



Exotic Plants at Fort Union National Monument

A Supplement to the 2011 Natural Resource Condition Assessment

Natural Resource Report NPS/SOPN/NRR—2012/504



ON THE COVER

Fort Union National Monument. Photo by National Park Service.

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Contents

Executive Summary	vii
Acronyms	ix
Acknowledgements	ix
1 Introduction	1
1.1 The Importance of Exotic Plants	1
1.2 The Shortgrass Steppe	2
2 Data and Methods	3
2.1 Significance of Impact and Feasibility of Control	3
2.2 Proportion of High Risk Blocks Infested	3
2.3 Proportion of Interior Plots Infested	4
2.4 Distribution of High Priority Species	5
3 Reference Conditions	7
4 The Condition of Exotic Plants at Fort Union NM	9
4.1 Significance of Impact	9
4.2 Feasibility of control	12
4.3 Proportion of High Priority Blocks Infested	12
4.4 Proportion of Interior Plots Infested	13
4.5 Distribution of High Priority Species	15
4.6 Overall Condition	15
4.7 Key uncertainties	19
5 Sources of Expertise	21
6 Literature Cited	23
Appendix A. Excerpt from Hiebert and Stubbendieck (1993) containing the Exotic Species Ranking System.	27
Appendix B. Exotic Species and their Density Classes at each Rapid Assessment Grid Point Sampled in 2011 by SOPN. Grid Point Locations Shown on Figure 2-3.	35
Appendix C. Distribution of Less-widespread Exotic Species Detected during 2009-2011 SOPN Monitoring and NHNM Monitoring (see Table 4-4).	37

Figures

Figure 2-1. High priority blocks sampled by SOPN in 2009, 2010, and 2011 at Fort Union NM.....	4
Figure 2-2. Fifty meter blocks are sampled on each side of a high-risk vector (e.g., roads and trails).....	5
Figure 2-3. Rapid Assessment grid sampled at Fort Union NM in 2011 by SOPN.....	6
Figure 2-4. SOPN interior (grassland) monitoring plots at Fort Union NM.....	6
Figure 4-1. The number of exotic species detected in the 2011 Rapid Assessment at Fort Union NM.....	12
Figure 4-2. Known distribution of kochia based on surveys conducted by SOPN and NHHM.....	16
Figure 4-3. Known distribution of prickly Russian thistle based on surveys conducted by SOPN and NHHM.....	16
Figure 4-4. Known distribution of field bindweed based on surveys conducted by SOPN and NHHM.....	17
Figure 4-5. Known distribution of white and yellow sweetclover based on surveys conducted by SOPN and NHHM.....	17
Figure 4-6. Known distribution of David's spurge based on surveys conducted by SOPN and NHHM.....	18
Figure 4-7. Known distribution of common lambsquarters based on surveys conducted by SOPN and NHHM.....	18
Figure C-1. Known distribution of Western salsify and meadow salsify based on surveys conducted by SOPN and NHHM.....	37
Figure C-2. Known distribution of red stem storksbill based on surveys conducted by SOPN and NHHM.....	37
Figure C-3. Known distribution of horehound based on surveys conducted by SOPN and NHHM.....	38
Figure C-4. Known distribution of mullein based on surveys conducted by SOPN and NHHM.....	38
Figure C-5. Known distribution of rescue brome, musk thistle, prickly lettuce (not detected by SOPN), curly dock, and Siberian elm based on surveys conducted by SOPN and NHHM.....	39

Tables

Table 4-1. Exotic species reported to occur at Fort Union NM by Willson et al. (2008), NHHM mapping (Muldavin et al. 2004), SOPN annual monitoring of high priority blocks (e.g., Folts-Zettner et al. 2010), 2011 Rapid Assessment (RA/grid) sampling, and 2010-2011 interior plot (grassland) monitoring.....	10
Table 4-2. Exotic species ranking for significance of impact at Fort Union NM based on Hiebert and Stubbendieck (2003), as reported by Willson et al. (2008).....	11
Table 4-3. Ranking of exotic species at Fort Union NM for feasibility of control based on Hiebert and Stubbendieck (2003), as reported by Willson et al. (2008). List from least feasible to most feasible.....	13
Table 4-4. Number and percentage of exotic plant species detected in 1) high priority blocks sampled in 2009-2011, 2) the Rapid Assessment grid sampled in 2011, and 3) interior plots sampled in 2010 and 2011 (the same six transects were sampled in each year) at Fort Union National Monument.....	14

Executive Summary

Globalization of commerce, transportation, human migration, and recreation in recent history have introduced invasive exotic species to new areas at an unprecedented rate. For the National Park Service (NPS), the consequences of these invasions present a significant challenge to the management of the agency's natural resources "unimpaired for the enjoyment of future generations." National parks, like other land-management organizations, are deluged by new exotic species arriving through predictable (e.g., road, trail, and riparian corridors), sudden (e.g., long-distance dispersal through cargo containers and air freight), and unexpected (e.g., weed seeds in restoration planting mixes) anthropogenic pathways.

Although a survey of vegetation at Fort Union National Monument (NM) in 2004 described the plant life at the park as relatively diverse, with the native shortgrass prairie still dominant, a number of exotic plants have been detected at the monument. A 2011 Natural Resource Condition Assessment (NRCA; Johnson et al. 2011) prepared for the park assessed park resource conditions, including those for vegetation. Johnson et al. (2011) reported over 30 exotic plant species at the park, with only one considered to be both an immediate problem and feasible to control (i.e., field bindweed [*Convolvulus arvensis*]). The purpose of this report is to provide recent information, primarily from Southern Plains Inventory and Monitoring Network (SOPN) sampling, to supplement that presented in the NRCA. Information presented here includes the results of three recent SOPN monitoring efforts— annual sampling of high priority blocks in 2009-2011, a Rapid Assessment grid sampled in 2011 for this assessment, and annual interior (grassland) plot sampling (2010-2011). A total of 15 invasive exotic species have been detected during the SOPN monitoring efforts, and an additional 16 have been reported from other studies discussed in this report. Maps showing the distribution of the species detected during SOPN monitoring are presented, as are species ratings (following Hiebert and Stubbendieck's [1993] Exotic Species Ranking System) in the categories of significance of impact and feasibility of control.

Acronyms

FOUN	Fort Union National Monument
NM	National Monument
NPS	National Park Service
NHNM	Natural Heritage New Mexico
NRCA	Natural Resource Condition Assessment
SOPN	Southern Plains Inventory & Monitoring Network

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1 Introduction

In recent history, globalization of commerce, transportation, human migration, and recreation have introduced invasive exotic species to new areas at an unprecedented rate. Biogeographical barriers that once restricted the location and expansion of species have been circumvented, culminating in the homogenization of the earth's biota. Although only 10% of introduced species become established, and only 1% become problematic or invasive (Williamson 1993; Williamson and Fitter 1996), nonnative species have profound impacts worldwide on the environment, economies, and human health.

This report presents the results of recent monitoring of exotic plant species at Fort Union National Monument (NM) and the condition of the park with regard to exotic plants. Fort Union NM (721 acres [292 hectares] in northeast New Mexico) preserves and protects the ruins of Fort Union and portions of the Santa Fe Trail and provides for public use of and education about the fort's significant role in the American Southwest. The park's vegetation is dominated by native grassland communities, with ruderal (disturbed or weedy) associations covering some cultural features. Small areas of other vegetation types exist and include oak montane scrub/pinyon-juniper woodland, herbaceous wetlands, and willow and cottonwood riparian areas.

A 2011 Natural Resource Condition Assessment (NRCA; Johnson et al. 2011) was prepared for the park to assess and report on park resource conditions. Vegetation was one of the resources assessed, including the threat from exotic plant species. Based on several earlier studies (e.g., Muldavin et al. 2004; Narumalani et al. 2004; and Folts-Zettner 2009), Johnson et al. (2011) reported 32 exotic plant species at the park. Only one was considered to be both an immediate problem and feasible to control—field bindweed (*Convolvulus arvensis*; Johnson et al. 2011). Our current report is intended to supplement the material on exotic species in Johnson et al. (2011). Information presented here includes the results of three recent Southern Plains Inventory and Monitoring Network (SOPN) monitoring efforts at Fort Union NM that were not included in the NRCA.

1.1 The Importance of Exotic Plants

Invasive species have been directly linked to the replacement of dominant native species (Tilman 1999), the loss of rare species (King 1985), changes in ecosystem structure, alteration of nutrient cycles and soil chemistry (Ehrenfeld 2003), shifts in community productivity (Vitousek 1990), reduced agricultural productivity, and changes in water availability (D'Antonio and Mahall 1991). The damage caused by these species to natural resources is often irreparable, and our understanding of the consequences incomplete. Invasive species are second only to habitat destruction as a threat to wildland biodiversity (Wilcove et al. 1998). Consequently, the dynamic relationships among plants, animals, soil, and water established over many thousands of years are at risk of being destroyed in a relatively brief period of time. For the National Park Service (NPS), the consequences of these invasions present a significant challenge to the management of the agency's natural resources "unimpaired for the enjoyment of future generations." National parks, like lands managed by other organizations, are deluged by new exotic species arriving through predictable (e.g., road, trail, and riparian corridors), sudden (e.g., long-distance dispersal through cargo containers and air freight), and unexpected (e.g., weed seeds in restoration planting mixes) anthropogenic pathways. Nonnative plants claim an estimated 4,600 acres of public land each year in the United States (Asher and Harmon 1995), significantly altering local flora. For example, exotic plants comprise an estimated 43% and 36% of the flora of the states of Hawaii and New York, respectively (Rejmanek and Randall 1994). Invasive plants infest an estimated 2.6 million acres of the 83 million acres managed by the NPS. Prevention and early detection are the principal strategies for successful invasive exotic plant management. While there is a need for long-term suppression programs to address high-impact species, eradication efforts are most successful for infestations of less than one hectare (2.5 acres) in size (Rejmanek and Pitcairn 2002).

Numerous pathways exist for exotic introduction at Fort Union NM. The most unique vector of introduction is through the adobe "mud" periodically brought into the monument to resurface and maintain the fort remnants. This soil

can harbor seeds of off-site exotics growing at the borrow pit that readily establish at the base of the walls and spread out into the fort area. Park visitors can introduce propagules hidden in mud on their cars and shoes, and in burs on socks and pant legs. Improperly cleaned work equipment is an efficient means of spreading exotic plant propagules. Dirty tires, tracks, and blades on off-site construction equipment can introduce seed when used in highly disturbed park areas. Park-owned mowers are effective at spreading exotic species, particularly those plants that can propagate vegetatively, when not thoroughly cleaned prior to mowing a new area. Mowing by itself often fosters the growth of exotics by providing disturbance and increasing exotic competitive advantage for light, water, and nutrients. Natural dispersal occurs from nearby exotic populations through the wind and migratory birds and animals.

