



Problematic Plant Monitoring in Herbert Hoover National Historic Site

2006–2017

Natural Resource Report NPS/HTLN/NRR—2020/2093



ON THE COVER

Wood betony (*Pedicularis canadensis*) in restored prairie at Herbert Hoover National Historic Site, West Branch, Iowa.
Photography by Adam Prato/NPS

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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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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 Herbert Hoover National Historic Site.	4
Figure 2. 2017 problematic plant frequency and abundance relationship at Herbert Hoover National Historic Site.	11

Tables

	Page
Table 1. Early detection problematic plant watch list used to guide surveys in Herbert Hoover National Historic Site.	2
Table 2. Park-established problematic plant watch list used to guide surveys in Herbert Hoover National Historic Site.	3
Table 3. Abundance and distribution of problematic plants found in Herbert Hoover NHS.	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 32 potentially problematic plant species in Herbert Hoover National Historic Site. Of the species found in 2017, we characterized 3 as very low frequency, 7 as low frequency, 4 as medium frequency, and 10 as high frequency. Kentucky bluegrass, reed canarygrass, and smooth brome, all grasses, were the most abundant. Seven woody plant species can be controlled relatively easily. The many problematic plant species found throughout the prairie reinforce the need to manage these plants within the park's prairie.

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 study presents results of problematic plant monitoring conducted at Herbert Hoover National Historic Site (NHS) in 2006, 2009, 2013 and 2017. The key metrics presented include plant abundance and geographic distribution within the park.



Conservation Corps Iowa crew members removing woody invasive plants at Herbert Hoover NHS, West Branch, Iowa. Photograph by Jessica Salesman/NPS

Methods

Watch Lists

We searched for problematic plants on two 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 = 56; Table 1) is composed of prioritized problematic exotic 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 = 31; 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 (Table 2). Of these, species that we did not search for during all of the previous survey periods are annotated in the tables. Although not on an official watch list, we also included smooth sumac (*Rhus glabra*), which was recorded during 2013 and 2017. 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 Herbert Hoover NHS (Figure 1). NPS staff used Trimble GPS units to conduct this project during July 8–9, 2006, July 21–22, 2009, July 29–30, 2013, and August 21–22, 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 then pooled those estimates for the entire unit. Cover was estimated 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. The same 50 search units were surveyed during each survey (Figure 1).

Table 1. Early detection problematic plant watch list used to guide surveys in Herbert Hoover NHS.

Scientific Name	Common Name
<i>Ailanthus altissima</i>	tree of heaven
<i>Alliaria petiolata</i>	garlic mustard
<i>Alnus glutinosa</i>	European alder
<i>Ampelopsis brevipedunculata</i> *	Amur peppervine
<i>Berberis thunbergii</i>	Japanese barberry
<i>Bromus</i> spp.	brome
<i>Bromus racemosus</i>	bald brome
<i>Carduus nutans</i>	nodding plumeless thistle
<i>Celastrus orbiculatus</i>	Oriental bittersweet
<i>Centaurea solstitialis</i>	yellow star-thistle
<i>Centaurea stoebe</i> ssp. <i>micranthos</i>	spotted knapweed
<i>Dipsacus fullonum</i>	Fuller's teasel
<i>Dipsacus laciniatus</i>	cutleaf teasel
<i>Elymus repens</i>	quackgrass
<i>Euonymus alatus</i>	burningbush
<i>Euphorbia cyparissias</i> *	cypress spurge
<i>Euphorbia esula</i>	leafy spurge
<i>Frangula alnus</i>	glossy buckthorn
<i>Hemerocallis fulva</i> *	orange daylily
<i>Holcus lanatus</i>	common velvetgrass
<i>Humulus japonicus</i>	Japanese hop
<i>Hydrilla verticillata</i>	waterthyme
<i>Hypericum perforatum</i>	common St. Johnswort
<i>Leonurus cardiaca</i> *	common motherwort
<i>Lespedeza bicolor</i>	shrub lespedeza
<i>Lespedeza cuneata</i>	sericea lespedeza
<i>Ligustrum</i> spp.*	privet
<i>Ligustrum obtusifolium</i> *	border privet
<i>Ligustrum vulgare</i>	European privet
<i>Lonicera × bella</i> *	showy fly honeysuckle
<i>Lonicera maackii</i>	Amur honeysuckle
<i>Lysimachia nummularia</i>	creeping jenny
<i>Lythrum salicaria</i>	purple loosestrife
<i>Myriophyllum spicatum</i>	Eurasian watermilfoil
<i>Onopordum acanthium</i> *	Scotch cottonthistle
<i>Phragmites australis</i>	common reed

