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Natural Resource Stewardship and Science

Invasive Exotic Plant Monitoring at Golden Spike National Historic Site

2016 Field Season

Natural Resource Report NPS/NCPN/NRR—2017/1513



ON THE COVER

Centaurea diffusa (diffuse knapweed). Photo: K. George Beck and James Sebastian, Colorado State University, Bugwood.org.

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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 2016 field season at Golden Spike National Historic Site (NHS). On July 5–6, 2016, six priority IEP species were detected on monitoring routes that covered all major roads, trails, and riparian areas at Golden Spike NHS. Three additional non-priority species were recorded only in transects. Scotch thistle (*Onopordum acanthium*), field bindweed, and rush skeletonweed (*Chondrilla juncea*) were the most prevalent species, representing 85% of all invasions found. Diffuse knapweed (*Centaurea diffusa*) was recorded for the first time in the park. A specimen was collected so it will be added to the park list as present. Exotic-plant patches of priority species that were on the list in all years declined from 97 in 2014 to 67 in 2016. This decline was largely driven by a decline in rush skeletonweed (*Chondrilla juncea*) patches, from 32 to 12. Quackgrass (*Elymus repens*), broad-leaf pepperwort (*Lepidium latifolium*), Canada thistle (*Cirsium arvense*), and Dalmatian toadflax (*Linaria dalmatica*) were all found in 2014, but were not found in 2016. The highest densities of plant patches were recorded along the Last Cut drainage, Hydro 1 drainage, Facility Road, Pacific Track Grade, County Road, and Poulsons Road. These were also the most prevalent species, representing 85% of all invasions found. Eighty-five percent of the patches detected were present in small, localized invasions that have a good chance of being successfully controlled through management actions. The network will return to Golden Spike NHS for a sixth year of monitoring in 2018.

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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 is focusing 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.
2. To determine status and trends of selected invasive plant populations of management significance.

This report summarizes the 2016 field season and fifth complete monitoring visit at Golden Spike National Historic Site (NHS).

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, 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 2016 were previously surveyed with monitoring routes and quadrats in 2008, 2010, 2012, and 2014 (Perkins and Weissinger 2009; Perkins 2011, 2013, 2015).

2.1 Developing a park target invasive exotic plant list

Prior to beginning monitoring in 2016, 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, and 2014. No species were added in 2016. 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.

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. The likelihood of eradicating these target species, or containing them within a park, is generally high. The list of priority species is reviewed before each field season.

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 con-

Table 2-1. Priority invasive plant list, Golden Spike NHS, 2008–2016.

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 2010–2012.

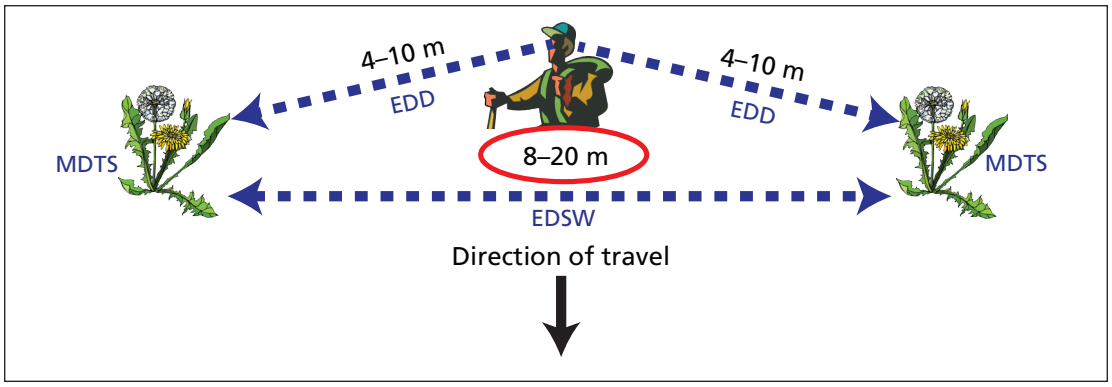


Figure 2-1. The maximum Effective Detection Distance (EDD) at Golden Spike NHS was 4–10 meters, making the Effective Detection Swath Width (EDSW) 8–20 meters.

ditions, but small enough 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, 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 GOSP was 4–10 meters in 2016, 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 8–20 meters at GOSP in 2016.

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, 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 8–20 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) canopy 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–a few plants (used for isolated single plants or very small patches (≤2 × 2 m),
2. few 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 canopy 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. Canopy 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, stream), the growth stage of exotic trees (i.e., sapling, pole, mature), evidence of prior treatment, and evidence of disturbances (e.g., recent fire, flood, small-mammal disturbance).

2.3 Monitoring transects

From 2010 to 2016, we established transects with three vegetation quadrats every 500 meters along monitoring routes. 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 canopy cover class or patch size class, then we went back to establishing 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.

Quadrat sampling methods used in 2010 and 2016 differed slightly from those used during the 2008 pilot field season. 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. Observers could make additional species observations, but non-priority species were not thoroughly mapped.

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. Start-

ing 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, 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 classes represented by a range of percent cover values (11–25, 26–50, 51– 75, and >75% cover), midpoints (18, 38, 63, and 88%) were used when calculating the mean and standard error. Due to differences in observers' knowledge, only priority species should be used when comparing results from year to year.

3 Results

3.1 Monitoring routes

We covered 19.5 kilometers (12.2 miles) along 12 monitoring routes in 2016 (Figure 3-1).* We recorded a total of six IEP species in 67 patches (Tables 3-1, 3-2; Figures 3-2, 3-3; Appendix A). Of the 67 patches, only 9 (13%) were larger than 40 m^2 (Table 3-3). The highest densities of plant patches were recorded along the Last Cut drainage, Hydro 1 drainage, Facility Road, Pacific Track Grade, County Road, and Poulsons Road. Scotch thistle (*Onopordum acanthium*), field bindweed, and rush skeletonweed (*Chondrilla juncea*) were the most prevalent species, representing 85% of all invasions found. Diffuse knapweed (*Centaurea diffusa*) was recorded for the first time in the park. A specimen was collected so it will be added to the park list as present. Only priority species should be examined when comparing years and areas, as these were the only species recorded consistently by all observers and in both years.

