



Problematic Plant Monitoring in Pipestone National Monument

2006–2017

Natural Resource Report NPS/HTLN/NRR—2020/2092



ON THE COVER

Exotic Plant Management Team featuring Conservation Corps Iowa treating invasive plants in Sioux quartzite prairie in Pipestone National Monument, Pipestone, Minnesota.

Photography by NPS

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Contents

Page

Figures iv

Tables iv

Abstract v

Introduction 1

Methods 2

 Watch Lists 2

 Field Methods 2

 Analytical Methods 5

 I-Ranks 5

 Taxonomic Notes 5

Results and Discussion 6

Literature Cited 12

Figures

	Page
Figure 1. Location of search units used to monitor problematic plants in Pipestone NM.	4
Figure 2. 2017 problematic plant abundance and frequency relationship at Pipestone NM.	11

Tables

	Page
Table 1. Early detection problematic plant watch list used to guide surveys in Pipestone NM.	2
Table 2. Park-established problematic plant watch list used to guide surveys in Pipestone NM.	3
Table 3. Abundance and distribution of problematic plants found in Pipestone NM.	7

Abstract

Managers are challenged with the impact of problematic plants, including exotic, invasive, and pest plant species. Information on the abundance, distribution, and location of these plants is essential for developing risk-based approaches to managing these species. Based on surveys conducted in 2006, 2009, 2013, and 2017, Heartland Inventory and Monitoring Network staff and contractors identified a cumulative total of 32 potentially problematic plant taxa in Pipestone National Monument (NM). Of the 27 species found in 2017, we characterized 6 as very low frequency, 7 as low frequency, 10 as medium frequency, and 4 as high frequency. No species in the very low, low, or medium frequency categories exceeded a 10-acre threshold, while most high-frequency species did. While eradication may be possible for a small number of species, we recommend that management at Pipestone NM focus on strategically protecting high value features in the park's cultural and natural landscapes.

Introduction

The National Park Service's (NPS) management policies distinguish between native and exotic (i.e., non-native) plant species (NPS 2006). Exotic plant species are typically plants that were introduced by human actions, whether intentional or not. Invasive plants, following the definition used in Executive Order 13751, are those plants that are exotic and cause ecological or economic harm. Finally, pest plants are defined less by their biology and more by their context in the same way that the term *weed* is defined (NPS 2006). Pest plants, which include native species, interfere with a specific management objective, including protecting human health. We suggest thinking of this collection of exotic, invasive, and pest plants as *potentially problematic* species.

Park managers, however, are required to control only problematic plants that lead to *resource impairment*. For plant populations causing effects that fall short

of the impairment threshold, park managers wield a high level of discretion in judging whether the population should be controlled or not. The standard for making this decision rests on five criteria: the origin of the species, prudence, feasibility, the harm (i.e., impact) that the plant causes to park resources, and the harm that removal causes (NPS 2006). As with impairment determinations, these decisions are based on professional judgment, environmental assessment, consultation with regulating agencies, evidence-based scholarship, subject matter expertise, and civic engagement with the public (NPS 2006).

This report presents the results of problematic plant monitoring conducted at Pipestone National Monument (NM) in 2006, 2009, 2013 and 2017. The key metrics presented include plant abundance and geographic distribution within the park.



Falls at Pipestone NM, Pipestone, Minnesota. NPS

Methods

Watch Lists

We searched for potentially problematic plants on three watch lists. The prioritization for developing the lists is flexible and described in detail in Young et al. (2007). In general, the early detection watch list (n = 55; Table 1) was composed of prioritized problematic plants not known to occur in the park based on NPSpecies (the national NPS database for plant occurrence registration). Prioritized problematic plants known to occur in the park based on NPSpecies constituted the park-established watch list (n = 33; Table 2). Because our prioritization, NPSpecies, and botanical nomenclature are subject to periodic updating, in this report we included only plant species that we searched for in 2017. Of these, species that we did not search for during all of the previous survey periods are annotated in the tables. While aquatic species were included on the watch lists, terrestrial plants were the focus of this survey. Aquatic plants were documented only occasionally.

Field Methods

We searched for problematic plant species on designated watch lists across Pipestone NM (Figure 1). NPS staff used Trimble GPS units to conduct this project during July 6–7, 2006, July 9–11, 2009, July 31–August 2, 2013, and August 25–26, 2017. Observers made three roughly equidistant passes through each search unit. On each pass through search units, observers estimated plant cover in a 3- to 12-m belt using the widest belt in which the observers were able to view plants and pooled those estimates for the entire unit. Cover was summarized for each plant species within each search unit using these cover values: 0 = 0, 1 = 0.1–0.9 m², 2 = 1–9.9 m², 3 = 10–49.9 m², 4 = 50–99.9 m², 5 = 100–499.9 m², 6 = 500–999.9 m², and 7 = 1,000–4,999.9 m². A total of 114 search units were surveyed during all surveys (Figure 1).

