National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Invasive Exotic Plant Monitoring at Golden Spike National Historical Park

2018 Field Season

Natural Resource Report NPS/NCPN/NRR—2019/1938



ON THE COVER

Cheatgrass (*Bromus tectorum*) growing in the railroad bed at Golden Spike National Historical Park. NPS/Luke Gommermann.

Invasive Exotic Plant Monitoring at Golden Spike National Historical Park

2018 Field Season

Natural Resource Report NPS/NCPN/NRR—2019/1938

Prepared by
Amy Washuta
Dustin W. Perkins
Northern Colorado Plateau Network
National Park Service
P.O. Box 848
Moab, UT 84532

Editing and Design
Alice Wondrak Biel
Northern Colorado Plateau Network
National Park Service
P.O. Box 848
Moab, UT 84532

June 2019

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

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate comprehensive information and analysis about natural resources and related topics concerning lands managed by the National Park Service. The series supports the advancement of science, informed decision-making, and the achievement of the National Park Service mission. The series also provides a forum for presenting more lengthy results that may not be accepted by publications with page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from the Northern Colorado Plateau Network website, as well as at the Natural Resource Publications Management website. If you have difficulty accessing information in this publication, particularly if using assistive technology, please email irma@nps.gov.

Please cite this publication as:

Washuta, A., and D. W. Perkins. 2019. Invasive exotic plant monitoring at Golden Spike National Historical Park: 2018 field season. Natural Resource Report NPS/NCPN/NRR—2019/1938. National Park Service, Fort Collins, Colorado.

NPS 431/154154, June 2019

Contents

Figures v
Tables v
Executive Summary vii
Acknowledgements ix

1 Introduction 1

2 Methods 3
2.1 Developing a park target invasive exotic plant list 3
2.2 Monitoring routes 4
2.3 Monitoring transects 5
2.4 Analyses 6

3 Results 7
3.1 Monitoring routes 7
3.2 Monitoring transects 11

4 Discussion 19

5 Literature Cited 21

Appendices 23

Figures

Figure 2-1. The maximum Effective Detection Distance (EDD) at Golden Spike National Historical Park ranged from 5 to 10 meters in 2018, making the Effective Detection Swath Width (EDSW) 10–20 meters. 4

Figure 3-1. Invasive exotic plant patches detected along monitoring routes, Administrative Area, Golden Spike National Historical Park, July 2–4, 2018. 8

Figure 3-2. Invasive exotic plant patches detected along monitoring routes, Big Fill Area, Golden Spike National Historical Park, July 2–4, 2018. 9

Figure 3-3. Number of patches and patch management index (PMI) of select priority IEP species along the same monitoring routes at Golden Spike National Historical Park, 2008–2018. 14

Figure 3-4. Invasive exotic plant monitoring transects, Golden Spike National Historical Park, July 2–4, 2018 15

Figure 3-5. Percent cover with standard error of IEPs that were consistently recorded in transects in 2008, 2010, 2014, 2016, and 2018 at Golden Spike National Historical Park 16

Figure 3-6. Percent of transects in which three common IEPs were recorded in 2008, 2010, 2014, 2016, and 2018 at Golden Spike National Historical Park 16

Tables

Table 2-1. Priority invasive exotic plant list, Golden Spike NHP, 2008–2018. 3

Table 3-1. Invasive exotic plants detected at Golden Spike NHP, July 2–4, 2018. 7

Table 3-2. Number of priority IEP patches per route, and patches per kilometer route type, Golden Spike NHP, July 2–4, 2018. 10

Table 3-3. Number of priority IEP patches detected along monitoring routes by patch size class and patch management index, Golden Spike NHP, July 2–4, 2018. 10

Table 3-4. Number of patches per kilometer of priority species monitored along the same routes, Golden Spike NHP, 2008–2018. 12

Table 3-5. Number of monitoring transects where three commonly encountered exotic plant species were detected/total transects monitored, mean percent cover, and standard error by monitoring route, Golden Spike NHP, 2008–2018. 17

Appendix A. Exotic plant patches detected on monitoring routes, Golden Spike NHP, July 2–4, 2018. 23

Appendix B. Exotic plant transect data detected at Golden Spike NHP, July 2–4, 2018. 26

Executive Summary

Invasive exotic plant (IEP) species are one of the biggest threats to natural ecosystem integrity and biodiversity, and controlling them is a high priority for the National Park Service. The Northern Colorado Plateau Network (NCPN) selected the early detection of IEPs as one of 11 monitoring protocols to be implemented as part of its long-term monitoring program. This report represents work completed during the 2018 field season at Golden Spike National Historical Park (NHP). On July 2–4, 2018, we recorded a total of 17 IEP species during monitoring at Golden Spike NHP. Seven priority species were detected in 73 patches along 20 kilometers (12.4 miles) of 13 monitoring routes that covered all major roads, trails, and riparian areas. Three additional IEP species were recorded only in transects. The highest densities of plant patches were recorded along the Hydro 1 and Last Cut drainages and Retired Service and Facility roads. Scotch thistle (*Onopordum acanthium*) was the most prevalent priority species, representing 51% of all recorded patches. Field bindweed (*Convolvulus arvensis*), rush skeletonweed (*Chondrilla juncea*), and moth mullein (*Verbascum blattaria*) constituted most other patches. One patch of broad-leaf pepperwort (*Lepidium latifolium*) and one patch of Canada thistle (*Cirsium arvense*) were found in 2018; neither species had been found since 2014. A voucher specimen of broad-leaf pepperwort was collected. The number of IEP patches and total IEP patches per kilometer did not change greatly between 2016 (67/3.43) and 2018 (73/3.74). The total IEP patches per kilometer remained lower than in 2014 (4.96), but has increased since the earlier monitoring seasons of 2010 (2.33) and 2012 (0.36). This year, a metric called the patch management index (PMI) was added to our analysis. PMI combines the size and density of a patch to assess its scale. Almost all patches (96%) were classified as "very low" or "low" in PMI, suggesting that effective control or eradication is possible through local management actions. The network will return to Golden Spike NHP for a seventh year of monitoring in 2020.

Acknowledgements

L. Gommermann and K. Fahey conducted field work. A. Wight was extremely helpful in generating routes, quadrats, and other GIS information. L. Crossland assisted with reviewing the park target invasive plant list and arranging site logistics. D. Witwicki and L. Gommermann improved this report with their thoughtful reviews. Data management was provided by H. Thomas. S. Karinen and M. Schrade assisted with logistical and administrative details.

1 Introduction

Invasive exotic species fragment native ecosystems, displace native plants and animals, and alter ecosystem function. Invasive species are second only to habitat loss as threats to global biodiversity (Scott and Wilcove 1998) and represent one of the most serious threats to natural ecosystem integrity (NRC 2002). Biological invasions are occurring at accelerated rates in nearly every major ecosystem (Mooney and Hobbs 2000). Exotic plants negatively affect park resources and visitor enjoyment by altering landscapes and fire regimes, reducing native plant communities and animal habitat, and increasing trail-maintenance needs. Recognizing these challenges, Northern Colorado Plateau Network (NCPN) parks identified invasive exotic plants (IEPs) as a high-priority vital sign for long-term monitoring (O'Dell et al. 2005).

IEPs are a subset of exotic plants "whose introduction does or is likely to cause economic or environmental harm or harm to human health" (Executive Order 13112). With the aim of facilitating strategic control approaches, this monitoring program detects early invasions, identifies existing invasions, and, to the extent possible, tracks changes in the abundance and distribution of target IEPs in parks along key invasive pathways.

Invasive exotic plants can spread into national parks via a number of different pathway types. Predictable IEP pathways include roads, trails, and riparian corridors. Long-distance dispersal through cargo containers and air freight are examples of sudden pathways. Anthropogenic pathways include horticultural escapes and seeds transported on shoes and in restoration seed mixes. For the National Park Service (NPS), the consequences of these plant invasions present a significant challenge to the agency's ability to maintain natural resources "unimpaired for the enjoyment of future generations."

Because regular, comprehensive monitoring of the distribution and abundance of all exotic plant species within NCPN units is beyond the fiscal capabilities of the network and parks, the NCPN focuses on the most likely areas where a broad range of invasive exotic plants may occur: riparian corridors, roads, trails, areas of high visitor impact (e.g., campgrounds), and park boundaries. This approach is cost-effective for finding many new invasions in areas where they are most likely to occur, but it may miss exotic plants dispersed to the interior areas of large parks by wind and/or animals.

Specific objectives of NCPN invasive exotic plant monitoring are:

1. To detect incipient populations and new introductions of invasive plant species before they become established in areas of management significance and invasion pathways, and
2. To determine status and trends of selected invasive plant populations of management significance.

This report summarizes the 2018 field season and sixth complete monitoring visit at Golden Spike National Historical Park (NHP, formerly Golden Spike National Historic Site).

2 Methods

We followed the invasive plant monitoring protocol developed by the NCPN (Perkins et al. 2016), adapted from Andersen and Dewey (2007). The protocol emphasizes quick collection of IEP location and abundance data in order to maximize the amount of area searched, thus increasing our chances of finding a higher percentage of both new invasions and established IEPs. By focusing on roads, trails, and waterways, which are major vectors for invasive plants, we capture the greatest amount of information (i.e., benefit) with the least amount of time and effort (i.e., cost).

After park and NCPN staff reviewed the list of target invasive plants (see Section 2.1), we established a series of co-located monitoring routes and quadrats along all roads, major drainages, and trails in the park. The quadrats, which are sampled in a quantitative manner, are used to make inference to the percent cover of IEPs located along the park's invasive pathways (i.e., the monitoring routes) and allow us to estimate trends in IEP percent cover over time. The monitoring routes, which are not quantitatively sampled, are used to increase the spatial coverage of mapping performed, with the goal of maximizing our opportunities for detecting IEPs in the park.