3.2 Monitoring transects

We sampled a total of 38 transects in 2016 (Figure 3-4, Appendix B). No priority species were detected on any transect. However, three species consistently recorded in transects in 2008, 2010, and 2014 were also detected in transects in 2016 (Table 3-4). In 2016, 100% of transects were found to contain at least one of these species. Crested wheatgrass had the highest percent cover (10.67% in the administrative area and 3.14% parkwide) and was detected in 37% of transects. Cheatgrass was the most widespread, present in 92% of transects monitored, and had a parkwide cover of 3.13%.

3.3 Priority patches over time

The number of invasive patches recorded (67) was a decrease from 97 in 2014, which was the highest number of invasive patches recorded in any of the five sample periods at Golden Spike NHS (Table 3-5). Species recorded in all sample periods also decreased, from 77 patches in 2014 to 52 in 2016 (Figure 3-5). This decline was largely driven by a decrease in rush skeletonweed patches, from 32 to 12. Rush skeletonweed had previously increased from no patches in 2012 to 32 in 2014. Scotch thistle, moth mullein (*Verbascum blattaria*), Dyer's woad (*Isatis tinctoria*), and field bindweed all stayed at approximately the same number of patches as 2014.

Quackgrass (*Elymus repens*), broad-leaf pepperwort (*Lepidium latifolium*), Canada thistle (*Cirsium arvense*), and Dalmatian toadflax (*Linaria dalmatica*) were all found in 2014, but not found in 2016. In addition to these declines, the number of patches larger than 40 m^2 declined from in 31 in 2014 (32% of patches) to 9 (13% of patches) in 2016. Notably, there were 9 and 12 patches of rush skeletonweed and Scotch thistle larger than 40 m^2 in 2014, respectively, declining to 0 in

*Figures start on page 11.

Table 3-1. Invasive exotic plants detected at Golden Spike NHS, July 5–6, 2016.

Scientific name	Common name	Method detected		Priority?
		Routes	Transects	
Centaurea diffusa	diffuse knapweed	X		Yes
Chondrilla juncea	rush skeletonweed	X		Yes
Convolvulus arvensis	field bindweed	X		Yes
Isatis tinctoria	Dyer's woad	X		Yes
Onopordum acanthium	Scotch thistle	X		Yes
Verbascum blattaria	moth mullein	X		Yes
Agropyron cristatum	crested wheatgrass		X	Transect*
Bromus tectorum	cheatgrass		X	Transect*
Sisymbrium altissimum	tumble mustard		X	Transect*

*Transect species are recorded only in transects. They are not recorded along monitoring routes.

2016. Percent cover for crested wheatgrass and tumble mustard appeared to have declined since 2008, but was at levels similar to those of 2014. Cheatgrass shows a similar trend, notably declining from 11.6% in 2014 to 3.1% in 2016. However, this species can vary widely in percent cover due to precipitation (Figure 3-6).

Table 3-2. Number of IEP patches per route surveyed, Golden Spike NHS, July 5–6, 2016.

Route	Route type	Length (m)	Patches	Patches/km
Hydro 1	Riparian	294.6	2	6.8
Last Cut Drainage	Riparian	1,872.9	25	13.3
All Riparian		*2,167.5*	*27*	*12.5*
Big Fill Section County Road	Road	5,151.2	5	1.0
County Road	Road	1,971.0	8	4.1
East Tour Road	Road	5,161.1	11	2.1
Facility Road	Road	676.4	4	5.9
Poulsons Road	Road	2,066.9	6	2.9
Residence Service Road	Road	163.6	0	0.0
Retired Service Road	Road	259.8	0	0.0
Water Tank Road	Road	459.3	0	0.0
Witkers Service Road	Road	460.4	1	2.2
All Roads		*16,369.7*	*35*	*6.7*
Pacific Track Grade	Trail	997.2	5	5.0
Total		**19,534.5**	**67**	**3.4**

Table 3-3. Priority species observed and size of patch detected along monitoring routes, Golden Spike NHS, July 5–6, 2016.

Scientific name	Common name	Total patches	Patch size class*				
			1	2	3	4	5
Centaurea diffusa	diffuse knapweed	1	1	0	0	0	0
Chondrilla juncea	rush skeletonweed	13	10	3	0	0	0
Convolvulus arvensis	field bindweed	15	1	13	1	0	0
Isatis tinctoria	Dyer's woad	3	1	2	0	0	0
Onopordum acanthium	Scotch thistle	29	11	16	2	0	0
Verbascum blattaria	moth mullein	6	0	0	1	2	3
Total		**67**	**24**	**34**	**4**	**2**	**3**

*Patch size classes: 1=1–a few plants (≤2 × 2 m), 2=few 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).

Table 3-4. Species consistently recorded in transects in 2008, 2010, 2014, and 2016 (July 5–6), Golden Spike NHS.

Scientific name	Common name	Route	Detected/Total	Percent cover (SE)
Agropyron cristatum	crested wheatgrass	Big Fill Area	4/27	0.08 (0.05)
		Administrative Area	10/11	10.67 (2.8)
		All 2016	*14/38*	*3.14 (1.1)*
Bromus tectorum	cheatgrass	Big Fill Area	26/27	3.53 (1.4)
		Administrative Area	9/11	2.14 (1.2)
		All 2016	*35/38*	*3.13 (1.0)*
Sisymbrium altissimum	tumble mustard	Big Fill Area	5/27	0.27 (0.19)
		Administrative Area	6/11	3.06 (1.91)
		All 2016	*11/38*	*1.08 (0.57)*
All species		**Big Fill Area**	**27/27**	**3.54 (1.4)**
		Administrative Area	**11/11**	**15.22 (5.8)**
		All 2016	***38/38***	***7.33 (3.0)***

These are non-priority species.

Table 3-5. Priority species observed and size of patches detected at Golden Spike NHS, July 12–13, 2008, July 21–23, 2010, August 6–7, 2012, July 16–18, 2014, and July 5–6, 2016.