Table 1. Early detection problematic plant watch list used to guide surveys in Pipestone NM.

Scientific Name	Common Name
<i>Acer ginnala</i>	Amur maple
<i>Acer platanoides</i>	Norway maple
<i>Alliaria petiolata</i>	garlic mustard
<i>Alnus glutinosa</i>	European alder
<i>Berberis thunbergii</i>	Japanese barberry
<i>Berteroa incana</i>	hoary alyssum
<i>Bromus tectorum</i>	cheatgrass
<i>Butomus umbellatus</i>	flowering rush
<i>Caragana arborescens</i>	Siberian peashrub
<i>Centaurea solstitialis</i>	yellow star-thistle
<i>Centaurea stoebe</i>	spotted knapweed
<i>Cynanchum louiseae</i>	Louise's swallow-wort
<i>Daucus carota</i>	Queen Anne's lace
<i>Digitalis lanata</i>	Grecian foxglove
<i>Dipsacus laciniatus</i>	cutleaf teasel
<i>Franklinia alatamaha</i>	Franklin tree
<i>Glechoma hederacea</i>	ground ivy
<i>Hemerocallis fulva</i> ^a	orange daylily
<i>Hieracium aurantiacum</i>	orange hawkweed
<i>Humulus japonicus</i>	Japanese hop
<i>Hypericum perforatum</i> ^a	common St. Johnswort
<i>Iris pseudacorus</i>	paleyellow iris
<i>Leucanthemum vulgare</i>	oxeye daisy
<i>Lonicera × bella</i>	showy fly honeysuckle
<i>Lonicera maackii</i>	Amur honeysuckle
<i>Lonicera morrowii</i>	Morrow's honeysuckle
<i>Lotus corniculatus</i>	bird's-foot trefoil
<i>Lotus glaber</i>	narrow-leaf bird's-foot trefoil
<i>Lysimachia nummularia</i>	creeping jenny
<i>Lythrum salicaria</i>	purple loosestrife
<i>Miscanthus sacchariflorus</i>	Amur silvergrass
<i>Morus alba</i>	white mulberry
<i>Myosotis scorpioides</i> ^a	true forget-me-not
<i>Myriophyllum spicatum</i>	Eurasian watermilfoil
<i>Onopordum acanthium</i> ^a	Scotch cottonthistle
<i>Pastinaca sativa</i>	wild parsnip
<i>Phragmites australis</i>	common reed

^a Searched for in 2013 and 2017 only.

Table 1 (continued). Early detection problematic plant watch list used to guide surveys in Pipestone NM.

Scientific Name	Common Name
<i>Polygonum cuspidatum</i>	Japanese knotweed
<i>Polygonum sachalinense</i>	giant knotweed
<i>Populus alba</i>	white poplar
<i>Potamogeton crispus</i>	curly pondweed
<i>Robinia pseudoacacia</i>	black locust
<i>Rorippa officinale</i> ^a	–
<i>Rosa multiflora</i>	multiflora rose
<i>Rumex acetosella</i> ^a	common sheep sorrel
<i>Saponaria officinalis</i> ^a	bouncingbet
<i>Schedonorus arundinaceus</i>	–
<i>Schedonorus pratensis</i>	meadow fescue
<i>Spiraea</i> spp. ^a	spirea
<i>Tanacetum vulgare</i>	common tansy
<i>Typha angustifolia</i>	narrowleaf cattail
<i>Viburnum opulus</i>	European cranberrybush
<i>Vicia cracca</i>	bird vetch
<i>Vicia villosa</i>	winter vetch
<i>Vinca minor</i>	common periwinkle

^a Searched for in 2013 and 2017 only.

Table 2. Park-established problematic plant watch list used to guide surveys in Pipestone NM.