All roads, trails, and riparian areas surveyed in 2018 were previously surveyed with monitoring routes and quadrats in 2008, 2010, 2012, 2014, and 2016 (Perkins and Weissinger 2009; Perkins 2011, 2013, 2015, 2017).

2.1 Developing a park target invasive exotic plant list

Prior to beginning monitoring in 2018, NCPN and park staff reviewed the list of high-priority target IEPs (Table 2-1) that was initially developed in 2008 and then reviewed in 2010, 2012, 2014, and 2016. No species were added in 2018. The original list was developed by reviewing past park literature and state and county weed lists, and consulting with park staff and county weed managers. The list of priority species will be reviewed again before each field season.

Our high-priority target IEP list includes existing IEPs and potential IEPs of high management concern. Because these methods were designed to be rapid, field crews were trained to develop a focused search image on the target plants, instead of looking for every possible invasive plant species. Species on our IEP priority list generally have the potential to be managed or even eradicated within the park.

Table 2-1. Priority invasive exotic plant list, Golden Spike NHP, 2008–2018.

Scientific name	Common name
Cardaria sp.	whitetop
Carduus nutans	musk thistle
Centaurea diffusa	diffuse knapweed
Centaurea maculosa	spotted knapweed
Centaurea repens	Russian knapweed
Centaurea solstitialis	yellow starthistle
Centaurea virgata	squarrose knapweed
Chondrilla juncea	rush skeletonweed
Cirsium arvense	Canada thistle
*Convolvulus arvensis**	field bindweed
Crupina vulgaris	common crupina
Elymus repens	quackgrass
Euphorbia esula	leafy spurge
Hypericum perforatum	common St. John's wort
Isatis tinctoria	Dyer's woad
Lepidium latifolium	broad-leaf pepperwort
Linaria dalmatica	Dalmatian toadflax
Marrubium vulgare	horehound
Onopordum acanthium	Scotch thistle
Salvia aethiopsis	Mediterranean sage
Senecio jacobaea	tansy ragwort
Taeniatherum caput-medusae	Medusahead
Tribulus terrestris	puncturevine
Verbascum blattaria	moth mullein

*Not on list in 2010 or 2012.

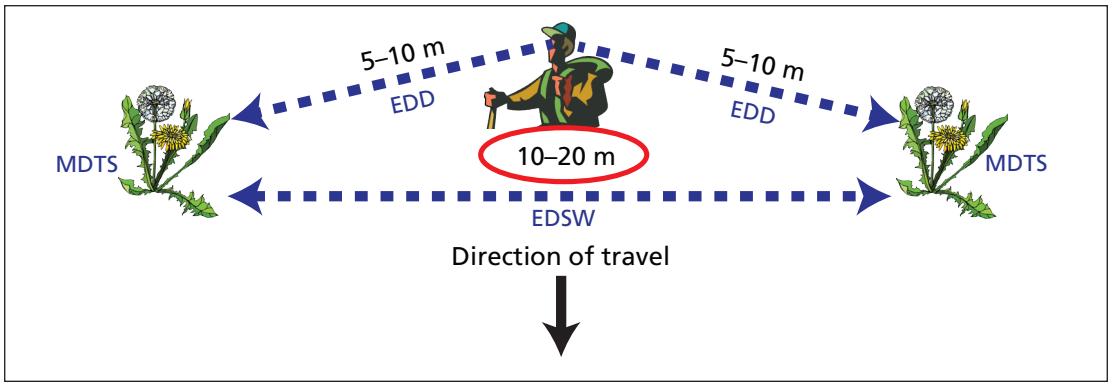


Figure 2-1. The maximum Effective Detection Distance (EDD) at Golden Spike National Historical Park ranged from 5 to 10 meters in 2018, making the Effective Detection Swath Width (EDSW) 10–20 meters.

2.2 Monitoring routes

2.2.1 Minimum detection target size

The minimum detection target size (MDTS) represents the patch size that was large enough to detect with a high level of confidence (typically at least 90% of the total number of patches of that size and larger in the monitoring area) under actual field conditions, but small enough so that any missed patches smaller than the MDTS could still feasibly be eradicated if not found until the next scheduled monitoring visit. The NCPN has established an MDTS of 40 m^2 (~20 × 20 ft) for all IEPs. Use of the MDTS is necessary because field technicians are not expected to find every single plant of every targeted weed species during route surveys. Although searching for single mature plants of some species, such as Russian olive (*Elaeagnus angustifolia*) and tamarisk (*Tamarix ramosissima*), is possible due to their large size, single plants of other species, such as field bindweed (*Convolvulus arvensis*), are nearly impossible to detect in most field conditions.

2.2.2 Effective detection distance

The effective detection distance (EDD) is the maximum distance from which a searcher could consistently detect (i.e., see and recognize) the MDTS of the least-visible targeted species with at least 90% detection efficiency (Figure 2-1). Crew members are trained by using fake plants of a targeted size and walking away and determining the maximum distance from which they could consistently see and recognize the patch with complete confidence. The size of the EDD is then estimated in the field by crew members. The distance is measured either by pacing or using a laser rangefinder. The EDD for Golden Spike NHP was between 5 and 10 meters in 2018, depending on vegetation.

2.2.3 Effective detection swath width

Effective detection swath width (EDSW) is defined as the maximum width of a linear search swath (band transect) in which a walking observer is confident of visually detecting 90% of all target species of the MDTS (Figure 2-1). The effective detection swath width (EDSW) is equal to two times the EDD, because the surveyor is able to effectively detect weeds for one EDD on either side of his/her search route. The EDSW ranged from 10 to 20 meters at Golden Spike NHP in 2018.

2.2.4 Patch separation resolution

We define patch separation resolution (PSR) as the minimum distance between plants that must be considered members of separate patches. Individuals or clusters of a target species separated by the PSR distance or more are recorded as separate patches. We consider plants separated by less than the PSR to be a single patch. The PSR is set at 50 meters, based on the assumption that most plants or groups of plants separated by less than 50 meters are typically considered to be one patch during planning and implementation of weed-control operations. If a patch is continuous for more than 50 meters, then cover estimates are made every 50 meters to aid in developing an effective management strategy for the entire patch.

2.2.5 Between feature position

Between feature positions allow electronic tracking of a user's route. GPS units are set to automatically generate these positions at a distance equal to the EDSW. Each time a surveyor walks the equivalent of one EDSW, the GPS unit creates a point.

2.2.6 Data collection methods

We walked one EDD out from one side of a monitoring route and then returned to the starting point by walking back one EDD from the route on the other side. While walking, we searched for IEPs by visually scanning (side-to-side) all of the land within the borders of the swath. However, if the terrain was uneven or steep, and the observer had to glance frequently at the ground to ensure safe foot placement, then searchers stopped approximately every 10–20 meters (the length of one EDSW) and visually scanned the area in all directions. As monitoring routes were traversed, locations of all target species were documented using global positioning system (GPS) units with at least five-meter accuracy.

Only species designated as priority were consistently recorded on monitoring routes. When a priority IEP was discovered, we recorded the following information: (1) monitoring route, (2) sequential number of the invasion per monitoring route, (3) patch size class (see below), (4) whether the plant was pulled, and (5) cover class (see below). If several species were present with similar distributions at a single point, then we recorded a point for each individual species and assigned it its own sequential identification number. Invasions more than 50 meters (55 yards) apart were considered separate invasions and recorded with a separate point.

Patch size class was estimated as follows:

1. 1–3 plants (used for isolated single plants or very small patches (≤2 × 2 m),
2. Four plants–40 m^2 (48 yd^2),
3. 40–400 m^2 (48–478 yd^2),
4. 400–1,000 m^2 (0.1–0.25 acre), and
5. 1,000–2,000 m^2 (0.25–0.5 acre).

We recorded cover class by estimating the amount, or "percentage," of ground covered by the vertical projection of plant matter as visualized from a bird's-eye view of the vegetation (Elzinga et al. 1998). This estimate included both the living and dead standing material of the vegetation of a single plant species. Percent cover of a patch was recorded using the following classes:

1. Trace (<1%)
2. Low (1–5%)
3. Moderate (6–25%)
4. High (26–50%)
5. Majority (51–100%).

We recorded the following ancillary information with every patch: descriptive notes (e.g., hillside, distance to road, wetland, or stream), the growth stage of exotic trees (i.e., seedling, sapling, mature, old growth), evidence of prior treatment, and evidence of disturbances (e.g., recent fire, flood, small-mammal disturbance).

2.3 Monitoring transects

In 2008, 2016, and 2018, we established transects with three vegetation quadrats every 500 meters along monitoring routes. In 2010, 2012, and 2014, we altered our methods slightly. There were still transects every 500 meters. However, if no invasives were detected for three consecutive transects (9 quadrats), then transects were established every 1,000 meters. If invasive plants were found in categories greater than 1 for cover class or patch size class, then we reverted to transects every 500 meters.

2.3.1 Quadrat establishment

We centered vegetation quadrats at 0.5, 5, and 10 meters away from the edge of a route on the same side as the route that was being walked and on alternating sides for riparian areas, small roads, or trails. A 1-m^2 sampling frame was used to sample vegetation cover and soil surface features. Observers could make additional species observations, but non-priority species were not thoroughly mapped.

Quadrat sampling methods used in the 2008 pilot field season differed slightly from those in all subsequent years. In 2008, all invasive species were recorded in monitoring quadrats, and quadrats were embedded in a larger (177-m^2) macroplot centered five meters from the monitoring route.

2.3.2 Data collection methods

In the monitoring quadrats, all priority IEP species observed were recorded. In all years except 2012, cheatgrass (*Bromus tectorum*) and crested wheatgrass (*Agropyron cristatum*) were also recorded in transects. Starting in 2014, observers also recorded tumble mustard (*Sisymbrium altissimum*) in quadrats. For each quadrat, we recorded percent cover of each IEP using the following classes: <1, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100%. Prior to 2018, cover was recorded using the following classes: <1, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11–25, 26–50, or >50%. We also recorded percent cover to the nearest 10% of dominant soil surface features (i.e., dead wood, dung, fungus, lichen, litter/duff, live root/bole, mineral soil/sediment, moss, biological soil crust, road, rock, standing water/flooded, stream, or trash/junk).