1.2 The Shortgrass Steppe

The central grassland region of North America is one of the largest contiguous grassland environments on earth (Lauenroth et al. 2008), and depending on which classification is used, there are at least three distinct grassland types: tallgrass prairie, mixed grass prairie, and shortgrass steppe (prairie). The shortgrass steppe extends east from the Rocky Mountains and south from Montana through the Nebraska panhandle and southeastern Wyoming into the high plains of Oklahoma, New Mexico, and Texas. Shortgrass prairie has been converted to agriculture less often than tallgrass or mixed grass prairie, although it has been heavily impacted by grazing. As much as 80% of the shortgrass prairie has been lost in Texas (Samson and Knopf 1994). Overall, 48% of the shortgrass prairie province has been lost to cropland or pastureland seeded with exotic grasses (Samson et al. 2004).

The shortgrass prairie is typified by low stature, which is primarily due to low precipitation and an adaptation to heavy grazing (Coupland 1961) from bison, pronghorn, and elk, which occurred in large numbers (Howe 1994). Unlike the more eastern species, shortgrass prairie species remain digestible and retain their protein content when dormant. In the shortgrass prairie, long-term vegetative production is closely tied to precipitation (Lauenroth and Sala 1992). Rainfall ranges from 30 to 56 cm per

year, and there is generally a one to two month summer drought that is not as prevalent in the mixed and tallgrass prairies (Walter 1975). The most productive years are those in which small precipitation events that stimulate nutrient availability are followed by large precipitation events that stimulate plant growth.

Extensive areas of shortgrass prairie are now dominated by invasive perennial and annual species whose presence is attributed to overgrazing by domestic livestock and dryland farming (Weaver and Albertson 1956). Ranching continues to remain one of the primary land uses throughout the region (Daniel B. Stephens & Associates 2007). Changes in fire patterns and fire frequency followed settlement; however, according to grassland experts Drs. Alan Knapp and William Lauenroth (pers. comm.), fire probably played a lesser role in maintaining a healthy prairie in the shortgrass steppe than other drivers, such as herbivory and climate variation. In addition to herbivory and fire, climate change is and will increasingly impact the shortgrass prairie region, creating changes in temperature and precipitation patterns and amounts (Morgan et al. 2008), which in turn, will affect the plants and animals native to the shortgrass ecosystem.

2 Data and Methods

All information included in this report regarding exotic species at Fort Union NM, except that from Willson et al. (2008) and Natural Heritage New Mexico (NHNM; Muldavin et al. 2004), excludes surveys and assessments from within and immediately adjacent to the fort ruins and the housing/maintenance area. These are considered highly disturbed cultural areas and therefore are excluded from SOPN monitoring. These areas contain many exotic species not found anywhere else within the park boundary. Monitored areas are, however, closely watched for range expansion of these exotic species. Most of the exotic plant species listed in Table 4-1 (discussed below) that were detected only by Willson et al. (2008) were most likely observed in and immediately adjacent to the fort ruins and/or housing/maintenance area.

In evaluating current condition and trend for exotic plants at Fort Union NM, five indicators/measures were considered in the context of existing and readily available data, appropriate methods, and subject-matter specialist interpretation: 1) significance of impact; 2) feasibility of control; 3) proportion of high risk blocks infested; 4) proportion of interior plots infested; and 5) distribution of high priority species.

2.1 Significance of Impact and Feasibility of Control

One of our first considerations for assessing exotic plants was to determine which species pose the greatest risk to Fort Union NM. We based our assessment of potential risk on the Exotic Species Ranking System of Hiebert and Stubbendieck (1993; Appendix A). This ranking system has been applied in parks throughout the Midwest (Stubbendieck et al. 1992; Stumpf et al. 1994), as well as at Fort Union NM and Capulin Volcano NM in New Mexico (Willson et al. 2008). Ranking is based on two primary components of the potential risk: *Significance of Impact* and *Feasibility of Control or Management*. Each component has several subcomponents and is ranked on a scale from 0-100 points.

Significance of Impact is subdivided into the current level of impact and the potential for the species to become a pest. The current level of

impact takes into account such things as abundance, distribution relative to disturbance, effects on natural processes and community character, potential threat to park resources, and visual impact. The potential for a species to become a pest considers life history traits that might preadapt a given species to become a problem, as well as its known impacts in other areas. Important life history characteristics include potential rate of increase, adaptations for long-distance dispersal, and the breadth of habitats in which the species can colonize and thrive.

Feasibility of Control or Management focuses on such factors as its abundance within the park, the ease with which it is controlled, its reproductive capability, proximity of other populations, potential side effects of control measures, and the potential for biological control.

2.2 Proportion of High Risk Blocks Infested

As part of the SOPN monitoring program, high priority vectors (e.g., roads and trails) were identified at Fort Union NM based on their potential risk for invasion by exotic plants. The highest priority vectors were surveyed in 2009, 2010, and 2011 (Figure 2-1). This effort is part of a sampling scheme that uses a three-year rotating panel design, whereby a new area (a panel) is surveyed each year for three years, after which the areas surveyed are repeated. The third panel was completed in 2011, so the first panel (sampled in 2009 for the first time) will be sampled again in 2012. It is important to emphasize that this sampling approach does not provide a complete survey of exotic plants throughout the park; rather, it provides a repeated snapshot of a limited area with high potential for new invasions. [Some sampling was also conducted in 2008 as part of a very limited pilot effort for experimenting with the methodology. However, this pilot sampling is not considered part of the rotating panel and its methodology was different from that used now; therefore, results are not presented here].

Sampling was conducted in August in 2009, and in July in 2010 and 2011. The monitoring methodology is described in detail in *Multi-Network Exotic Plant Monitoring Protocol and Standard*



Figure 2-1. High priority blocks sampled by SOPN in 2009, 2010, and 2011 at Fort Union NM.

Operating Procedures (i.e., Folts-Zettner et al. 2012, in review). The approach is based on a generalized linear model, where 50-meter blocks on both sides of the vector (right [R] and left [L]) are surveyed from a transect running along (e.g., trails) or adjacent to (e.g., along the mow strip of roads) the vector (Figure 2-2). The full protocol also includes estimation of four density classes assigned to each block ranging from scattered plants to a dense matrix, as well as four distance classes used to determine the extent to which exotic plants are limited to the zone immediately adjacent to the vector. These measures provide more specific detail for the park than is warranted for this assessment; they are provided along with other information in the SOPN's annual reports (e.g., Folts-Zettner et al. 2010; Folts-Zettner and Sosinski 2010; Folts-Zettner and Sosinski 2011).

2.3 Proportion of Interior Plots Infested

We used three data sources for estimating the proportion of interior plots occupied by a given exotic species. The first data source, a Rapid Assessment, was conducted by SOPN as part of this condition assessment; additional points (i.e., in addition to the high priority blocks)

were sampled throughout the monument outside of the fort ruins. These additional points were intended to supplement our standard monitoring blocks for this assessment, so they will not be included in the rotating panel. To determine where to sample, we developed a 200-m grid and sampled each of the intersections within the landscape (Figure 2-3). At each point (intersection on the grid), field personnel sampled the area by walking ~10 m out from and around the point in all directions. Exotic plants detected in the surrounding area were recorded, and for each exotic plant a density class (i.e., a few plants to a dense matrix) was determined.

The second data source consisted of the secondary exotic plant monitoring conducted in 2010 and 2011 in interior landscape grassland areas in conjunction with the SOPN Grassland Monitoring efforts (Figure 2-4). This monitoring consists of collecting plant occurrence and cover data from five 2 x 1-m nested quadrats along each of six 50-m permanent transects.

A third data source was drawn from the vegetation mapping project carried out by NHHM between 2000 and 2003 (Muldavin et al. 2004). Of the 27 400 m² vegetation plots documented, eight were complete inventories and 19 docu-

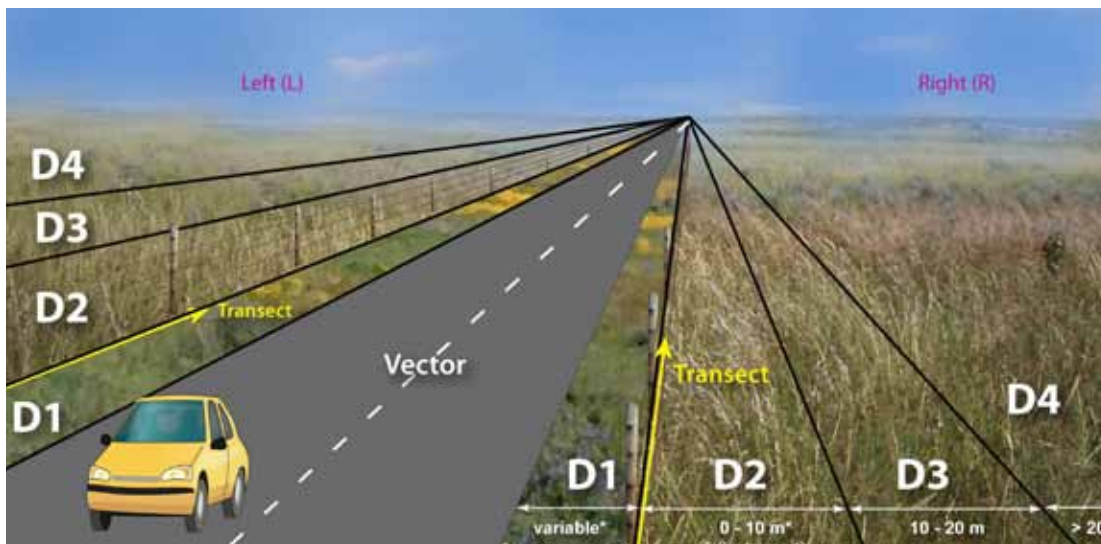


Figure 2-2. Fifty meter blocks are sampled on each side of a high-risk vector (e.g., roads and trails).

mented only the dominant species. Information from this source appears in Table 4-1 (in Section 4) and some figures in Section 4.5.

