



Problematic Plant Monitoring in George Washington Carver National Monument

2006–2020

Natural Resource Report NPS/HTLN/NRR—2022/2396



ON THE COVER

Smooth sumac (*Rhus glabra*) in the north unit of George Washington Carver National Monument, Diamond, Missouri, prior to control and site restoration.

Photography by NPS

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June 2022

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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Please cite this publication as:

Young, C. C. 2022. Problematic plant monitoring in George Washington Carver National Monument: 2006–2020. Natural Resource Report NPS/HTLN/NRR—2022/2396. National Park Service, Fort Collins, Colorado. <https://doi.org/10.36967/nrr-2293655>.

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Abstract

Managers are challenged with the impact of problematic plants, including exotic, invasive, and pest plant species. Information on the cover and frequency of these plant species is essential for developing risk-based approaches to managing them. Based on surveys conducted in 2006, 2013, 2016, and 2020, Heartland Inventory and Monitoring Network staff and contractors identified a cumulative total of 50 potentially problematic plant species in George Washington Carver National Monument. Of the 35 species found in 2020, we characterized 8 as very low frequency, 9 as low frequency, 10 as medium frequency, and 8 as high frequency. Of these, midpoint cover estimates of only 1 high frequency species, tall fescue, exceeded the 10-acre threshold. Because of the number, extent, and cover of problematic plants in the park and the small park size, control efforts should focus on treating high priority species across the entire park. High priority species may include plant species capable of rapid spread, species at low population levels, and species that can be effectively controlled.

Introduction

The National Park Service’s management policies distinguish between native and exotic (i.e., non-native) plant species (NPS 2006). Exotic plant species are characterized as 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 the objective of protecting human health. We suggest thinking of this collection of exotic, invasive, and pest plants as *potentially problematic* species.

Park managers, however, are only required to control any 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 George Washington Carver National Monument (NM) in 2006, 2013, 2016, and 2020. The key metrics presented include plant cover and geographic distribution within the park.



Treatment of Japanese honeysuckle (*Lonicera japonica*) in Carver Woods, George Washington Carver National Monument, Diamond, Missouri. NPS

Methods

All methods presented here are based on the Heartland Inventory and Monitoring Network invasive exotic plant monitoring protocol (Kull et al. 2022).

Watch Lists

We searched for potentially problematic plants on two lists. Prioritized problematic plants not previously found during monitoring in the park constituted the early detection watch list (n = 71; Table 1). Prioritized problematic plants known to occur in the park based on previous monitoring constituted the park-established watch list (n = 50; Table 2). In this report we included only plant species that we searched for in 2020. Of these, any species not sought during all previous survey periods were annotated in the table. While aquatic species were included on the watch lists, terrestrial plants were the focus of this survey. Aquatic plants were documented only occasionally.

Table 1. Early detection problematic plant watch list used to guide surveys in George Washington Carver National Monument.

Scientific Name	Common Name
<i>Acer ginnala</i>	Amur maple
<i>Albizia julibrissin</i>	silk tree
<i>Alliaria petiolata</i>	garlic mustard
<i>Alnus glutinosa</i>	European alder
<i>Arthraxon hispidus</i> ^a	small carpgrass
<i>Arundo donax</i>	giant reed
<i>Bothriochloa bladhii</i>	Caucasian bluestem, Australian bluestem
<i>Bromus</i> sp.	annual brome sp. (NOT <i>B. inermis</i>)
<i>Centaurea solstitialis</i>	yellow star-thistle
<i>Centaurea stoebe</i> ssp. <i>micranthos</i>	spotted knapweed
<i>Cirsium arvense</i>	Canada thistle
<i>Cirsium vulgare</i>	bull thistle
<i>Clematis terniflora</i> ^d	sweet autumn virgin's bower

^a Searched for in 2016 and 2020 only

^b Searched for in 2013, 2016, and 2020 only

^c Searched for in 2006 and 2020 only

^d Searched for in 2020 only

Table 1 (continued). Early detection problematic plant watch list used to guide surveys in George Washington Carver National Monument.

Scientific Name	Common Name
<i>Cynanchum louiseae</i> ^b	Louise's swallow-wort
<i>Cynanchum rossicum</i> ^b	European swallow-wort
<i>Dioscorea oppositifolia</i>	Chinese yam
<i>Dipsacus fullonum</i>	Fuller's teasel
<i>Dipsacus laciniatus</i>	cutleaf teasel
<i>Egeria densa</i> ^b	Brazilian waterweed
<i>Eichhornia crassipes</i> ^b	common water hyacinth
<i>Elaeagnus angustifolia</i>	Russian olive
<i>Elaeagnus umbellata</i>	autumn olive
<i>Elaeagnus umbellata/angustifolia</i>	Russian/autumn olive complex
<i>Euphorbia cyparissias</i> ^b	cypress spurge
<i>Euphorbia esula</i>	leafy spurge
<i>Hesperis matronalis</i>	dames rocket
<i>Holcus lanatus</i>	common velvetgrass
<i>Humulus japonicus</i> ^b	Japanese hop
<i>Iris pseudacorus</i> ^b	pale yellow iris
<i>Leonurus cardiaca</i> ^b	common motherwort
<i>Lepidium latifolium</i> ^b	broadleaved pepperweed
<i>Lespedeza bicolor</i>	shrub lespedeza
<i>Ligustrum</i> sp.	privet sp.
<i>Ligustrum obtusifolium</i> ^b	border privet
<i>Linaria vulgaris</i> ^b	butter and eggs
<i>Lonicera morrowii</i>	Morrow's honeysuckle
<i>Lonicera</i> shrub (<i>maackii/morrowii/tatarica</i>)	bush honeysuckle sp. (Amur-Morrow's-Tatarian complex)
<i>Lotus corniculatus</i>	bird's-foot trefoil
<i>Lotus tenuis</i> ^c	narrow-leaf bird's-foot trefoil
<i>Lysimachia nummularia</i>	creeping jenny
<i>Lythrum salicaria</i>	purple loosestrife
<i>Microstegium vimineum</i>	Nepalese browntop, Japanese stiltgrass
<i>Miscanthus sinensis</i>	Chinese silvergrass
<i>Myosotis scorpioides</i> ^b	true forget-me-not
<i>Myriophyllum aquaticum</i>	parrot feather watermilfoil