2.4 Analyses

We calculated the mean number of patches per kilometer for monitoring routes. Percent cover estimates were generated from the monitoring quadrat data. We calculated the mean and standard error of percent cover by species for monitoring quadrats. For cover classes representing a range of values (this occurred in years prior to 2018), midpoints were used when calculating the mean and standard error. Due to differences in observers' knowledge, only priority species were used when comparing results across years.

We developed a patch management index (PMI) to quantify both the extent and the density of a patch into a single value that helps identify the scale of the problem. Park managers will be able to use this tool to help prioritize IEP treatment. PMI was determined using the following formula:

Patch size class (1–5) × Cover class (1–5) = Patch management index (1–25)

We then grouped PMI into five classes:

1. Very low (1–5)
2. Low (6–10)
3. Moderate (11-–15)
4. High (16–20)
5. Very high (21–25)

Patches identified as very low or low PMI will generally be easier to control or remove than patches with a high or very high PMI. In many cases, directing resources toward controlling patches with very low or low PMI can be a highly effective management strategy; the goal of early detection is to allow managers to eliminate patches before they can grow into bigger problems. Other times, a species with many inventoried patches that are mostly very low or low in PMI may or may not be easier to treat (and possibly eradicate) than a different species that has few inventoried patches that are high or very high in PMI. Therefore, park managers should consider PMI within the context of information on species and patch numbers.

3 Results

3.1 Monitoring routes

3.1.1 2018 results

In 2018, we recorded a total of 17 IEP species during monitoring at Golden Spike National Historical Park (Table 3-1). Seven priority species were detected in 73 patches along 20 kilometers (12.4 miles) of 13 monitoring routes (Figures 3-1, 3-2; Tables 3-1, 3-2; Appendix A). We established one new monitoring route: the VC Sidewalk Area. The highest densities of plant patches were recorded along the Hydro 1 (20.3/km) and Last Cut (10.7 km) drainages and Retired Service (11.5 km) and Facility (7.4 km) roads (Table 3-2). Scotch thistle (*Onopordum acanthium*) was the most prevalent priority species, representing 51% of all recorded patches (Table 3-3). Field bindweed (*Convolvulus arvensis*), rush skeletonweed (*Chondrilla juncea*), and moth mullein (*Verbascum blattaria*) constituted most other patches.

Of the 73 patches, 21 (29%) were larger than 40 m^2 (Table 3-3). Almost all patches (96%) were classified as "very low" or "low" on the patch management index, indicating they were relatively small in size, low in cover, or both. Moth mullein stood out as having the largest patches: six were 1,000–2,000 m^2 and three were classified as "medium" to "very high" in PMI. Scotch thistle patches were prevalent, but most (86%) were less than 40 m^2 and classified as "very low" in PMI.

In 2018, the NCPN field crew observed several exotic species not currently on the priority list. Summer cypress (*Bassia scoparia*) was seen in moderate cover near the western end of the county road near the visitor center. Rattlesnake brome (*Bromus briziformis*) was seen along the Big Fill Section County Road and Last Cut Drainage, and one infestation was mapped (see Figure 3-2). Japanese brome (*Bromus japonicus*) was seen at the end of the Residence Service Road and near the end of the Pacific Track Grade. Tansy mustard (*Descurainia sophia*) was observed in trace cover along routes near the visitor center. Yellow sweetclover (*Melilotus officinalis*) was seen in trace-to-moderate cover along roadsides and in Last Cut Drainage. Russian thistle (*Salsola* sp.) was seen in low-to-high covers along Poulsons Road and in lower cover in Last Cut Drainage. Yellow

Table 3-1. Invasive exotic plants detected at Golden Spike NHP, July 2–4, 2018.

Scientific name	Common name	Method detected		Park priority?
		Routes	Transects	
Cirsium arvense	Canada thistle	✓	–	Yes
Chondrilla juncea	rush skeletonweed	✓	–	Yes
Convolvulus arvensis	field bindweed	✓	✓	Yes
Isatis tinctoria	Dyer's woad	✓	–	Yes
Lepidium latifolium	broad-leaf pepperwort	✓	–	Yes
Onopordum acanthium	Scotch thistle	✓	–	Yes
Verbascum blattaria	moth mullein	✓	–	Yes
Agropyron cristatum	crested wheatgrass	–	✓	Transect only*
Bromus tectorum	cheatgrass	–	✓	Transect only*
Sisymbrium altissimum	tumble mustard	–	✓	Transect only*
Bassia scoparia	summer cypress	✓	–	No
Bromus briziformis	rattlesnake brome	✓	–	No
Bromus japonicus	Japanese brome	✓	–	No
Descurainia sophia	tansy mustard	✓	–	No
Melilotus officinalis	yellow sweetclover	✓	–	No
Salsola sp.	Russian thistle	✓	–	No
Tragopogon dubius	yellow salsify	✓	–	No

*"Transect only" species are recorded only in transects (not along monitoring routes).

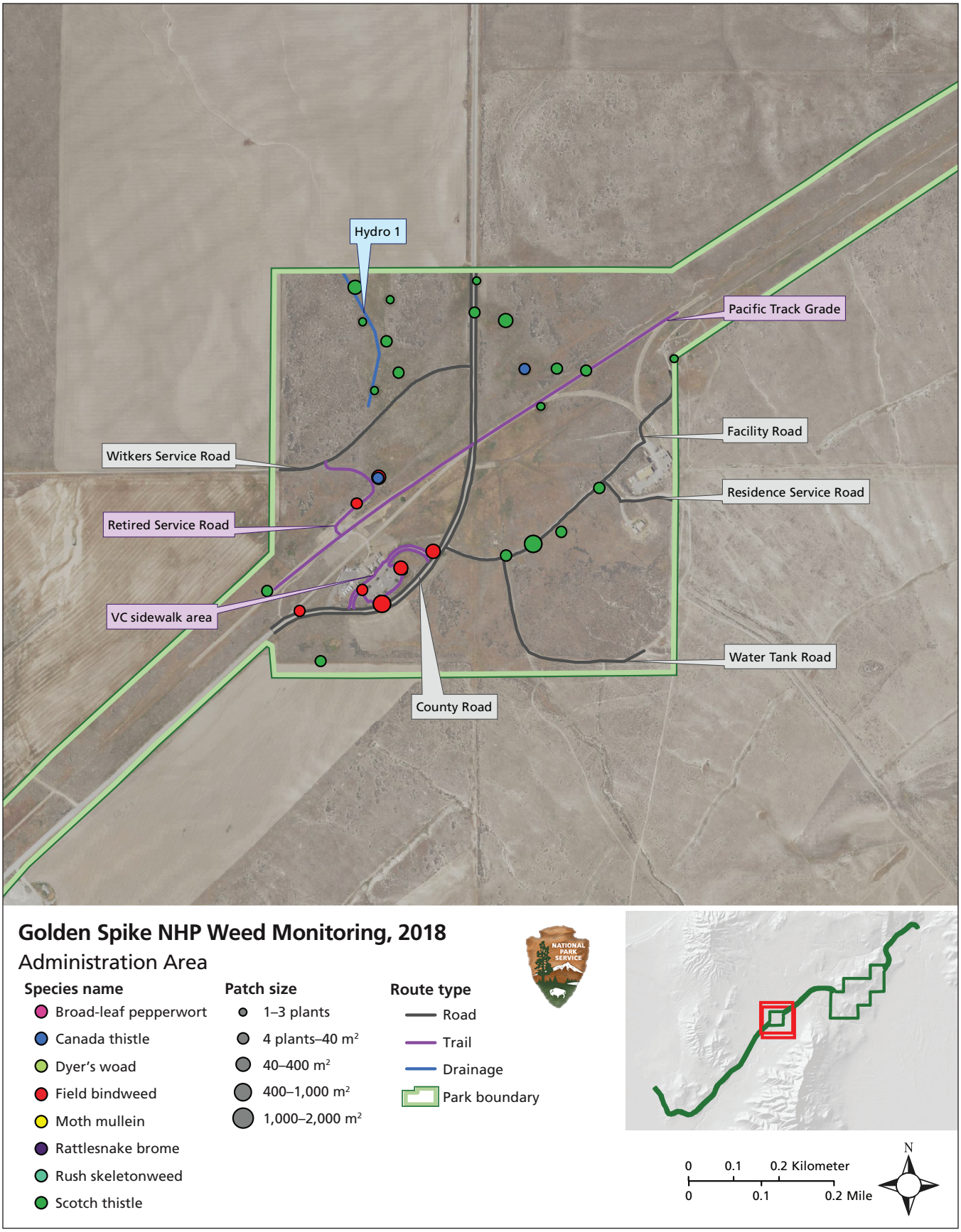


Figure 3-1. Invasive exotic plant patches detected along monitoring routes, Administrative Area, Golden Spike National Historical Park, July 2–4, 2018.