2.4 Distribution of High Priority Species

For this measure, we used the NHNM vegetation mapping plot data, all information available from SOPN annual monitoring of high priority blocks (sampled in 2009-2011), SOPN annual monitoring of interior (grassland) plots (sampled in 2010-2011), and the Rapid Assessment grid sampled in 2011 by SOPN explicitly for this condition assessment.



PHOTO: FOREST & KIM STARR; U.S. GEOLOGICAL SURVEY; BUGWOOD.ORG

Leaves and form of prickly Russian thistle (*Salsola tragus*).

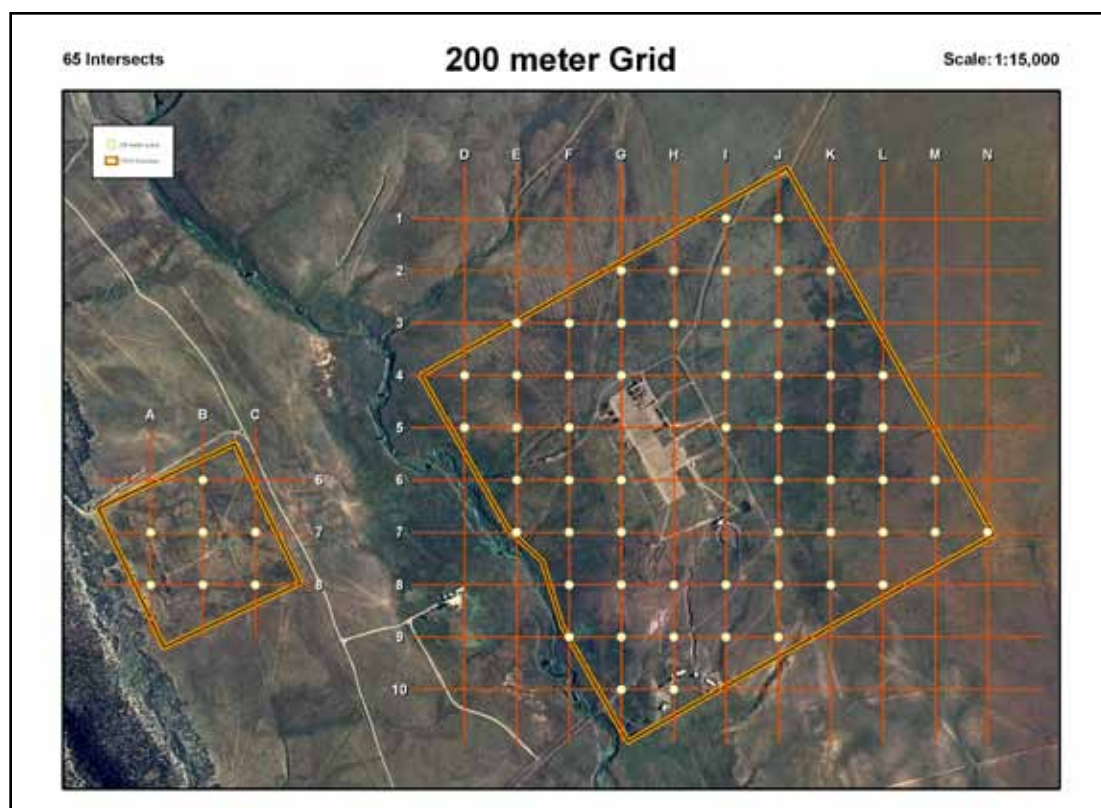


Figure 2-3. Rapid Assessment grid sampled at Fort Union NM in 2011 by SOPN.

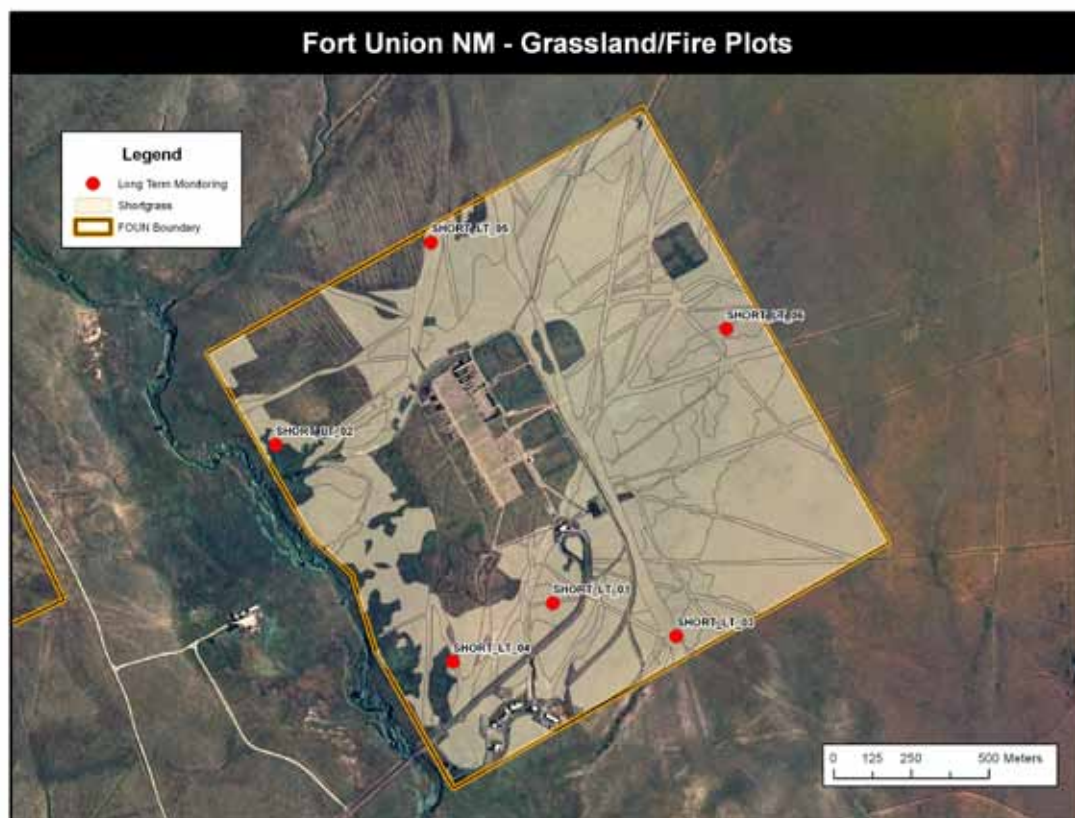


Figure 2-4. SOPN interior (grassland) monitoring plots at Fort Union NM.

3 Reference Conditions

The most appropriate reference condition for a park is probably the complete absence of exotic species. However, such a reference condition is likely not a realistic standard at this point in time. We consider a more realistic reference condition to be the capability for the integrity of the primary communities to be maintained. By this, we mean that the ecological attributes and natural processes remain within the natural variation for the community type. A condition of substantial concern is warranted when exotic plants threaten to alter these primary communities to the point where they no longer maintain these attributes or processes. For example, when exotic species dominate a community where key native species are expected for that community type, then the area would be considered as severely degraded. However, substantial concern is warranted when the trend for a community is clearly toward such a degraded outcome rather than it actually having been realized.



PHOTO: NPS

Fort ruins
and grassland
vegetation at Fort
Union NM.

4 The Condition of Exotic Plants at Fort Union NM

There are currently 31 exotic plant species reported to occur at Fort Union NM (Table 4-1). The majority, 71%, are forbs, while 26% are graminoid species; only one species, Siberian elm (*Ulmus pumila*), is a tree. Most species are perennial (58%) or annual (32%); a small number are either annual/biennial or biennial. Two of the 31 species, field bindweed and prickly Russian thistle (*Salsola tragus*), were detected in all five of the individual monitoring efforts noted in Table 4-1. Kochia (*Kochia scoparia*) was detected in all but the NHPM mapping effort. Fifteen of the species were not reported by NHPM monitoring, but by either Willson et al. (2008; eight species), NHPM (Muldavin et al. 2004; three species), or both studies (four species); many of these plants may be found only within/around the fort ruins and/or residential area of the park.

The New Mexico Department of Agriculture (2009) has listed musk thistle (*Carduus nutans*) as a Class B Noxious weed, which instructs that management should be designed to contain the infestation and stop any further spread in areas with severe infestations. Both cheatgrass (*Bromus tectorum*) and Siberian elm have been designated as Class C Noxious weeds, meaning that management decisions for these species should be determined at the local level, based on feasibility of control and level of infestation. Field bindweed, previously designated a noxious weed, has been dropped from the current list.

4.1 Significance of Impact

Based on the ranking system of Hiebert and Stubbendieck (1993), field bindweed, white sweetclover (*Melilotus alba*), cheatgrass (*Bromus tectorum*), musk thistle (*Carduus nutans*), Bermudagrass (*Cynodon dactylon*), kochia, and yellow sweetclover (*Melilotus officinalis*) have the highest potential impact at Fort Union NM (Table 4-2). It should be noted that Stubbendieck et al. (1992) considered a species with a significance of impact rating of 50 or greater to be a highly disruptive species. According to this criterion, only field bindweed and white sweetclover would be considered to be highly disruptive. At the time that Willson et al. (2008)

conducted their fieldwork, field bindweed occupied 3.3 acres (1.3 ha) and occurred in the residence area and the road-side near the front gate. Current monitoring and observation has identified an expanded distribution to include the area around the visitor center and among the fort ruins. Of the exotic plants detected at the park, this species is considered to have the highest pest potential (see Table 4-2). White sweetclover was not reported by Willson et al. (2008), but was detected during 2009-2011 NHPM annual monitoring and the 2011 Rapid Assessment (see Table 4-1).

A number of the species noted above were also listed as low or moderate (field bindweed) urgency by Willson et al. (2008) based on categories defined by Hiebert and Stubbendieck (1993). We did not use these categories in our assessment because they are based on the amount of increased effort that would result from delays in management action. While this is certainly an important consideration, we believe that in the context of ecological condition, the potential impact to the ecosystem far outweighs changes in the effort required to control the species. Exotic bromes (e.g., cheatgrass), for example, are well known to dramatically



PHOTO: JAN SAMANEK

Field bindweed (*Convolvulus arvensis*), considered a highly disruptive exotic species

Table 4-1. Exotic species reported to occur at Fort Union NM by Willson et al. (2008), NHNM mapping (Muldavin et al. 2004), SOPN annual monitoring of high priority blocks (e.g., Folts-Zettner et al. 2010), 2011 Rapid Assessment (RA/grid) sampling, and 2010-2011 interior plot (grassland) monitoring.