^a Searched for in 2016 and 2020 only

^b Searched for in 2013, 2016, and 2020 only

^c Searched for in 2006 and 2020 only

^d Searched for in 2020 only

Table 1 (continued). Early detection problematic plant watch list used to guide surveys in George Washington Carver National Monument.

Scientific Name	Common Name
<i>Myriophyllum spicatum</i> ^b	Eurasian watermilfoil
<i>Najas minor</i> ^b	brittle waternymph
<i>Onopordum acanthium</i> ^b	Scotch cottonthistle
<i>Pastinaca sativa</i>	wild parsnip
<i>Paulownia tomentosa</i>	princess tree
<i>Phragmites australis</i>	common reed
<i>Polygonum cuspidatum</i>	Japanese knotweed
<i>Populus alba</i>	white poplar
<i>Populus tremuloides</i>	quaking aspen
<i>Prunus mahaleb</i> ^b	Mahaleb cherry
<i>Pueraria montana</i>	kudzu
<i>Rhamnus cathartica</i>	common buckthorn
<i>Robinia pseudoacacia</i>	black locust
<i>Saponaria officinalis</i> ^b	bouncingbet
<i>Schedonorus pratensis</i>	meadow fescue
<i>Sesbania herbacea</i>	bigpod sesbania
<i>Spiraea</i> sp.	spirea sp.
<i>Spiraea japonica</i>	Japanese meadowsweet, Japanese spirea
<i>Tamarix ramosissima</i> ^c	saltcedar
<i>Tanacetum vulgare</i> ^b	common tansy
<i>Typha angustifolia</i>	narrowleaf cattail
<i>Typha hybrid</i> ^b	hybrid cattail
<i>Typha</i> sp. ^b	cattail sp.
<i>Viburnum opulus</i> ^b	European cranberrybush
<i>Vinca minor</i>	common periwinkle
<i>Wisteria sinensis</i>	Chinese wisteria

^a Searched for in 2016 and 2020 only

^b Searched for in 2013, 2016, and 2020 only

^c Searched for in 2006 and 2020 only

^d Searched for in 2020 only

Table 2. Park-established problematic plant watch list used to guide surveys in George Washington Carver National Monument.

Scientific Name	Common Name
<i>Ailanthus altissima</i>	tree-of-heaven
<i>Arctium minus</i>	lesser burdock
<i>Berberis thunbergii</i>	Japanese barberry
<i>Bromus inermis</i>	smooth brome
<i>Bromus racemosus</i>	bald brome, spiked brome
<i>Bromus sterilis</i>	poverty brome
<i>Bromus tectorum</i>	cheatgrass
<i>Carduus nutans</i>	nodding plumeless thistle
<i>Celastrus orbiculatus</i>	Oriental bittersweet
<i>Cirsium</i> sp.	thistle sp.
<i>Cornus foemina</i>	stiff dogwood
<i>Daucus carota</i> ^b	Queen Anne's lace
<i>Elymus repens</i> ^b	quackgrass
<i>Euonymus alatus</i>	burningbush, winged euonymus
<i>Euonymus fortunei</i>	winter creeper
<i>Glechoma hederacea</i>	ground ivy
<i>Hedera helix</i>	English ivy
<i>Hemerocallis fulva</i> ^b	orange daylily
<i>Hypericum perforatum</i> ^b	common St. Johnswort
<i>Juniperus virginiana</i> ^b	eastern redcedar
<i>Lespedeza cuneata</i>	sericea lespedeza
<i>Ligustrum sinense</i>	Chinese privet
<i>Ligustrum vulgare</i>	European privet
<i>Lonicera japonica</i>	Japanese honeysuckle
<i>Lonicera maackii</i>	Amur honeysuckle
<i>Maclura pomifera</i>	Osage orange
<i>Melilotus officinalis</i>	yellow sweetclover
<i>Morus alba</i>	white mulberry
<i>Nasturtium officinale</i> ^b	watercress
<i>Phalaris arundinacea</i>	reed canarygrass
<i>Poa compressa</i>	Canada bluegrass
<i>Poa compressa/pratensis</i>	Canada/Kentucky bluegrass complex
<i>Poa pratensis</i>	Kentucky bluegrass
<i>Potamogeton crispus</i> ^b	curly pondweed
<i>Potentilla recta</i>	sulphur cinquefoil
<i>Pyrus calleryana</i> ^a	Callery pear

^a Searched for in 2016 and 2020 only

^b Searched for in 2013, 2016, and 2020 only

^c Searched for in 2006 and 2020 only

Table 2 (continued). Park-established problematic plant watch list used to guide surveys in George Washington Carver National Monument.