Scientific name	Common name	Year	Total patches	Patch size class*				
				1	2	3	4	5
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	1	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	14	9	4	2	3
		2016	13	10	3	0	0	0
Isatis tinctoria	Dyer's woad	2008	28	20	4	3	1	0
		2010	25	12	5	5	1	2
		2012	0	0	0	0	0	0
		2014	4	2	0	1	1	0
		2016	3	1	2	0	0	0
Onopordum acanthium	Scotch thistle	2008	26	8	8	10	0	0
		2010	20	7	6	6	1	0
		2012	2	1	1	0	0	0
		2014	28	6	10	7	1	4
		2016	29	11	16	2	0	0
Verbascum blattaria	moth mullein	2008	0	0	0	0	0	0
		2010	1	0	0	1	0	0
		2012	4	0	2	2	0	0
		2014	6	3	2	1	1	0
		2016	6	0	0	1	2	3
Total		**2008**	**59**	**30**	**13**	**15**	**1**	**0**
		2010	**46**	**19**	**11**	**12**	**2**	**2**
		2012	**6**	**1**	**3**	**2**	**0**	**0**
		2014	**77**	**26**	**23**	**15**	**6**	**7**
		2016	**52**	**23**	**21**	**3**	**2**	**3**

Only species that were priority species in all five sampling periods are included.

*Patch size classes: 1=1–a few plants (≤2 × 2 m), 2=few 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).

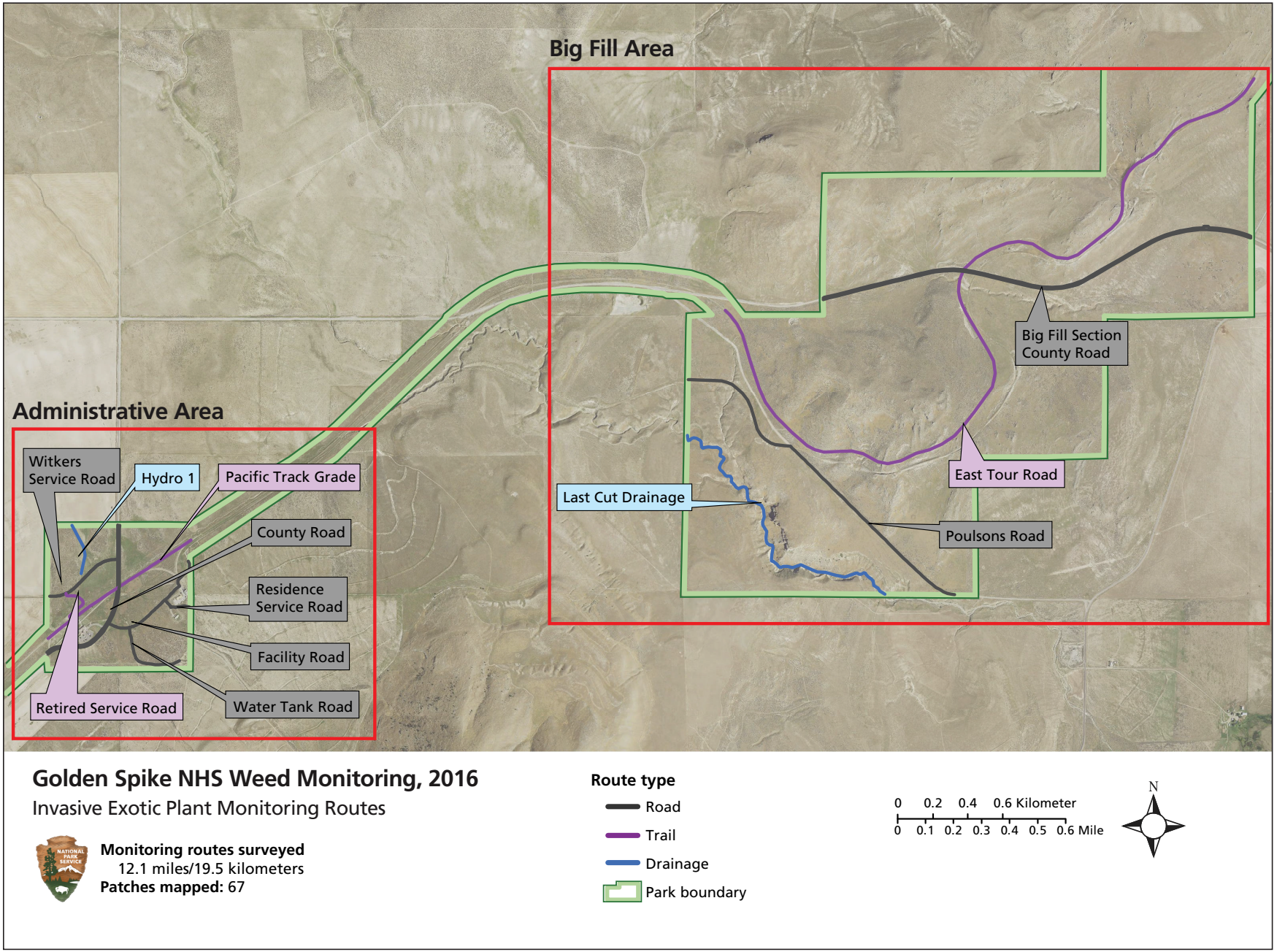


Figure 3-1. Invasive plant monitoring routes, Golden Spike NHS, July 5–6, 2016.