Scientific Name	Common Name
<i>Arctium minus</i>	lesser burdock
<i>Bromus inermis</i>	smooth brome
<i>Bromus racemosus</i> ^b	bald brome
<i>Carduus nutans</i>	nodding plumeless thistle
<i>Cirsium arvense</i>	Canada thistle
<i>Cirsium vulgare</i>	bull thistle
<i>Elaeagnus</i> spp.	elaeanthus
<i>Elaeagnus angustifolia</i>	Russian olive
<i>Elaeagnus umbellata</i>	Autumn olive
<i>Elymus repens</i>	quackgrass
<i>Euphorbia cyparissias</i> ^a	cypress spurge
<i>Euphorbia esula</i>	leafy spurge
<i>Hesperis matronalis</i>	dames rocket
<i>Leonurus cardiaca</i> ^a	common motherwort
<i>Linaria vulgaris</i>	butter and eggs
<i>Lolium perenne</i>	perennial ryegrass
<i>Lonicera</i> spp.	honeysuckle
<i>Lonicera tatarica</i>	Tatarian honeysuckle
<i>Melilotus officinalis</i>	yellow sweetclover
<i>Phalaris arundinacea</i>	reed canarygrass
<i>Phleum pratense</i>	timothy
<i>Poa</i> spp.	bluegrass
<i>Poa compressa</i>	Canada bluegrass
<i>Poa pratensis</i>	Kentucky bluegrass
<i>Potentilla recta</i>	sulphur cinquefoil
<i>Rhamnus cathartica</i>	common buckthorn
<i>Rumex crispus</i> ^a	curly dock
<i>Securigera varia</i>	crownvetch
<i>Sonchus arvensis</i>	field sowthistle
<i>Typha</i> spp. ^a	cattail
<i>Typha × glauca</i> ^a	–
<i>Ulmus pumila</i>	Siberian elm
<i>Verbascum thapsus</i>	common mullein

^a Searched for in 2013 and 2017 only.

^b Searched for in 2009, 2013, and 2017 only.

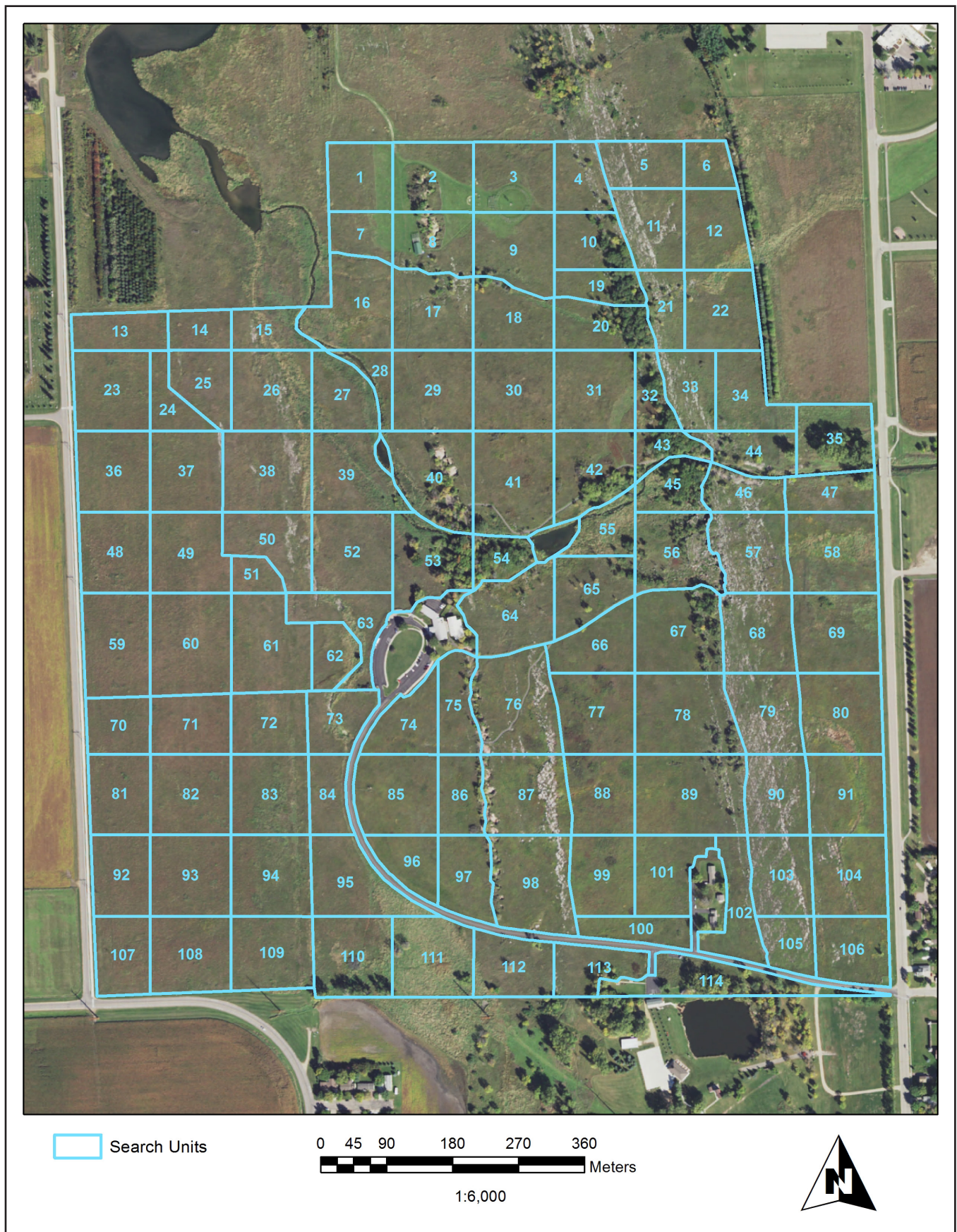


Figure 1. Location of search units used to monitor problematic plants in Pipestone NM. Search unit size averaged 2.3 acres.