Scientific Name	Common Name	Life Form ¹	Type ²	Willson et al. 2008 ³	NHNM Mapping	High Priority Blocks (2009 -2011)	2011 RA	2010-2011 Interior Plots
<i>Agropyron species</i>	Wheatgrass species	G	Unk		•			
<i>Agrostis gigantea</i>	Redtop bentgrass	G	P	•				
<i>Bromus cartharticus</i>	Rescue brome	G	A	•		•		
<i>Bromus japonicus</i>	Japanese brome	G	A	•	•			
<i>Bromus tectorum</i>	Cheatgrass (N)	G	A	•				
<i>Carduus nutans</i>	Musk thistle (N)	F	P		•	•		
<i>Chenopodium album</i>	Common lambsquarters	F	A			•		
<i>Convolvulus arvensis</i>	Field bindweed (n)	F	P	•	•	•	•	•
<i>Cynodon dactylon</i>	Bermudagrass	G	P	•				
<i>Euphorbia davidii</i>	David's spurge	F	A			•		•
<i>Erodium cicutarium</i>	Red stem storksbill (n)	F	A	•		•	•	
<i>Kochia scoparia</i>	Kochia (n)	F	A	•		•	•	•
<i>Lactuca serriola</i>	Prickly lettuce	F	A/B	•	•			
<i>Marrubium vulgare</i>	Horehound	F	P	•		•	•	
<i>Melilotus lupulina</i>	Black medic clover	F	P	•				
<i>Melilotus alba</i>	White Sweetclover	F	P			•	•	
<i>Melilotus officinalis</i>	Yellow sweetclover	F	P	•	•	•		
<i>Medicago sativa</i>	Alfalfa	F	P	•				
<i>Plantago lanceolata</i>	Buckhorn plantain	F	P	•				
<i>Plantago major</i>	Broadleaved plantain	F	P	•				
<i>Poa annua</i>	Annual bluegrass	G	A		•			
<i>Poa pratensis</i>	Kentucky bluegrass	G	P		•			
<i>Rumex crispus</i>	Curly dock	F	P			•		
<i>Salsola tragus</i>	Prickly (n) Russian thistle	F	A	•	•	•	•	•
<i>Sonchus asper</i>	Spiny sowthistle	F	A	•				
<i>Taraxacum officinale</i>	Dandelion	F	P	•	•			
<i>Tragopogon dubius</i>	Western salsify	F	P	•		•		
<i>Tragopogon pratensis</i>	Meadow salsify	F	P	•	•			
<i>Ulmus pumila</i>	Siberian elm (N)	T	P	•	•	•		
<i>Urtica dioecae</i>	Stinging nettle	F	P		•			
<i>Verbascum thapsus</i>	Mullein (n)	F	B	•	•	•	•	

Notes: 1 Life form: G = Graminoid, F = Forb/Herb, T = Tree.

2 Type: A = Annual, P = Perennial, B = Biennial.

3 List used by Willson et al. (2008) was based on lists compiled by park staff and NHNM.

Noxious species: N = Listed as Noxious in New Mexico; n = Listed as noxious in other, nearby states.

Table 4-2. Exotic species ranking for significance of impact at Fort Union NM based on Hiebert and Stubbendieck (2003), as reported by Willson et al. (2008).

Scientific Name	Common Name	Significance of Impact		
		Level of Impact ³	Pest Potential ⁴	Total ⁵
<i>Convolvulus arvensis</i> ¹	Field bindweed (n)	21	43	64
<i>Melilotus alba</i> ²	White Sweetclover	25	29	54
<i>Bromus tectorum</i> ¹	Cheatgrass (N)	22	27	49
<i>Carduus nutans</i> ²	Musk thistle (N)	8	41	49
<i>Cynodon dactylon</i> ¹	Bermudagrass	21	26	47
<i>Kochia scoparia</i> ¹	Kochia (n)	12	34	46
<i>Melilotus officinalis</i> ¹	Yellow sweetclover	17	27	44
<i>Bromus japonicus</i> ¹	Japanese brome	18	25	43
<i>Ulmus pumila</i> ¹	Siberian elm (N)	6	36	42
<i>Marrubium vulgare</i> ¹	Horehound	10	32	42
<i>Taraxacum officinale</i> ¹	Dandelion	4	32	36
<i>Chenopodium album</i> ²	Common lambsquarters	9	27	36
<i>Agrostis gigantea</i> ¹	Redtop bentgrass	3	32	35
<i>Tragopogon dubius</i> ¹	Western salsify	3	32	35
<i>Salsola tragus</i> ¹	Prickly Russian thistle (n)	10	23	33
<i>Medicago lupulina</i> ¹	Black medic clover	3	29	32
<i>Bromus cartharticus</i> ¹	Rescue brome	3	27	30
<i>Plantago major</i> ¹	Broadleaved plantain	3	26	29
<i>Erodium cicutarium</i> ¹	Red stem storksbill (n)	3	25	28
<i>Plantago lanceolata</i> ¹	Buckhorn plantain	3	25	28
<i>Tragopogon pratensis</i> ¹	Meadow salsify	3	25	28
<i>Lactuca serriola</i> ¹	Prickly lettuce	5	21	26
<i>Sonchus asper</i> ¹	Spiny sowthistle	3	23	26
<i>Medicago sativa</i> ¹	Alfalfa	3	22	25
<i>Euphorbia davidii</i> ²	David's spurge	6	19	25
<i>Verbascum thapsus</i> ¹	Mullein (n)	6	16	22
<i>Rumex crispus</i> ²	Curly dock	-7	26	19

¹ Species ranking was conducted by, and reported in, Willson et al. (2008).

² Species not in Willson et al. (2008); ranked by T. Folts-Zettner of SOPN.

³ Level of Impact scores range from -8 to 50 points.

⁴ Pest potential scores range from 4 to 50 points.

⁵ Total scores range from -4 to 100 points.

Noxious species: N = Listed as Noxious in New Mexico; n = Listed as noxious in other, nearby states.

change the character of an ecosystem including such changes as major shifts in community composition and structure (Knapp 1996), as well as substantially altered fire regimes (Whisenant 1990). In many cases (e.g., Knapp 1996), these changes have become, for all practical purposes, irreversible. Field bindweed is a perennial plant with taproots and high difficulty of control. The annuals kochia and prickly Russian thistle rapidly establish in disturbed areas and spread seed widely as their dead stems tumble across the grasslands in the wind. Thus, from a standpoint of potential impact to

the Fort Union ecosystem, we would consider these species to be a substantial concern.

Additional species that ranked relatively high in their significance of impact were yellow sweetclover, Japanese brome (*Bromus japonicus*), Siberian elm, and horehound (*Marrubium vulgare*). These species may also have a negative impact on the condition of the natural resources at Fort Union NM. Yellow and white sweetclover are efficiently distributed by way of their wind-born seeds, and they degrade native grasslands by out-growing and shading native sun-loving species. [Note that yellow and white

sweetclover are discussed together in some sections of this report, because they have similar characteristics and are often difficult to reliably differentiate in the field]. Horehound is a perennial plant with taproots and a relatively high difficulty of control; it forms dense stands that crowd out and replace native plants.

4.2 Feasibility of control

Based on the ranking by Willson et al. (2008), dandelion (*Taraxacum officinale*) ranked lowest in feasibility of control (i.e., it is the hardest to control), followed by yellow sweetclover, red top bentgrass (*Agrostis gigantea*), field bindweed, cheatgrass, broadleaved plantain (*Plantago major*), and white sweetclover (Table 4-3). Dandelion, red top bentgrass, cheatgrass, and broadleaved plantain were detected only by Willson et al. (2008 [and by NHNM in the case of dandelion]), and not during any of the SOPN sampling described in this condition assessment. These plants have only been found around fort ruins and/or housing/maintenance areas of the park. The seeds of both yellow and white sweetclover are distributed by the wind, and they are viable for long periods of time (up to 30 years). The perennial field bindweed has deep taproots and shallow, horizontal lateral

roots, as well as long-surviving seeds; the plant can also reproduce vegetatively. The spread of field bindweed at Fort Union NM was probably exacerbated by mowing equipment spreading pieces of the plant to uninfested areas. Cheatgrass, largely successful due to its root system that can obtain moisture from the upper layers of the soil and expand over the winter, has been actively controlled in the vicinity of the fort ruins.

4.3 Proportion of High Priority Blocks Infested

The four most widespread species within the high-risk areas sampled were kochia (in 66% of blocks), prickly Russian thistle (in 62% of blocks), white sweetclover (in 25% of blocks), and field bindweed (in 20% of blocks) (Table 4-4; also see Figures in sections 4.4 and 4.5). Three of these species, kochia, white sweetclover, and field bindweed, were also rated among the top seven plant species for significance of impact. Both kochia and prickly Russian thistle are annuals that can invade a recently disturbed area with a rapid increase in individual plants. Other exotic species detected within the high-risk areas occurred in <1% to 10% of the blocks.