Scientific Name	Common Name
<i>Rhus copallinum</i> ^b	winged sumac
<i>Rhus glabra</i>	smooth sumac
<i>Rosa multiflora</i>	multiflora rose
<i>Rumex acetosella</i> ^b	common sheep sorrel
<i>Rumex crispus</i> ^b	curly dock
<i>Schedonorus arundinaceus</i>	tall fescue
<i>Securigera varia</i>	crown vetch
<i>Sonchus arvensis</i> ^b	field sowthistle
<i>Sorghum halepense</i>	Johnsongrass
<i>Torilis arvensis</i> ^b	spreading hedgeparsley
<i>Torilis japonica</i> ^b	erect hedgeparsley
<i>Ulmus pumila</i>	Siberian elm
<i>Verbascum thapsus</i>	common mullein
<i>Vicia villosa</i> ^c	winter vetch

^a Searched for in 2016 and 2020 only

^b Searched for in 2013, 2016, and 2020 only

^c Searched for in 2006 and 2020 only

Field Methods

We searched for problematic plant species on designated watch lists (Table 1) across George Washington Carver NM (Figure 1). Contracted staff conducted the monitoring August 18–August 21, 2006, and June 24–27, 2013. NPS staff used Trimble GPS units to conduct monitoring August 22–24, 2016, and July 27–30, 2020. Observers made three roughly equidistant passes through each search unit, normally in the east-west direction. On each pass through the 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 taxon 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, 7 = 1,000–4,999.9 m². In 2006, we searched 97 units. As the park area expanded, more search units were added, and 114 search units were surveyed in 2013, 2016, and 2020 (Figure 1).

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 approximately 1.9 acres. The fraction of the park observed assuming a 3-m belt was calculated as 10.18% in 2006 and, with the addition of search units and a larger park area, as 10.24% in 2013, 2016, and 2020. The fraction of the park observed assuming a 12-m belt was calculated as 40.74% in 2006 and as 40.94% in 2013, 2016, and 2020.

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.



Figure 1. Location of search units used to monitor problematic plants in George Washington Carver National Monument. Search unit size averaged 1.9 acres.

The park-wide frequency of problematic plants was calculated as the percentage of occupied search units (n = 97 in 2006, n = 114 in 2013, 2016, and 2020; 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 cover. In this study, we evaluated if the cover data collected in 2020 differed from any previous years based on non-overlapping cover ranges.

I-Ranks

We report the I-ranks or invasive ranks from *NatureServe Explorer* (NatureServe 2018) that are calculated using a standard protocol to assess the impacts of these plants (see Morse et al. 2004 for calculation details). The I-ranks consist of four sub-ranks: ecological impact, current distribution/cover, trend in distribution/cover, and management difficulty. Because of their more direct implications for park management, the ecological impact and management difficulty sub-ranks, when available, were presented in Table 3 of the Results section (NatureServe 2018). Some plants could not be assigned an I-rank due to missing source data.

Taxonomic Notes

The *Poa* species, including *Poa pratensis* and *Poa compressa* were identified to species and as a taxonomic complex. The cover and frequency estimates for these taxa are also likely best interpreted as a group.

Results and Discussion

Plant cover and frequency estimates for the problematic plants encountered at George Washington Carver NM are presented in Table 3 and the 2020 data are depicted graphically using frequency and the midpoint of the cover range (Figure 2). In the figure we grouped plants in four categories: (1) very low frequency ($\leq 2\%$, $n = 8$), (2) low frequency ($> 2\text{--}10\%$, $n = 9$), (3) medium frequency ($> 10\text{--}40\%$, $n = 10$), and (4) high frequency ($> 40\%$, $n = 8$). While many factors impact a manager's ability to control problematic plants, we use midpoint abundance of 10 acres as a guideline to identify lower and higher probabilities for successful control. Only the cover midpoint of tall fescue (*Schedonorus arundinacea*) exceeded this threshold and will be difficult to control.

Based on non-overlapping cover ranges, we observed several changes—all decreases—in species cover in 2020 compared to at least one previous year. This included reduced cover in smooth brome (*Bromus inermis*), poverty brome (*Bromus sterilis*), and cheatgrass (*Bromus tectorum*). The woody vine Japanese honeysuckle (*Lonicera japonica*) and the vining herb crown vetch (*Securigera varia*) also decreased in cover.

Across the monitoring record, George Washington Carver NM was found to support 50 problematic plant species. Several of these species are well established throughout much of the park. Within the prairie, several invasive cool season grasses were widespread in 2020; bald brome (*Bromus racemosus*),

bluegrass (*Poa* spp.), and tall fescue each occupied more than 60% of search units. Johnsongrass (*Sorghum halepense*), an invasive warm season grass, was found in over 37% of search units with an increase observed in its distribution since 2006. Despite control efforts in the prairie, the frequency of sericea lespedeza (*Lespedeza cuneata*) remains relatively high (62.3%).