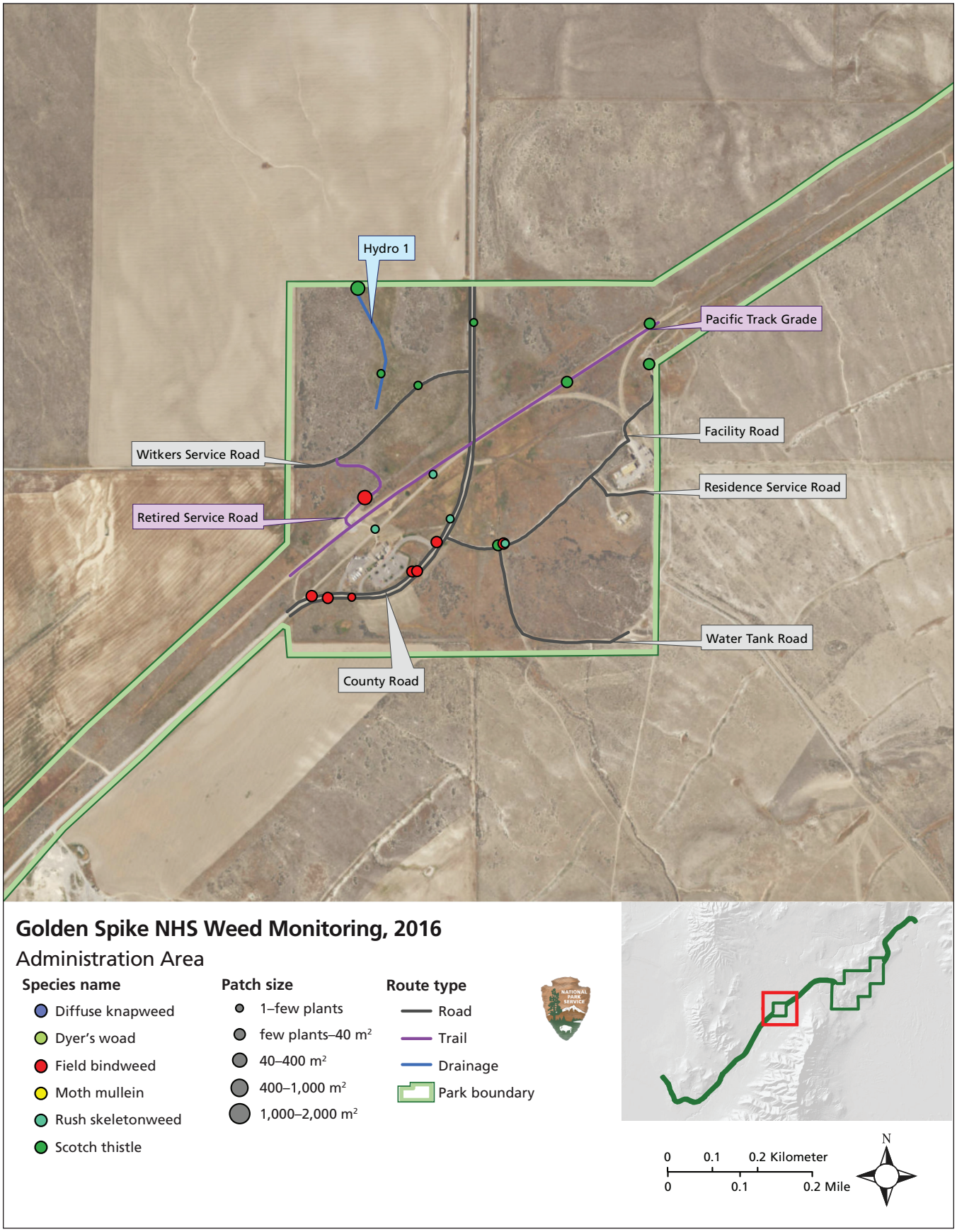


Figure 3-2. Invasive plant monitoring routes and invasive patches detected along monitoring routes, Administrative Area, Golden Spike NHS, July 5–6, 2016.