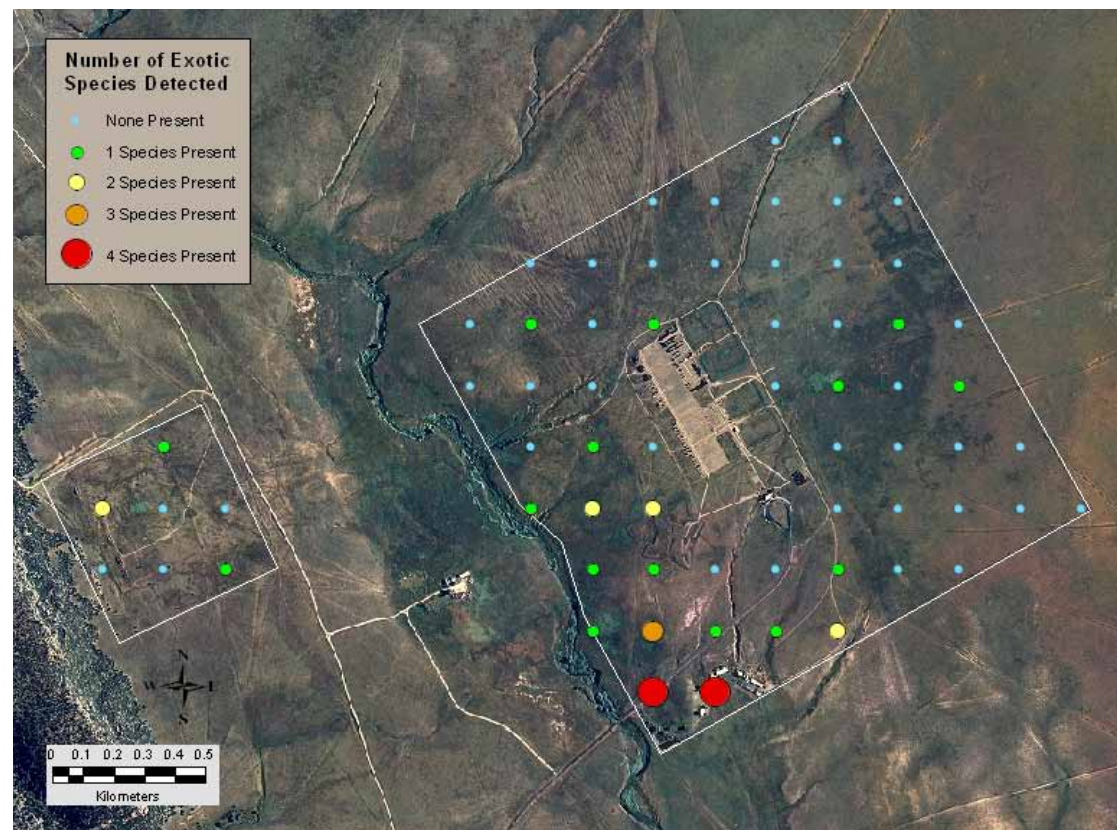


Figure 4-1. The number of exotic species detected in the 2011 Rapid Assessment at Fort Union NM.

Table 4-3. Ranking of exotic species at Fort Union NM for feasibility of control based on Hiebert and Stubbendieck (2003), as reported by Willson et al. (2008). List from least feasible to most feasible.

Scientific Name	Common Name	Feasibility of Control ³
<i>Taraxacum officinale</i> ¹	Dandelion	18
<i>Melilotus officinalis</i> ¹	Yellow sweetclover	23
<i>Agrostis gigantea</i> ¹	Red top bentgrass	23
<i>Convolvulus arvensis</i> ¹	Field bindweed (n)	24
<i>Bromus tectorum</i> ¹	Cheatgrass (N)	28
<i>Plantago major</i> ¹	Broadleaved plantain	28
<i>Melilotus alba</i> ²	White Sweetclover	32
<i>Marrubium vulgare</i> ¹	Horehound	33
<i>Erodium cicutarium</i> ¹	Red stem storksbill (n)	33
<i>Medicago sativa</i> ¹	Alfalfa	33
<i>Verbascum thapsus</i> ¹	Mullein (n)	33
<i>Tragopogon dubius</i> ¹	Western salsify	37
<i>Plantago lanceolata</i> ¹	Buckhorn plantain	37
<i>Bromus japonicus</i> ¹	Japanese brome	38
<i>Medicago lupulina</i> ¹	Black medic clover	38
<i>Lactuca serriola</i> ¹	Prickly lettuce	42
<i>Ulmus pumila</i> ¹	Siberian elm (N)	47
<i>Sonchus asper</i> ¹	Spiny sowthistle	47
<i>Cynodon dactylon</i> ¹	Bermudagrass	48
<i>Carduus nutans</i> ²	Musk thistle (N)	51
<i>Salsola tragus</i> ¹	Prickly Russian thistle (n)	52
<i>Bromus cartharticus</i> ¹	Rescue brome	57
<i>Rumex crispus</i> ²	Curly dock	60
<i>Kochia scoparia</i> ¹	Kochia (n)	62
<i>Tragopogon pratensis</i> ¹	Meadow salsify	62
<i>Chenopodium album</i> ²	Common lambsquarters	66
<i>Euphorbia davidii</i> ²	David's spurge	70

Note: Shaded rows are species ranked highest for significance of impact (scores ≥ 44).

¹ Species ranking conducted by, and reported in, Willson et al. (2008).

² Species not in Willson et al. (2008); ranked by T. Folts-Zettner of SOPN.

³ Potential scores range from 3 to 100 points.

4.4 Proportion of Interior Plots Infested

As previously mentioned, interior plots were sampled in three separate efforts— the Rapid

Assessment / grid sampling conducted for this condition assessment, the annual interior (grassland) plot sampling, and during the vegetation mapping project by NHNM. Three of the same four species that were most wide-

Table 4-4. Number and percentage of exotic plant species detected in 1) high priority blocks sampled in 2009-2011, 2) the Rapid Assessment grid sampled in 2011, and 3) interior plots sampled in 2010 and 2011 (the same six transects were sampled in each year) at Fort Union National Monument.

		High Priority Blocks		Rapid Assessment (grid)		Interior Plots			
Scientific Name	Common Name	# Blocks	% (n=242)	# Pts.	% (n=65)	# Transects 2010	% (n=6)	# Transects 2011	% (n=6)
<i>Kochia scoparia</i>	Kochia (n)	160	66%	10	15%	2	33%	2	33%
<i>Salsola tragus</i>	Prickly Russian thistle (n)	149	62%	15	23%	3	50%	4	67%
<i>Melilotus alba</i>	White Sweetclover	60	25%	1	2%	---	---	---	---
<i>Convolvulus arvensis</i>	Field bindweed (n)	49	20%	5	8%	0	0%	1	17%
<i>Chenopodium album</i>	Common lambsquarters	24	10%	---	---	---	---	---	---
<i>Euphorbia davidii</i>	David's spurge	18	7%	---	---	3	50%	0	0%
<i>Tragopogon dubius</i>	Western salsify	13	5%	---	---	---	---	---	---
<i>Erodium cicutarium</i>	Red stem storksbill (n)	11	5%	1	2%	---	---	---	---
<i>Marrubium vulgare</i>	Horehound	11	5%	1	2%	---	---	---	---
<i>Verbascum thapsus</i>	Mullein (n)	4	2%	1	2%	---	---	---	---
<i>Carduus nutans</i>	Musk thistle (N)	3	1%	---	---	---	---	---	---
<i>Melilotus officinalis</i>	Yellow sweetclover	3	1%	---	---	---	---	---	---
<i>Bromus catharticus</i>	Rescue brome	1	0%	---	---	---	---	---	---
<i>Rumex crispus</i>	Curley dock	1	0%	---	---	---	---	---	---
<i>Ulmus pumila</i>	Siberian elm (N)	1	0%	---	---	---	---	---	---

Note: Shaded rows indicate species ranked highest for significance of impact (scores ≥ 44 ; see Table 4-2).

spread in the high priority blocks were also most widespread in the grid sampling, but in a different order: prickly Russian thistle (at 23% of points), kochia (at 15% of points), and field bindweed (at 8% of points). Four additional species were detected in the grid, all at 2% of the points (Table 4-4). Density classes for each species at each point are shown in Appendix B. The number of exotic species detected at each of the Rapid Assessment grid points varied from 0 to 4. No species were detected at most points, 1 species was detected at a number of points, and 2-4 species were detected at a small number of points (Figure 4-1).

The 2010-2011 interior plot sampling (grassland monitoring) at Fort Union NM detected a total of four species. The two most widespread exotics in both years were prickly Russian thistle (50-67%) and kochia (33% in both years). David's spurge (*Euphorbia davidii*) was found in 50% of transects in 2010 but 0% in 2011. A similar situation occurred with field bindweed (0% in 2010 and 17% in 2011). It should be noted that 2010 was a fairly wet year, while 2011 was very dry; these conditions may have affected the presence/absence of these and other annual species.

Exotic species found during the vegetation mapping project by NHNM are shown in Table 4-1 and on the figures presented in the next section of the report.

4.5 Distribution of High Priority Species

The known distributions of high priority exotic species at Fort Union NM are shown in this section (i.e., Figures 4-2 to 4-7). Distributions (based on SOPN monitoring and NHNM mapping) are shown for the highest priority species that have been detected by SOPN monitoring (see Table 4-4); distributions are not shown for exotic species detected only by Willson et al. (2008) within and immediately adjacent to the fort ruins and the housing/maintenance area. Distributions of the less widespread species listed in Table 4-4 (e.g., Western salsify [*Tragopogon dubius*] and red stem storksbill [*Erodium cicutarium*]) are shown in Appendix C.

Kochia was ranked sixth in significance of impact at Fort Union NM (Table 4-2), but it has been detected in both high priority blocks and interior blocks (Table 4-4, Figure 4-2). Although prickly Russian thistle was ranked below the top ten species by Willson et al. (2008; for significance of impact), its distribution at the monument is similar to that of kochia (Figure 4-3). Field bindweed, ranked highest for significance of impact, was also detected in both high priority and interior blocks (in all three SOPN monitoring efforts; Figure 4-4), although its distribution is smaller than both kochia and prickly Russian thistle. The other three exotic species found to be most widespread by SOPN monitoring were found in either both high priority blocks and interior blocks (white sweetclover and David's spurge, Figures 4-5 and 4-6, respectively) or high priority blocks only (common lambsquarters; Figure 4-7). Figure 4-5 shows distributions for both sweetclover species.

4.6 Overall Condition

Based on the four sampling efforts discussed in this condition assessment (i.e., high priority blocks, Rapid Assessment grid, interior (grassland) plots, and NHNM vegetation mapping), the most widespread species at Fort Union NM are prickly Russian thistle, kochia, and field bindweed, followed by white sweetclover and David's spurge. Of these plants, only field bind-

weed and white sweetclover received a score high enough to categorize them as a highly disruptive species (by Willson et al. 2008 and T. Folts-Zettner, SOPN, following Stubbendieck et al. 1992). Field bindweed received a rating of 24 (out of 100) in the feasibility of control category, and white sweetclover received a score of 32.

Willson et al. (2008) concluded that the shortgrass prairie community at Fort Union NM was stable and lacked serious threats from exotic plants at the time. They pointed to the wet areas near Coyote Creek and areas of disturbance around the residential buildings and roads as areas of potential concern. They also stated that control efforts should be undertaken in these areas as exotic plants become established, to avoid their spread, but that the dry climate would probably limit the occurrence of exotic species to those areas that receive supplemental water (Willson et al. 2008). SOPN agrees that the shortgrass community is fairly stable, but has a greater concern regarding the threat level. During the 6-8 years between Willson et al.'s and NHNM's work and that of the SOPN, populations of several exotic species appear to be spreading.

