



Problematic Plant Monitoring in Wilson's Creek National Battlefield

2006–2016

Natural Resource Report NPS/HTLN/NRR—2020/2087





ON THIS PAGE

Johnsongrass (*Sorghum halepense*) treatment with tractor and pull-behind wick at Wilson's Creek National Battlefield.
Photography by NPS

ON THE COVER

Treatment of invasive plants in restored prairie, Wilson's Creek National Battlefield.
Photography by NPS

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Natural Resource Report NPS/HTLN/NRR—2020/2087

Craig C. Young

National Park Service
Heartland Inventory and Monitoring Network
Republic, Missouri

Editing and Design by
Tani Hubbard

National Park Service &
Northern Rockies Conservation Cooperative
12661 E. Broadway Blvd.
Tucson, AZ 85748

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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, 2013, and 2016, Heartland Inventory and Monitoring Network staff and contractors identified a cumulative total of 54 potentially problematic plant taxa in Wilson's Creek National Battlefield. Of the 47 species found in 2016, we characterized 12 as very low frequency, 16 as low frequency, 10 as medium frequency, and 9 as high frequency. Most species in the very low, low, and medium frequency categories did not exceed 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 Wilson's Creek National Battlefield 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 Wilson's Creek National Battlefield (NB) in 2006, 2013 and 2016. The key metrics presented include plant abundance and geographic distribution within the park.



Spraying Johnsongrass (*Sorghum halepense*) with the pull-behind wick at Wilson's Creek NB.

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 = 70; Table 1) is 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 = 37; Table 2). A third list, the park-based watch list, consisted of two native and two non-native species that can invade prairie (n = 4; Table 3). Because our prioritization, NPSpecies, and botanical nomenclature are subject to periodic updating, in this report we included species searched for in 2016. 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 Wilson's Creek NB (Figure 1). During August 22–27, 2006, Dan Tena-glia, a contract botanist for this project, navigated along transects using a Thales GPS unit. During June 17–23, 2013, staff with ESS and subcontractor George Yatskievych from the Missouri Botanical Garden navigated using a Trimble GeoXT GPS unit to conduct the survey. Jordan Bell, Sherry Leis, and Craig Young with the NPS Heartland Inventory and Monitoring Network conducted the survey using Trimble GPS units during July 20–27, 2016.

Observers estimated plant cover in a 3- to 12-m belt along transects, using the widest belt in which the observers were able to view plants. In 2006 only, the observer had the discretion to leave the search belt to find additional observations and target locations likely to support exotic plants (e.g., field edges and roads). Cover was estimated for each plant species along each transect 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. In each year, 171 transects were surveyed (Figure 1). While the intended length of

transects was 200 m, in some cases transects were clipped (n = 71) at search area or park boundary edges. Average transect length was 159.9 m.

Table 1. Early detection problematic plant watch list used to guide surveys in Wilson's Creek NB.

Scientific Name	Common Name
<i>Acer ginnala</i>	Amur maple
<i>Ailanthus altissima</i>	tree of heaven
<i>Albizia julibrissin</i>	silk tree
<i>Alliaria petiolata</i>	garlic mustard
<i>Alnus glutinosa</i>	European alder
<i>Arundo donax</i>	giant reed
<i>Berberis thunbergii</i>	Japanese barberry
<i>Bothriochloa bladhii</i>	Caucasian bluestem
<i>Celastrus orbiculatus</i>	Oriental bittersweet
<i>Centaurea solstitialis</i>	yellow star-thistle
<i>Centaurea stoebe</i> ssp. <i>micranthos</i>	spotted knapweed
<i>Cirsium</i> spp.*	thistle
<i>Cirsium arvense</i>	Canada thistle
<i>Cirsium vulgare</i>	bull thistle
<i>Cornus foemina</i>	stiff dogwood
<i>Cynanchum louiseae</i> *	Louise's swallow-wort
<i>Cynanchum rossicum</i> *	European swallow-wort
<i>Dioscorea oppositifolia</i>	Chinese yam
<i>Dipsacus laciniatus</i>	cutleaf teasel
<i>Egeria densa</i> *	Brazilian waterweed
<i>Eichhornia crassipes</i> *	common water hyacinth
<i>Elaeagnus angustifolia</i>	Russian olive
<i>Elaeagnus umbellata</i>	autumn olive
<i>Elymus repens</i> *	quackgrass
<i>Euonymus alatus</i>	burning bush
<i>Euonymus fortunei</i>	winter creeper
<i>Euphorbia cyparissias</i> *	cypress spurge
<i>Euphorbia esula</i>	leafy spurge
<i>Glechoma hederacea</i>	ground ivy
<i>Iris pseudacorus</i> *	pale yellow iris
<i>Lepidium latifolium</i> *	broadleaved pepperweed
<i>Lespedeza bicolor</i>	shrub lespedeza

* Searched for in 2013 and 2016 only.