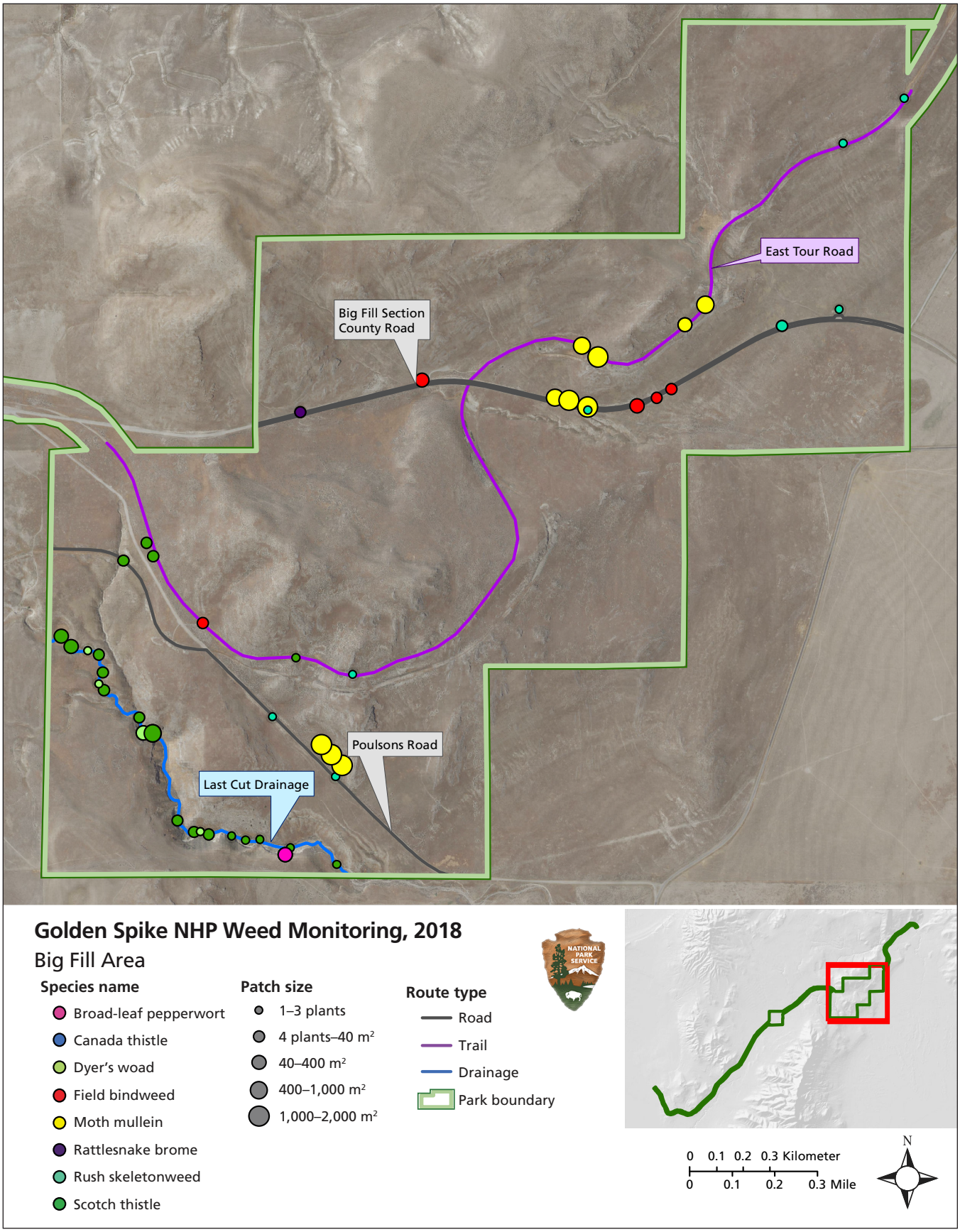


Figure 3-2. Invasive exotic plant patches detected along monitoring routes, Big Fill Area, Golden Spike National Historical Park, July 2–4, 2018.

Table 3-2. Number of priority IEP patches per route, and patches per kilometer route type, Golden Spike NHP, July 2–4, 2018.

Route	Route type	Length (km)	Patches	Patches/km
Hydro 1	Riparian	0.295	6	20.3
Last Cut Drainage	Riparian	1.873	20	10.7
All Riparian		*2.168*	*26*	*12.0*
Big Fill Section County R.	Road	5.152	10	1.9
County Road	Road	1.972	5	2.5
East Tour Road	Road	5.161	11	2.1
Facility Road	Road	0.676	5	7.4
Poulsons Road	Road	2.067	6	2.9
Residence Service Road	Road	0.163	0	0.0
Retired Service Road	Road	0.260	3	11.5
Water Tank Road	Road	0.448	0	0.0
Visitor Center Sidewalk Area	Road	0.551	3	5.4
Witkers Service Road	Road	0.462	0	0.0
All Roads		*16.910*	*43*	*2.5*
Pacific Track Grade	Trail	0.997	4	4.0
Overall totals		20.076	73	3.64

Table 3-3. Number of priority IEP patches detected along monitoring routes by patch size class and patch management index, Golden Spike NHP, July 2–4, 2018.

			Patch size class[a]					Patch management index[b]				
Scientific name	Common name	Total patches	1	2	3	4	5	Very low	Low	Medium	High	Very high
Chondrilla juncea	rush skeletonweed	8	7	1	0	0	0	8	0	0	0	0
Cirsium arvense	Canada thistle	1	0	1	0	0	0	0	1	0	0	0
Convolvulus arvensis	field bindweed	12	0	6	5	1	0	2	10	0	0	0
Isatis tinctoria	Dyer's woad	4	3	1	0	0	0	4	0	0	0	0
Lepidium latifolium	broad-leaf pepperwort	1	0	0	1	0	0	0	1	0	0	0
Onopordum acanthium	Scotch thistle	37	13	19	3	2	0	29	8	0	0	0
Verbascum blattaria	moth mullein	10	0	1	0	3	6	7	0	2	0	1
Total		**73**	**23**	**29**	**9**	**6**	**6**	**50**	**20**	**2**	**0**	**1**

[a]Patch size classes: 1 = 1–3 plants (≤2 × 2 m), 2 = 4 plants–40 m^2 (48 yd^2), 3 = 40–400 m^2 (48–478 yd^2), 4 = 400–1,000 m^2 (0.1–0.25 acre), 5 = 1,000–2,000 m^2 (0.25–0.5 acre).

[b]PMI classes: Very low (1–5), Low (6–10), Medium (11–15), High (16–20), Very high (21–25). PMI = Patch size class (1–5) × Patch percent cover (1–5).

salsify (*Tragopogon dubius*) was seen in trace cover across most of the park.

3.1.2 Priority patches over time

For IEP species consistently monitored from 2008 to 2018, there were a total of 3.74 patches per kilometer in 2018, which was similar to 2016 (3.43 patches/km) (Table 3-4). The lowest patches per kilometer (0.36) occurred in 2012, after several exotic-plant treatments within the park (NPS 2012). Since a sharp decline in 2012, Scotch thistle has been increasing in total number of patches—though in both 2016 and 2018, all patches were "very low" or "low" on the patch management index (Figure 3-3). Moth mullein has been increasing in both number of patches and PMI class since it was first detected in 2010. Conversely, field bindweed and Dyer's woad (*Isatis tinctoria*) remained much less common in recent sampling years than they were in earlier sampling years—though they both appear to have rebounded from very low numbers or absence in 2010 and 2012. Rush skeletonweed has declined in patches per kilometer each sampling year since 2014.

3.2 Monitoring transects

We sampled a total of 42 transects in 2018 (Figure 3-4, Appendix B). The only priority species detected on a transect was field bindweed, with one detection. However, the non-priority, transect-only species, crested wheatgrass (*Agropyron cristatum*), cheatgrass (*Bromus tectorum*), and tumble mustard (*Sisymbrium altissimum*), were recorded consistently in transects during 2008, 2010, 2014, 2016, and 2018 (Figures 3-5, 3-6). In 2018, 100% of transects were found to contain at least one of these species (Table 3-5). Cheatgrass was the most prevalent species, found in 95% of transects, with an average cover of 11.27% across all transects. Crested wheatgrass was found in 31% of transects, with an average cover of 1.49% across all transects. Tumble mustard was found in 21% of transects, with an average cover of 0.06% across all transects.

Crested wheatgrass has declined in average percent cover across the park, from 6.4% in both 2008 and 2010 to 1.5% in 2018 (see Figure 3-5, Table 3-5). Cheatgrass increased in average percent cover, from 3.13% in 2016 to 11.27% in 2018, which is a return to a percent cover similar to that of all years prior to 2016. In contrast, the percent of transects in which crested wheatgrass, cheatgrass, and tumble mustard were detected shows little change across all sampling years (see Figure 3-6).

Table 3-4. Number of patches per kilometer of priority species monitored along the same routes, Golden Spike NHP, 2008–2018.

Scientific name	Common name	Year	Total patches (per km)	Patch management index				
				Very low	Low	Medium	High	Very high
Carduus nutans	musk thistle	2008	2 (0.10)	1	1	0	0	0
		2010	0	0	0	0	0	0
		2012	0	0	0	0	0	0
		2014	0	0	0	0	0	0
		2016	0	0	0	0	0	0
		2018	0	0	0	0	0	0
Centaurea diffusa	diffuse knapweed	2008	0	0	0	0	0	0
		2010	0	0	0	0	0	0
		2012	0	0	0	0	0	0
		2014	0	0	0	0	0	0
		2016	1 (0.05)	1	0	0	0	0
		2018	0	0	0	0	0	0
Chondrilla juncea	rush skeletonweed	2008	0	0	0	0	0	0
		2010	0	0	0	0	0	0
		2012	0	0	0	0	0	0
		2014	32 (1.64)	31	1	0	0	0
		2016	13 (0.67)	13	0	0	0	0
		2018	8 (0.41)	8	0	0	0	0
Cirsium arvense	Canada thistle	2008	1 (0.05)	0	0	1	0	0
		2010	0	0	0	0	0	0
		2012	0	0	0	0	0	0
		2014	1 (0.05)	0	1	0	0	0
		2016	0	0	0	0	0	0
		2018	1 (0.05)	0	1	0	0	0
Convolvulus arvensis	field bindweed	2008	41 (2.10)	7	25	9	0	0
		2010	0	0	0	0	0	0
		2012	1 (0.05)	1	0	0	0	0
		2014	20 (1.02)	6	13	1	0	0
		2016	15 (0.77)	1	14	0	0	0
		2018	12 (0.61)	2	10	0	0	0
Elymus repens	quackgrass	2008	0	0	0	0	0	0
		2010	0	0	0	0	0	0
		2012	0	0	0	0	0	0
		2014	4 (0.20)	1	3	0	0	0
		2016	0	0	0	0	0	0
		2018	0	0	0	0	0	0
Isatis tinctoria	Dyer's woad	2008	28 (1.43)	24	3	0	1	0
		2010	25 (1.27)	12	12	1	0	0
		2012	0	0	0	0	0	0
		2014	4 (0.21)	4	0	0	0	0
		2016	3 (0.15)	3	0	0	0	0
		2018	4 (0.21)	4	0	0	0	0

Table 3-4. Number of patches per kilometer of priority species monitored along the same routes, Golden Spike NHP, 2008–2018, cont.

