquefoil[3]	*Potentilla rect L.*															1 pt			
Tall whitetop[1]	*Cardaria draba*	3 qt	4 qt	12 oz				2-3 pt				0.75-1 oz							
Tamarisk, Saltcedar[1]	*Tamarix* spp., including hybrids					2 qts	1.5 qt + 1.5 qt												
Tree-of-Heaven[1]	*Ailantus altissima*	2 -5 qt				1-1.5 pt		2-3 pt											3-6 qts
Uruguayan pampas grass[6]	*Cortaderia sellonana*	0.5-1 pt						2-3 pt											
Yellow nutsedge[3]	*Cyperus esculentus*	1-5 qt																	
Yellow starthistle[1]	*Centaurea solstitialis*	4.5-7.5 pt	1.5-4 qt			1 pt			3.5 – oz	3.5 -7 oz		1 oz				1-1.5 pt			3 pts

Category B - MEDIUM

Noxious Weed		2,4-D					Aminopyralid			Atrazine*	Chlorsulfuron methyl		Clopyralid		Dichlobenil		Fluroxypyr	Fluazifop-P-butyl
Common Name	**Scientific Name**	Various	Grazon P+D (+picloram)	Curtail: (+clopyralid)	GrazonNext (+aminopyralid)	Crossbow (+triclopyr)	Milestone	Chaparral (+metsulfuron)	Milestone + Garlon 4	Aatrex	Telar XP	Cimmaron Plus (+metasulfuron)	Transline	Reclaim	Redeem (+triclopyr)	Casoron	Vista	Fusilade 2000, Fusilade DX
Diffuse knapweed[1]	*Centaurea diffusa*	1 - 2 qt	2 - 3 qt	4 pt			5-7 oz						⅔- 1 pt	⅓- 1 ⅓ pt	2 pt		8 oz	
Halogeton[3]	*Halogeton glomeratus*	2 - 2.7 qt																
Johnsongrass[3]	*Sorghum halepense*																	
Russian knapweed[1]	*Acroptilon repens*			1-2 qt			4-6 oz						1- 1 ⅓ pt	1- 1 ⅓ pt		0.92 - 3.84 qt		
Russian olive[1]	*Elaeagnus angustifolia*					2 gal			7 oz + 2 qt									
Siberian elm[1]	*Ulmus pumila*																	
Tamarisk, Saltcedar[1]	*Tamarix ramosissima*																	

Category B – MEDIUM

Noxious Weed		Glyphosate		Imazapic		Imazapyr			Indaziflam		Isoxaben	Metsulfuron methyl	Metribuzin	Paraquat*	Pendimethalin	Picloram*	Prodiamine	Thifensulfuron-methyl	Triclopyr
Common Name	**Scientific Name**	Rodeo	Round Up	Plateau	Journey (+ Glyphosate)	Arsenal	Arsenal + Rodeo	Chopper	Rejuvra	Esplanade 2000	Gallery	Ally, Allie, Gropper, Escort	Sencor	Gramoxone	Pendulum	Tordon 22K	Evade	Volta	Garlon
Diffuse knapweed[1]	*Centaurea diffusa*								3.5 – 7 oz	3.5 -7 oz						1-2 pt			
Halogeton[3]	*Halogeton glomeratus*			4-12 oz					3.5 – 7 oz	3.5 – 7 oz		0.5-1 oz							
Johnsongrass[3]	*Sorghum halepense*												0.5 lb				1		
Russian knapweed[1]	*Acroptilon repens*	3-7.5 pt	4-4.8 qt			2 pt										1-2 qt			
Russian olive[1]	*Elaeagnus angustifolia*	1-5 qt	1.5-3.3 qt			2.4 pt	1.5 qt + 1.5 qt												1-3 qt
Siberian elm[1]	*Ulmus pumila*	3-7.5 pt	1.5-3.3 qt			1-1.5 pt		2-3 pt											3-6 qt
Tamarisk, Saltcedar[1]	*Tamarix ramosissima*					2 qt	1.5 qt + 1.5 qt												