Table 1 (continued). Early detection problematic plant watch list used to guide surveys in Wilson's Creek NB.

Scientific Name	Common Name
<i>Ligustrum obtusifolium</i> *	border privet
<i>Ligustrum sinense</i>	Chinese privet
<i>Linaria vulgaris</i>	butter and eggs
<i>Lonicera</i> spp.	honeysuckle
<i>Lonicera maackii</i>	Amur honeysuckle
<i>Lonicera morrowii</i>	Morrow's honeysuckle
<i>Lotus corniculatus</i>	bird's-foot trefoil
<i>Lysimachia nummularia</i>	creeping jenny
<i>Lythrum salicaria</i>	purple loosestrife
<i>Microstegium vimineum</i>	Nepalese browntop
<i>Miscanthus sinensis</i>	Chinese silvergrass
<i>Myosotis scorpioides</i> *	true forget-me-not
<i>Myriophyllum aquaticum</i> *	parrot feather watermilfoil
<i>Myriophyllum spicatum</i> *	Eurasian watermilfoil
<i>Najas minor</i> *	brittle waternymph
<i>Rorippa officinale</i> *	watercress
<i>Onopordum acanthium</i> *	Scotch cottonthistle
<i>Pastinaca sativa</i>	wild parsnip
<i>Paulownia tomentosa</i>	princesstree
<i>Phragmites australis</i>	common reed
<i>Polygonum cuspidatum</i>	Japanese knotweed
<i>Populus tremuloides</i>	quaking aspen
<i>Potamogeton crispus</i> *	curly pondweed
<i>Potentilla alba</i>	white cinquefoil
<i>Prunus mahaleb</i> *	Mahaleb cherry
<i>Pueraria montana</i> *	kudzu
<i>Rhamnus cathartica</i>	common buckthorn
<i>Securigera varia</i>	crownvetch
<i>Sesbania herbacea</i>	bigpod sesbania
<i>Sonchus arvensis</i> *	field sowthistle
<i>Spiraea japonica</i>	Japanese meadowsweet
<i>Tanacetum vulgare</i> *	common tansy
<i>Typha</i> spp.*	cattail
<i>Typha angustifolia</i>	narrowleaf cattail
<i>Typha × glauca</i> *	hybrid cattail
<i>Viburnum opulus</i> *	European cranberrybush
<i>Vinca minor</i>	common periwinkle
<i>Wisteria sinensis</i>	Chinese wisteria

* Searched for in 2013 and 2016 only.

Table 2. Park-established problematic plant watch list used to guide surveys in Wilson's Creek NB.

Scientific Name	Common Name
<i>Arctium minus</i>	lesser burdock
<i>Bromus inermis</i>	smooth brome
<i>Bromus racemosus</i>	–
<i>Bromus sterilis</i>	poverty brome
<i>Bromus tectorum</i>	cheatgrass
<i>Carduus nutans</i>	nodding plumeless thistle
<i>Daucus carota</i> *	Queen Anne's lace
<i>Dipsacus fullonum</i>	Fuller's teasel
<i>Hedera helix</i>	English ivy
<i>Hermodactylus fulva</i> *	orange daylily
<i>Hesperis matronalis</i>	dames rocket
<i>Holcus lanatus</i>	common velvetgrass
<i>Humulus japonicus</i>	Japanese hop
<i>Hypericum perforatum</i> *	common St. Johnswort
<i>Leonurus cardiaca</i> *	common motherwort
<i>Lespedeza cuneata</i>	sericea lespedeza
<i>Lonicera japonica</i>	Japanese honeysuckle
<i>Maclura pomifera</i>	osage orange
<i>Melilotus officinalis</i>	yellow sweetclover
<i>Morus alba</i>	white mulberry
<i>Phalaris arundinacea</i>	reed canarygrass
<i>Poa compressa</i>	Canada bluegrass
<i>Poa pratensis</i>	Kentucky bluegrass
<i>Potentilla recta</i>	sulphur cinquefoil
<i>Rhus glabra</i>	smooth sumac
<i>Robinia pseudoacacia</i>	black locust
<i>Rosa multiflora</i>	multiflora rose
<i>Rumex acetosella</i> *	common sheep sorrel
<i>Rumex crispus</i> *	curly dock
<i>Saponaria officinalis</i> *	bouncingbet
<i>Schedonorus arundinaceus</i>	tall fescue
<i>Schedonorus pratensis</i>	meadow fescue
<i>Sorghum halepense</i>	Johnsongrass
<i>Torilis arvensis</i>	spreading hedgeparsley
<i>Torilis japonica</i>	erect hedgeparsley
<i>Ulmus pumila</i>	Siberian elm
<i>Verbascum thapsus</i>	common mullein