Scientific name	Common name	Year	Total patches (per km)	Patch management index				
				Very low	Low	Medium	High	Very high
Lepidium latifolium	broad-leaf pepperwort	2008	0	0	0	0	0	0
		2010	0	0	0	0	0	0
		2012	0	0	0	0	0	0
		2014	1 (0.05)	0	1	0	0	0
		2016	0	0	0	0	0	0
		2018	1 (0.05)	0	1	0	0	0
Linaria dalmatica	Dalmatian toadflax	2008	0	0	0	0	0	0
		2010	0	0	0	0	0	0
		2012	0	0	0	0	0	0
		2014	1 (0.05)	1	0	0	0	0
		2016	0	0	0	0	0	0
		2018	0	0	0	0	0	0
Marrubium vulgare	horehound	2008	2 (0.10)	1	0	1	0	0
		2010	0	0	0	0	0	0
		2012	0	0	0	0	0	0
		2014	0	0	0	0	0	0
		2016	0	0	0	0	0	0
		2018	0	0	0	0	0	0
Onopordum acanthium	Scotch thistle	2008	26 (1.33)	20	6	0	0	0
		2010	20 (1.02)	9	11	0	0	0
		2012	2 (0.10)	2	0	0	0	0
		2014	28 (1.43)	16	9	3	0	0
		2016	29 (1.48)	26	3	0	0	0
		2018	37 (1.90)	29	8	0	0	0
Verbascum blattaria	moth mullein	2008	0	0	0	0	0	0
		2010	1 (0.051)	0	1	0	0	0
		2012	4 (0.21)	3	1	0	0	0
		2014	6 (0.31)	5	1	0	0	0
		2016	6 (0.31)	3	3	0	0	0
		2018	10 (0.51)	7	0	2	0	1
All species		2008	100 (5.12)	53	35	11	1	0
		2010	46 (2.34)	23	27	3	0	0
		2012	7 (0.36)	7	1	0	0	0
		2014	97 (4.96)	64	29	4	0	0
		2016	67 (3.43)	47	20	0	0	0
		2018	73 (*3.74)	51	20	2	0	1

*Total patches/km for 2018 differs here from Table 3-2 (3.64 patches/km) because VC Sidewalk Area (a new route in 2018) was not included in multi-year comparisons.

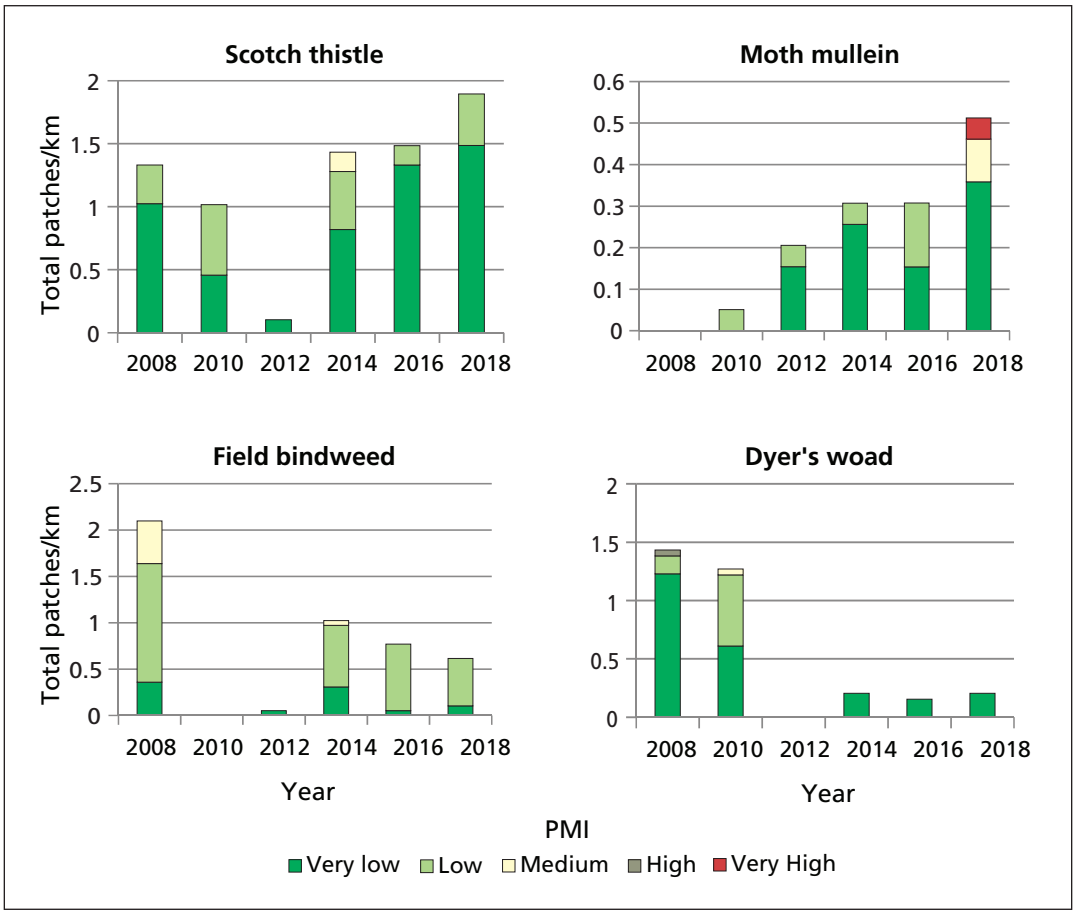


Figure 3-3. Number of patches and patch management index (PMI) of select priority IEP species along the same monitoring routes at Golden Spike National Historical Park, 2008–2018.

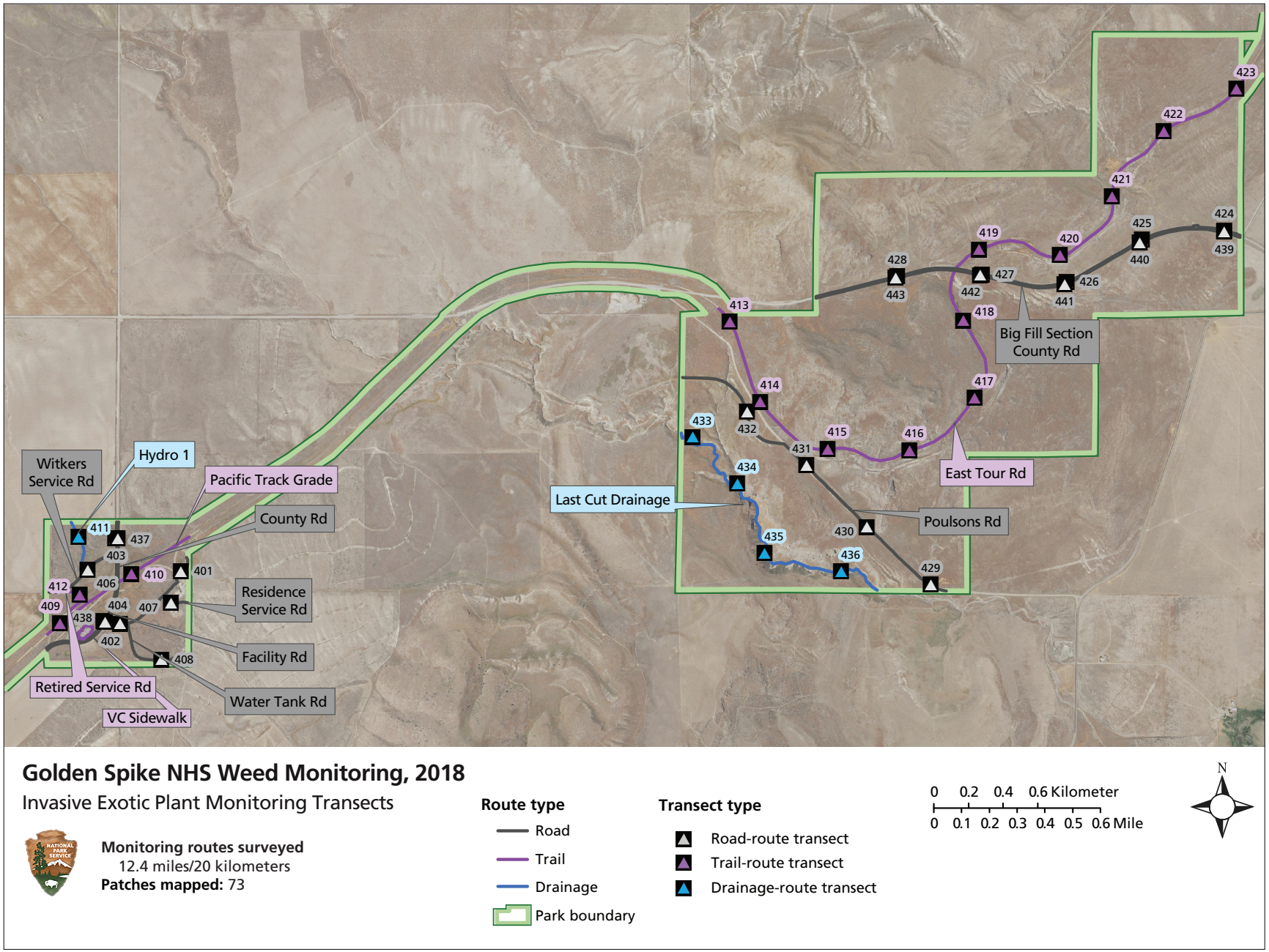


Figure 3-4. Invasive exotic plant monitoring transects, Golden Spike National Historical Park, July 2–4, 2018.