Category C - LOW

Noxious Weed		2,4-D					Aminopyralid			Atrazine*	Chlorsulfuron methyl		Clopyralid		Dichlobenil		Fluroxypyr	Fluazifop-P-butyl
Common Name	**Scientific Name**	Various	Grazon P+D (+picloram)	Curtail: (+clopyralid)	GrazonNext (+aminopyralid)	Crossbow (+triclopyr)	Milestone	Chaparral (+metsulfuron)	Milestone + Garlon 4	Aatrex	Telar XP	Cimmaron Plus (+metasulfuron)	Transline	Reclaim	Redeem (+triclopyr)	Casoron	Vista	Fusilade 2000, Fusilade DX
Bald brome[3]	*Bromus racemosus*																	
California burclover[4]	*Medicago polymorpha*	0.67-4 pt																
Cheatgrass[1]	*Bromus tectorum*																	
Field bindweed[3]	*Convolvulus arvensis*		2-4 pt													0.92 - 3.84 qt		
Field brome	*Bromus arvensis*																	
Horehound[5]	*Marrubium vulgare*	1-4 pt																

Category C - LOW

Noxious Weed		2,4-D					Aminopyralid			Atrazine*	Chlorsulfuron methyl		Clopyralid		Dichlobenil		Fluroxypyr	Fluazifop-P-butyl
Common Name	**Scientific Name**	Various	Grazon P+D (+picloram)	Curtail: (+clopyralid)	GrazonNext (+aminopyralid)	Crossbow (+triclopyr)	Milestone	Chaparral (+metsulfuron)	Milestone + Garlon 4	Aatrex	Telar XP	Cimmaron Plus (+metasulfuron)	Transline	Reclaim	Redeem (+triclopyr)	Casoron	Vista	Fusilade 2000, Fusilade DX
Jointed goatgrass[1]	*Aegilops cylindrica*																	
Kochia[3]	*Bassia scoparia*									3.2-4 pt						0.92 - 3.84 qt	8 oz	
Puncturevine[3]	*Tribulus terrestris*	2 qt																
Red brome[4]	*Bromus rubens*									1-2 pt								1-1.5 pt
Rescuegrass[3]	*Bromus catharticus*																	
Ripgut brome[3]	*Bromus diandrus*																	
Russian thistle[3]	*Salsola kali*	0.75-4 pt											2-4 pt	2-4 pt				
Smooth brome[3]	*Bromus inermis*																	
Spreading wallflower	*Erysimum repandum*	1/4-3/8 lb																