Analytical Methods

A park-wide cover range was estimated for each problematic plant species encountered during each year. First, we calculated the minimum and maximum fraction of the park observed. To do this we used an average search unit size of 2.3 acres (9,595 m²). When calculated as a square, a unit of this size has length and width of 97.9 m. The fraction of the park observed assuming a 3-m belt (3 transects × 97.9-m length × 3-m width) was calculated as 9.2%. The fraction of the park observed assuming a 12-m belt (3 transects × 97.9-m length × 12-m width) was calculated as 36.8%.

To calculate the minimum of the estimated cover range for each species, the lower endpoints associated with the assigned cover class values for that species were summed and then divided by the reference frame fraction observed assuming the widest possible (12-m) survey belt (i.e., maximum fraction observed; Equation 1).

Equation 1:

$$\text{Minimum cover estimate} = \frac{\sum \text{low end of cover value range for species}}{\text{fraction of park observed assuming 12-m (max) belt width}}$$

Maximum cover for each species was calculated similarly, summing the upper endpoints of the cover values in each occupied search unit and assuming that a 3-m belt was surveyed (i.e., minimum fraction of area observed; Equation 2).

Equation 2:

$$\text{Maximum cover estimate} = \frac{\sum \text{high end of cover value range for species}}{\text{fraction of park observed assuming 3-m (min) belt width}}$$

Cover values were then converted from square meters to acres by multiplying each value by 0.000247105.

The park-wide frequency of problematic plants was calculated as the percentage of occupied search units (Equation 3). We treated all search units as equivalent for the purposes of frequency calculations.

Equation 3:

$$\text{Frequency of a problematic plant species} = \frac{\sum \text{search units occupied by species}}{\sum \text{search units surveyed}} \times 100$$

Taken together, the minimum and maximum cover estimates provided an estimated range of cover that accounts for the uncertainty arising from the sampling method. Non-overlapping ranges represent the strongest evidence for differences in abundance.

Finally, we created maps for each problematic plant species (not included in this report). The maps show occupied search units and the estimated cover value for each search unit during each survey period.

I-Ranks

The I-rank or invasive ranks are calculated using a standard protocol to assess the impacts of these plants (Morse et al. 2004). The I-ranks consist of four sub-ranks: ecological impact, current abundance/distribution, trend in distribution/abundance, and management difficulty. Because of their more direct implications for park management, the ecological impact and management difficulty sub-ranks, when available, are presented in Table 3 of the Results section (NatureServe 2018).

Taxonomic Notes

Certain species groups have likely resulted in conflated identifications over the course of the study. Autumn olive (*Elaeagnus umbellata*) was identified to the species level in 2009 and 2017 but only to the genus level in 2006. Similarly, bush honeysuckle species (*Lonicera* spp.) were identified only to the genus level in 2006, 2009, and 2013 but also to species occasionally in 2006 and consistently in 2017. Bluegrass (*Poa* spp.) was identified to species during 2017 and occasionally in 2009 but only to genus in other years. Finally, two cattail taxa, *Typha* spp. and *Typha x glauca*, may have been conflated during different years. Patterns in the abundance and distribution of all of the above groups may be best understood at the genus level.

Results and Discussion

Table 3 presents the plant abundance and frequency estimates in all survey years, and the 2017 data are depicted graphically using frequency and the mid-point of the abundance range (Figure 2). In Figure 2, we grouped plants in four categories: (1) very low frequency ($\leq 2\%$, $n = 3$), (2) low frequency ($> 2\text{--}10\%$, $n = 7$), (3) medium frequency ($> 10\text{--}40\%$, $n = 4$), and (4) high frequency ($> 40\%$, $n = 10$). While many factors impact our ability to control problematic plants, we use 10 acres as a guideline to identify lower and higher probability of successful control. For very low through medium frequency species, abundance was always below this threshold. For high frequency species, only one of four species (25.0%) fell below this threshold.