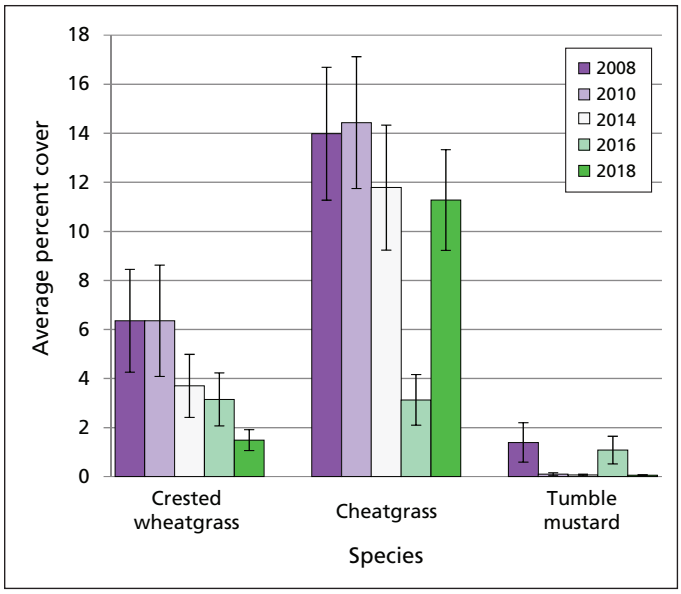


Figure 3-5. Percent cover with standard error of IEPs that were consistently recorded in transects in 2008, 2010, 2014, 2016, and 2018 at Golden Spike National Historical Park. (In 2012, these species were not looked for in transects due to a miscommunication.)

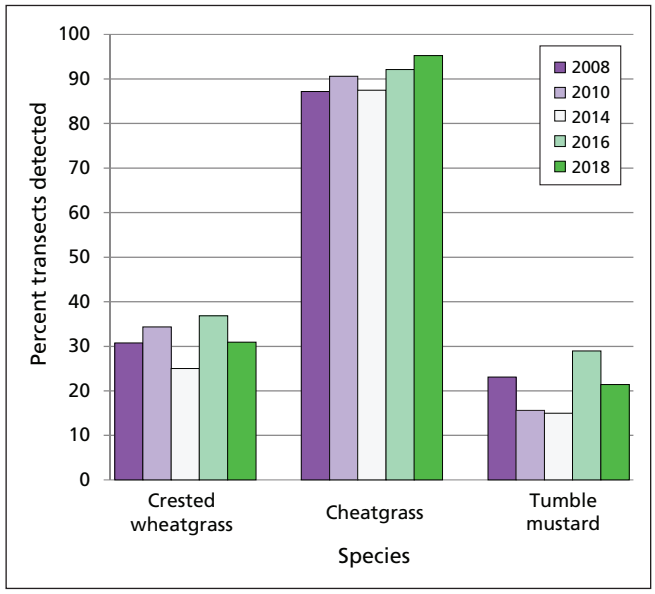


Figure 3-6. Percent of transects in which three common IEPs were recorded in 2008, 2010, 2014, 2016, and 2018 at Golden Spike National Historical Park. (In 2012, these species were not looked for in transects due to a miscommunication.)

Table 3-5. Number of monitoring transects where three commonly encountered exotic plant species were detected/total transects monitored, mean percent cover, and standard error by monitoring route, Golden Spike NHP, 2008–2018.

		Crested wheatgrass		Cheatgrass		Tumble mustard		All species	
Route	Year	Detected/ total	% cover (SE)	Detected/ total	% cover (SE)	Detected/ total	% cover (SE)	Detected/ total	% cover (SE)
Administrative Area[1]	2008	11/12	20.51 (4.78)	7/12	9.00 (6.08)	0/12	–	12/12	29.51 (5.49)
	2010	8/10	17.93 (5.61)	8/10	7.07 (2.93)	3/10	0.27 (0.18)	10/10	25.27 (4.58)
	2014	9/12	12.31 (3.15)	8/12	6.98 (4.11)	1/12	0.03 (0.03)	11/12	19.31 (3.65)
	2016	10/11	10.67 (2.64)	9/11	2.14 (1.17)	6/11	3.06 (1.82)	11/11	15.86 (3.91)
	2018	12/13	4.29 (0.87)	11/13	5.88 (2.47)	4/13	0.29 (0.04)	13/13	10.27 (2.13)
Big Fill[2]	2008	1/27	0.06 (0.06)	27/27	16.20 (2.82)	9/27	20.10 (1.15)	27/27	18.27 (3.16)
	2010	3/22	0.91 (0.80)	21/22	17.78 (3.49)	2/22	0.02 (0.02)	22/22	18.71 (3.40)
	2014	1/28	0.01 (0.01)	27/28	13.85 (3.16)	5/28	0.08 (0.04)	27/28	13.94 (3.18)
	2016	4/27	0.08 (0.05)	26/27	3.53 (1.37)	5/27	0.27 (0.19)	27/27	3.89 (1.40)
	2018	1/29	0.23 (0.23)	29/29	13.69 (2.66)	5/29	0.04 (0.02)	29/29	13.96 (2.69)
Parkwide	2008	12/39	6.35 (2.09)	34/39	13.98 (2.71)	9/39	1.39 (0.80)	39/39	21.73 (2.85)
	2010	11/32	6.23 (2.27)	29/32	14.43 (2.69)	5/32	0.10 (0.06)	32/32	20.76 (2.75)
	2014	10/40	3.70 (1.29)	35/40	11.79 (2.55)	6/40	0.07 (0.03)	38/40	15.55 (2.49)
	2016	14/38	3.14 (1.08)	35/38	3.13 (1.03)	11/38	1.08 (0.57)	38/38	7.35 (1.72)
	2018	13/42	1.49 (0.42)	40/42	11.27 (2.05)	9/42	0.06 (0.02)	42/42	12.82 (1.98)

[1]Administrative Area Routes: County Road, Facility Road, Hydro 1, Pacific Track Grade, Residence Service Road, Retired Service Road, Water Tank Road, Witkers Service Road

[2]Big Fill Routes: Big Fill Section County Road, East Tour Road, Last Cut Drainage, Poulsons Road

4 Discussion

The number of IEP patches and total patches per kilometer monitored did not change greatly between 2016 (67/3.43) and 2018 (73/3.74) (see Table 3-4). The vast majority of priority patches in Golden Spike NHP are small, and most are low in cover. The two riparian routes surveyed in the park, Hydro 1 and Last Cut drainages, are hotspots for priority IEP patches.

Seven non-priority species detected in 2018 (see Table 3-1, Section 3.1.1). The network will review the priority list for 2020 based on these observations and park concerns.

One patch of broad-leaf pepperwort (voucher specimen collected in 2018) and one patch of Canada thistle were detected in 2018 (see Table 3-3). Though these two species were not detected in 2016, they have been seen in earlier monitoring years in similarly low numbers. These two species are good candidates for control due to the infrequent number of infestations. Scotch thistle and moth mullein appear to be on the rise in recent years in both patch frequency and PMI (see Figure 3-3). Control efforts on these species could help control their spread. Prevalence of field bindweed and Dyer's woad showed little fluctuation across recent sampling years (see Figure 3-3). Both species consist mostly of very low to low PMI patches that have the potential to be controlled. Rush skeletonweed has declined in patches per kilometer each sampling year since 2014 (see Table 3-4). The 2018 NCPN crew frequently pulled this species or at least removed and disposed of flowers or fruits when it was encountered.

The patch management index was originally intended to elucidate changes in IEP populations over time, but it can also be used to inform treatment decisions. A very low or low classification indicates a patch that is either small in area, sparse in cover, or both. However, patches with very low or low PMI should not be interpreted as insignificant. On the contrary, these patches may be some of the most important areas to treat, especially for isolated and/or uncommon species. Prioritizing treatment of small-scale patches can effectively prevent future spread and possible eradication.

For more widespread species, such as Scotch thistle, the large number of patches with very low and low PMI indicates that this species is sparsely scattered across a broad landscape. Therefore, while controlling an individual patch might require minimal effort, controlling the population will require traversing larger areas. Similarly, while patches with higher PMI, such as moth mullein, will be more difficult to manage and treat due to their larger size and denser cover, they also represent opportunities for possible eradication if patch numbers for a given species are low. If we had mapped widespread species, such as cheatgrass, crested wheatgrass, and tumble mustard, they would likely have had high PMIs, indicating that control would be difficult or infeasible with current methods. Ultimately, managers should consider species traits (e.g., how likely and quickly plants may spread) and environmental conditions (precipitation and temperature), and combine this information with patch numbers and PMI values when determining treatment priorities.

Percent cover of cheatgrass and tumble mustard has not changed dramatically across sampling years (see Figure 3-5). Cheatgrass had much lower cover in 2016 than in all other years, but this species can vary in response to precipitation. Crested wheatgrass has declined in percent cover each year since 2008. Tumble mustard consistently has a very low percent cover, due in part to its skeletal architecture, but is found regularly in transects across the park (see Figure 3-6).

Estimates of percent cover in this report are limited to the routes surveyed. Actual percent cover of IEPs across the entire park cannot be inferred with these methods. Because we have chosen to monitor along areas most likely to be invaded by a broad suite of IEPs, it is likely that the percent cover for most IEP species is lower in the interior of the park than along the monitoring routes.

The NCPN will continue to work with Golden Spike NHP staff and area weed experts to review and update the list of priority species each year. Presence and absence data for most priority species should be reliable for the areas searched. However, absence data

for other species are suspect, as they are not consistently recorded from year to year. The network will continue to collect data on tumble mustard, cheatgrass, and crested wheatgrass in transects only.