Based on the qualitative assessment of the condition findings across the five indicators/measures described in this report, we consider the overall condition of Fort Union NM as "threatened." Although a condition of "threatened" is cause for some concern, the reference condition for this park included the existence of some exotic species and a history of use and modification by humans. The shortgrass prairie itself has been fairly stable, although it remains to be seen how it will handle the current drought, which is forecast to be long-term. The ubiquitous kochia and prickly Russian thistle will likely persist, as their widespread distribution and efficient dispersal mechanisms will make control difficult. These exotics, in addition to field bindweed and the sweetclovers, were observed in 2011 to be setting seed while native plants were drought-dormant. As the quantity of bare ground increases during the drought, the ability of these and other exotics to establish will increase. The spread of field bindweed from the housing and fort infestations into the prairie is of the greatest concern, as this noxious weed is extremely prolific, difficult to control, and has the potential to severely impact the native plant community.



Figure 4-2. Known distribution of kochia based on surveys conducted by SOPN and NHHM.

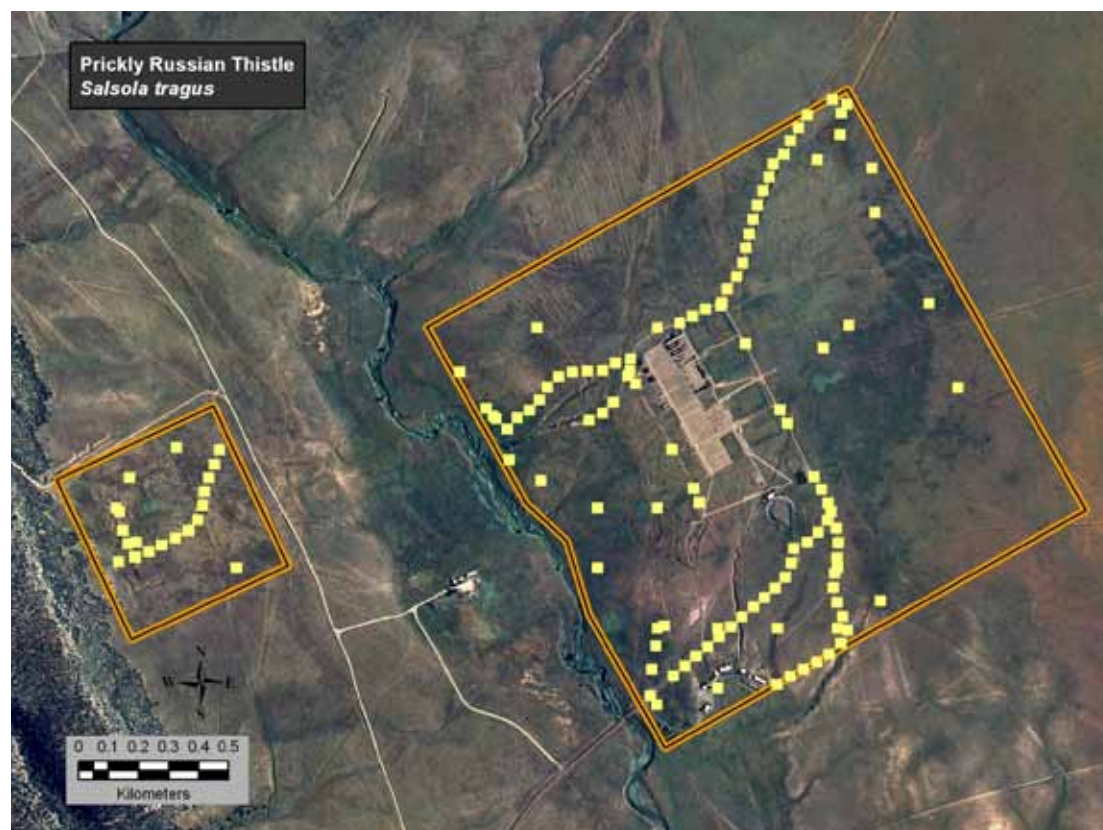


Figure 4-3. Known distribution of prickly Russian thistle based on surveys conducted by SOPN and NHHM.



Figure 4-4. Known distribution of field bindweed based on surveys conducted by SOPN and NHHM.



Figure 4-5. Known distribution of white and yellow sweetclover based on surveys conducted by SOPN and NHHM.

Figure 4-6.
Known
distribution
of David's
spurge based
on surveys
conducted
by SOPN and
NHNM.



Figure 4-7.
Known
distribution
of common
lambsquarters
based on
surveys
conducted
by SOPN and
NHNM.



The frequently disturbed areas surrounding the fort ruins and housing harbor a wide array of exotic plants, especially those that respond well to mowing and the additional moisture and shade provided by the walls. Fortunately, most of these exotics will remain confined to these areas because the conditions they need are generally not available in the prairie. These areas need to be monitored during every season to detect and eradicate additional problematic species (i.e., that can be introduced through soil brought in for mud plaster). Cheatgrass is one such species that is found only within the fort and is being actively controlled to prevent its spread. The most valuable control tool that the park has is an educated and vigilant maintenance staff. Maintenance personnel are “on the ground” daily in all seasons and have the opportunity to detect the occurrence of new plants and plants that may be growing in new locations.

4.7 Key uncertainties

There are several areas of potential uncertainty in this exotic plant assessment. These are: the status of un-surveyed areas; subjectivity in the ranking system of Hiebert and Stubbendieck (1993); the number of years since Willson et al. (2008) and Muldavin et al. (2004) collected data and/or applied the ranking system; and the confounding effects of ongoing exotic plant treatments.

One of the biggest elements of uncertainty in this exotic plant assessment is the status of un-surveyed areas. We do not know whether or not exotic plants occur in the areas that are not surveyed. Also, interior portions of the landscape at the monument were sampled during the secondary exotic plant monitoring in grassland areas; these plots (six transects) will be surveyed annually (2010 and 2011 so far). As shown in Figure 2-4, these transects cover a relatively small proportion of the interior landscape. The 2011 Rapid Assessment was conducted by SOPN for this condition assessment to cover a larger proportion of the interior landscape at the monument. While this grid accomplished that goal, it was sampled in only one year, and

plant occurrences can change from year to year depending upon factors such as rainfall, especially in the arid landscape of Fort Union.

The species ranking approach developed by Hiebert and Stubbendieck (1993) does an excellent job of defining the criteria by which individual species are ranked in terms of the significance of impact and feasibility of control. However, there is a certain degree of subjectivity that goes into any ranking system. Despite this potential for subjectivity, we believe that the overall ranking did reflect at least the top species of concern. There were, however, a few species that we would probably have ranked differently than did Willson et al. (2008); for example, we believe that *kochia* was ranked too high in feasibility of control. However, even with this ranking for control, *kochia* ranked high in overall concern, which is consistent with our belief.

The Willson et al. (2008) report was an important source of information for this assessment. However, it should be noted that Willson et al. (2008) visited the monument and collected the information used to rank the exotic species in August of 2003— more than eight years ago. Coverages of some of the plants may have changed over this period, affecting the ranking positions. Also, species that were detected only by Willson et al., and not during SOPN monitoring, were most likely detected in the fort ruins where SOPN monitors do not sample. For example, a few of the species with relatively high significance of impact scores (e.g., cheatgrass and Bermudagrass, 49 and 47, respectively) have not been detected in any of the SOPN sampling efforts from 2009-2011 (see tables 4-1 and 4-4).

Another area of uncertainty is the confounding effects of ongoing treatments. For example, areas that were treated within a year or two of surveys may show a lower percent occurrence, even if that is a temporary state from having been treated. This is especially true for areas that have easy access and are highly visible.

5 Sources of Expertise

Surveys for exotic plants at Fort Union NM were conducted by teams well trained in species identification and methods. These included: 1) the exotic plants monitoring team of the SOPN, 2) the vegetation monitoring team of the SOPN, 3) the Chihuahuan Desert/Southern Shortgrass Prairie Exotic Plants Management Team, 4) James Stubbendieck of the University of Nebraska-Lincoln (for Willson et al. 2008); and 5) Yvonne Chauvin of NHHM (for Muldavin et al. 2004). All of these teams work extensively with exotic plants and our confidence is very high regarding the reliability of their surveys.



PHOTO: AL SCHNEIDER

Mullein
(*Verbascum
thapsus*) an exotic
species detected by
SOPN at FOUN.

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Appendix A. Excerpt from Hiebert and Stubbendieck (1993) containing the Exotic Species Ranking System

Handbook for Ranking Exotic Plants for Management and Control

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An Exotic Plant Ranking System

Why Use an Analytical Approach?

Several sound reasons exist for using an analytical approach as the basis of prioritizing exotic species. One of the basic reasons for using a decision analysis process is to get scientists involved in the decision-making process. Using a consistent and logical decision-making process prevents a biologist from compromising scientific excellence by becoming involved in environmental decisions based on incomplete information. Selecting an action alternative is similar to selecting a hypothesis. The action becomes an experimental manipulation to test the validity of the “hypothesis.” A decision analysis process not only adds validity to a decision, but this process often demonstrates that inaction due to lack of complete information can have serious consequences (Maguire 1991).

If an analytical approach was not employed, decisions would most likely be based on the opinion of an individual or a group of individuals or decisions would be based on precedent. Granted, many field ecologists have a good idea of which exotic species are impacting natural ecosystem processes or impacting species composition. However, decisions based on judgment alone are rarely based on defined criteria, do not usually document the reasoning process, and give no assurance that the full array of significant factors were considered. Such decisions may suffer from personal biases and political whims. Decisions are hard to defend if challenged, and proposals for funding are hard to justify. Decisions based on precedent may be easier to defend but are not responsive to the variation in exotic species or natural system interactions over space and time. Thus, priorities set for managing exotic species based on precedent may not reflect current ecological and economic realities.

On the other hand, consistently using an analytical tool such as the Exotic Species Ranking System, can ensure that ecological knowledge is applied to the decision process and can remedy some of the problems associated with decisions based on judgment and precedent alone. An analytical framework encourages researchers to consider the full range of factors and consequences of their decisions. An analytical framework documents the procedures and the reasons for the decisions made, thus reducing the risk aversion characteristic of park managers. Decisions are defensible. Solid justification for program authorization and funding is at hand.