In the woodlands, common problematic tree species include eastern redcedar (*Juniperus virginiana*) and Osage orange (*Maclura pomifera*). The shrub multiflora rose (*Rosa multiflora*) and the vines Japanese honeysuckle (*Lonicera japonica*) and wintercreeper (*Euonymus fortunei*) are also relatively widespread in the understory. With respect to early detections, tree-of-heaven (*Ailanthus altissima*) and Japanese barberry (*Berberis thunbergii*) were found on the park for the first time in 2020. Callery pear (*Pyrus calleryana*), another invasive tree, was first found in 2016 and then again in 2020. Since 2016, efforts to control the large crown vetch patch in the northern prairie appear to be containing its spread and reducing the cover compared to previous levels in 2006 and 2013. Given the large number, extent, and cover of distinct groups of problematic plants in the prairie, forest, and pond at George Washington Carver NM, managers must strategically prioritize any control projects. These monitoring data continue to provide a generalized understanding of problematic plant cover and distribution to support management decisions.

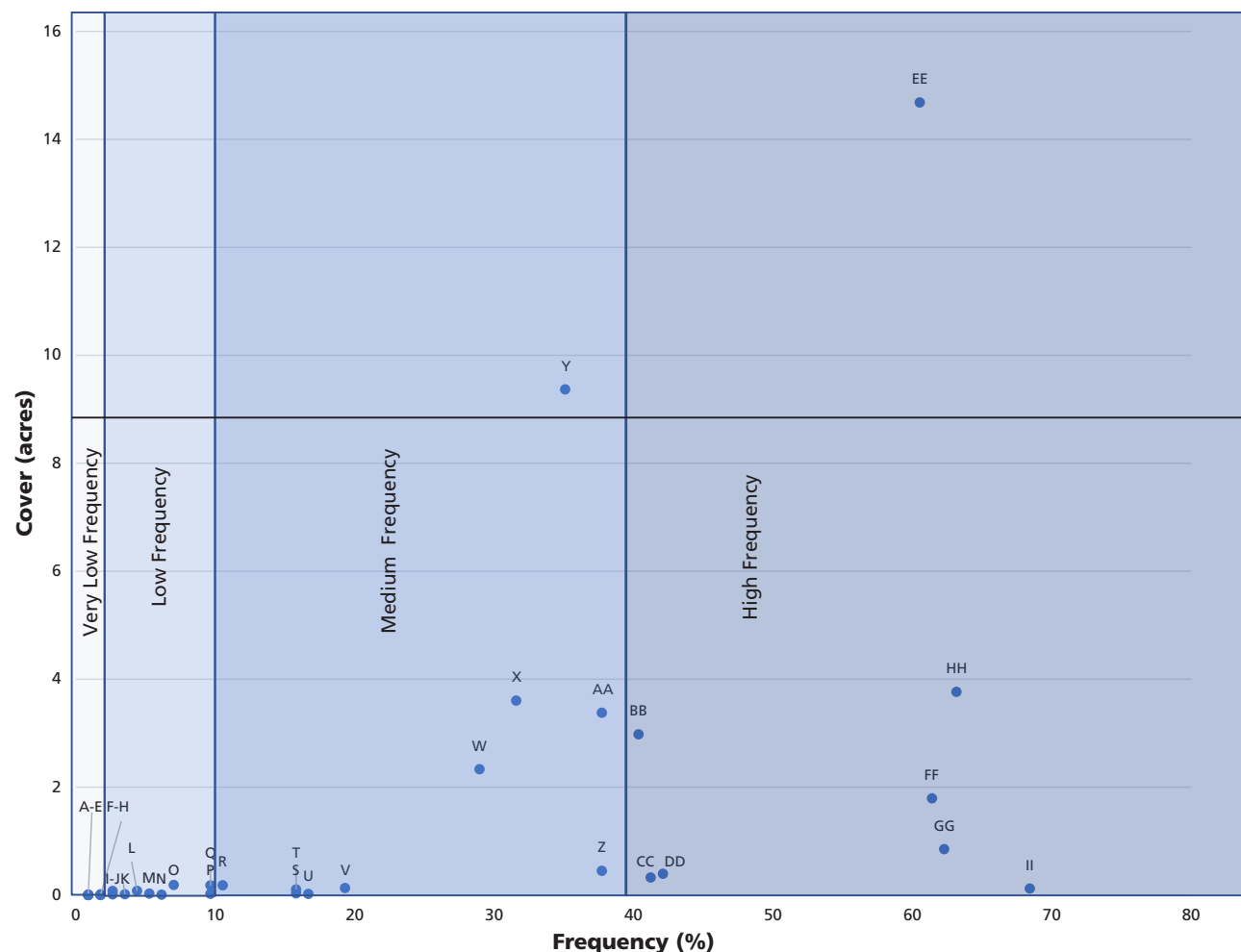


Figure 2. Problematic plant cover and frequency relationship in 2020 at George Washington Carver National Monument. The cover measure used is based on the midpoint of the cover range. Plants are placed into four categories: very low frequency ($\leq 2\%$), low frequency ($> 2\text{--}10\%$), medium frequency ($> 10\text{--}40\%$) 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 A) *Ailanthus altissima*, B) *Berberis thunbergii*, C) *Euonymus alatus*, D) *Verbascum thapsus*, E) *Poa compressa/pratensis*, F) *Lonicera maackii*, G) *Nasturtium officinale*, H) *Securigera varia*, I) *Bromus tectorum*, J) *Glechoma hederacea*, K) *Poa compressa*, L) *Morus alba*, M) *Daucus carota*, N) *Ulmus pumila*, O) *Bromus inermis*, P) *Melilotus officinalis*, Q) *Bromus sterilis*, R) *Rhus glabra*, S) *Hypericum perforatum*, T) *Pyrus calleryana*, U) *Carduus nutans*, V) *Ligustrum vulgare*, W) *Euonymus fortunei*, X) *Juniperus virginiana*, Y) *Maclura pomifera*, Z) *Rosa multiflora*, AA) *Sorghum halepense*, BB) *Rhus copallinum*, CC) *Lonicera japonica*, DD) *Torilis arvensis*, EE) *Schedonorus arundinaceus*, FF) *Poa pratensis*, GG) *Lespedeza cuneata*, HH) *Bromus racemosus*, II) *Rumex crispus*.

Table 3. Cover and frequency of potentially problematic plants found in George Washington Carver National Monument. 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 high (H), medium (M), low (L), insignificant (I), a range of the above ranks, native (for species native to U.S.), or not available (n/a). The assignment of “decrease from” a particular year or “increase from” a particular year next to a species indicates that the cover in that year for that species changed relative to the noted year based on non-overlapping cover intervals. Note that cover and frequency were based on 97 search units in 2006 and 114 search units in 2013, 2016, and 2020.