Category C - LOW

Noxious Weed		Glyphosate		Imazapic		Imazapyr			Indaziflam		Isoxaben	Metsulfuron methyl	Metribuzin	Paraquat*	Pendimethalin	Picloram*	Prodiamine	Thifensulfuron-methyl	Triclopyr
Common Name	**Scientific Name**	Rodeo	Round Up	Plateau	Journey (+ Glyphosate)	Arsenal	Arsenal + Rodeo	Chopper	Rejuvra	Esplanade 2000	Gallery	Ally, Allie, Gropper, Escort	Sencor	Gramoxone	Pendulum	Tordon 22K	Evade	Volta	Garlon
Bald brome[3]	*Bromus racemosus*	0.5-3 qt							3.5 – 7 oz	3.5 – 7 oz			0.5-1 pt						
California burclover[4]	*Medicago polymorpha*		24-32 oz						3.5 – 7 oz	3.5 – 7 oz									
Cheatgrass[1]	*Bromus tectorum*	0.5-1 pt		2-12 oz + 1 qt MSO	16-21 oz + 1 qt MSO				3.5 – 7 oz	3.5 – 7 oz									
Field bindweed[3]	*Convolvulus arvensis*		0.25-5 qt													0.5 pt- 2 qt			
Field brome	*Bromus arvensis*	0.5-3 qt							3.5 – 7 oz	3.5 – 7 oz			0.5-1 pt						
Horehound[5]	*Marrubium vulgare*											0.2-1 oz				2-4 pt			2.5- 3.33 pt
Jointed goatgrass[1]	*Aegilops cylindrica*	2.5-3 pt		0.063-0.188 lbs					3.5 – 7 oz	3.5 – 7 oz									
Kochia[3]	*Bassia scoparia*		0.5-5 qt						3.5 – 7 oz	3.5 – 7 oz	16 oz		0.5 lb		1.8-4.8 pt		1 lb		
Puncturevine[3]	*Tribulus terrestris*	0.75-4 pt							3.5 – 7 oz	3.5 – 7 oz					1.2-4.8 qt				
Red brome[4]	*Bromus rubens*	0.5-1 pt		2-12 oz + 1 qt MSO	1⅓- 2 pt				3.5 – 7 oz	3.5 – 7 oz									
Rescuegrass[3]	*Bromus catharticus*	0.5-3 qt							3.5 – 7 oz	3.5 – 7 oz			0.5-0.6 lb				1 lb		
Ripgut brome[3]	*Bromus diandrus*	0.5-3 qt							3.5 – 7 oz	3.5 – 7 oz			0.5-1 pt						
Russian thistle[3]	*Salsola kali*		8 oz- 5 qt						3.5 – 7 oz	3.5 – 7 oz	16 oz		0.25-0.75 pt			1-1.5 oz			
Smooth brome[3]	*Bromus inermis*	0.5-3 qt							3.5 – 7 oz	3.5 – 7 oz			0.5-1 pt						
Spreading wallflower	*Erysimum repandum*																	0.3-0.6 oz	

MSO=Methylated seed oil

9.8 Roads and Rights-of-Way Treatments

While noxious weed treatments on roads and rights-of-way (linear corridors) use the same techniques described above, treatments occur on a regular basis and are aimed at moving quickly to disrupt traffic as little as possible. The techniques used to treat noxious weeds in linear corridors include:

- Chemical spraying using trucks or All-Terrain Vehicles (ATV) for efficient application,
- Mechanical mowing timed to occur prior to seed-head maturation,
- Boom axe or chainsaw used to cut vegetation within 15-30 ft of pavement edge,
- Cut-stump treatments,
- Pile burning of collected plan material,
- Controlled burns, and
- Maintenance of fire guards along road shoulder or fence line.

Other measures used to prevent weed introduction and retain native vegetation along linear corridors include techniques that reduce erosion and other disturbances (keeping equipment off unstable slopes), re-seeding areas with native species, use of weed free materials (straw, wattles, fill, and seed), cleaning vehicles and equipment before beginning treatment and leaving a treatment area, and coordination with landowners to treat weeds on the roads and adjacent areas.

10.0 Native Vegetation Re-Planting

It is highly recommended that native species revegetation occurs after noxious weeds are removed from areas where weeds comprised 50% or more of the vegetation community. Areas dominated by noxious weeds for long periods of time likely do not have the native seed bank necessary for passive native species recolonization. Also, revegetating with native species prevents recolonizing noxious weeds, restores native pastures, and provides habitat for wildlife. Below are recommendations for native species revegetation scenarios based on native to noxious weeds ratios prior to clearing.

10.1 Passive Restoration

Passive restoration can occur in habitats dominated by native vegetation. Noxious weeds can be removed by hand and the native seed bank and surrounding vegetation is left to recolonize cleared areas. These are areas where weeds comprise less than 50% of vegetative cover.

10.2 Active Restoration

Habitats with more than 50% noxious weeds cover prior to treatments require native species replanting after weed treatments occur. If a ground water is deep or no natural flooding occurs on a regular basis, planted vegetation will require supplemental irrigation. Below are different techniques for planting native vegetation.

10.2.1 Direct Seeding

Photo courtesy of Fred Phillips Consulting.