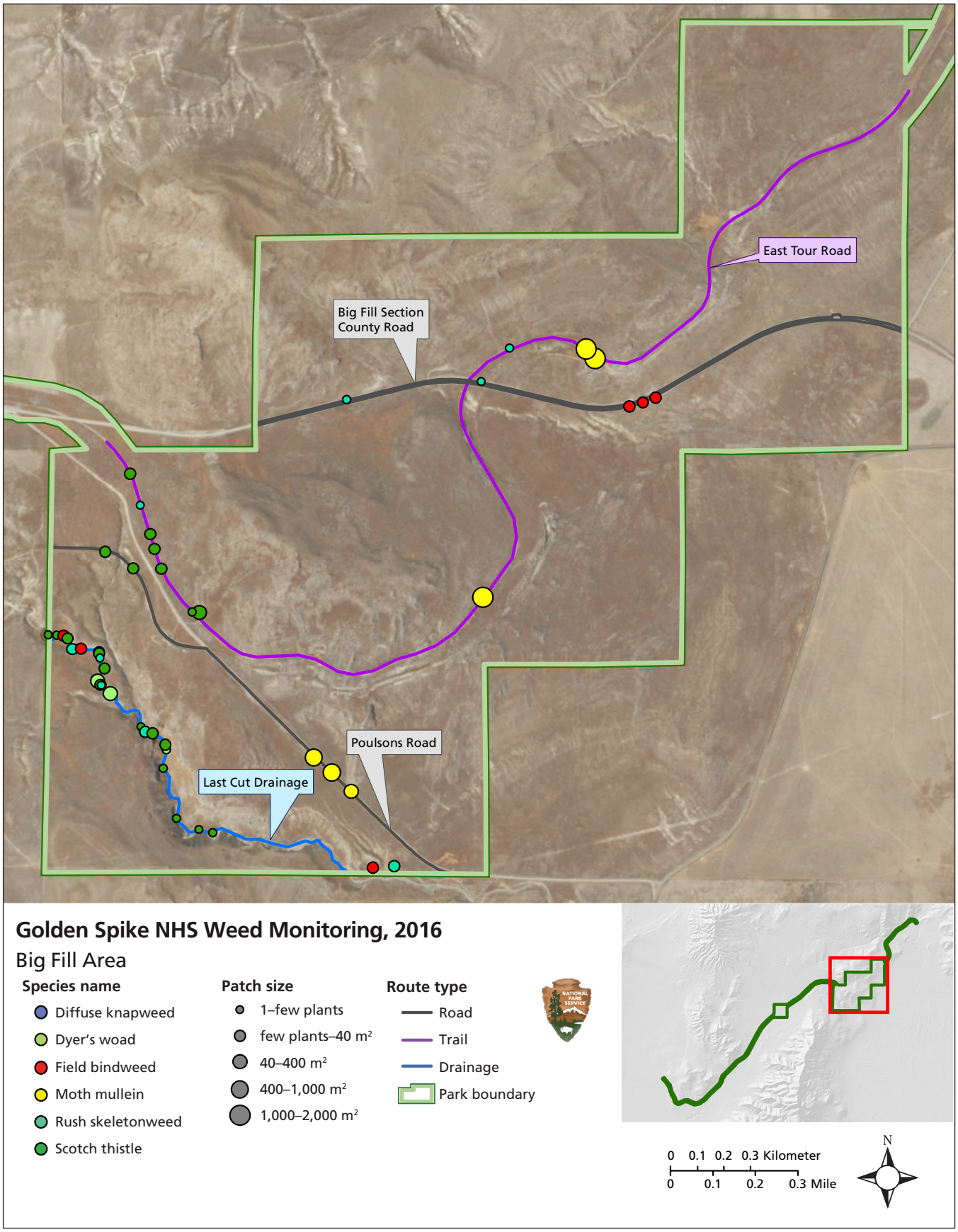


Figure 3-3. Invasive plant monitoring routes and invasive patches detected along monitoring routes, Big Fill Area, Golden Spike NHS, July 5–6, 2016.

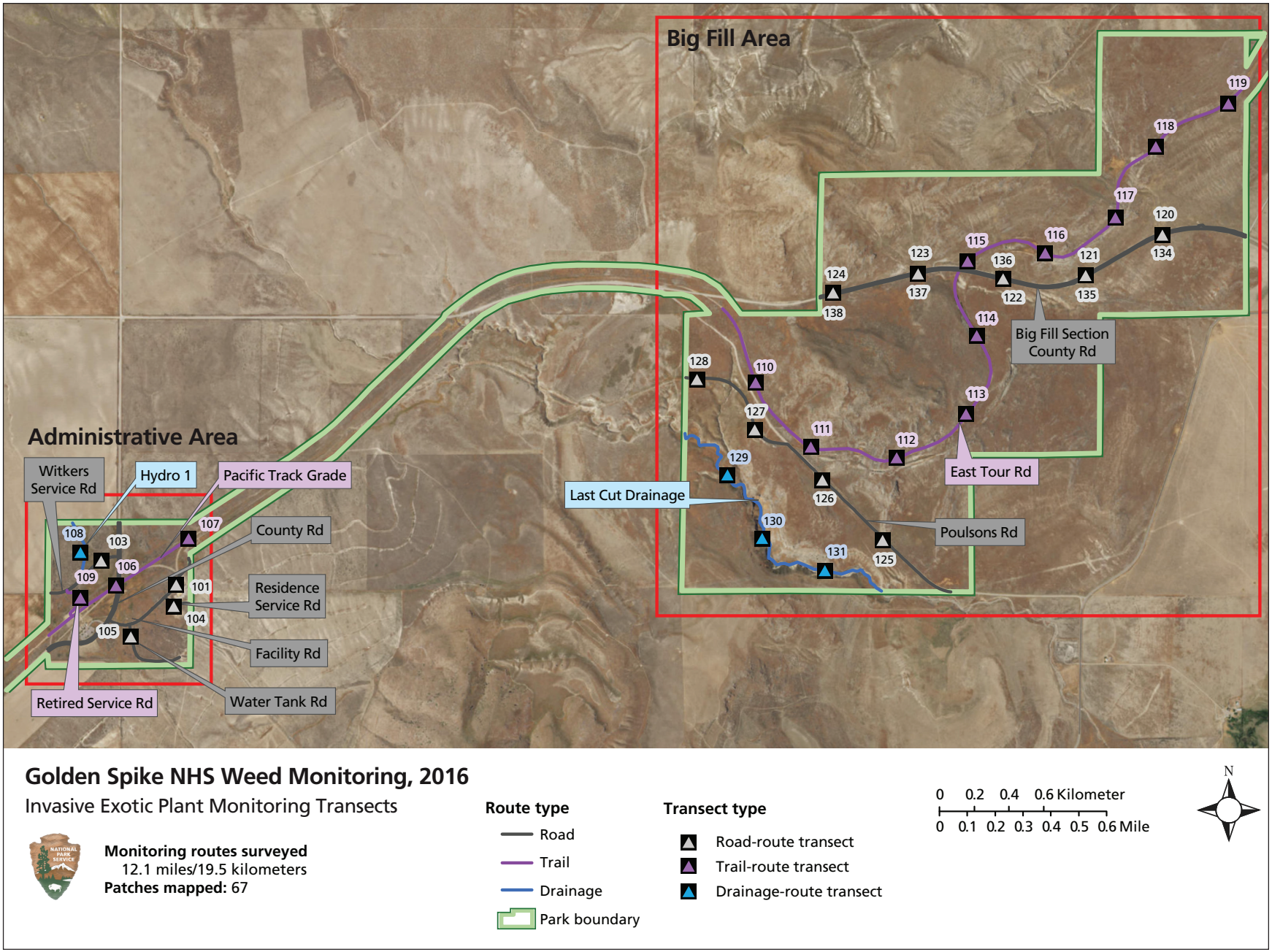


Figure 3-4. Invasive plant monitoring transects, Golden Spike NHS, July 5–6, 2016.