Scientific Name	Common Name	Year	Minimum Cover Estimate (acres)	Maximum Cover Estimate (acres)	Frequency	EI	Mgmt
<i>Ailanthus altissima</i>	tree-of-heaven	2020	0.0001	0.0022	0.88	ML	ML
<i>Arctium minus</i>	lesser burdock	2006	0.0001	0.0022	1.03	LI	MI
<i>Arctium minus</i>	lesser burdock	2013	0.0009	0.0347	5.26	LI	MI
<i>Berberis thunbergii</i>	Japanese barberry	2020	0.0001	0.0022	0.88	HM	I
<i>Bromus inermis</i>	smooth brome	2006	0.6575	7.3741	21.65	M	ML
<i>Bromus inermis</i> (decrease from 2006)	smooth brome	2013	0.0374	0.5278	11.40	M	ML
<i>Bromus inermis</i> (decrease from 2006)	smooth brome	2016	0.0165	0.4167	11.40	M	ML
<i>Bromus inermis</i> (decrease from 2006)	smooth brome	2020	0.0151	0.3625	7.02	M	ML
<i>Bromus racemosus</i>	bald brome, spiked brome	2006	3.5744	54.0762	32.99	n/a	n/a
<i>Bromus racemosus</i>	bald brome, spiked brome	2013	0.4138	7.3550	71.05	n/a	n/a
<i>Bromus racemosus</i> (decrease from 2006)	bald brome, spiked brome	2016	0.0839	1.5335	39.47	n/a	n/a
<i>Bromus racemosus</i>	bald brome, spiked brome	2020	0.3962	7.1352	63.16	n/a	n/a
<i>Bromus sterilis</i>	poverty brome	2006	0.0867	1.0416	9.28	ML	U
<i>Bromus sterilis</i> (increase from 2006)	poverty brome	2013	1.1258	17.3690	37.72	ML	U
<i>Bromus sterilis</i> (decrease from 2013)	poverty brome	2016	0.0348	0.4213	12.28	ML	U
<i>Bromus sterilis</i> (decrease from 2013)	poverty brome	2020	0.0148	0.3473	9.65	ML	U
<i>Bromus tectorum</i>	cheatgrass	2013	0.6326	8.5029	56.14	H	HM
<i>Bromus tectorum</i> (decrease from 2013)	cheatgrass	2016	0.0063	0.1291	4.39	H	HM
<i>Bromus tectorum</i> (decrease from 2013)	cheatgrass	2020	0.0007	0.0282	2.63	H	HM
<i>Carduus nutans</i>	nodding plumeless thistle	2013	0.0096	0.3714	44.74	MI	HM
<i>Carduus nutans</i>	nodding plumeless thistle	2016	0.0013	0.0478	10.53	MI	HM
<i>Carduus nutans</i>	nodding plumeless thistle	2020	0.0011	0.0413	16.67	MI	HM
<i>Celastrus orbiculatus</i>	Oriental bittersweet	2006	0.0001	0.0044	2.06	ML	M
<i>Cirsium</i> sp.	thistle sp.	2016	0.0001	0.0022	0.88	ML	M

^a Searched for in 2016 and 2020 only

^b Searched for in 2013, 2016, and 2020 only

^c Searched for in 2006 and 2020 only

Table 3 (continued). Cover and frequency of potentially problematic plants found in George Washington Carver National Monument. 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 high (H), medium (M), low (L), insignificant (I), a range of the above ranks, native (for species native to U.S.), or not available (n/a). The assignment of “decrease from” a particular year or “increase from” a particular year next to a species indicates that the cover in that year for that species changed relative to the noted year based on non-overlapping cover intervals. Note that cover and frequency were based on 97 search units in 2006 and 114 search units in 2013, 2016, and 2020.