Direct seeding offers many advantages over other techniques. When conditions are optimal, it produces large numbers of plants over an extensive area in a relatively short period. Through sheer volume, seeded plants out-compete recolonizing noxious weeds and survive harsh environmental conditions that would decimate smaller populations. Seeding is less expensive than other native planting techniques, especially for large tracts of land. Grass and herbaceous vegetation establish best from seed. Seeds from regional genetic stock have the most success germinating and surviving in the conditions found on the Navajo Nation. However, many seeds can only be obtained from commercial growers in other regions. USDA Natural Resource Conservation Service (NRCS) can provide information on the most appropriate seeds or seed mix for the desired area (https://www.nrcs.usda.gov/wps/portal/nrcs/main/plantmaterials /pmc/west/azpmc/). Additional native plant seed resources also include the NNDFW Diné Native Plants Program, NNDFW Botanist, State Cooperative Extension programs, local BIA Branch of Natural Resource Office, and the Navajo Nation Department of Agriculture Window Rock Office. Planting locally gathered seeds is successful but requires more time and effort than purchasing seed from a commercial source.

Prior to planting, some seeds with hard seed coats should be scarified mechanically or chemically. Scarification, a pre-germination process, opens the seed coat so water and gas can penetrate. When seeds naturally pass through the digestive tracts of animals, they undergo both chemical and mechanical scarification as part of the digestion process. As a substitute, seeds can be mechanically scarified by grinding them in a blender for about 10 seconds or by scraping a hole in the coat using sandpaper. Chemical scarification uses strong acids or other chemicals to partially open the seed coat; however, it is more dangerous and less effective than mechanical methods.

10.2.2 Propagating Cuttings

Vegetative propagation is more predictable and often quicker than starting with seeds. Desirable traits can be selected—for example, a superior flower color or thornless branch. However, plants propagated from the same stock over a long period may become susceptible to sudden environmental changes, insect attacks, and diseases. Harvesting cuttings from a variety of populations or from different areas ensures greater diversity and resistance to such problems. Native cottonwood and willows have high survival rates when planted as vegetative cuttings.

> **Cutting Guidelines**. Check recommendations for individual species to identify the optimal season to harvest cuttings. In general, the best time to cut is when the plants are

dormant—usually from December to early February. Ideally, cuttings are planted within a week of harvesting, after they are submerged in water for at least 7 days. If cuttings are not planted for a few months, refrigerate them at 35ºF to maintain dormancy. Try to select juvenile plants (1-2 years or younger if big enough) for cuttings, especially for woody species like cottonwood and willow. Younger plants are less likely to have growth inhibitors. If you must cut older plants, target the newest, most flexible growth near the base. When possible, prune older plants to generate new growth.

Preparing Cuttings. Before planting (either on site or in pots), re-cut and, for some species, apply rooting hormone. Make a new cut just above the original one but below a leaf node or bud, where concentrations of growth-influencing hormones or auxins are highest. This cut can be diagonal or straight. The diagonal method makes the cutting easier to plant and creates more surface area for water uptake. A straight cut lessens water loss and makes it easier to recognize the top and bottom ends. If rooting hormone is used, dip the cut end into an IBA (Indole-3-butyric acid) rooting hormone, such as Rootone, and gently tap to remove excess powder. This hormone speeds up root development. To prevent contamination, remove and apply the estimated amount of hormone for the cuttings present and discard extra after use. Cuttings from some species, like willow, are soaked for at least 7 days, but no longer than 12-14 days because the roots will begin to grow and will risk breaking off during planting. Once poles are removed from water they should not spend more than 12 hours out of water before planting.