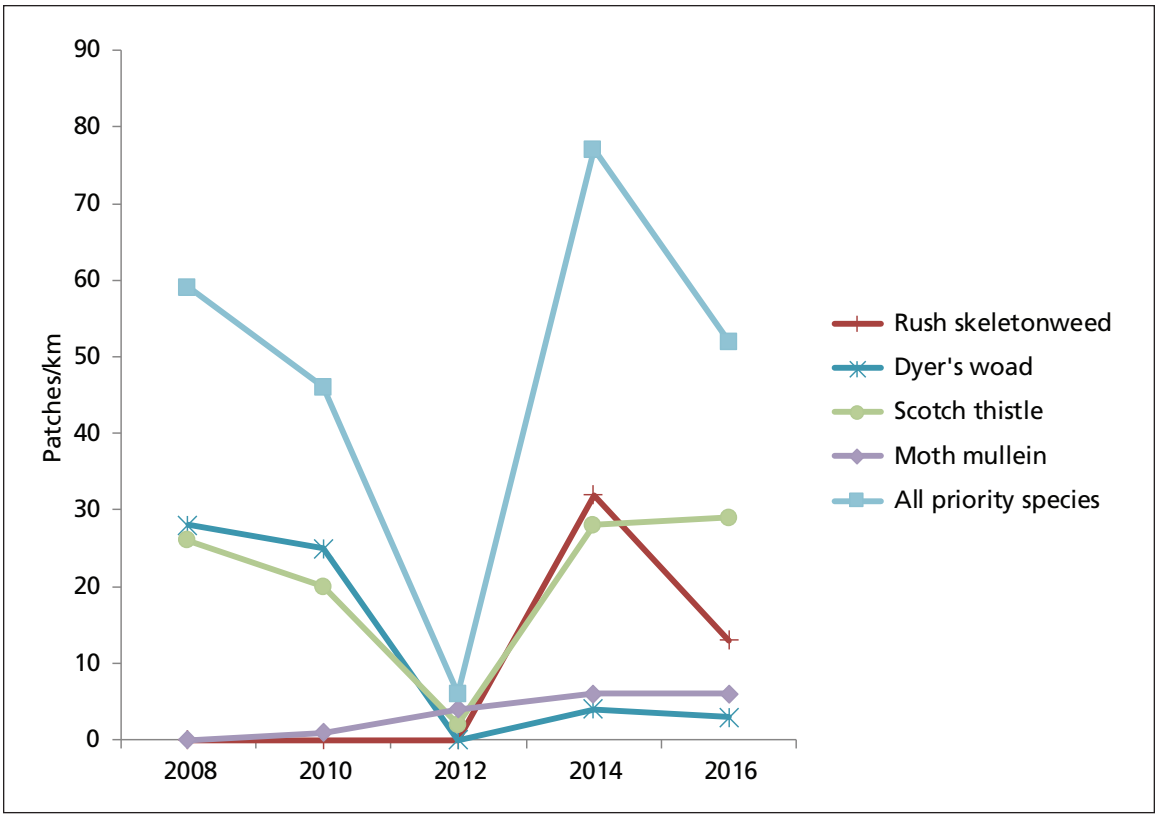


Figure 3-5. Patches per kilometer of the highest-density priority invasive species consistently recorded on monitoring routes in all years at Golden Spike NHS, 2008–2016.

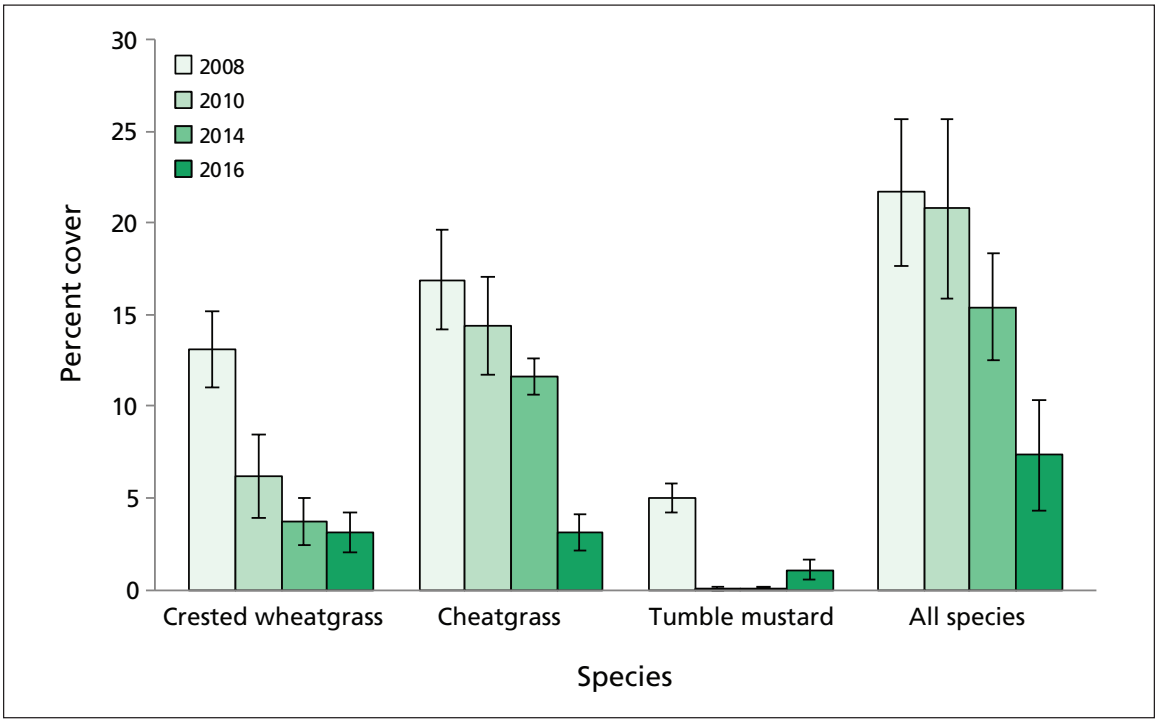


Figure 3-6. Percent cover and standard error of invasive species consistently recorded in transects in all years and percent cover of total invasive species found at Golden Spike NHS, 2008, 2010, 2014, and 2016. In 2012, these species were not looked for in transects due to a miscommunication.

4 Discussion

The NCPN will continue to work with Golden Spike NHS 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 NCPN does not have any species to recommend adding to the list for 2018, but we are open to suggestions from park staff and the Northern Rockies Exotic Plant Management Team. The network will continue to collect data on tumble mustard, cheatgrass, and crested wheatgrass in transects only.

Priority IEPs decreased in 2016 from 2014, when they were present in the highest numbers of all sample periods from 2008 to 2016. This decline was largely driven by a decline in rush skeletonweed patches. Quackgrass, broad-leaf pepperwort, Canada thistle, and Dalmatian toadflax were all found in 2014, but not found in 2016. However, diffuse knapweed was recorded for the first time in the park. In addition to the declines, the number of patches greater than 40 m^2 declined from 31 in 2014 to 9 in 2016, mostly due to rush skeletonweed and Scotch thistle. The smaller number of patches and the smaller size of patches means that the populations of these species will be easier for park management to control. They may also be indicative of the control efforts by the park and the Northern Rockies Exotic Plant Management Team.