* Searched for in 2013 and 2016 only.

Table 3. Park-based problematic plant watch list used to guide surveys in Wilson's Creek NB.

Scientific Name	Common Name
<i>Juniperus virginiana</i> *	eastern redcedar
<i>Ligustrum vulgare</i>	European privet
<i>Lolium perenne</i>	Perennial ryegrass
<i>Rhus copallinum</i> *	winged sumac

* Searched for in 2013 and 2016 only.

Analytical Methods

We note an important assumption here with respect to the analytical methods: we treated all data similarly, which required the assumption that observations during 2006 were also made within a 3- to 12-m wide belt. This change should be considered when comparing metrics between 2006 and subsequent years.

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 the distance between transects (200 m). The maximum fraction of the park observed assuming a 12-m belt was calculated as $12 \text{ m}/200 \text{ m} = 0.06$, while the minimum fraction observed assuming a 3-m belt was $3 \text{ m}/200 \text{ m} = 0.015$.

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 4 of the Results section (NatureServe 2018).

Taxonomic Notes

Certain species groups have likely resulted in conflated identifications during the study. The *Ligustrum*, *Poa*, and *Torilis* species identifications may be best evaluated at the genus level. The *Lolium* sp. identifications need further elucidation in the future to see if they are actually *Schedonorus phoenix*.