* Searched for in 2013 and 2017 only.

Table 1 (continued). Early detection problematic plant watch list used to guide surveys in Herbert Hoover NHS.

Scientific Name	Common Name
<i>Poa compressa</i>	Canada bluegrass
<i>Populus alba</i>	white poplar
<i>Polygonum cuspidatum</i>	Japanese knotweed
<i>Potamogeton crispus</i>	curly pondweed
<i>Rhamnus cathartica</i>	common buckthorn
<i>Rorippa officinale</i> *	watercress
<i>Saponaria officinalis</i> *	bouncingbet
<i>Schedonorus arundinaceus</i>	Tall fescue
<i>Schedonorus pratensis</i>	meadow fescue
<i>Securigera varia</i>	crownvetch
<i>Sonchus arvensis</i>	field sowthistle
<i>Sorghum halepense</i>	Johnsongrass
<i>Tanacetum vulgare</i> *	common tansy
<i>Torilis arvensis</i>	spreading hedgeparsley
<i>Torilis japonica</i> *	erect hedgeparsley
<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

* Searched for in 2013 and 2017 only.

Table 2. Park-established problematic plant watch list used to guide surveys in Herbert Hoover NHS.

Scientific Name	Common Name
<i>Acer ginnala</i>	Amur maple
<i>Arctium minus</i>	lesser burdock
<i>Bromus inermis</i>	smooth brome
<i>Bromus tectorum</i>	cheatgrass
<i>Cirsium arvense</i>	Canada thistle
<i>Cirsium vulgare</i>	bull thistle
<i>Daucus carota</i>	Queen Anne's lace
<i>Elaeagnus</i> spp.	elaeanus
<i>Elaeagnus angustifolia</i>	Russian olive
<i>Elaeagnus umbellata</i>	autumn olive
<i>Glechoma hederacea</i>	ground ivy
<i>Hesperis matronalis</i>	dames rocket
<i>Linaria vulgaris</i> *	butter and eggs
<i>Lonicera</i> spp.	honeysuckle
<i>Lonicera morrowii</i>	Morrow's honeysuckle
<i>Lonicera tatarica</i>	Tatarian honeysuckle
<i>Lotus corniculatus</i>	bird's-foot trefoil
<i>Melilotus officinalis</i>	yellow sweetclover
<i>Morus alba</i>	white mulberry
<i>Pastinaca sativa</i>	wild parsnip
<i>Phalaris arundinacea</i>	reed canarygrass
<i>Poa</i> spp.	bluegrass
<i>Poa pratensis</i>	Kentucky bluegrass
<i>Potentilla recta</i>	sulphur cinquefoil
<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>Spiraea</i> spp.*	spirea
<i>Ulmus pumila</i>	Siberian elm
<i>Verbascum thapsus</i>	common mullein

* Searched for in 2013 and 2017 only.