Percent cover of crested wheatgrass, cheatgrass, and tumble mustard remain relatively low compared to levels recorded in 2008. Cheatgrass had lower cover in 2016 than 2014, but this species can vary in response to precipitation. 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 plausible that the percent cover for most IEP species is lower in the interior of the park than along the monitoring routes.

IEPs at Golden Spike NHS 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 sixth sample of monitoring routes will occur in 2018. 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.

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Appendix A. Exotic Plant Patches Detected on Monitoring Routes at Golden Spike NHS, July 5–6, 2016

Plot_ID	Species	Master_Common_Name	Pulled	N_Coord	E_Coord	Cover_Class	Size_Class
Big Fill Section County Road	Chondrilla juncea	rush skeletonweed	0	4610456.403	375394.172	5	1
Big Fill Section County Road	Chondrilla juncea	rush skeletonweed	0	4610524.207	375903.967	5	1
Big Fill Section County Road	Convolvulus arvensis	Field bindweed	0	4610463.872	376564.11	3	2
Big Fill Section County Road	Convolvulus arvensis	Field bindweed	0	4610430.499	376464.222	5	2
Big Fill Section County Road	Convolvulus arvensis	Field bindweed	0	4610445.397	376515.709	5	2
County Road	Chondrilla juncea	rush skeletonweed	0	4608537.554	370955.675	5	1
County Road	Convolvulus arvensis	Field bindweed	0	4608366.369	370646.706	5	2
County Road	Convolvulus arvensis	Field bindweed	0	4608486.5	370925.605	3	2
County Road	Convolvulus arvensis	Field bindweed	0	4608420.745	370882.338	4	2
County Road	Convolvulus arvensis	Field bindweed	0	4608361.892	370683.564	4	2
County Road	Convolvulus arvensis	Field bindweed	0	4608419.828	370871.271	3	2
County Road	Convolvulus arvensis	Field bindweed	0	4608363.516	370736.807	5	1
County Road	Onopordum acanthium	Scotch thistle	0	4608975.355	371008.286	5	1
East Tour Road	Chondrilla juncea	rush skeletonweed	0	4610055.583	374614.552	5	1
East Tour Road	Chondrilla juncea	rush skeletonweed	0	4610650.431	376010.955	5	1
East Tour Road	Onopordum acanthium	Scotch thistle	0	4610176.257	374575.035	2	2
East Tour Road	Onopordum acanthium	Scotch thistle	0	4609946.273	374651.521	2	2
East Tour Road	Onopordum acanthium	Scotch thistle	0	4609890.773	374667.411	2	2
East Tour Road	Onopordum acanthium	Scotch thistle	0	4609653.344	374809.742	5	1
East Tour Road	Onopordum acanthium	Scotch thistle	0	4609816.073	374693.677	2	2
East Tour Road	Onopordum acanthium	Scotch thistle	0	4609650.48	374837.618	2	3
East Tour Road	Verbascum blattaria	Moth mullein	0	4609707.653	375909.802	1	5
East Tour Road	Verbascum blattaria	Moth mullein	0	4610612.083	376334.866	1	5
East Tour Road	Verbascum blattaria	Moth mullein	0	4610648.429	376301.696	1	5
Facility Road	Chondrilla juncea	rush skeletonweed	0	4608482.724	371077.828	5	1
Facility Road	Convolvulus arvensis	Field bindweed	0	4608482.679	371074.658	3	2
Facility Road	Onopordum acanthium	Scotch thistle	0	4608882.98	371398.838	2	2
Facility Road	Onopordum acanthium	Scotch thistle	0	4608478.606	371062.672	2	2
Hydro 1	Onopordum acanthium	Scotch thistle	0	4609050.926	370749.883	2	3
Hydro 1	Onopordum acanthium	Scotch thistle	0	4608861.797	370801.499	2	1
Last Cut Drainage	Centaurea diffusa	Diffuse knapweed	1	4609554.342	374337.119	5	1

Appendix A. Exotic Plant Patches Detected on Monitoring Routes at Golden Spike NHS, July 5-6, 2016, cont.

Plot_ID	Species	Master_Common_Name	Pulled	N_Coord	E_Coord	Cover_Class	Size_Class
Last Cut Drainage	Chondrilla juncea	rush skeletonweed	0	4609511.585	374356.506	2	2
Last Cut Drainage	Chondrilla juncea	rush skeletonweed	0	4609478.494	374461.213	5	1
Last Cut Drainage	Chondrilla juncea	rush skeletonweed	0	4609374.304	374465.801	5	1
Last Cut Drainage	Chondrilla juncea	rush skeletonweed	0	4609198.647	374633.607	2	2
Last Cut Drainage	Convolvulus arvensis	Field bindweed	0	4609500.581	374458.09	3	2
Last Cut Drainage	Convolvulus arvensis	Field bindweed	0	4609562.445	374323.043	4	2
Last Cut Drainage	Convolvulus arvensis	Field bindweed	0	4609513.535	374388.988	3	2
Last Cut Drainage	Convolvulus arvensis	Field bindweed	0	4608685.067	375494.552	3	2
Last Cut Drainage	Isatis tinctoria	Dyer's woad	0	4609390.464	374452.837	2	2
Last Cut Drainage	Isatis tinctoria	Dyer's woad	0	4609342.823	374500.212	2	2
Last Cut Drainage	Isatis tinctoria	Dyer's woad	0	4609129.524	374711.666	5	1
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4609496.233	374458.743	2	2
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4609565.317	374296.913	2	1
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4609149.987	374709.723	2	2
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4609217.374	374617.151	5	1
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4609566.032	374266.308	2	1
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4609437.967	374478.657	2	2
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4608870.561	374751.429	5	1
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4609061.578	374700.001	5	1
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4609551.973	374338.917	2	2
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4608829.642	374835.256	5	1
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4609376.158	374463.672	2	2
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4609193	374660.005	3	2
Last Cut Drainage	Onopordum acanthium	Scotch thistle	0	4608817.677	374888.043	5	1
Pacific Track Grade	Chondrilla juncea	rush skeletonweed	0	4608636.852	370918.178	5	1
Pacific Track Grade	Chondrilla juncea	rush skeletonweed	0	4608514.993	370788.08	5	1
Pacific Track Grade	Convolvulus arvensis	Field bindweed	0	4608585.349	370765.784	2	3
Pacific Track Grade	Onopordum acanthium	Scotch thistle	0	4608842.609	371215.829	2	2
Pacific Track Grade	Onopordum acanthium	Scotch thistle	0	4608972.632	371400.315	2	2
Poulsons Road	Chondrilla juncea	rush skeletonweed	0	4608691.486	375574.326	2	2
Poulsons Road	Onopordum acanthium	Scotch thistle	0	4609880.178	374481.711	2	2
Poulsons Road	Onopordum acanthium	Scotch thistle	0	4609817.69	374586.476	2	2
Poulsons Road	Verbascum blattaria	Moth mullein	0	4609044.762	375338.733	2	4