Planting Techniques. Techniques for planting cuttings vary considerably; virtually all are effective for fast-rooting species such as cottonwood and willow. Rooting times vary by species from under a week to several months. Planting areas with a 6-inch – 4-foot depth to water table are recommended for planting cottonwood and willow tree species. Willows can be planted in clusters with 3 poles at least 7 feet in length with a minimum diameter of ½ inch. Holes are augured to a 6-inch diameter and at least 4 feet deep or just below the water table. All poles are planted at least 4 feet deep in the augured holes at the lowest water table of the year. Insert the cutting into the soil with the nodes pointing upward. The above ground portion of the pole is cut at a maximum height of 2 feet high and a minimum height of 18 inches. When planted all poles are slurred in with a water auger leaving no air gaps between pole and soil to maintain maximum soil to stem contact. Coat the tops of all poles with latex paint to seal in moisture. If planted in the ground water, planting areas should not require supplemental irrigation.

10.2.3 Deep Pot Upland Plants

Upland trees benefit from being grown in deep pots. Deep potted plants are planted in a hand augured planting holes that are 4-in wide and deep enough to reach the capillary fringe of the lowest water table of the year. One to three feet of the plant with budding sites above the ground. The plant root ball is not planted in saturated soil, but just right above the saturated soil zone.

10.2.4 Containerized Plants

Containerized plants are available all year and can establish quickly if they have well-established root systems. This method is expensive, time consuming, and difficult to transport, and is not practical for sites that are hard to access. Tree species are often planted in five-gallon containers while shrubs and forbs are planted as one-gallon containers. Herbaceous plants that naturally grow with multiple stems or rhizomatous roots are grown in flats of various sizes. If plants are not planted into the water table, drip irrigation may be necessary.

Augured or excavated 3-18-inch planting holes are dug to the lowest water table of the year. The native soil from the holes is utilized to secure the plant. When the plants are removed from the container, the root ball is pulled apart and loosened prior to planting. Once planted, a water well ring is formed on the surface soil around all tree plantings to enhance water retention. Remove noxious weeds present in the native tree containers prior to planting.

10.2.5 Bioengineering and Erosion Control

Figure 10-1. Harvested willow poles are planted along a bankline to provide additional erosion protection. *Left*: Work crews prep the bundles of willow poles after they have soaked in the Colorado River. *Right*: the same location one year after planting. Photos courtesy of Fred Phillips Consulting.

Bioengineering is implemented to prevent erosion and noxious weed recolonization along stream, wash, and riverbanks (**Figure 10-1**). This technique uses native vegetation poles, bundles, and plugs cut or harvested from local native stock. Poles are collected using the methods discussed above under Propagating Cuttings. They are planted individually or as bundles (approximately 3 poles per bundle) using a power auger or punch to create a narrow hole perpendicular to water flow that extends to the water table. Two rows of poles are planted along the bank line, one at the average low-water mark and one at the average high-water mark. When the water table is reached, a pole or bundle is immediately placed in the hole down to the water table. Soil is packed around the cutting to prevent air pockets.

Willow bundle plantings are good for areas with fluctuating water levels (**Figure 10-2**). To make bundles, 3-5 poles are tied into bundles of approximately 3 to 18 inches in diameter with the growing tips oriented up. The terminal bud is removed so the energy is re-routed to the lateral

buds for more efficient root and stem sprouting. Vertical trenches are excavated approximately on 3-foot centers with a slope of 2:1 or more to ensure adequate protections of the bank line and to encourage rapid growth. Ensure that the bottom of the trench is still under water during low flows and place bundles in them with the cut ends in the water. Bundles are secured with a wooden stake and the bundle is back filled with soil.

Figure 10-2. Bundles of fast-growing plants planted along the streambank can provide erosion control when steep banks cannot be re-graded. *Left*: grass bundles installed along a steep bank with willow bundles planted in between to stabilize and capture soils on the bankline. *Right*: The same bankline one year later. Photos courtesy of Fred Phillips Consulting.

The toe of the slope is highly erodible and is planted with fast growing native wetland vegetation plugs if perennial water is present. Wetland plugs are planted during the lowest water flow of the year to ensure that plants are submerged in the water table. A hole is dug at the toe of the slope, in the water table and the wetland plug's roots are submerged in the water.