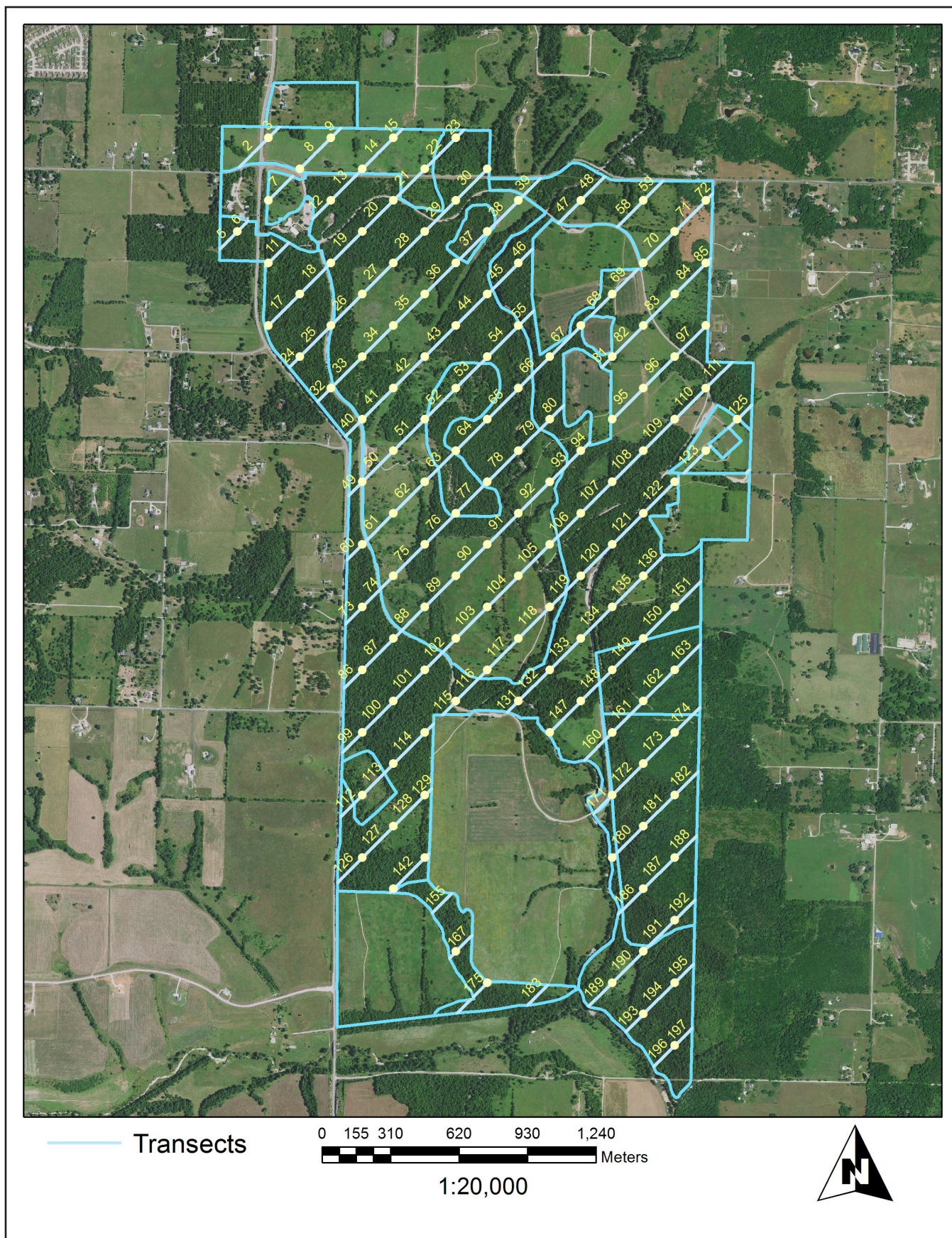


Figure 1. Location of transects used to monitor problematic plants in Wilson's Creek NB.

Results and Discussion

Table 4 presents the plant abundance and frequency estimates in all survey years, and the 2016 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 generally below this threshold with only 4 of 38 (10.5%) species occurring above the 10-acre guideline. For high frequency species, only one of nine species (11.1%) fell below this threshold.

Wilson’s Creek NB supports a relatively large number of potentially problematic plants, ranging from potential candidates for eradication, such as garlic mustard (*Alliaria petiolata*), to high abundance species, such as sericea (*Lespedeza cuneata*). Managers must strategically prioritize projects because of the number, abundance, and extent of these 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 4. Abundance and distribution of problematic plants found in Wilson's Creek NB. 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	Year	Frequency	Low Cover Estimate (acres)	High Cover Estimate (acres)
<i>Ailanthus altissima</i>	tree of heaven	M-L	M-L	2006	2.3	0.0498	1.1630
<i>Ailanthus altissima</i>	tree of heaven	M-L	M-L	2013	0.6	0.0412	0.8220
<i>Ailanthus altissima</i>	tree of heaven	M-L	M-L	2016	5.3	0.0556	1.3854
<i>Alliaria petiolata</i>	garlic mustard	M-L	M	2013	0.6	0.0041	0.1631
<i>Alliaria petiolata</i>	garlic mustard	M-L	M	2016	1.8	0.0012	0.0445
<i>Arctium minus</i>	lesser burdock	L-I	M-I	2006	0.6	0.0004	0.0148
<i>Arctium minus</i>	lesser burdock	L-I	M-I	2013	0.6	0.0004	0.0148
<i>Arctium minus</i>	lesser burdock	L-I	M-I	2016	0.6	0.0004	0.0148
<i>Bromus inermis</i>	smooth brome	M	M-L	2006	4.7	8.8632	170.0115
<i>Bromus inermis</i>	smooth brome	M	M-L	2013	16.4	15.7006	282.8562
<i>Bromus inermis</i>	smooth brome	M	M-L	2016	7.0	0.9271	9.0572
<i>Bromus racemosus</i>	bald brome	n/a	n/a	2006	39.2	38.2741	747.5305
<i>Bromus racemosus</i>	bald brome	n/a	n/a	2013	76.0	49.0302	646.3937
<i>Bromus racemosus</i>	bald brome	n/a	n/a	2016	60.2	12.4306	172.5238
<i>Bromus sterilis</i>	poverty brome	M-L	U	2006	12.9	0.1425	4.0163
<i>Bromus sterilis</i>	poverty brome	M-L	U	2013	45.6	23.1126	392.2742
<i>Bromus sterilis</i>	poverty brome	M-L	U	2016	32.2	2.0547	30.2045
<i>Bromus tectorum</i>	cheatgrass	H	H-M	2006	1.2	0.0045	0.1779
<i>Bromus tectorum</i>	cheatgrass	H	H-M	2013	7.6	0.8113	14.3107
<i>Bromus tectorum</i>	cheatgrass	H	H-M	2016	3.5	0.4547	9.1165
<i>Carduus nutans</i>	nodding plumeless thistle	M-I	H-M	2006	2.3	0.2072	1.6902
<i>Carduus nutans</i>	nodding plumeless thistle	M-I	H-M	2013	32.2	0.6935	16.1195
<i>Carduus nutans</i>	nodding plumeless thistle	M-I	H-M	2016	11.1	0.0301	1.1713
<i>Celastrus orbiculatus</i>	Oriental bittersweet	M-L	M	2006	2.3	0.0165	0.6524
<i>Celastrus orbiculatus</i>	Oriental bittersweet	M-L	M	2013	5.8	0.3875	5.6010
<i>Celastrus orbiculatus</i>	Oriental bittersweet	M-L	M	2016	8.8	0.3451	4.7197