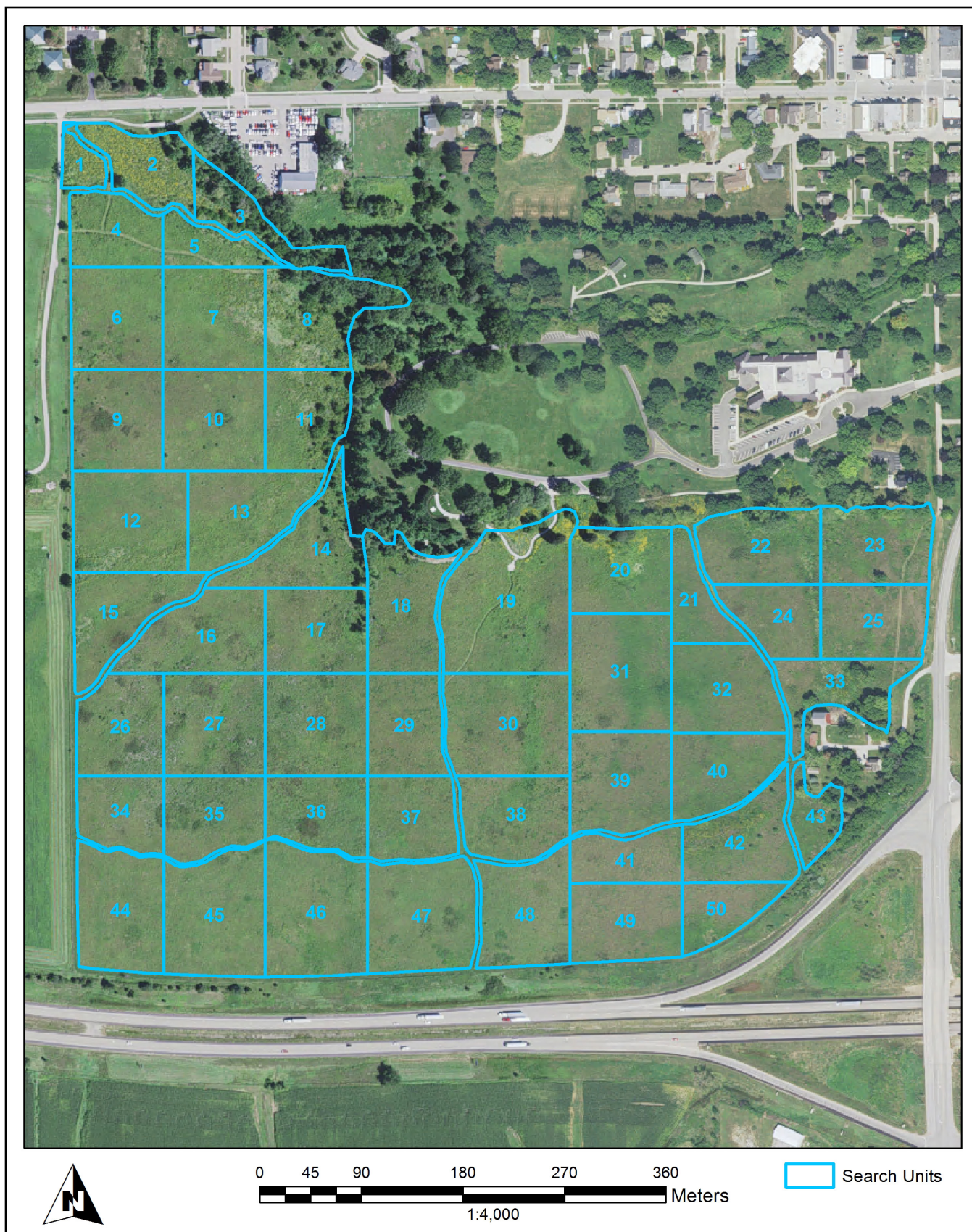


Figure 1. Location of search units used to monitor problematic plants in Herbert Hoover NHS. Search unit size averaged 1.7 acres.

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 1.7 acres (6,774 m²). When calculated as a square, a unit of this size has length and width of 82.3 m. The fraction of the park observed assuming a 3-m belt (3 transects × 82.3-m length × 3-m width) was calculated as 10.9%. The fraction of the park observed assuming a 12-m belt (3 transects × 82.3-m length × 12-m width) was calculated as 43.7%.

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 and 2013. Similarly, bush honeysuckle species (*Lonicera* spp.) were identified only to the genus level in 2006, 2009, and 2013 but as distinct species in 2017. Finally, bluegrass (*Poa* spp.) was identified to species during 2017 and occasionally in 2009 but only to genus in other 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 all species found in Herbert Hoover NHS, abundance was always below this threshold.