Pipestone NM supports a relatively large number of problematic plants. Invasive grasses—Kentucky bluegrass (*Poa pratensis*), reed canarygrass (*Phalaris arundinacea*), and smooth brome (*Bromus inermis*)—are the most abundant problematic plant species

in the prairies. All of these are difficult to control with available tools, especially given their current extent. The majority of the other problematic plant species remain at levels where control, and possibly even local eradication, seems possible. Managers must strategically prioritize projects because of the number of problematic plants. Maps with plant locations and abundance are available for park use. These data are highly effective for early detection of problematic plants in the park. The extensive nature of this sampling design, however, may include high levels of unspecified observer error. Nevertheless, the data provide a generalized understanding of problematic plant abundance and distribution to effectively support problematic plant management decisions.

Table 3. Abundance and distribution of problematic plants found in Pipestone NM. Ecological impact (EI) and general management difficulty (Mgmt) are based on NatureServe I-Rank sub-ranks (Morse et al. 2004; NatureServe 2018). Sub-ranks are given as high (H), medium (M), low (L), insignificant (I), a range of these ranks, unknown (U), native, or not available (n/a).

Scientific Name	Common Name	EI	Mgmt	PeriodID	Frequency	Low Cover Estimate (acres)	High Cover Estimate (acres)
<i>Arctium minus</i>	lesser burdock	L-I	M-I	2013	5.3	0.0022	0.0870
<i>Arctium minus</i>	lesser burdock	L-I	M-I	2017	6.1	0.0011	0.0411
<i>Bromus inermis</i>	smooth brome	M	M-L	2006	95.6	24.2326	401.3364
<i>Bromus inermis</i>	smooth brome	M	M-L	2009	99.1	31.5945	500.9482
<i>Bromus inermis</i>	smooth brome	M	M-L	2013	100.0	20.7401	275.8702
<i>Bromus inermis</i>	smooth brome	M	M-L	2017	98.2	21.6371	315.9151
<i>Bromus racemosus</i> ^b	bald brome	n/a	n/a	2009	25.4	0.1708	2.3907
<i>Bromus racemosus</i> ^b	bald brome	n/a	n/a	2013	23.7	0.1573	2.1227
<i>Bromus racemosus</i> ^b	bald brome	n/a	n/a	2017	2.6	0.0002	0.0073
<i>Bromus tectorum</i>	cheatgrass	H	H-M	2013	0.9	0.0007	0.0266
<i>Bromus tectorum</i>	cheatgrass	H	H-M	2017	0.9	0.0001	0.0024
<i>Carduus nutans</i>	nodding plumeless thistle	M-I	H-M	2006	30.7	0.0102	0.3989
<i>Carduus nutans</i>	nodding plumeless thistle	M-I	H-M	2009	32.5	0.0091	0.3553
<i>Carduus nutans</i>	nodding plumeless thistle	M-I	H-M	2013	20.2	0.0058	0.2248
<i>Carduus nutans</i>	nodding plumeless thistle	M-I	H-M	2017	2.6	0.0002	0.0073
<i>Cirsium arvense</i>	Canada thistle	M-L	H-M	2006	63.2	0.3513	6.1099
<i>Cirsium arvense</i>	Canada thistle	M-L	H-M	2009	62.3	0.5366	8.2858
<i>Cirsium arvense</i>	Canada thistle	M-L	H-M	2013	49.1	0.0727	1.8168
<i>Cirsium arvense</i>	Canada thistle	M-L	H-M	2017	54.4	0.1710	3.5986
<i>Cirsium vulgare</i>	bull thistle	M-L	M-L	2006	21.9	0.0156	0.3478
<i>Cirsium vulgare</i>	bull thistle	M-L	M-L	2009	18.4	0.0038	0.1475
<i>Cirsium vulgare</i>	bull thistle	M-L	M-L	2013	13.2	0.0058	0.2296
<i>Cirsium vulgare</i>	bull thistle	M-L	M-L	2017	23.7	0.0030	0.1136
<i>Daucus carota</i>	Queen Anne's lace	I	I	2013	0.9	0.0001	0.0024
<i>Daucus carota</i>	Queen Anne's lace	I	I	2017	2.6	0.0002	0.0073

^a Searched for in 2013 and 2017 only.

^b Searched for in 2009, 2013, and 2017 only.

Table 3 (continued). Abundance and distribution of problematic plants found in Pipestone NM. Ecological impact (EI) and general management difficulty (Mgmt) are based on NatureServe I-Rank sub-ranks (Morse et al. 2004; NatureServe 2018). Sub-ranks are given as high (H), medium (M), low (L), insignificant (I), a range of these ranks, unknown (U), native, or not available (n/a).