Scientific Name	Common Name	Year	Minimum Cover Estimate (acres)	Maximum Cover Estimate (acres)	Frequency	EI	Mgmt
<i>Cornus foemina</i>	stiff dogwood	2013	0.0006	0.0239	0.88	n/a	n/a
<i>Cornus foemina</i>	stiff dogwood	2016	0.0006	0.0239	0.88	n/a	n/a
<i>Daucus carota</i> ^b	Queen Anne's lace	2016	0.0001	0.0022	0.88	I	I
<i>Daucus carota</i> ^b	Queen Anne's lace	2020	0.0014	0.0565	5.26	I	I
<i>Elymus repens</i> ^b	quackgrass	2016	0.0002	0.0065	2.63	ML	HM
<i>Euonymus alatus</i>	burningbush, winged euonymus	2006	0.0001	0.0022	1.03	LI	L
<i>Euonymus alatus</i> (increase from 2006)	burningbush, winged euonymus	2016	0.0031	0.1216	5.26	LI	L
<i>Euonymus alatus</i> (decrease from 2016)	burningbush, winged euonymus	2020	0.0001	0.0022	0.88	LI	L
<i>Euonymus fortunei</i>	winter creeper	2006	0.0297	0.7008	13.40	M	LI
<i>Euonymus fortunei</i>	winter creeper	2013	0.4352	4.4846	14.04	M	LI
<i>Euonymus fortunei</i>	winter creeper	2016	0.2302	4.3702	26.32	M	LI
<i>Euonymus fortunei</i>	winter creeper	2020	0.2111	4.4515	28.95	M	LI
<i>Glechoma hederacea</i>	ground ivy	2006	0.0012	0.0481	2.06	MI	U
<i>Glechoma hederacea</i>	ground ivy	2013	0.0060	0.1204	0.88	MI	U
<i>Glechoma hederacea</i> (increase from 2006)	ground ivy	2016	0.0664	1.3267	1.75	MI	U
<i>Glechoma hederacea</i>	ground ivy	2020	0.0067	0.1465	2.63	MI	U
<i>Hedera helix</i>	English ivy	2013	0.0001	0.0022	0.88	M	ML
<i>Hemerocallis fulva</i> ^b	orange daylily	2013	0.0006	0.0239	0.88	MI	L
<i>Hypericum perforatum</i> ^b	common St. Johnswort	2013	0.0098	0.2681	16.67	ML	M
<i>Hypericum perforatum</i> ^b	common St. Johnswort	2016	0.0004	0.0130	5.26	ML	M
<i>Hypericum perforatum</i> ^b	common St. Johnswort	2020	0.0016	0.0608	15.79	ML	M
<i>Juniperus virginiana</i> ^b	eastern redcedar	2013	0.0439	1.1429	29.82	Native	Native
<i>Juniperus virginiana</i> ^b	eastern redcedar	2016	0.1976	3.4279	30.70	Native	Native
<i>Juniperus virginiana</i> ^b	eastern redcedar	2020	0.3880	6.8181	31.58	Native	Native

^a Searched for in 2016 and 2020 only

^b Searched for in 2013, 2016, and 2020 only

^c Searched for in 2006 and 2020 only

Table 3 (continued). Cover and frequency of potentially problematic plants found in George Washington Carver National Monument. 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 high (H), medium (M), low (L), insignificant (I), a range of the above ranks, native (for species native to U.S.), or not available (n/a). The assignment of “decrease from” a particular year or “increase from” a particular year next to a species indicates that the cover in that year for that species changed relative to the noted year based on non-overlapping cover intervals. Note that cover and frequency were based on 97 search units in 2006 and 114 search units in 2013, 2016, and 2020.