The high frequency species included three invasive grasses—Kentucky bluegrass (*Poa pratensis*), reed canarygrass (*Phalaris arundinacea*), and smooth

brome (*Bromus inermis*). These plants will continue to challenge management in the relatively small prairie. Seven of the species identified, including three bush honeysuckle species (*Lonicera* spp.), were woody plants that can be relatively easily controlled. 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 Herbert Hoover NHS. 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	Ecological Impact	Management Difficulty	PeriodID	Frequency	Low Cover Estimate (acres)	High Cover Estimate (acres)
<i>Alliaria petiolata</i>	garlic mustard	M-L	M	2017	2	0.0006	0.0224
<i>Arctium minus</i>	lesser burdock	L-I	M-I	2009	6	0.0577	1.1782
<i>Arctium minus</i>	lesser burdock	L-I	M-I	2013	4	0.0057	0.1152
<i>Arctium minus</i>	lesser burdock	L-I	M-I	2017	8	0.0007	0.0286
<i>Bromus inermis</i>	smooth brome	M	M-L	2006	80	0.7135	8.6464
<i>Bromus inermis</i>	smooth brome	M	M-L	2009	48	1.4380	16.6141
<i>Bromus inermis</i>	smooth brome	M	M-L	2013	82	1.3454	18.5644
<i>Bromus inermis</i>	smooth brome	M	M-L	2017	66	1.0332	18.0652
<i>Carduus nutans</i>	nodding plumeless thistle	M-I	H-M	2006	2	0.0006	0.0224
<i>Cirsium arvense</i>	Canada thistle	M-L	H-M	2006	18	0.0132	0.3017
<i>Cirsium arvense</i>	Canada thistle	M-L	H-M	2009	10	0.0181	0.3843
<i>Cirsium arvense</i>	Canada thistle	M-L	H-M	2013	16	0.0010	0.0367
<i>Cirsium arvense</i>	Canada thistle	M-L	H-M	2017	10	0.0008	0.0306
<i>Cirsium vulgare</i>	bull thistle	M-L	M-L	2006	12	0.0064	0.1437
<i>Cirsium vulgare</i>	bull thistle	M-L	M-L	2009	4	0.0062	0.1356
<i>Cirsium vulgare</i>	bull thistle	M-L	M-L	2013	8	0.0012	0.0490
<i>Daucus carota</i>	Queen Anne's lace	I	I	2006	6	0.0012	0.0469
<i>Daucus carota</i>	Queen Anne's lace	I	I	2009	22	0.0578	0.8431
<i>Daucus carota</i>	Queen Anne's lace	I	I	2013	70	0.0183	0.4976
<i>Daucus carota</i>	Queen Anne's lace	I	I	2017	64	0.0318	0.8157
<i>Elaeagnus</i> spp.	oleaster	H	H	2006	36	0.0234	0.5944
<i>Elaeagnus</i> spp.	oleaster	H	H	2013	34	0.0162	0.4201
<i>Elaeagnus umbellata</i>	autumn olive	H	L	2009	28	0.0588	1.2210
<i>Elaeagnus umbellata</i>	autumn olive	H	L	2017	52	0.0071	0.2775
<i>Elymus repens</i>	quackgrass	M-L	H-M	2006	20	0.0011	0.0408
<i>Elymus repens</i>	quackgrass	M-L	H-M	2013	16	0.0081	0.2090

* Searched for in 2013 and 2017 only.