* Searched for in 2013 and 2016 only.

Table 4 (continued). Abundance and distribution of problematic plants found in Wilson's Creek NB. 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	Year	Frequency	Low Cover Estimate (acres)	High Cover Estimate (acres)
<i>Cirsium vulgare</i>	bull thistle	M-L	M-L	2006	1.8	0.0124	0.4893
<i>Cirsium vulgare</i>	bull thistle	M-L	M-L	2016	0.6	0.0041	0.1631
<i>Dactylis glomerata</i>	orchardgrass	L-I	M-L	2006	15.2	0.0737	2.9060
<i>Dactylis glomerata</i>	orchardgrass	L-I	M-L	2016	25.7	0.2183	6.1875
<i>Daucus carota</i> *	Queen Anne's lace	I	I	2013	21.1	2.8240	30.5323
<i>Daucus carota</i> *	Queen Anne's lace	I	I	2016	41.5	0.8224	18.7783
<i>Dioscorea oppositifolia</i>	Chinese yam	M-L	M-I	2006	0.6	0.0004	0.0148
<i>Dipsacus fullonum</i>	Fuller's teasel	L	M-L	2006	1.2	0.0045	0.1779
<i>Dipsacus fullonum</i>	Fuller's teasel	L	M-L	2016	1.8	0.0049	0.1927
<i>Dipsacus laciniatus</i>	cutleaf teasel	L	M-L	2013	1.8	0.0049	0.1927
<i>Elaeagnus umbellata</i>	autumn olive	H	L	2006	4.1	0.1030	2.4595
<i>Elaeagnus umbellata</i>	autumn olive	H	L	2013	4.1	0.0993	2.3113
<i>Elaeagnus umbellata</i>	autumn olive	H	L	2016	8.2	0.0688	1.9044
<i>Euonymus alatus</i>	burningbush	L-I	L	2006	4.1	0.0177	0.6968
<i>Euonymus alatus</i>	burningbush	L-I	L	2016	9.4	0.0325	1.2751
<i>Euonymus fortunei</i>	winter creeper	M	L-I	2006	7.6	0.0165	0.6375
<i>Euonymus fortunei</i>	winter creeper	M	L-I	2013	8.2	0.0836	2.4974
<i>Euonymus fortunei</i>	winter creeper	M	L-I	2016	32.7	0.0601	2.3129
<i>Hesperis matronalis</i>	dames rocket	M-I	H-L	2013	0.6	0.0041	0.1631
<i>Hesperis matronalis</i>	dames rocket	M-I	H-L	2016	0.6	0.0004	0.0148
<i>Humulus japonicus</i>	Japanese hop	M-L	M-L	2006	1.8	0.0086	0.3410
<i>Humulus japonicus</i>	Japanese hop	M-L	M-L	2013	1.8	0.0494	1.1482
<i>Humulus japonicus</i>	Japanese hop	M-L	M-L	2016	4.1	0.0214	0.8451
<i>Hypericum perforatum</i>	common St. Johnswort	M-L	M	2013	0.6	0.0004	0.0148
<i>Hypericum perforatum</i>	common St. Johnswort	M-L	M	2016	5.3	0.0074	0.2817

* Searched for in 2013 and 2016 only.