Scientific Name	Common Name	Year	Minimum Cover Estimate (acres)	Maximum Cover Estimate (acres)	Frequency	EI	Mgmt
<i>Lespedeza cuneata</i>	sericea lespedeza	2006	0.3238	5.5455	35.05	ML	ML
<i>Lespedeza cuneata</i>	sericea lespedeza	2013	0.0150	0.5886	35.96	ML	ML
<i>Lespedeza cuneata</i>	sericea lespedeza	2016	0.2370	4.7536	62.28	ML	ML
<i>Lespedeza cuneata</i>	sericea lespedeza	2020	0.0773	1.6262	62.28	ML	ML
<i>Ligustrum sinense</i>	Chinese privet	2013	0.0272	0.6033	8.77	M	L
<i>Ligustrum vulgare</i>	European privet	2006	0.0540	0.8243	14.43	HL	HM
<i>Ligustrum vulgare</i>	European privet	2016	0.0115	0.3354	17.54	HL	HM
<i>Ligustrum vulgare</i>	European privet	2020	0.0095	0.2529	19.30	HL	HM
<i>Lonicera japonica</i>	Japanese honeysuckle	2006	4.4187	68.4449	27.84	M	HM
<i>Lonicera japonica</i> (decrease from 2006)	Japanese honeysuckle	2013	0.2843	3.7544	36.84	M	HM
<i>Lonicera japonica</i>	Japanese honeysuckle	2016	0.2318	4.5495	41.23	M	HM
<i>Lonicera japonica</i> (decrease from 2006)	Japanese honeysuckle	2020	0.0191	0.6330	41.23	M	HM
<i>Lonicera maackii</i>	Amur honeysuckle	2006	0.0006	0.0240	1.03	HM	M
<i>Lonicera maackii</i>	Amur honeysuckle	2013	0.0006	0.0239	0.88	HM	M
<i>Lonicera maackii</i>	Amur honeysuckle	2020	0.0001	0.0043	1.75	HM	M
<i>Maclura pomifera</i>	Osage orange	2006	1.6027	24.0821	19.59	ML	L
<i>Maclura pomifera</i>	Osage orange	2013	0.2717	3.8572	31.58	ML	L
<i>Maclura pomifera</i>	Osage orange	2016	0.7892	10.0690	29.82	ML	L
<i>Maclura pomifera</i>	Osage orange	2020	1.1110	17.6231	35.09	ML	L
<i>Melilotus officinalis</i>	yellow sweetclover	2006	0.0123	0.2488	5.15	M	M
<i>Melilotus officinalis</i>	yellow sweetclover	2013	0.0118	0.3463	13.16	M	M
<i>Melilotus officinalis</i>	yellow sweetclover	2016	0.0423	0.6004	19.30	M	M
<i>Melilotus officinalis</i>	yellow sweetclover	2020	0.0012	0.0456	9.65	M	M

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Table 3 (continued). Cover and frequency of potentially problematic plants found in George Washington Carver National Monument. 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 high (H), medium (M), low (L), insignificant (I), a range of the above ranks, native (for species native to U.S.), or not available (n/a). The assignment of “decrease from” a particular year or “increase from” a particular year next to a species indicates that the cover in that year for that species changed relative to the noted year based on non-overlapping cover intervals. Note that cover and frequency were based on 97 search units in 2006 and 114 search units in 2013, 2016, and 2020.

Scientific Name	Common Name	Year	Minimum Cover Estimate (acres)	Maximum Cover Estimate (acres)	Frequency	EI	Mgmt
<i>Morus alba</i>	white mulberry	2006	0.0098	0.2697	9.28	ML	ML
<i>Morus alba</i>	white mulberry	2016	0.0024	0.0912	10.53	ML	ML
<i>Morus alba</i>	white mulberry	2020	0.0068	0.1508	4.39	ML	ML
<i>Nasturtium officinale</i> ^b	watercress	2013	0.0013	0.0500	2.63	ML	MI
<i>Nasturtium officinale</i> ^b	watercress	2020	0.0001	0.0043	1.75	ML	MI
<i>Phalaris arundinacea</i>	reed canarygrass	2013	0.0001	0.0022	0.88	H	HM
<i>Poa compressa</i>	Canada bluegrass	2013	0.0008	0.0304	3.51	ML	HL
<i>Poa compressa</i>	Canada bluegrass	2020	0.0008	0.0304	3.51	ML	HL
<i>Poa compressa/pratensis</i>	Canada/Kentucky bluegrass complex	2006	0.7709	15.0722	7.22	M	M
<i>Poa compressa/pratensis</i> (decrease from 2006)	Canada/Kentucky bluegrass complex	2020	0.0006	0.0239	0.88	M	M
<i>Poa pratensis</i>	Kentucky bluegrass	2013	0.2871	5.0666	64.91	M	ML
<i>Poa pratensis</i>	Kentucky bluegrass	2016	1.5997	20.6231	59.65	M	ML
<i>Poa pratensis</i>	Kentucky bluegrass	2020	0.1851	3.4001	61.40	M	ML
<i>Potamogeton crispus</i> ^b	curly pondweed	2013	0.0007	0.0261	1.75	M	ML
<i>Potamogeton crispus</i> ^b	curly pondweed	2016	0.0001	0.0043	1.75	M	ML
<i>Potentilla recta</i>	sulphur cinquefoil	2006	0.0003	0.0109	5.15	HL	ML
<i>Pyrus calleryana</i> ^a	Callery pear	2016	0.0308	0.2650	10.53	LI	ML
<i>Pyrus calleryana</i> ^a	Callery pear	2020	0.0081	0.2008	15.79	LI	ML
<i>Rhus copallinum</i> ^b	winged sumac	2013	0.0982	1.9841	42.11	native	native
<i>Rhus copallinum</i> ^b	winged sumac	2016	0.1298	2.0446	32.46	native	native
<i>Rhus copallinum</i> ^b	winged sumac	2020	0.4607	5.4957	40.35	native	native

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^b Searched for in 2013, 2016, and 2020 only

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Table 3 (continued). Cover and frequency of potentially problematic plants found in George Washington Carver National Monument. 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 high (H), medium (M), low (L), insignificant (I), a range of the above ranks, native (for species native to U.S.), or not available (n/a). The assignment of “decrease from” a particular year or “increase from” a particular year next to a species indicates that the cover in that year for that species changed relative to the noted year based on non-overlapping cover intervals. Note that cover and frequency were based on 97 search units in 2006 and 114 search units in 2013, 2016, and 2020.