Other erosion control techniques include the following:

- **Erosion blankets:** This technique helps hold soil and seed in place during inundation and create a microclimate conducive to germination of native grass and forb seeds. Blankets consisting of all-natural materials break down between one to 2 years after vegetation is established and are wildlife friendly. The blanket is installed over the prepared seed bed and staked into place with wooden stakes and/or metal staples by hand crews. The edges of the blanket are buried in a shallow trench.
- **Fiberschines**: This technique uses a coconut-fiber roll product to protect the streambank by stabilizing the toe of the slope and trapping sediment from the sloughing streambank. Cuttings and herbaceous riparian plants are planted into the fiberschine and behind it so that riparian vegetation stabilizes the streambank when the fiberschine decomposes.
- **Brush Layer:** This technique uses bundles of willow cuttings buried in trenches along the slope of an eroding streambank. This willow "terrace" is used to reduce

the length of the slope of the streambank. The willow cuttings will sprout and take root, thus stabilizing the streambank with a dense matrix of roots. Some toe protection such as a wattle, fiberschine, or rock may be necessary with this technique.

- **Mulch Over Reseeding:** Straw mulch consists of wheat, barley, oat or rye straw, hay, and grass cut from native grasses that are "weed free". Straw mulch could be applied at a rate of 2 tons per acre to designated seeding areas to provide a protective environment for seed germination. Mulching will occur in the upper overbank zone and portions of the transition zone.
- **Brush revetment:** This method is used to protect and build the toe of eroding banks. This practice consists of a series of evergreen or other brushy trees tied end to end, placed along the toe of the stream bank, and anchored by bolster rock, earth anchors, or fence posts. The revetment provides temporary structural protection to the toe while vegetation becomes established by slowing velocities and diverting the current away from the bank edges. Over time, fine sediments accumulate, partially burying the degrading material. The mass of tree limbs also has the added benefit of creating aquatic habitat as the revetment material generally does not sprout. Once bank vegetation is established, T-posts are removed.

11.0 Project Maintenance and Monitoring

Monitoring and maintenance are essential to successful weed management projects. Monitoring a site after treatment can determine the effectiveness of the project. Monitoring guides adaptive management and can determine the need for alternative treatments. Maintenance, including follow-up weed treatments and native species planting, is an integral part of an integrated weed management plan. Most weed species require multiple treatments before complete eradication occurs. Often once one weed species is removed from a site, secondary weed infestations can occur. Planting native vegetation can reduce re-colonizing weed species by out-competing them. Follow-up maintenance is critical for reducing the re-colonization of primary and secondary weed species of concern. For noxious tree weed treatments in forestlands, intermediate and maintenance treatments are prescribed for a given rotation age, based on the goals and objectives of each treatment.

11.1 Project Monitoring

Establishing and implementing a monitoring program determines the success of the project activities and a long-term adaptive management strategy. Monitoring is necessary to determine the efficacy of proposed treatments on priority weed species, identify infestations of new and emerging weed species, and better understand the factors that influence weed spread within the Navajo Nation. To determine the effectiveness of treatment activities a monitoring report will be

prepared. The monitoring report will include the species controlled, method of treatment(s) used, a map of the treated area, issues encountered, and overall control achieved at the site. If using chemical treatments, the name and amount of herbicide used, dates sprayed, time of day sprayed, wind speed, and temperature at time of herbicide application is also required.

11.1. Treatment Effectiveness Monitoring

Monitoring weed spread and/or treatment effectiveness is conducted through annual weed mapping of treatment sites (see Section 6.0). During the project planning phase, the perimeter of the affected area is mapped (using methods outlined in Section 6.0) and percent cover calculated. If the treatment area is a long linear corridor (road or right-of-way) the infested areas is mapped by vehicle along the corridor. This baseline measurement is used to compare acreage of infestation against future acreage calculations following treatments to determine treatment effectiveness. Results from monitoring will be presented in annual weed monitoring reports. By tracking the size of the weed infestation, BIA can determine if treatment methods are successful, and if objectives are being met. If necessary, treatments will be adjusted through the adaptive management process to ensure that the project objectives are achieved.