IEPs at Golden Spike NHP will generally be monitored at the same time of year, every other year. Consistency in timing of monitoring should ensure consistency in detection probabilities and cover estimates of most species. For many species, sampling at any time from May to September is not expected to drastically alter the chances of detecting invasive species patches larger than the minimum detection target size. A complete seventh sample of monitoring routes will occur in 2020. Long-term trend reporting will focus on trends in species distributions, trends in percent cover of individual species, and changes in IEP percent cover of priority species by monitoring route. Extra-area surveys will also be considered for inventories at the park's request.

5 Literature Cited

Andersen, K. A., and S. A. Dewey. 2007. USU Wildland weed mapping methods training supplement. Master's thesis. Utah State University, Logan, Utah. 107 pp. plus appendix.

Elzinga, C. L., D. W. Salzer, and J. W. Willoughby. 1998. Measuring and monitoring plant populations. USDI-BLM Technical Ref. 1730-1. Bureau of Land Management, Denver, Colorado. 477 pp.

Mooney, H., and R. J. Hobbs, eds. Invasive species in a changing world. Washington, D.C.: Island Press. 457 pp.

National Research Council (NRC). 2002. Predicting invasions of nonindigenous plants and plant pests. National Academy of Sciences, Washington, D.C.

National Park Service (NPS). 2012. Northern Rocky Mountain Exotic Plant Management Team fiscal year 2012 report. 30 pp.

O'Dell, T., S. Garman, A. Evenden, M. Beer, E. Nance, D. Perry, R. DenBleyker, et al. 2005. Northern Colorado Plateau Inventory and Monitoring Network vital signs monitoring plan. National Park Service, Inventory and Monitoring Network, Moab, Utah. 174 pp. plus appendices.

Perkins, D. W. 2011. Invasive exotic plant monitoring at Golden Spike National Historic Site: 2010 field season. Natural Resource Technical Report NPS/NCPN/NRTR—2011/458. National Park Service, Fort Collins, Colorado.

——. 2013. Invasive exotic plant monitoring in Golden Spike National Historic Site: 2012 field season. Natural Resource Technical Report NPS/ NCPN/NRTR—2013/748. National Park Service, Fort Collins, Colorado.

——. 2015. Invasive exotic plant monitoring at Golden Spike National Historic Site: Field season 2014. Natural Resource Report NPS/NCPN/NRR—2015/945. National Park Service, Fort Collins, Colorado.

——. 2017. Invasive exotic plant monitoring at Golden Spike National Historic Site: Field season 2016. Natural Resource Report NPS/NCPN/NRR—2017/1513. National Park Service, Fort Collins, Colorado.

Perkins, D. W., K. Edvarchuk, S. Dewey, H. Thomas, and A. Wight. 2016. Invasive exotic plant monitoring protocol narrative for Northern Colorado Plateau Network parks: Version 1.02. Natural Resource Report NPS/NCPN/NRR—2016/1340. National Park Service, Fort Collins, Colorado.

Perkins, D. W., and R. Weissinger. 2009. Invasive exotic plant monitoring at Golden Spike National Historic Site: 2008 pilot field season. Natural Resource Technical Report NPS/NCPN/NRTR—2009/226. National Park Service, Fort Collins, Colorado.

Scott, J. M., and D. S. Wilcove. 1998. Improving the future for endangered species. BioScience 48(8):579–580.

Appendices

Appendix A. Exotic plant patches detected on monitoring routes, Golden Spike NHP, July 2–4, 2018.

Plot_ID	Species	Master_Common_Name	Pulled	N_Coord	E_Coord	Cover Class	Size_Class
Big Fill Section County Road	Bromus briziformis	Rattlesnake chess	0	4610411.224	375217.784	1	2
Big Fill Section County Road	Chondrilla juncea	rush skeletonweed	0	4610737.739	377035.009	1	2
Big Fill Section County Road	Chondrilla juncea	rush skeletonweed	1	4610420.58	376301.406	5	1
Big Fill Section County Road	Chondrilla juncea	rush skeletonweed	1	4610800.419	377251.015	5	1
Big Fill Section County Road	Convolvulus arvensis	Field bindweed	0	4610466.882	376561.959	2	2
Big Fill Section County Road	Convolvulus arvensis	Field bindweed	0	4610436.868	376487.499	3	3
Big Fill Section County Road	Convolvulus arvensis	Field bindweed	0	4610499.476	376617.659	3	2
Big Fill Section County Road	Convolvulus arvensis	Field bindweed	0	4610532.703	375677.246	2	3
Big Fill Section County Road	Verbascum blattaria	Moth mullein	0	4610431.628	376301.922	1	5
Big Fill Section County Road	Verbascum blattaria	Moth mullein	0	4610456.996	376231.058	1	5
Big Fill Section County Road	Verbascum blattaria	Moth mullein	0	4610466.295	376178.22	1	4
County Road	Convolvulus arvensis	Field bindweed	0	4608380.972	370817.85	2	4
County Road	Convolvulus arvensis	Field bindweed	0	4608487.868	370921.607	2	3
County Road	Convolvulus arvensis	Field bindweed	0	4608366.324	370650.108	4	2
County Road	Onopordum acanthium	Scotch thistle	0	4608975.179	371006.97	3	2
County Road	Onopordum acanthium	Scotch thistle	1	4609039.808	371010.753	5	1
East Tour Road	Chondrilla juncea	rush skeletonweed	0	4611596.421	377494.816	5	1
East Tour Road	Chondrilla juncea	rush skeletonweed	1	4609422.781	375414.61	5	1
East Tour Road	Chondrilla juncea	rush skeletonweed	1	4611426.235	377264.456	4	1
East Tour Road	Convolvulus arvensis	Field bindweed	0	4609616.988	374848.681	2	2
East Tour Road	Onopordum acanthium	Scotch thistle	0	4609869.39	374662.241	2	2
East Tour Road	Onopordum acanthium	Scotch thistle	0	4609918.675	374636.599	1	2
East Tour Road	Onopordum acanthium	Scotch thistle	1	4609486.529	375200.638	5	1
East Tour Road	Verbascum blattaria	Moth mullein	0	4610619.936	376340.058	1	5
East Tour Road	Verbascum blattaria	Moth mullein	0	4610817.209	376744.726	1	4
East Tour Road	Verbascum blattaria	Moth mullein	0	4610741.912	376668.972	1	2
East Tour Road	Verbascum blattaria	Moth mullein	0	4610661.631	376280.189	1	4
Facility Road	Onopordum acanthium	Scotch thistle	0	4608880.603	371414.484	5	1
Facility Road	Onopordum acanthium	Scotch thistle	0	4608503.226	371126.155	1	4
Facility Road	Onopordum acanthium	Scotch thistle	0	4608617.459	371260.653	2	2
Facility Road	Onopordum acanthium	Scotch thistle	0	4608528.003	371183.87	1	2

Appendix A. Exotic plant patches detected on monitoring routes, Golden Spike NHP, July 2–4, 2018, cont.

Plot_ID	Species	Master_Common_Name	Pulled	N_Coord	E_Coord	Cover Class	Size_Class
Facility Road	Onopordum acanthium	Scotch thistle	0	4608479.625	371070.84	2	2
Hydro 1	Onopordum acanthium	Scotch thistle	0	4609026.396	370762.673	2	3
Hydro 1	Onopordum acanthium	Scotch thistle	0	4609001.478	370834.701	5	1
Hydro 1	Onopordum acanthium	Scotch thistle	1	4608816.674	370803.011	5	1
Hydro 1	Onopordum acanthium	Scotch thistle	0	4608852.731	370851.796	1	2
Hydro 1	Onopordum acanthium	Scotch thistle	0	4608916.936	370826.52	3	2
Hydro 1	Onopordum acanthium	Scotch thistle	0	4608956.443	370778.397	5	1
Last Cut Drainage	Isatis tinctoria	Dyer's woad	0	4608829.52	374839.542	5	1
Last Cut Drainage	Isatis tinctoria	Dyer's woad	0	4609386.196	374457.091	5	1
Last Cut Drainage	Isatis tinctoria	Dyer's woad	0	4609201.71	374624.724	1	2
Last Cut Drainage	Isatis tinctoria	Dyer's woad	0	4609511.686	374415.588	5	1
Last Cut Drainage	Lepidium latifolium	Broad-leaf pepperwort	0	4608743.226	375159.273	3	3
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4609200.789	374659.672	2	4
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4609497.417	374457.781	1	2
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4609363.398	374475.309	1	2
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4609260.353	374610.06	1	2
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4608705.175	375354.092	1	1
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4608827.755	374815.067	1	2
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4609429.496	374471.893	2	2
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4608870.803	374753.834	1	2
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4608800.417	375064.622	2	1
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4608769.198	375179.834	5	1
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4608812.748	374958.554	2	1
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4608796.955	375010.174	2	1
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4609527.044	374351.906	1	3
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4609566.264	374314.256	2	3
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4608818.968	374872.376	3	2
Not on route	Cirsium arvense	Canada thistle	0	4608860.334	371108.76	4	2
Not on route	Onopordum acanthium	Scotch thistle	0	4608959.111	371069.971	3	3
Not on route	Onopordum acanthium	Scotch thistle	0	4608264.186	370692.926	4	2
Pacific Track Grade	Onopordum acanthium	Scotch thistle	0	4608407.449	370583.397	3	2
Pacific Track Grade	Onopordum acanthium	Scotch thistle	0	4608783.33	371141.58	5	1
Pacific Track Grade	Onopordum acanthium	Scotch thistle	0	4608856.968	371234.39	3	2

Appendix A. Exotic plant patches detected on monitoring routes, Golden Spike NHP, July 2–4, 2018, cont.