Scientific Name	Common Name	EI	Mgmt	PeriodID	Frequency	Low Cover Estimate (acres)	High Cover Estimate (acres)
<i>Elaeagnus</i> spp.	oleaster	I	I	2006	3.5	0.0269	0.5361
<i>Elaeagnus umbellata</i>	autumn olive	H	L	2009	1.8	0.0134	0.2681
<i>Elaeagnus umbellata</i>	autumn olive	H	L	2017	0.9	0.0001	0.0024
<i>Elymus repens</i>	quackgrass	M-L	H-M	2006	28.9	0.0058	0.2248
<i>Elymus repens</i>	quackgrass	M-L	H-M	2009	0.9	0.0067	0.1340
<i>Elymus repens</i>	quackgrass	M-L	H-M	2013	54.4	0.1090	2.1939
<i>Elymus repens</i>	quackgrass	M-L	H-M	2017	26.3	0.0062	0.2417
<i>Euphorbia esula</i>	leafy spurge	M	H	2009	3.5	0.0075	0.1655
<i>Euphorbia esula</i>	leafy spurge	M	H	2013	1.8	0.0007	0.0290
<i>Glechoma hederacea</i>	ground ivy	M-I	U	2017	1.8	0.0001	0.0048
<i>Hesperis matronalis</i>	dames rocket	M-I	H-L	2006	9.6	0.0007	0.0266
<i>Hesperis matronalis</i>	dames rocket	M-I	H-L	2009	14.0	0.0017	0.0629
<i>Hesperis matronalis</i>	dames rocket	M-I	H-L	2013	0.9	0.0001	0.0024
<i>Hesperis matronalis</i>	dames rocket	M-I	H-L	2017	0.9	0.0001	0.0024
<i>Leonurus cardiaca</i>	common motherwort	n/a	n/a	2013	6.1	0.0083	0.1969
<i>Leonurus cardiaca</i>	common motherwort	n/a	n/a	2017	10.5	0.0008	0.0290
<i>Linaria vulgaris</i>	butter and eggs	M-L	H-M	2006	3.5	0.0004	0.0121
<i>Linaria vulgaris</i>	butter and eggs	M-L	H-M	2009	3.5	0.0009	0.0338
<i>Linaria vulgaris</i>	butter and eggs	M-L	H-M	2013	9.6	0.0092	0.2307
<i>Linaria vulgaris</i>	butter and eggs	M-L	H-M	2017	30.7	0.0338	0.8044
<i>Lonicera</i> spp.	honeysuckle	n/a	n/a	2006	21.1	0.2668	3.8156
<i>Lonicera</i> spp.	honeysuckle	n/a	n/a	2009	18.4	0.4251	5.7181
<i>Lonicera</i> spp.	honeysuckle	n/a	n/a	2013	15.8	0.0812	1.3650
<i>Lonicera tatarica</i>	Tatarian honeysuckle	M	M	2006	0.9	0.0007	0.0266
<i>Lonicera tatarica</i>	Tatarian honeysuckle	M	M	2017	24.6	0.0430	1.0400

^a Searched for in 2013 and 2017 only.

^b Searched for in 2009, 2013, and 2017 only.

Table 3 (continued). Abundance and distribution of problematic plants found in Pipestone NM. Ecological impact (EI) and general management difficulty (Mgmt) are based on NatureServe I-Rank sub-ranks (Morse et al. 2004; NatureServe 2018). Sub-ranks are given as high (H), medium (M), low (L), insignificant (I), a range of these ranks, unknown (U), native, or not available (n/a).