If treated weed populations are large, monitoring plots located along transects may be established to sub-sample smaller areas. Plots are established by stretching a 100m tape measure across the treatment area. The start and end points of the transect are recorded with a GPS and the bearing of the transect is recorded to help relocate transects in subsequent surveys. Plots (1 x 0.5m) are established every 10 meters along the transect, and noxious weed cover is estimated using the methods outlined in Elzinga et al. 1998. Multiple transects are necessary if the treatment site is large. Data collected from the plots is measured over time and is compared year-to-year. For long linear corridors (roads and rights-of-way) vehicles will stop at established intervals to estimate vegetation cover in an established larger plot area. An example monitoring plot data sheet located in Appendix H.

11.1.2 Photo Monitoring

Photo monitoring is a qualitative way to show change over time in an area of interest. This is the most effective method for visualizing and capturing landscape conditions at a given point in time. Photo points are established immediately after treatment occurs, marked with permanent markers, and GPS coordinates are recorded. Care is taken to ensure that the photo point locations are described in detail so they can be found during follow-up visits. To relocate points and replicate photos, photos from previous sessions are taken to the field. Photos are immediately transferred to a database and labeled with a unique identifier and description so that information does not get lost with time. An example Photo Monitoring Datasheet is in Appendix H.

11.1.3 Adaptive Management

Adaptive management is a system of management practices based on clearly identified outcomes, monitoring to determine if management actions are meeting outcomes and, if not,

facilitating management changes that will best ensure that outcomes are met or to re-evaluate the outcomes. This document is a living document that will revised through adaptive management. Weed populations are dynamic. Revisions to the plan will be done every five years with updates to the priority weed list and revised recommendations for techniques utilized in weed management projects. They decline when managed with integrated weed treatments and expand when no weed treatments occur. Currently, it is unknown how expansive weed populations are across the Navajo Nation without extensive weed mapping efforts. Even if there were extensive weed mapping efforts, weed populations continually change and expand. There are many uncertainties that can occur in a dynamic system due to weed expansion, the effectiveness of a treatment, and different management priorities. Monitoring through adaptive management will help determine if the project objectives are being met and if the treatments are staying within the environmental effects that were anticipated with this PEIS. If the parameters discussed above are not being met, the techniques, timing and frequency of treatments, etc. can be changed through adaptive management. Implementing an integrated weed management program increases the chance of overall success and decreases the risk of any large failures (Sheley and Petroff 1999, Bormann and Kiester 2004).

The BIA is required to involve the public in adaptive management by:

1. Maintaining open channels of information to the public, including transparency of the monitoring process that precedes adaptive management and the decision-making process by which it is implemented.

2. Providing post-activity opportunity for public and affected outside agency review of adaptive management practices, including practices that were exceptions to any resource management plan or that had permitting and/or other regulatory requirements not satisfied by prior coordination.

11.2 Project Maintenance

As discussed above, follow-up maintenance is required to effectively eradicate many weed species. For example, successful long-term management programs for tamarisk require more than five years of treatments using multiple control methods, including: mechanical, fire, and chemical treatments (USFS 2012). Secondary weeds (i.e., camelthorn) may colonize a treatment site once it is cleared. Planting native vegetation at treatment sites reduces re-colonizing noxious weeds. Periodic weeding using hand pulling or spraying or small mechanical tools is necessary until native vegetation matures and creates a canopy. Weed treatments should occur every other month during the growing season (April-September) to treat re-sprouting and secondary infestations. Consistent maintenance after the first treatment is the most cost-effective way to ensure eradication or control of weeds, because less time and materials are required for small, young weed. Treatment sites, especially those planted with native vegetation, should be fenced to prevent livestock from entering so native vegetation can establish and mature. Fencing will require maintenance to ensure that it is effective at preventing livestock intrusions.