Table 4 (continued). Abundance and distribution of problematic plants found in Wilson's Creek NB. 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	Year	Frequency	Low Cover Estimate (acres)	High Cover Estimate (acres)
<i>Juniperus virginiana</i>	eastern redcedar	native	native	2013	55.6	34.4905	543.4251
<i>Juniperus virginiana</i>	eastern redcedar	native	native	2016	72.5	38.4817	537.4633
<i>Lespedeza cuneata</i>	sericea lespedeza	M-L	M-L	2006	51.5	95.1589	1670.4001
<i>Lespedeza cuneata</i>	sericea lespedeza	M-L	M-L	2013	45.0	10.4212	165.4994
<i>Lespedeza cuneata</i>	sericea lespedeza	M-L	M-L	2016	58.5	37.2935	540.2210
<i>Ligustrum spp</i>	privet	NA	NA	2016	9.4	0.1030	2.4447
<i>Ligustrum sinense</i>	Chinese privet	M	L	2013	1.8	0.0494	1.1482
<i>Ligustrum vulgare</i>	European privet	H-L	H-M	2006	1.8	0.0086	0.3410
<i>Ligustrum vulgare</i>	European privet	H-L	H-M	2016	1.2	0.0008	0.0297
<i>Lolium sp.</i>	ryegrass	H-L	H-M	2006	24.0	8.9798	96.3693
<i>Lolium sp.</i>	ryegrass	H-L	H-M	2016	1.8	0.0049	0.1927
<i>Lonicera japonica</i>	Japanese honeysuckle	M	H-M	2006	43.3	10.4797	150.5463
<i>Lonicera japonica</i>	Japanese honeysuckle	M	H-M	2013	60.2	9.0490	134.4531
<i>Lonicera japonica</i>	Japanese honeysuckle	M	H-M	2016	64.3	1.1532	22.0582
<i>Lonicera maackii</i>	Amur honeysuckle	H-M	M	2006	1.2	4.1225	82.5298
<i>Lonicera maackii</i>	Amur honeysuckle	H-M	M	2013	4.7	0.0960	2.1778
<i>Lonicera maackii</i>	Amur honeysuckle	H-M	M	2016	17.0	0.5749	7.2995
<i>Maclura pomifera</i>	osage orange	M-L	L	2006	37.4	33.1450	580.2618
<i>Maclura pomifera</i>	osage orange	M-L	L	2013	39.8	14.9671	209.7954
<i>Maclura pomifera</i>	osage orange	M-L	L	2016	55.6	27.3389	380.0887
<i>Melilotus officinalis</i>	sweetclover	M	M	2006	10.5	0.0445	1.7495
<i>Melilotus officinalis</i>	sweetclover	M	M	2013	4.1	0.0511	1.2075
<i>Melilotus officinalis</i>	sweetclover	M	M	2016	9.4	0.1808	3.9108
<i>Miscanthus sinensis</i>	Chinese silvergrass	M-L	H-L	2006	0.6	0.0004	0.0148
<i>Morus alba</i>	white mulberry	M-L	M-L	2006	5.3	0.0593	1.5337
<i>Morus alba</i>	white mulberry	M-L	M-L	2016	5.8	0.5527	11.3833

* Searched for in 2013 and 2016 only.

Table 4 (continued). Abundance and distribution of problematic plants found in Wilson's Creek NB. 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	Year	Frequency	Low Cover Estimate (acres)	High Cover Estimate (acres)
<i>Morus rubra</i>	red mulberry	M-L	M-L	2016	3.5	0.2100	4.2733
<i>Phalaris arundinacea</i>	reed canarygrass	H	H-M	2013	1.2	0.0045	0.1779
<i>Poa</i> spp.	bluegrass	H	H-M	2006	4.7	0.1404	3.1333
<i>Poa compressa</i>	Canada bluegrass	M-L	H-L	2006	1.2	0.0082	0.3262
<i>Poa compressa</i>	Canada bluegrass	M-L	H-L	2016	2.3	0.0016	0.0593
<i>Poa pratensis</i>	Kentucky bluegrass	M	M-L	2013	25.7	10.5637	172.9010
<i>Poa pratensis</i>	Kentucky bluegrass	M	M-L	2016	22.2	1.9884	28.4039
<i>Potentilla recta</i>	sulphur cinquefoil	H-L	M-L	2006	0.6	0.0004	0.0148
<i>Potentilla recta</i>	sulphur cinquefoil	H-L	M-L	2016	0.6	0.0004	0.0148
<i>Pyrus calleryana</i>	Callery pear	L-I	M-L	2016	1.8	0.0049	0.1927
<i>Rhus copallinum</i> *	winged sumac	native	native	2013	36.3	15.3246	199.3940
<i>Rhus copallinum</i> *	winged sumac	native	native	2016	43.9	10.6659	157.9907
<i>Rhus glabra</i>	smooth sumac	native	native	2006	26.3	1.5930	23.2855
<i>Rhus glabra</i>	smooth sumac	native	native	2013	19.3	5.5277	52.2001
<i>Rhus glabra</i>	smooth sumac	native	native	2016	22.8	5.5084	79.4212
<i>Rorippa officinale</i> *	watercress	M-L	M-I	2016	1.8	0.0012	0.0445
<i>Rosa multiflora</i>	multiflora rose	L	L	2006	55.6	5.3358	65.8370
<i>Rosa multiflora</i>	multiflora rose	L	L	2013	65.5	25.3777	409.5156
<i>Rosa multiflora</i>	multiflora rose	L	L	2016	73.1	3.1823	53.7783
<i>Rumex crispus</i> *	curly dock	L-I	ML	2016	5.3	0.0111	0.4300
<i>Schedonorus phoenix</i>	tall fescue	M	H-M	2013	51.5	43.9863	785.7148
<i>Schedonorus phoenix</i>	tall fescue	M	H-M	2016	46.8	12.5785	149.6468
<i>Securigera varia</i>	crownvetch	H	L	2006	2.3	0.0535	1.3113
<i>Securigera varia</i>	crownvetch	H	L	2013	7.0	4.3453	87.3071
<i>Securigera varia</i>	crownvetch	H	L	2016	6.4	0.1417	3.1778