Scientific Name	Common Name	EI	Mgmt	PeriodID	Frequency	Low Cover Estimate (acres)	High Cover Estimate (acres)
<i>Melilotus officinalis</i>	sweetclover	M	M	2006	70.2	1.7148	27.7429
<i>Melilotus officinalis</i>	sweetclover	M	M	2009	43.9	3.2991	43.9847
<i>Melilotus officinalis</i>	sweetclover	M	M	2013	51.8	0.0614	1.4990
<i>Melilotus officinalis</i>	sweetclover	M	M	2017	18.4	0.0014	0.0508
<i>Morus alba</i>	white mulberry	M-L	M-L	2017	0.9	0.0001	0.0024
<i>Phalaris arundinacea</i>	reed canarygrass	H	H-M	2006	50.9	4.2003	58.0084
<i>Phalaris arundinacea</i>	reed canarygrass	H	H-M	2009	47.4	6.4893	107.2640
<i>Phalaris arundinacea</i>	reed canarygrass	H	H-M	2013	49.1	4.6225	80.1356
<i>Phalaris arundinacea</i>	reed canarygrass	H	H-M	2017	58.8	4.1138	80.8686
<i>Phleum pratense</i>	timothy	M-L	M	2006	0.9	0.0007	0.0266
<i>Phleum pratense</i>	timothy	M-L	M	2013	4.4	0.0088	0.2162
<i>Phleum pratense</i>	timothy	M-L	M	2017	5.3	0.0004	0.0145
<i>Poa</i> spp.	bluegrass	n/a	n/a	2006	99.1	28.8841	530.1845
<i>Poa</i> spp.	bluegrass	n/a	n/a	2009	97.4	21.8661	360.3943
<i>Poa</i> spp.	bluegrass	n/a	n/a	2013	97.4	1.9419	28.2261
<i>Poa pratensis</i>	Kentucky bluegrass	M	M-L	2009	0.9	0.0067	0.1340
<i>Poa pratensis</i>	Kentucky bluegrass	M	M-L	2017	98.2	4.3559	60.5912
<i>Rhamnus cathartica</i>	common buckthorn	M	M	2006	59.6	3.5390	42.4328
<i>Rhamnus cathartica</i>	common buckthorn	M	M	2009	27.2	0.4489	7.8749
<i>Rhamnus cathartica</i>	common buckthorn	M	M	2013	29.8	0.1059	1.9435
<i>Rhamnus cathartica</i>	common buckthorn	M	M	2017	32.5	0.0647	1.5049
<i>Rumex crispus</i> ^a	curly dock	L-I	M-L	2013	28.1	0.0076	0.2949
<i>Rumex crispus</i> ^a	curly dock	L-I	M-L	2017	31.6	0.0024	0.0870
<i>Securigera varia</i>	crownvetch	H	L	2006	18.4	0.7818	10.8535
<i>Securigera varia</i>	crownvetch	H	L	2009	19.3	1.2907	17.3774
<i>Securigera varia</i>	crownvetch	H	L	2013	19.3	0.1821	2.9808
<i>Securigera varia</i>	crownvetch	H	L	2017	22.8	0.1739	2.7864

^a Searched for in 2013 and 2017 only.

^b Searched for in 2009, 2013, and 2017 only.

Table 3 (continued). Abundance and distribution of problematic plants found in Pipestone NM. Ecological impact (EI) and general management difficulty (Mgmt) are based on NatureServe I-Rank sub-ranks (Morse et al. 2004; NatureServe 2018). Sub-ranks are given as high (H), medium (M), low (L), insignificant (I), a range of these ranks, unknown (U), native, or not available (n/a).

Scientific Name	Common Name	EI	Mgmt	PeriodID	Frequency	Low Cover Estimate (acres)	High Cover Estimate (acres)
<i>Sonchus arvensis</i>	field sowthistle	L-I	H-L	2006	0.9	0.0001	0.0024
<i>Sonchus arvensis</i>	field sowthistle	L-I	H-L	2009	4.4	0.0082	0.1920
<i>Sonchus arvensis</i>	field sowthistle	L-I	H-L	2013	0.9	0.0001	0.0024
<i>Sonchus arvensis</i>	field sowthistle	L-I	H-L	2017	7.9	0.0012	0.0459
<i>Typha</i> spp.	cattail	n/a	n/a	2006	2.6	0.0470	0.5364
<i>Typha</i> spp.	cattail	n/a	n/a	2013	1.8	0.0739	1.4767
<i>Typha</i> × <i>glauca</i> ^a	Hybrid cattail	n/a	n/a	2017	1.8	0.0403	0.4024
<i>Ulmus pumila</i>	Siberian elm	M-L	M-L	2006	4.4	0.0070	0.1437
<i>Ulmus pumila</i>	Siberian elm	M-L	M-L	2009	0.9	0.0336	0.2683
<i>Ulmus pumila</i>	Siberian elm	M-L	M-L	2013	8.8	0.0079	0.1800
<i>Ulmus pumila</i>	Siberian elm	M-L	M-L	2017	4.4	0.0015	0.0604
<i>Verbascum thapsus</i>	common mullein	M-L	L	2006	19.3	0.0160	0.3647
<i>Verbascum thapsus</i>	common mullein	M-L	L	2009	13.2	0.0034	0.1330
<i>Verbascum thapsus</i>	common mullein	M-L	L	2013	5.3	0.0016	0.0629
<i>Verbascum thapsus</i>	common mullein	M-L	L	2017	16.7	0.0019	0.0701

^a Searched for in 2013 and 2017 only.

^b Searched for in 2009, 2013, and 2017 only.