Table 3 (continued). Abundance and distribution of problematic plants found in Herbert Hoover NHS. 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	Ecological Impact	Management Difficulty	PeriodID	Frequency	Low Cover Estimate (acres)	High Cover Estimate (acres)
<i>Glechoma hederacea</i>	ground ivy	M-I	U	2006	12	0.0075	0.1845
<i>Glechoma hederacea</i>	ground ivy	M-I	U	2009	8	0.0124	0.2711
<i>Glechoma hederacea</i>	ground ivy	M-I	U	2013	10	0.0074	0.1825
<i>Glechoma hederacea</i>	ground ivy	M-I	U	2017	4	0.0283	0.2285
<i>Leonurus cardiaca</i> *	common motherwort	n/a	n/a	2017	2	0.0001	0.0020
<i>Lonicera</i> spp.	honeysuckle	n/a	n/a	2006	70	0.2084	2.3407
<i>Lonicera</i> spp.	honeysuckle	n/a	n/a	2009	74	0.4340	7.4184
<i>Lonicera</i> spp.	honeysuckle	n/a	n/a	2013	60	0.0185	0.6212
<i>Lonicera maackii</i>	Amur honeysuckle	H-M	M	2017	40	0.0673	1.4464
<i>Lonicera morrowii</i>	Morrow's honeysuckle	M-L	M	2017	72	0.1127	2.1296
<i>Lonicera tatarica</i>	Tatarian honeysuckle	M	M	2017	36	0.0122	0.3722
<i>Lotus corniculatus</i>	bird's-foot trefoil	M-L	M-L	2006	10	0.0402	0.4772
<i>Lotus corniculatus</i>	bird's-foot trefoil	M-L	M-L	2009	4	0.0011	0.0449
<i>Lotus corniculatus</i>	bird's-foot trefoil	M-L	M-L	2013	6	0.0679	1.3595
<i>Lotus corniculatus</i>	bird's-foot trefoil	M-L	M-L	2017	8	0.0345	0.3641
<i>Melilotus officinalis</i>	sweetclover	M	M	2006	84	6.8851	128.5576
<i>Melilotus officinalis</i>	sweetclover	M	M	2009	88	0.8128	12.2886
<i>Melilotus officinalis</i>	sweetclover	M	M	2013	64	0.1236	1.6613
<i>Melilotus officinalis</i>	sweetclover	M	M	2017	66	0.2003	4.1706
<i>Morus alba</i>	white mulberry	M-L	M-L	2006	68	0.1146	2.0938
<i>Morus alba</i>	white mulberry	M-L	M-L	2009	64	0.1480	2.0739
<i>Morus alba</i>	white mulberry	M-L	M-L	2013	46	0.0293	0.7157
<i>Morus alba</i>	white mulberry	M-L	M-L	2017	62	0.0832	1.8542
<i>Pastinaca sativa</i>	wild parsnip	L-I	L	2006	70	0.1144	1.7445
<i>Pastinaca sativa</i>	wild parsnip	L-I	L	2009	66	0.2593	3.9258
<i>Pastinaca sativa</i>	wild parsnip	L-I	L	2013	70	0.0977	2.2069
<i>Pastinaca sativa</i>	wild parsnip	L-I	L	2017	62	0.0257	0.6821

* Searched for in 2013 and 2017 only.