Scientific Name	Common Name	Year	Minimum Cover Estimate (acres)	Maximum Cover Estimate (acres)	Frequency	EI	Mgmt
<i>Rhus glabra</i>	smooth sumac	2006	0.6993	7.4716	19.59	native	native
<i>Rhus glabra</i> (decrease from 2006)	smooth sumac	2013	0.0116	0.4604	19.30	native	native
<i>Rhus glabra</i> (decrease from 2006)	smooth sumac	2016	0.0063	0.2476	21.05	native	native
<i>Rhus glabra</i> (decrease from 2006)	smooth sumac	2020	0.0148	0.3494	10.53	native	native
<i>Rosa multiflora</i>	multiflora rose	2006	0.7342	11.5333	37.11	L	L
<i>Rosa multiflora</i>	multiflora rose	2013	0.0812	1.9088	35.09	L	L
<i>Rosa multiflora</i>	multiflora rose	2016	0.0364	1.0823	39.47	L	L
<i>Rosa multiflora</i>	multiflora rose	2020	0.0281	0.8728	37.72	L	L
<i>Rumex acetosella</i>	common sheep sorrel	2013	0.0056	0.2215	10.53	LI	H
<i>Rumex crispus</i> ^b	curly dock	2013	0.0308	1.2162	61.40	LI	ML
<i>Rumex crispus</i> ^b	curly dock	2016	0.0018	0.0652	26.32	LI	ML
<i>Rumex crispus</i> ^b	curly dock	2020	0.0063	0.2346	68.42	LI	ML
<i>Schedonorus arundinaceus</i>	tall fescue	2013	0.8638	11.2257	79.82	M	HM
<i>Schedonorus arundinaceus</i>	tall fescue	2016	3.2554	30.5952	56.14	M	HM
<i>Schedonorus arundinaceus</i>	tall fescue	2020	2.4688	26.8946	60.53	M	HM
<i>Securigera varia</i>	crown vetch	2006	0.3033	2.4271	1.03	H	L
<i>Securigera varia</i>	crown vetch	2013	0.0314	0.2889	2.63	H	L
<i>Securigera varia</i> (decrease from 2006, 2013)	crown vetch	2016	0.0007	0.0261	1.75	H	L
<i>Securigera varia</i> (decrease from 2006, 2013)	crown vetch	2020	0.0007	0.0261	1.75	H	L

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^b Searched for in 2013, 2016, and 2020 only

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Table 3 (continued). Cover and frequency of potentially problematic plants found in George Washington Carver National Monument. 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 high (H), medium (M), low (L), insignificant (I), a range of the above ranks, native (for species native to U.S.), or not available (n/a). The assignment of “decrease from” a particular year or “increase from” a particular year next to a species indicates that the cover in that year for that species changed relative to the noted year based on non-overlapping cover intervals. Note that cover and frequency were based on 97 search units in 2006 and 114 search units in 2013, 2016, and 2020.

Scientific Name	Common Name	Year	Minimum Cover Estimate (acres)	Maximum Cover Estimate (acres)	Frequency	EI	Mgmt
<i>Sonchus arvensis</i>	field sowthistle	2013	0.0001	0.0022	0.88	LI	HL
<i>Sonchus arvensis</i>	field sowthistle	2016	0.0007	0.0239	9.65	LI	HL
<i>Sorghum halepense</i>	Johnsongrass	2006	0.4822	7.8821	28.87	ML	HM
<i>Sorghum halepense</i>	Johnsongrass	2013	0.0167	0.6581	28.95	ML	HM
<i>Sorghum halepense</i>	Johnsongrass	2016	0.1639	2.4399	34.21	ML	HM
<i>Sorghum halepense</i>	Johnsongrass	2020	0.3800	6.3748	37.72	ML	HM
<i>Torilis arvensis</i> ^b	spreading hedgeparsley	2013	0.0456	1.4450	54.39	n/a	n/a
<i>Torilis arvensis</i> ^b	spreading hedgeparsley	2016	0.0092	0.3562	38.60	n/a	n/a
<i>Torilis arvensis</i> ^b	spreading hedgeparsley	2020	0.0284	0.7630	42.11	n/a	n/a
<i>Torilis japonica</i>	erect hedgeparsley	2006	0.3033	2.4271	1.03	n/a	n/a
<i>Ulmus pumila</i>	Siberian elm	2013	0.0007	0.0261	1.75	ML	ML
<i>Ulmus pumila</i>	Siberian elm	2016	0.0010	0.0347	14.04	ML	ML
<i>Ulmus pumila</i>	Siberian elm	2020	0.0004	0.0152	6.14	ML	ML
<i>Verbascum thapsus</i>	common mullein	2006	0.0009	0.0350	6.19	ML	L
<i>Verbascum thapsus</i>	common mullein	2013	0.0019	0.0717	11.40	ML	L
<i>Verbascum thapsus</i>	common mullein	2016	0.0006	0.0217	8.77	ML	L
<i>Verbascum thapsus</i>	common mullein	2020	0.0001	0.0022	0.88	ML	L
<i>Vicia villosa</i> ^c	winter vetch	2006	0.0667	0.6061	3.09	n/a	n/a

^a Searched for in 2016 and 2020 only

^b Searched for in 2013, 2016, and 2020 only

^c Searched for in 2006 and 2020 only

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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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Natural Resource Stewardship and Science

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