Origin

An earlier version of the system presented here was developed by Ron Hiebert. The system was modeled after a ranking system that was developed at Point Reyes National Seashore (Self 1986). The purpose of this system was to rank the effects of exotic species on the natural recovery of former residential sites at Indiana Dunes National Lakeshore. Hiebert (1990) observed that some exotic species were found only in severely and recently disturbed areas and seemed to have little effect on the succession process. Other exotic species were persistent but did not reproduce or spread, while others were persistent and had high rates of reproduction. Populations of some exotics were expanding within disturbed areas, while others were observed to invade surrounding undisturbed sites. Some of the most invasive and disruptive species were those with life history characteristics (high seed output, long-distance dispersal adaptations, ability to reproduce vegetatively) consistent with those related to weediness (Baker 1965). The present system was developed to support general NPS and park-specific policy, giving high priority to species causing major impacts (and are easily controlled) and giving low priority to species causing little impact (and extremely difficult to control).

Also, the system is designed to identify species that are currently rare and causing little impact but have a high potential to become a problem in the future.

The ranking system presented in this handbook has since been applied to ranking the exotic plants of Indiana Dunes (Klick et al. 1989) and six small national park system areas dominated by prairies and savannahs (Stubbendieck et al. 1992). As part of the latter, 14 plant ecologists reviewed the system. The system was modified to rank exotic plants in Olympic National Park (Olson et al. 1991) and was modified and used to rank both exotic plants and animals in the state of Minnesota (Minnesota Department of Natural Resources 1991). The system has been revised based on the above experiences and recommendations of users and expert reviewers.

Rationale For Use

The ranking system provides an ecologist or resource management specialist with a tool to sort exotic plant species based on their present level of impact and their innate ability to become a pest. Based on conscientious consideration of all the factors in the system, a person with good taxonomic and ecological skills should be able to separate those species that are innocuous from those that are disruptive or have a high potential to become disruptive. The resulting species rank can then be weighed against the ease or feasibility of control, and the urgency of action or the cost of delay in action can be determined.

For example, purple loosestrife (*Lythrum salicaria*) is ranked as the most disruptive exotic plant at Indiana Dunes National Lakeshore. Extensive efforts to eradicate or control its spread have not been successful. However, due to the significance of the impact, the National Park Service is funding research on its basic biology and on experimental control methods. In contrast, Scotch pine (*Pinus sylvestris*) is found to rarely reproduce and to cause only minor impacts throughout most of the park. Significant impacts are limited to one small prairie opening. Control is relatively simple--saw the pine down. Therefore, the park decided to eradicate Scotch pine from the prairie opening and to monitor its status in other park locations.

An example of the urgency ranking as applied is European alder (*Alnus glutinosa*). This species was found at or in close proximity to one razed residential site at Indiana Dunes National Lakeshore. However, the species had spread into a large, dense clone of thousands of ramets in just six years and was also reproducing sexually. The species was reported to be highly invasive and to cause major impacts in other natural areas. Therefore, the National Park Service considered quick action to be prudent.

In summary, the ranking system encourages resource managers to logically apply criteria that address the present impact of a species on ecological

processes and structure and on other park resources. The ranking system also predicts the potential of a species to become a pest in the future. Normally, applying the system will greatly reduce the list of exotic species with which a park manager needs to be concerned. The decision to take management action against a species determined to be disruptive then can be weighed on the basis of the level of impact, the feasibility of successful control, and the prediction of the cost

of delay in action. The information accumulated in the system's application serves as solid documentation to support management's decisions and to justify program funding

Description

The Exotic Species Ranking System in Table 1 uses numerical ratings, is written in outline format, and is divided into two main sections: I. Significance of Impact and II. Feasibility of Control or Management. Each section is based on a scale of 100 points.

Table 1. Exotic Species Ranking System (Ronald D. Hiebert)

I. Significance of Impact

A. Current Level of Impact

1. Distribution relative to disturbance regime
 - a. found only within sites disturbed within the last 3 years of sites regularly disturbed -10
 - b. found in sites disturbed within the last 10 years 1
 - c. found in midsuccessional sites disturbed 11-50 years before present (BP) 2
 - d. found in late-successional sites disturbed 51-100 years BP 5
 - e. found in high-quality natural areas with no known major disturbance for 100 years 10
2. Abundance
 - a. number of populations (stands)
 - (1) few; scattered (<5) 1
 - (2) intermediate number; patchy (6-10) 3
 - (3) several; widespread and dense (>10) 5
 - b. areal extent of populations
 - (1) <5 ha 2
 - (2) 5-10 ha 3
 - (3) 11-50 ha 3
 - (4) >50 ha 5
3. Effect on natural processes and character
 - a. plant species having little or no effect 0
 - b. delays establishment of native species in disturbed sites up to 10 years 3
 - c. long-term (more than 10 years) modification or retardation of succession 7
 - d. invades and modifies existing native communities 10
 - e. invades and replaces native communities 15
4. Significance of threat to park resources
 - a. threat to secondary resources negligible 0
 - b. threat to areas' secondary (successional) resources 2
 - c. endangerment to areas' secondary (successional) resources 4
 - d. threat to areas' primary resources 8
 - e. endangerment to areas' primary resources 10

Table 1 (cont).

5. Level of visual impact to an ecologist	
a. little or no visual impact on landscape	0
b. minor visual impact on natural landscape	2
c. significant visual impact on natural landscape	4
d. major visual impact on natural landscape	5
Total Possible = 50	
B. Innate Ability of Species to Become a Pest	
1. Ability to complete reproductive cycle in area of concern	
a. not observed to complete reproductive cycle	0
b. observed to complete reproductive cycle	5
2. Mode of reproduction	
a. reproduces almost entirely by vegetative means	1
b. reproduces only by seeds	3
c. reproduces vegetatively and by seed	5
3. Vegetative reproduction	
a. no vegetative reproduction	0
b. vegetative reproduction rate maintains population	1
c. vegetative reproduction rate results in moderate increase in population size	3
d. vegetative reproduction rate results in rapid increase in population size	5
4. Frequency of sexual reproduction for mature plant	
a. almost never reproduces sexually in area	0
b. once every five or more years	1
c. every other year	3
d. one or more times a year	5
5. Number of seeds per plant	
a. few (0-10)	1
b. moderate (11-1,000)	3
c. many-seeded (>1,000)	5
6. Dispersal ability	
a. little potential for long-distance dispersal	0
b. great potential for long-distance dispersal	5
7. Germination requirements	
a. requires open soil and disturbance to germinate	0
b. can germinate in vegetated areas but in a narrow range or in special conditions	3
c. can germinate in existing vegetation in a wide range of conditions	5
8. Competitive ability	
a. poor competitor for limiting factors	0
b. moderately competitive for limiting factors	3
c. highly competitive for limiting factors	5
9. Known level of impact in natural areas	
a. not known to cause impacts in any other natural area	0
b. known to cause impacts in natural areas, but in other habitats and different climate zones	1
c. known to cause low impact in natural areas in similar habitats and climate zones	3
d. known to cause moderate impact in natural areas in similar habitats and climate zones	5
e. known to cause high impact in natural areas in similar habitats and climate zones	10
Total Possible = 50	

Table 1 (cont).

II. Feasibility of Control or Management		
A. Abundance Within Park		
1. Number of populations (stands)		
a. several; widespread and dense		1
b. intermediate number; patchy		3
c. few; scattered		5
2. Areal extent of populations		
a. > 50		1
b. 11-50 ha		2
c. 5-10		3
d. < 5ha		5
B. Ease of Control		
1. Seed banks		
a. seeds remain viable in the soil for at least 3 years		0
b. seeds remain viable in the soil for 2-3 years		5
c. seeds viable in the soil for 1 year or less		15
2. Vegetative regeneration		
a. any plant part is a viable propagule		0
b. sprouts from roots or stumps		5
c. no resprouting following removal of aboveground growth		10
3. Level of effort required		
a. repeated chemical or mechanical control measures required		1
b. one or two chemical or mechanical treatments required		5
c. can be controlled with one chemical treatment		10
d. effective control can be achieved with mechanical treatment		15
4. Abundance and proximity of propagules near park		
a. many sources of propagules near park		0
b. few sources of propagules near park, but these are readily dispersed		5
c. few sources of propagules near park, but these are not readily dispersed		10
d. no sources of propagules are in close proximity		15
C. Side Effects of Chemical/Mechanical Control Measures		
1. control measures will cause major impacts to community		0
2. control measures will cause moderate impacts to community		5
3. control measures will have little or no impact on community		15
D. Effectiveness of Community Management		
1. the following options are not effective		0
2. cultural techniques (burning, flooding) can be used to control target species		5
3. routine management of community or restoration or preservation practices (e.g., prescribed burning, flooding, controlled disturbance) effectively controls target species		10
E. Biological Control		
1. biological control not feasible (not practical possible, or probable)		0
2. potential may exist for biological control		5
3. biological control feasible		10
Total Possible = 100		
Urgency		
1. Delay in action will result in large increase in effort required for successful control.		High
2. Delay in action will result in moderate increase in effort required for successful control.		Medium
3. Delay in action will result in little increase in effort required for successful control.		Low

I. Significance of Impact is further divided into A. Current Level of Impact and B. Innate Ability of Species to Become a Pest. Stubbendieck et al. (1992) considered a species with a combined score of over 50 points for significance of impact to be

seriously disruptive and needing appropriate attention. Species receiving high scores for feasibility of control will be easier to control than those receiving lower scores. A step-by-step description of the system follows.

I. Significance of Impact

- A. Current Level of Impact: This section concentrates on ranking the species based on the present degree and extent of impact caused by the exotic species. Element 1 addresses where the species is found along a disturbance regime. If the species is found in only sites that are recently or frequently disturbed, the species is not considered a serious threat. If the species is found in mature undisturbed natural communities, the species is considered a serious threat. Element 2 addresses how many populations (stands) are found in the park and the size of the populations. Element 3 rates a species based on its effects on the ecological processes and structure of native communities. Element 4 addresses which park resources are threatened. Finally, element 5 addresses the visual impact as seen by an ecologist.
- B. Innate Ability of Species to Become a Pest: This section ranks a species based on the life history traits that preadapt it to become a problem and its known impacts in other areas. Important life history characteristics include potential rate of increase, adaptations for long-distance dispersal, and the breadth of habitats in which the species can colonize and thrive. Element 1 is essentially a screening device. If the species cannot reproduce in the area, the species most likely will not pose much of a threat. Likely species that will not reproduce in an area are horticultural species transferred from areas with different environmental conditions. Element 2 addresses how a species reproduces. The assumption is that vegetative reproduction allows an adapted ecotype to be maintained, resulting in local spread. Sexual reproduction allows for the maintenance of genetic variation and propagules for long-distance dispersal and the possibility of forming highly adapted gene combinations. If the species can reproduce both vegetatively and sexually, that species has the best of both worlds.