12.0 Demonstration Projects

A number of demonstration projects were identified by BIA Navajo Region Agencies to initiate noxious weed treatments and serve as models for future projects (**Table 12-1**). Demonstration projects have completed weed mapping, compliance, permitting, and reporting, and departmental funding has been requested or confirmed. Monitoring and maintenance of these sites will provide valuable information that can improve and enhance weed treatment methods for future projects.

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Table 12-1. Demonstration Projects identified by the five BIA Navajo Region Agencies including Western, Shiprock, Chinle, Eastern (Crownpoint), Navajo Partitioned Land, and Fort Defiance Agencies. The table outlines the weed species mapped at the site, habitat and land use, proposed methods, and funding years for project implementation.

Agency	Project Name	Habitat Type	Methods	Weed Mapping (ac)	Species Mapped	FY
Western	Tsah Bii Kin (Tonalea Lake)	Riparian	Mechanical, Chemical	38	TAMAR	2014 - 2015
Western	Tsegi Canyon	Riparian	Mechanical, Chemical	32	ELAN	2014-2015
Western	San Juan River	Riparian	Mechanical, Chemical, Manual	1850	TAMAR, ELAN, ACRE, ALMA, SARA	2014-2015
Western	Oljato Wash and Parrish Creek (Tyende)	Riparian	Not Specified	52	Not Specified	2014-2015
Western	Nitsin Canyon (Navajo Canyon)	Riparian	Mechanical, Chemical	150	ELAN, TAMAR	2014-2015
Western	Shonto Wash – Phase 1	Riparian	Chemical, Mechanical, Biological	14	TAMAR, ELAN	2020 to 2021
Western	WNA – Phase 2	Rangeland	Mechanical, Chemical, Biological	206,389	ELAN	2014 to 2015
Fort Defiance	Kin Dah Lichi	Sagebrush, Pinon, Juniper	Mechanical, Chemical	1,516	ELAN, BRTE, COAR, SAKA, CANU, CIVU	2014 to 2015
Fort Defiance	New Lands	Stream Corridor	Mechanical, Chemical	227	PEHA, CIVU, LIDA, ONAC, ELAN, TAMAR ALMA13, ULPU, BRTE, COAR4, TRTE, MAVU, SAKA	2015 to 2016
Fort Defiance	District 14	Stream Corridor	Chemical	1,661	ELAN, TAMAR, CIVU, BRTE, COAR, CEIN, HAGL, CANU, TRTE	2016 & 2017
Fort Defiance	Commercial Forest	Forest	Chemical and Mechanical	324	BRRA, ULPU, CIVU, BRTE, SOAR, CANU, TRTE, ACRE, ELAN, SAKA, CIAR	2018-2019
Fort Defiance	District 7 (BIA 15)	Rangeland	Mechanical, Chemical, Biological	4,570	ACRE3, CEDI3, CEBI2, LIDA	2020-2021
Fort Defiance	HWY 264 and 191	Roads	Mechanical, Chemical	21,230	ACRE3, CEDI3, CEBI2, LIDA	2020-2021
Fort Defiance	Colorado Pueblo Wash	Riparian	Mechanical, Chemical	1,821	TAMAR, ELAN	2020-2021
Fort Defiance	Kinlichee	Riparian	Mechanical, Chemical	1,500	TAMAR, ELAN	2020-2021
Northern	LMD 13	Stream Corridor	Mechanical, Chemical, Biological	398,196	TAMA, ELAN, ACRE3, CANU	2020 & 2021
Eastern	Canoncito/Alamo			2,000	Not specified	2015 & 2016
Navajo Partitioned Land	Precinct 1, 2, and 3	Stream Corridor and Rangeland	Chemical and Mechanical	1,500	ACRE, BRTE, TAMA, SALSOL	2015-2016
Chinle	Many Farms Plot	Agricultural field		1,990	TAMAR, ELAN	2020-2021

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