Plot_ID	Species	Master_Common_Name	Pulled	N_Coord	E_Coord	Cover Class	Size_Class
Pacific Track Grade	Onopordum acanthium	Scotch thistle	0	4608860.913	371174.075	2	2
Poulsons Road	Chondrilla juncea	rush skeletonweed	1	4609036.652	375350.623	5	1
Poulsons Road	Chondrilla juncea	rush skeletonweed	1	4609261.977	375111.728	5	1
Poulsons Road	Onopordum acanthium	Scotch thistle	0	4609851.353	374549.557	2	2
Poulsons Road	Verbascum blattaria	Moth mullein	0	4609080.227	375373.889	5	5
Poulsons Road	Verbascum blattaria	Moth mullein	0	4609119.855	375334.631	3	5
Poulsons Road	Verbascum blattaria	Moth mullein	0	4609157.115	375296.638	3	5
Retired Service Road	Cirsium arvense	Canada thistle	0	4608637.724	370809.589	3	2
Retired Service Road	Convolvulus arvensis	Field bindweed	0	4608639.393	370811.044	3	3
Retired Service Road	Convolvulus arvensis	Field bindweed	0	4608585.84	370766.057	3	2
VC sidewalk area	Convolvulus arvensis	Field bindweed	0	4608409.255	370777.578	3	2
VC sidewalk area	Convolvulus arvensis	Field bindweed	0	4608453.793	370856.485	3	3
VC sidewalk area	Onopordum acanthium	Scotch thistle	1	4608447.807	370861.816	5	1

Appendix B. Exotic plant transect data detected at Golden Spike NHP, July 2–4, 2018.

Route	Transect	Area	E_Coord	N_Coord	Species	Master Common Name	Alive?	Average Cover
Big Fill Section County Road	424	Big Fill	377411.565	4610750.315	Bromus tectorum	Cheatgrass	Y	1.333
Big Fill Section County Road	425	Big Fill	376937.553	4610697.018	Bromus tectorum	Cheatgrass	Y	6
Big Fill Section County Road	426	Big Fill	376500.62	4610452.358	Bromus tectorum	Cheatgrass	Y	17
Big Fill Section County Road	427	Big Fill	376010.413	4610496.989	Bromus tectorum	Cheatgrass	Y	1.5
Big Fill Section County Road	428	Big Fill	375518.199	4610485.571	Bromus tectorum	Cheatgrass	Y	2
Big Fill Section County Road	439	Big Fill	377411.64	4610742.225	Bromus tectorum	Cheatgrass	Y	0.5
Big Fill Section County Road	440	Big Fill	376923.441	4610679.828	Bromus tectorum	Cheatgrass	Y	11.667
Big Fill Section County Road	441	Big Fill	376488.039	4610439.403	Bromus tectorum	Cheatgrass	Y	1.333
Big Fill Section County Road	441	Big Fill	376488.039	4610439.403	Convolvulus arvensis	Field bindweed	Y	2
Big Fill Section County Road	442	Big Fill	376000.164	4610491.774	Bromus tectorum	Cheatgrass	Y	10.333
Big Fill Section County Road	443	Big Fill	375508.901	4610475.842	Bromus tectorum	Cheatgrass	Y	10.667
County Road	403	Administrative Area	370991.862	4608965.702	Agropyron cristatum	crested wheatgrass	Y	5
County Road	403	Administrative Area	370991.862	4608965.702	Bromus tectorum	Cheatgrass	Y	0.5
County Road	403	Administrative Area	370991.862	4608965.702	Sisymbrium altissimum	Tumble mustard	Y	0.333
County Road	404	Administrative Area	370923.429	4608487.625	Agropyron cristatum	crested wheatgrass	Y	5
County Road	404	Administrative Area	370923.429	4608487.625	Bromus tectorum	Cheatgrass	Y	0.167
County Road	437	Administrative Area	371005.793	4608965.966	Agropyron cristatum	crested wheatgrass	Y	4.5
County Road	437	Administrative Area	371005.793	4608965.966	Bromus tectorum	Cheatgrass	Y	1.167
County Road	438	Administrative Area	370932.895	4608484.319	Agropyron cristatum	crested wheatgrass	Y	2.167
County Road	438	Administrative Area	370932.895	4608484.319	Bromus tectorum	Cheatgrass	Y	0.167
East Tour Road	413	Big Fill	374549.295	4610222.494	Bromus tectorum	Cheatgrass	Y	36.667
East Tour Road	413	Big Fill	374549.295	4610222.494	Sisymbrium altissimum	Tumble mustard	Y	0.167
East Tour Road	414	Big Fill	374724.721	4609756.427	Bromus tectorum	Cheatgrass	Y	15
East Tour Road	414	Big Fill	374724.721	4609756.427	Sisymbrium altissimum	Tumble mustard	Y	0.333
East Tour Road	415	Big Fill	375115.913	4609486.287	Bromus tectorum	Cheatgrass	Y	2
East Tour Road	416	Big Fill	375590.365	4609476.877	Bromus tectorum	Cheatgrass	Y	4.333
East Tour Road	417	Big Fill	375967.998	4609779.185	Bromus tectorum	Cheatgrass	Y	33.333
East Tour Road	418	Big Fill	375900.342	4610227.794	Bromus tectorum	Cheatgrass	Y	1.5
East Tour Road	418	Big Fill	375900.342	4610227.794	Sisymbrium altissimum	Tumble mustard	Y	0.167
East Tour Road	419	Big Fill	375993.498	4610640.036	Bromus tectorum	Cheatgrass	Y	7.667
East Tour Road	420	Big Fill	376461.245	4610608.696	Bromus tectorum	Cheatgrass	Y	50
East Tour Road	421	Big Fill	376763.277	4610947.646	Bromus tectorum	Cheatgrass	Y	22.667

Appendix B. Exotic plant transect data detected at Golden Spike NHP, July 2–4, 2018, cont.

Route	Transect	Area	E_Coord	N_Coord	Species	Master Common Name	Alive?	Average Cover
East Tour Road	421	Big Fill	376763.277	4610947.646	Sisymbrium altissimum	Tumble mustard	Y	0.167
East Tour Road	422	Big Fill	377061.195	4611324.77	Bromus tectorum	Cheatgrass	Y	25
East Tour Road	423	Big Fill	377482.884	4611569.874	Bromus tectorum	Cheatgrass	Y	40
Facility Road	401	Administrative Area	371371.778	4608776.701	Agropyron cristatum	crested wheatgrass	Y	5
Facility Road	401	Administrative Area	371371.778	4608776.701	Bromus tectorum	Cheatgrass	Y	13.5
Facility Road	402	Administrative Area	371020.141	4608471.917	Agropyron cristatum	crested wheatgrass	Y	5
Facility Road	402	Administrative Area	371020.141	4608471.917	Bromus tectorum	Cheatgrass	Y	4.333
Facility Road	402	Administrative Area	371020.141	4608471.917	Sisymbrium altissimum	Tumble mustard	Y	0.5
Hydro 1	411	Administrative Area	370779.617	4608976.387	Agropyron cristatum	crested wheatgrass	Y	12.333
Last Cut Drainage	433	Big Fill	374334.904	4609553.549	Bromus tectorum	Cheatgrass	Y	13.667
Last Cut Drainage	433	Big Fill	374334.904	4609553.549	Sisymbrium altissimum	Tumble mustard	Y	0.333
Last Cut Drainage	434	Big Fill	374592.331	4609284.777	Bromus tectorum	Cheatgrass	Y	0.333
Last Cut Drainage	435	Big Fill	374749.851	4608882.175	Bromus tectorum	Cheatgrass	Y	1
Last Cut Drainage	436	Big Fill	375194.861	4608775.442	Bromus tectorum	Cheatgrass	Y	0.167
Pacific Track Grade	409	Administrative Area	370672.107	4608474.889	Agropyron cristatum	crested wheatgrass	Y	1.667
Pacific Track Grade	409	Administrative Area	370672.107	4608474.889	Bromus tectorum	Cheatgrass	Y	1
Pacific Track Grade	410	Administrative Area	371085.982	4608759.601	Agropyron cristatum	crested wheatgrass	Y	2.667
Pacific Track Grade	410	Administrative Area	371085.982	4608759.601	Bromus tectorum	Cheatgrass	Y	10.167
Pacific Track Grade	410	Administrative Area	371085.982	4608759.601	Sisymbrium altissimum	Tumble mustard	Y	0.167
Poulsons Road	429	Big Fill	375712.729	4608699.298	Agropyron cristatum	crested wheatgrass	Y	6.667
Poulsons Road	429	Big Fill	375712.729	4608699.298	Bromus tectorum	Cheatgrass	Y	20.333
Poulsons Road	430	Big Fill	375344.199	4609033.115	Bromus tectorum	Cheatgrass	Y	23.333
Poulsons Road	431	Big Fill	374993.293	4609389.968	Bromus tectorum	Cheatgrass	Y	1
Poulsons Road	432	Big Fill	374650.143	4609700.359	Bromus tectorum	Cheatgrass	Y	36.667
Residence Service Road	407	Administrative Area	371314.722	4608593.166	Agropyron cristatum	crested wheatgrass	Y	1.167
Residence Service Road	407	Administrative Area	371314.722	4608593.166	Bromus tectorum	Cheatgrass	Y	17
Retired Service Road	412	Administrative Area	370785.84	4608638.933	Agropyron cristatum	crested wheatgrass	Y	7.333
Water Tank Road	408	Administrative Area	371259.302	4608264.427	Bromus tectorum	Cheatgrass	Y	28.333
Water Tank Road	408	Administrative Area	371259.302	4608264.427	Sisymbrium altissimum	Tumble mustard	Y	0.167
Witkers Service Road	406	Administrative Area	370831.709	4608783.764	Agropyron cristatum	crested wheatgrass	Y	4
Witkers Service Road	406	Administrative Area	370831.709	4608783.764	Bromus tectorum	Cheatgrass	Y	0.167

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.

NPS 431/154154, June 2019

National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525

www.nature.nps.gov

EXPERIENCE YOUR AMERICA™