* Searched for in 2013 and 2016 only.

Table 4 (continued). Abundance and distribution of problematic plants found in Wilson's Creek NB. 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	Year	Frequency	Low Cover Estimate (acres)	High Cover Estimate (acres)
<i>Sonchus arvensis</i> *	field sowthistle	L-I	H-L	2013	2.9	0.00947	0.37066
<i>Sonchus arvensis</i> *	field sowthistle	L-I	H-L	2016	2.9	0.0058	0.2224
<i>Sorghum halepense</i>	Johnsongrass	M-L	H-M	2006	5.8	0.1450	3.3112
<i>Sorghum halepense</i>	Johnsongrass	M-L	H-M	2013	10.5	0.5412	11.7325
<i>Sorghum halepense</i>	Johnsongrass	M-L	H-M	2016	17.0	1.5679	22.3070
<i>Torilis arvensis</i>	spreading hedgeparsley	n/a	native	2013	55.0	6.1686	117.2694
<i>Torilis arvensis</i>	spreading hedgeparsley	n/a	native	2016	30.4	0.0474	1.8088
<i>Torilis japonica</i>	erect hedgeparsley	n/a	native	2006	25.7	0.6033	9.2351
<i>Torilis japonica</i>	erect hedgeparsley	n/a	native	2013	1.2	0.0082	0.3262
<i>Ulmus pumila</i>	Siberian elm	M-L	M-L	2013	2.9	0.0577	1.4744
<i>Ulmus pumila</i>	Siberian elm	M-L	M-L	2016	1.2	0.0045	0.1779
<i>Verbascum thapsus</i>	common mullein	M-L	L	2006	18.1	0.0684	2.6836
<i>Verbascum thapsus</i>	common mullein	M-L	L	2013	24.0	0.2096	5.8465
<i>Verbascum thapsus</i>	common mullein	M-L	L	2016	10.5	0.0148	0.5634
<i>Vinca minor</i>	common periwinkle	I	U	2006	1.2	0.0082	0.3262
<i>Vinca minor</i>	common periwinkle	I	U	2013	0.6	0.2059	1.6457
<i>Vinca minor</i>	common periwinkle	I	U	2016	1.2	0.0082	0.3262

* Searched for in 2013 and 2016 only.