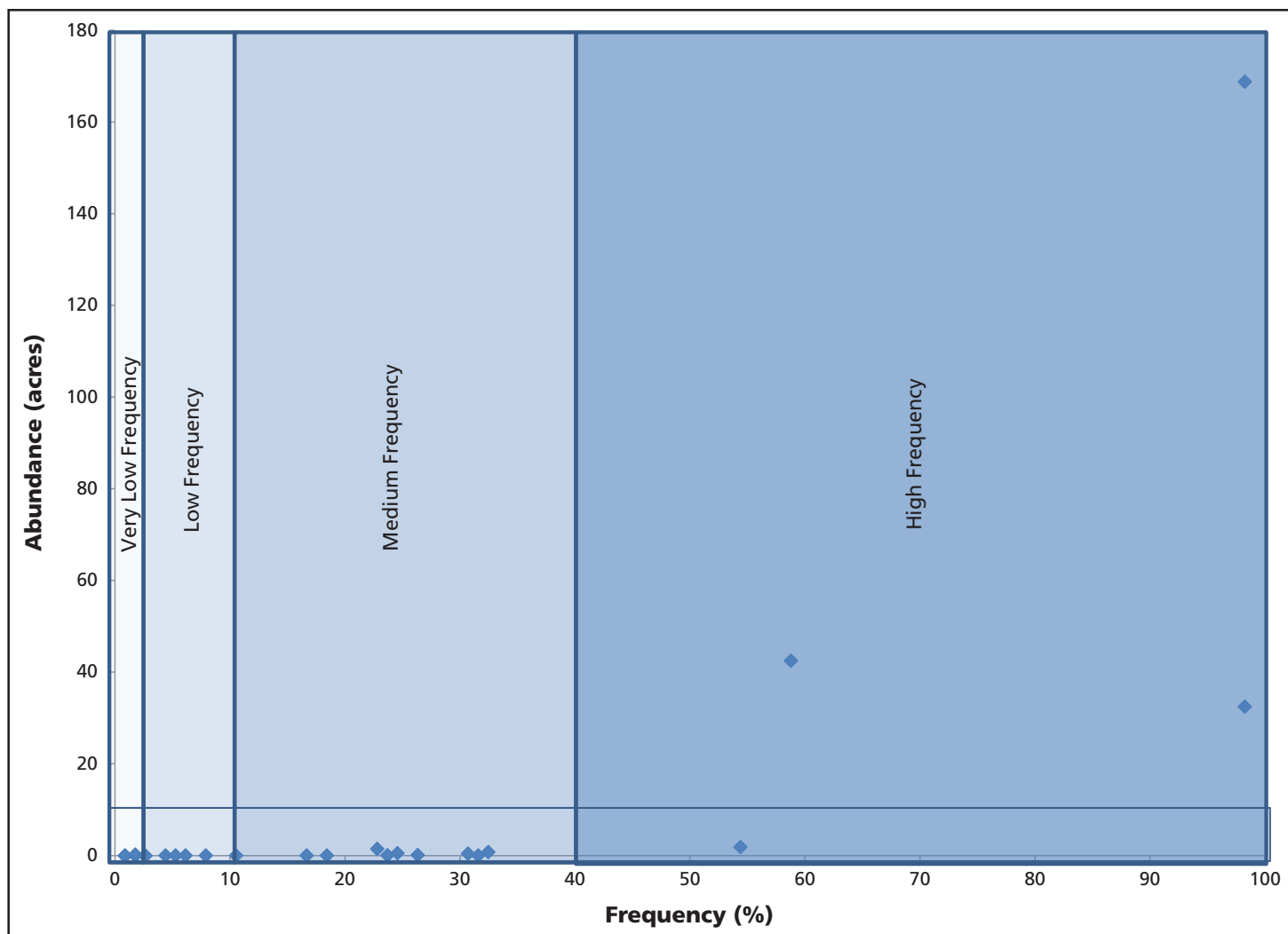


Figure 2. 2017 problematic plant abundance and frequency relationship at Pipestone NM. The abundance measure used is based on the mid-point of the abundance range. Plants are categorized into four categories: very low frequency ($\leq 2\%$), low frequency ($>2\text{--}10\%$), medium frequency ($>10\text{--}40\%$) and high frequency ($>40\%$). The horizontal line marks the 10-acre threshold at which successful control of a plant becomes less likely. Species in ascending order of frequency include *Bromus tectorum*, *Elaeagnus umbellata*, *Hesperis matronalis*, *Morus alba*, *Euphorbia esula*, *Typha* spp, *Bromus racemosus*, *Carduus nutans*, *Daucus carota*, *Ulmus pumila*, *Phleum pretense*, *Arctium minus*, *Sonchus arvensis*, *Leonurus cardiac*, *Verbascum Thapsus*, *Melilotus officinalis*, *Securigera varia*, *Cirsium vulgare*, *Lonicera tatarica*, *Elymus repens*, *Linaria vulgaris*, *Rumex crispus*, *Rhamnus cathartica*, *Cirsium arvense*, *Phalaris arundinacea*, *Poa pratensis*, and *Bromus inermis*.

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