Elements 3, 4, and 5 address the factors that determine the intrinsic rate of increase of a species--how many seeds are produced how often. Element 6 deals with the species ability to disperse. This factor can usually be rated based on the presence or absence of special adaptations for seed or fruit dispersal, such as wings and pappi for wind dispersal, bladders for water dispersal, or bristles for animal dispersal. Element 7 asks if the species needs bare soil (disturbed) to germinate or if the species can germinate in a relatively closed (undisturbed) community. Element 8 looks at what the species can do once the species has colonized an area. Is the species able to outcompete native species for light, water, etc.? Finally, scientists should not ignore what the effects of the species have been in other natural areas.

II. Feasibility of Control or Management

Less is known about the feasibility of managing exotic plants in natural areas than what impacts they have on the natural systems. Most research efforts in controlling plants have been in agriculture where the goal is to control all but one species while not harming the single-crop species. In natural areas, the goal is to control one or a few species while not harming diverse assemblages of native species. However, many factors will affect the funds and effort required for control and the probability of success.

- A. **Abundance Within Park:** No explanation is needed here. The larger the populations and the larger the number of populations, the larger the funds and effort required to manage the species.
- B. **Ease of Control:** This section not only deals with life history characteristics that impact the level of effort that will be needed to control the species, but also the probability of success if unlimited funds and personnel are used. Element 1 addresses the seed bank which directly influences the needed duration of a control program. Information on the longevity of viable seeds in soil is not available for many species, therefore making this element hard to score. However, a best estimate should be made based on the information that is available. Element 2 addresses the vegetative reproduction of the species, which influences the number and kinds of treatments required to control the species, whether the underground parts of the plant must be removed, and also dictates the protocol for disposal of plant material. Element 3 not only addresses the level of effort required, but also the kind(s) of control measures required. Element 3 follows the preferred steps of the NPS Integrated Pest Management Program in that mechanical treatment is preferred over chemical treatment. Element 4 deals with the presence or absence of propagules adjacent to the park and the probability of propagules being dispersed into the park. Consideration should be given to the park's ability to control the species outside its boundaries through cooperative control programs.
- C. **Side Effects of Chemical/Mechanical Control Measures:** As stated earlier, researchers must consider what effects eradication or control measures will have on the system being restored or preserved. Will the treatment open up areas for the same species to recolonize or be invaded by other equally or more impacting exotics? In some cases, the lesser of two unsatisfactory options may be not taking any action.
- D. **Effectiveness of Community Management:** Controlling exotic species through sound management of the system based on ecological study is by far the preferred control method. In some cases, controlling trampling by visitors, restoring historical fire regimes, or restoring shoreline processes or natural hydrological regimes will shift the competitive edge to the desired native species.
- E. **Biological Control:** Biological control is ecologically feasible for many exotic species. However, due to the high costs to develop well-tested biological control agents, it is only economically feasible for exotic species causing major impacts over a broad geographical area and normally only if the species are causing an economic impact as well as an ecological impact. Similarly, biological control is not feasible if the species to be controlled has some economic value. Abundance of closely related native species in the area where the exotic is to be controlled also lowers the feasibility because of possible negative side effects. The responsibility of conducting long-term studies involved with selecting and screening possible control agents lies with the U.S. Department of Agriculture.

Urgency: After the species are ranked according to their level of impact and feasibility of control or management, the exotic species that demands the most attention should be addressed first. The cost of delaying an action either financially or in impact to the natural resources of the park is a good criterion to use in making this often difficult decision.

Appendix B. Exotic Species and their Density Classes at each Rapid Assessment Grid Point Sampled in 2011 by SOPN. Grid Point Locations Shown on Figure 2-3.

Point	Species	Density ^A
A07	<i>Kochia scoparia</i>	2
A07	<i>Salsola tragus</i>	2
A08	NONE	0
B06	<i>Salsola tragus</i>	2
B07	NONE	0
B08	NONE	0
C07	NONE	0
C08	<i>Salsola tragus</i>	1
D04	NONE	0
D05	NONE	0
E03	NONE	0
E04	<i>Salsola tragus</i>	2
E05	NONE	0
E06	NONE	0
E07	<i>Convolvulus arvensis</i>	1
F03	NONE	0
F04	NONE	0
F05	NONE	0
F06	<i>Kochia scoparia</i>	1
F07	<i>Kochia scoparia</i>	1
F07	<i>Salsola tragus</i>	2
F08	<i>Salsola tragus</i>	1
F09	<i>Kochia scoparia</i>	1
G02	NONE	0
G03	NONE	0
G04	<i>Salsola tragus</i>	1
G06	NONE	1
G07	<i>Kochia scoparia</i>	2
G07	<i>Salsola tragus</i>	2
G08	<i>Kochia scoparia</i>	1
G09	<i>Convolvulus arvensis</i>	2
G09	<i>Kochia scoparia</i>	2
G09	<i>Salsola tragus</i>	2
G10	<i>Convolvulus arvensis</i>	2
G10	<i>Kochia scoparia</i>	1
G10	<i>Melilotus alba</i>	2
G10	<i>Verbascum thapsus</i>	1
H02	NONE	0

Point	Species	Density ^A
H03	NONE	0
H08	NONE	0
H09	<i>Salsola tragus</i>	1
H10	<i>Convolvulus arvensis</i>	2
H10	<i>Erodium cicutarium</i>	1
H10	<i>Marrubium vulgare</i>	1
H10	<i>Salsola tragus</i>	2
I01	NONE	0
I02	NONE	0
I03	NONE	0
I04	NONE	0
I05	NONE	0
I08	NONE	0
I09	<i>Salsola tragus</i>	2
J01	NONE	0
J02	NONE	0
J03	NONE	0
J04	NONE	0
J05	<i>Kochia scoparia</i>	1
J06	NONE	0
J07	NONE	0
J08	<i>Salsola tragus</i>	2
J09	<i>Convolvulus arvensis</i>	1
J09	<i>Salsola tragus</i>	1
K02	NONE	0
K03	NONE	0
K04	<i>Kochia scoparia</i>	2
K05	NONE	0
K06	NONE	0
K07	NONE	0
K08	NONE	0
L04	NONE	0
L05	<i>Salsola tragus</i>	1
L07	NONE	0
L08	NONE	0
M06	NONE	0
M07	NONE	0
N07	NONE	0

^A Density: 1 = few plants (1-5); 2 = scattered patches; NONE = no exotics detected

Appendix C. Distribution of Less-widespread Exotic Species Detected during 2009-2011 SOPN Monitoring and NHNM Monitoring (see Table 4-4).



Figure C-1. Known distribution of Western salsify and meadow salsify based on surveys conducted by SOPN and NHNM.



Figure C-2. Known distribution of red stem storks-bill based on surveys conducted by SOPN and NHNM.



Figure C-3. Known distribution of horehound based on surveys conducted by SOPN and NHNM.

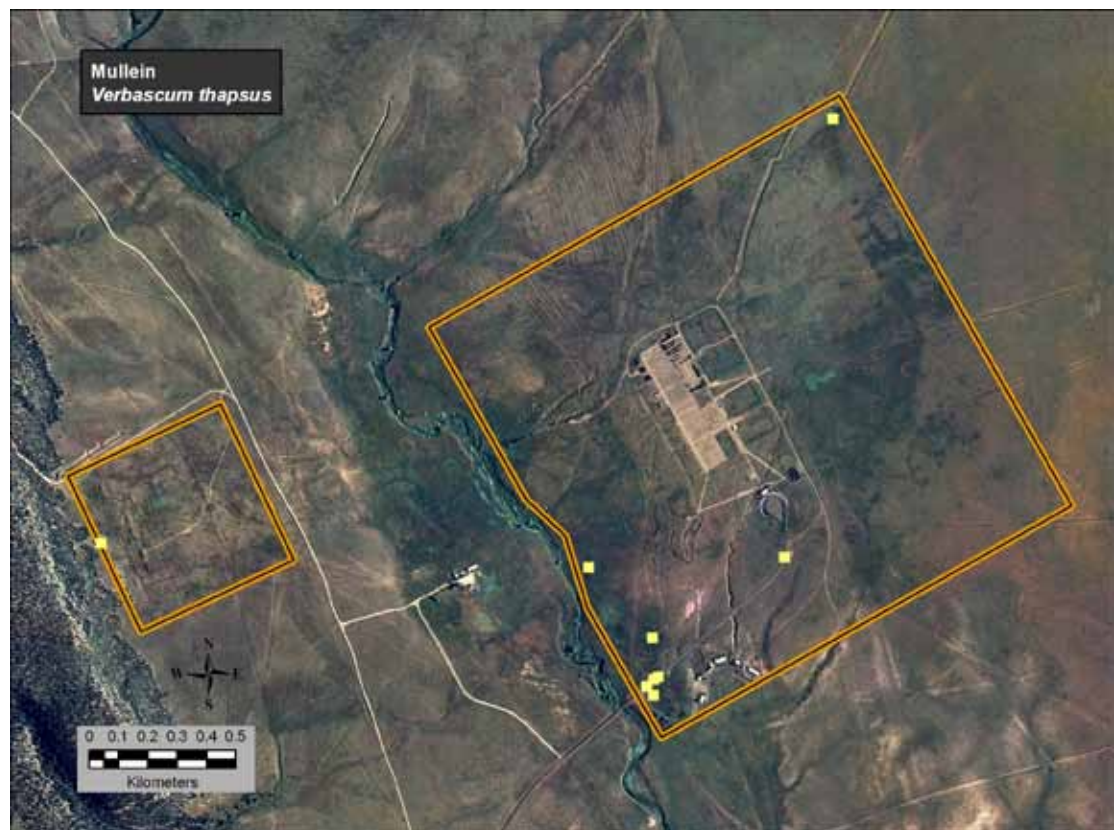


Figure C-4. Known distribution of mullein based on surveys conducted by SOPN and NHNM.



Figure C-5. Known distribution of rescue brome, musk thistle, prickly lettuce (not detected by SOPN), curley dock, and Siberian elm based on surveys conducted by SOPN and NHNM.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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