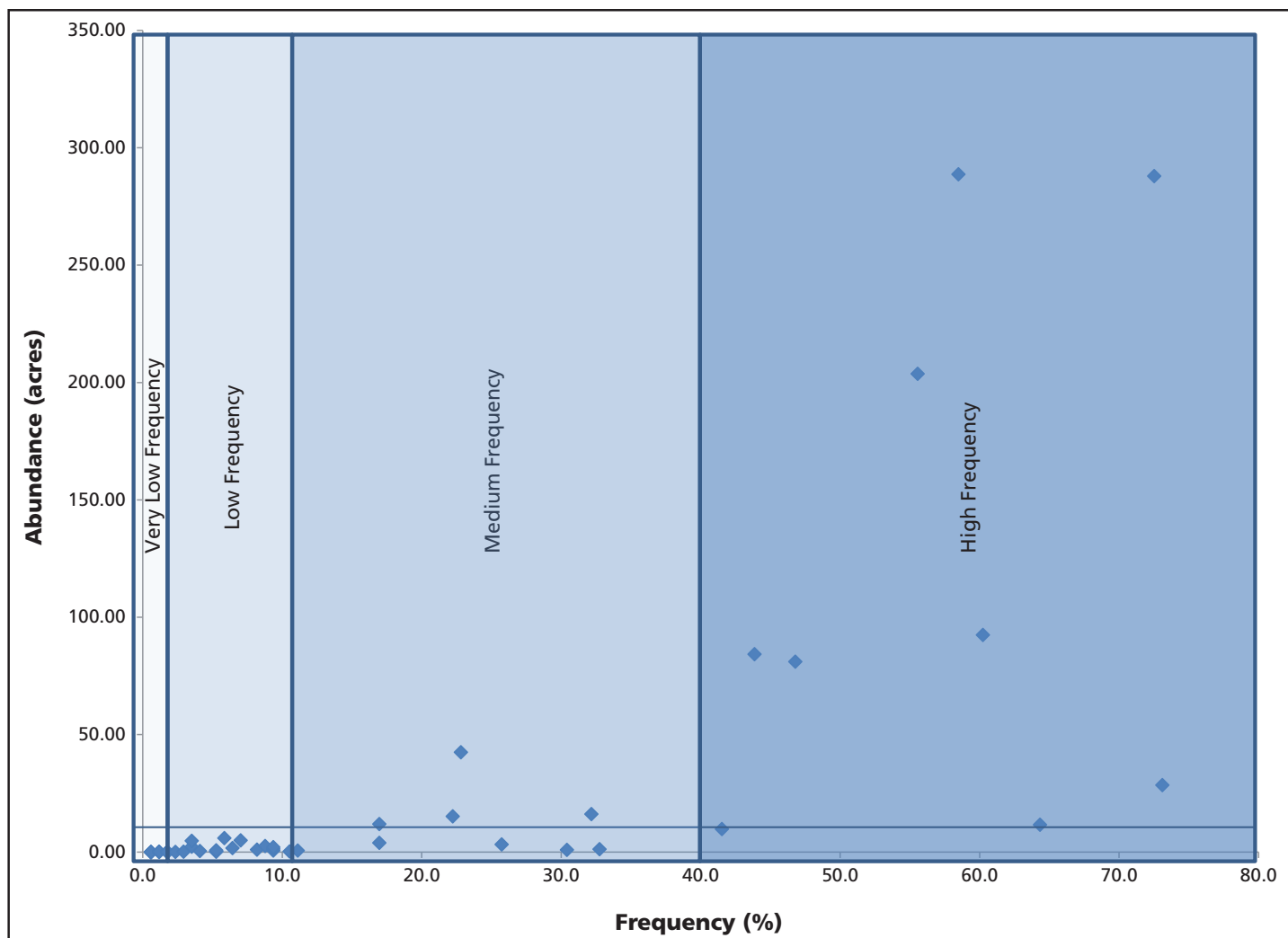


Figure 2. 2016 problematic plant frequency and abundance relationship at Wilson's Creek NB. The abundance measure used is based on the mid-point of the abundance range. Plants are categorized into four categories: very low frequency ($\leq 2\%$), low frequency ($>2\text{--}10\%$), medium frequency ($>10\text{--}40\%$) 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 *Arctium minus*, *Hesperis matronalis*, *Potentilla recta*, *Cirsium vulgare*, *Ligustrum vulgare*, *Ulmus pumila*, *Vinca minor*, *Alliaria petiolata*, *Rorippa officinale*, *Dipsacus fullonum*, *Lolium* sp., *Pyrus calleryana*, *Poa compressa*, *Sonchus arvensis*, *Morus rubra*, *Bromus tectorum*, *Humulus japonicus*, *Hypericum perforatum*, *Rumex crispus*, *Ailanthus altissima*, *Morus alba*, *Securigera varia*, *Bromus inermis*, *Elaeagnus umbellata*, *Celastrus orbiculatus*, *Euonymus alatus*, *Ligustrum* spp., *Melilotus officinalis*, *Verbascum thapsus*, *Carduus nutans*, *Lonicera maackii*, *Sorghum halepense*, *Poa pratensis*, *Rhus glabra*, *Dactylis glomerata*, *Torilis arvensis*, *Bromus sterilis*, *Euonymus fortunei*, *Daucus carota*, *Rhus copallinum*, *Schedonorus phoenix*, *Maclura pomifera*, *Lespedeza cuneate*, *Bromus racemosus*, *Lonicera japonica*, *Juniperus virginiana*, and *Rosa multiflora*.

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1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525