Table 3 (continued). Abundance and distribution of problematic plants found in Herbert Hoover NHS. 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	Ecological Impact	Management Difficulty	PeriodID	Frequency	Low Cover Estimate (acres)	High Cover Estimate (acres)
<i>Phalaris arundinacea</i>	reed canarygrass	H	H-M	2006	50	1.8696	30.7419
<i>Phalaris arundinacea</i>	reed canarygrass	H	H-M	2009	48	1.3176	26.0698
<i>Phalaris arundinacea</i>	reed canarygrass	H	H-M	2013	66	0.9145	13.6445
<i>Phalaris arundinacea</i>	reed canarygrass	H	H-M	2017	62	1.7576	17.6349
<i>Poa</i> spp.	bluegrass	n/a	n/a	2006	90	0.0382	1.0666
<i>Poa</i> spp.	bluegrass	n/a	n/a	2009	14	0.0141	0.3385
<i>Poa</i> spp.	bluegrass	n/a	n/a	2013	92	0.1924	3.3946
<i>Poa pratensis</i>	Kentucky bluegrass	M	M-L	2009	68	0.1787	2.7354
<i>Poa pratensis</i>	Kentucky bluegrass	M	M-L	2017	98	0.4993	7.9915
<i>Rhamnus cathartica</i>	common buckthorn	M	M	2006	2	0.0001	0.002
<i>Rhamnus cathartica</i>	common buckthorn	M	M	2013	8	0.0007	0.0286
<i>Rhus glabra</i>	smooth sumac	native	native	2013	22	0.0016	0.0632
<i>Rhus glabra</i>	smooth sumac	native	native	2017	44	0.2189	3.1054
<i>Rosa multiflora</i>	multiflora rose	L	L	2006	18	0.0015	0.0592
<i>Rosa multiflora</i>	multiflora rose	L	L	2009	16	0.0030	0.1183
<i>Rosa multiflora</i>	multiflora rose	L	L	2013	6	0.0012	0.0469
<i>Rosa multiflora</i>	multiflora rose	L	L	2017	10	0.0003	0.0102
<i>Rumex crispus</i>	curly dock	n/a	n/a	2013	12	0.0003	0.0122
<i>Rumex crispus</i>	curly dock	n/a	n/a	2017	12	0.0003	0.0122
<i>Schedonorus arundinaceus</i>	tall fescue	M	H-M	2013	30	0.0029	0.1122
<i>Schedonorus arundinaceus</i>	tall fescue	M	H-M	2017	2	0.0001	0.002
<i>Securigera varia</i>	crownvetch	H	L	2006	2	0.0006	0.0224
<i>Securigera varia</i>	crownvetch	H	L	2009	2	0.0283	0.2265
<i>Securigera varia</i>	crownvetch	H	L	2013	4	0.0011	0.0449
<i>Securigera varia</i>	crownvetch	H	L	2017	8	0.0226	0.4525

* Searched for in 2013 and 2017 only.

Table 3 (continued). Abundance and distribution of problematic plants found in Herbert Hoover NHS. 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	Ecological Impact	Management Difficulty	PeriodID	Frequency	Low Cover Estimate (acres)	High Cover Estimate (acres)
<i>Sonchus arvensis</i>	field sowthistle	L-I	H-L	2006	8	0.0114	0.2303
<i>Sonchus arvensis</i>	field sowthistle	L-I	H-L	2009	12	0.0003	0.0122
<i>Sonchus arvensis</i>	field sowthistle	L-I	H-L	2013	2	0.0001	0.002
<i>Ulmus pumila</i>	Siberian elm	M-L	M-L	2006	18	0.0697	0.7506
<i>Ulmus pumila</i>	Siberian elm	M-L	M-L	2009	12	0.0352	0.3886
<i>Ulmus pumila</i>	Siberian elm	M-L	M-L	2013	12	0.0024	0.0939
<i>Ulmus pumila</i>	Siberian elm	M-L	M-L	2017	16	0.0040	0.1591
<i>Verbascum thapsus</i>	common mullein	M-L	L	2006	14	0.0019	0.0755
<i>Verbascum thapsus</i>	common mullein	M-L	L	2009	2	0.0001	0.002
<i>Verbascum thapsus</i>	common mullein	M-L	L	2013	6	0.0012	0.0469
<i>Verbascum thapsus</i>	common mullein	M-L	L	2017	4	0.0001	0.0041

* Searched for in 2013 and 2017 only.

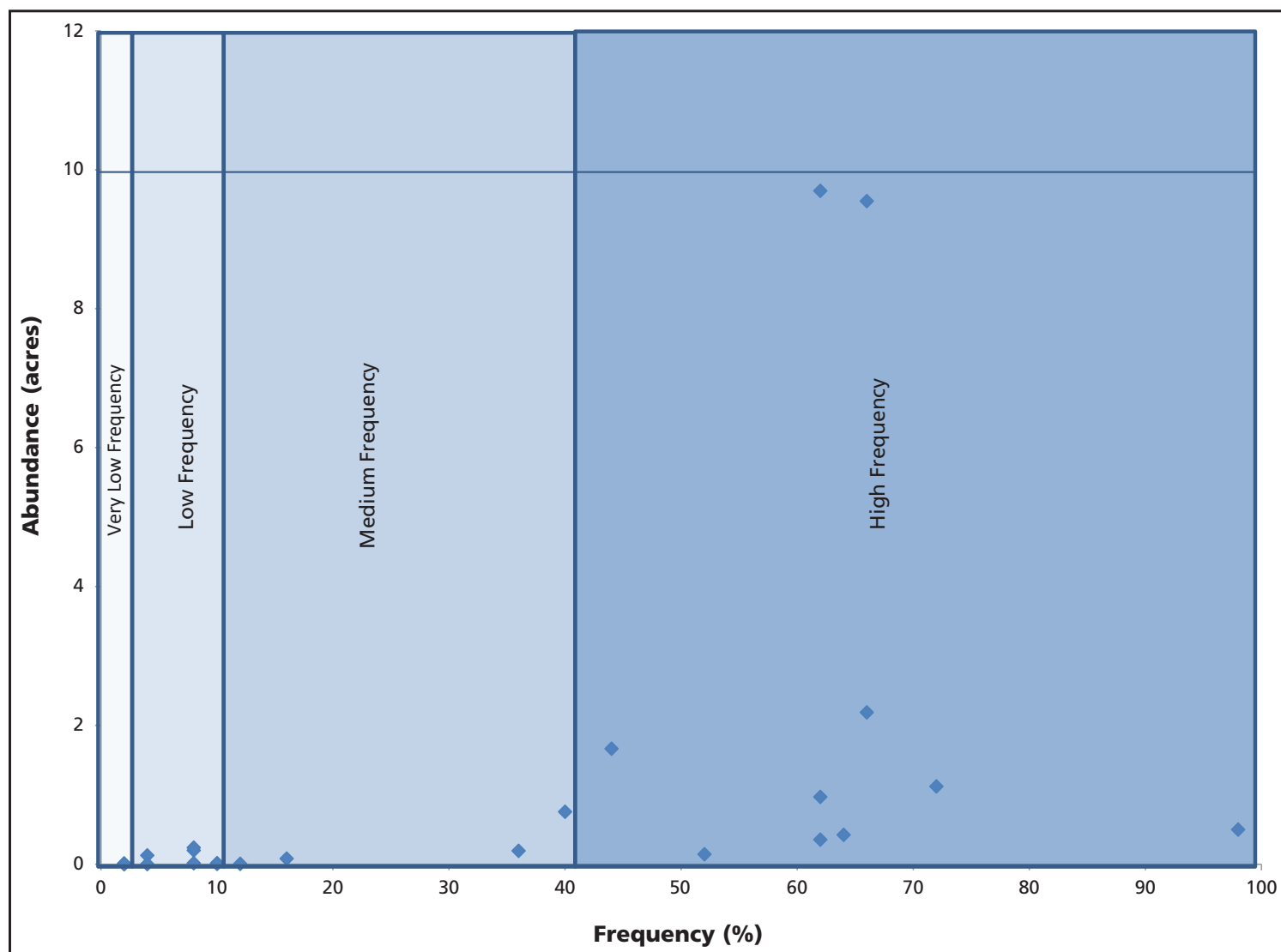


Figure 2. 2017 problematic plant frequency and abundance relationship at Herbert Hoover NHS. The abundance measure used is based on the mid-point of the abundance range. Plants are categorized into four categories: very low frequency ($\leq 2\%$), low frequency ($>2\text{--}10\%$), medium frequency ($>10\text{--}40\%$) 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 *Alliaria petiolata*, *Leonurus cardiac*, *Schedonorus phoenix*, *Glechoma hederacea*, *Verbascum thapsus*, *Arctium minus*, *Lotus corniculatus*, *Securigera varia*, *Cirsium arvense*, *Rosa multiflora*, *Rumex crispus*, *Ulmus pumila*, *Lonicera tatarica*, *Lonicera maackii*, *Rhus glabra*, *Elaeagnus umbellata*, *Morus alba*, *Pastinaca sativa*, *Phalaris arundinacea*, *Daucus carota*, *Bromus inermis*, *Melilotus officinalis*, *Lonicera morrowii*, and *Poa pratensis*.

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Natural Resource Stewardship and Science

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