Appendix A. Exotic Plant Patches Detected on Monitoring Routes at Golden Spike NHS, July 5-6, 2016, cont.

Plot_ID	Species	Master_Common_Name	Pulled	N_Coord	E_Coord	Cover_Class	Size_Class
Poulsons Road	Verbascum blattaria	Moth mullein	0	4609100.786	375270.851	2	4
Poulsons Road	Verbascum blattaria	Moth mullein	0	4608973.303	375412.401	2	3
Witkers Service Road	Onopordum acanthium	Scotch thistle	0	4608835.005	370883.949	3	1

Appendix B. Exotic Plant Transect Data Detected at Golden Spike NHS, July 5–6, 2016

Route	Transect	Area	E_Coord	N_Coord	Species	Master_Common_Name	Alive?	AverageCover
Big Fill Section County Road	120	Big Fill	377039.161	4610736.473	Agropyron cristatum	crested wheatgrass	Y	1.333
Big Fill Section County Road	122	Big Fill	376117.491	4610471.988	Agropyron cristatum	crested wheatgrass	Y	0.167
Big Fill Section County Road	124	Big Fill	375140.219	4610391.543	Agropyron cristatum	crested wheatgrass	Y	0.167
Poulsons Road	126	Big Fill	375074.548	4609311.598	Agropyron cristatum	crested wheatgrass	Y	0.5
East Tour Road	110	Big Fill	374676.676	4609855.263	Bromus tectorum	Cheatgrass	Y	11.5
East Tour Road	111	Big Fill	375010.704	4609496.922	Bromus tectorum	Cheatgrass	Y	10.5
East Tour Road	112	Big Fill	375494.435	4609432.721	Bromus tectorum	Cheatgrass	Y	0.5
East Tour Road	113	Big Fill	375899.15	4609697.161	Bromus tectorum	Cheatgrass	Y	1.5
East Tour Road	114	Big Fill	375957.338	4610133.677	Bromus tectorum	Cheatgrass	Y	1.333
East Tour Road	115	Big Fill	375899.732	4610582.51	Bromus tectorum	Cheatgrass	Y	0.5
East Tour Road	116	Big Fill	376357.164	4610616.834	Bromus tectorum	Cheatgrass	Y	1.333
East Tour Road	117	Big Fill	376756.203	4610845.469	Bromus tectorum	Cheatgrass	Y	7.167
East Tour Road	118	Big Fill	376988.058	4611242.944	Bromus tectorum	Cheatgrass	Y	3.333
East Tour Road	119	Big Fill	377409.463	4611493.629	Bromus tectorum	Cheatgrass	Y	0.5
Big Fill Section County Road	120	Big Fill	377039.161	4610736.473	Bromus tectorum	Cheatgrass	Y	0.333
Big Fill Section County Road	121	Big Fill	376600.342	4610497.824	Bromus tectorum	Cheatgrass	Y	0.667
Big Fill Section County Road	122	Big Fill	376117.491	4610471.988	Bromus tectorum	Cheatgrass	Y	0.5
Big Fill Section County Road	123	Big Fill	375626.175	4610510.538	Bromus tectorum	Cheatgrass	Y	2
Big Fill Section County Road	124	Big Fill	375140.219	4610391.543	Bromus tectorum	Cheatgrass	Y	2.167
Poulsons Road	125	Big Fill	375419.309	4608957.436	Bromus tectorum	Cheatgrass	Y	0.75
Poulsons Road	126	Big Fill	375074.548	4609311.598	Bromus tectorum	Cheatgrass	Y	10.5
Poulsons Road	127	Big Fill	374678.109	4609597.056	Bromus tectorum	Cheatgrass	Y	0.667
Poulsons Road	128	Big Fill	374350.369	4609888.361	Bromus tectorum	Cheatgrass	Y	35
Last Cut Drainage	129	Big Fill	374525.186	4609333.222	Bromus tectorum	Cheatgrass	Y	0.833
Last Cut Drainage	130	Big Fill	374721.755	4608966.739	Bromus tectorum	Cheatgrass	Y	0.667
Last Cut Drainage	131	Big Fill	375090.791	4608787.904	Bromus tectorum	Cheatgrass	Y	0.667
Big Fill Section County Road	134	Big Fill	377023.934	4610725.636	Bromus tectorum	Cheatgrass	Y	0.5
Big Fill Section County Road	135	Big Fill	376587.377	4610485.365	Bromus tectorum	Cheatgrass	Y	0.333
Big Fill Section County Road	136	Big Fill	376103.746	4610468.353	Bromus tectorum	Cheatgrass	Y	0.5
Big Fill Section County Road	137	Big Fill	375612.849	4610502.743	Bromus tectorum	Cheatgrass	Y	1.167
East Tour Road	112	Big Fill	375494.435	4609432.721	Sisymbrium altissimum	Tumble mustard	Y	0.167
Big Fill Section County Road	124	Big Fill	375140.219	4610391.543	Sisymbrium altissimum	Tumble mustard	Y	1

Appendix B. Exotic Plant Transect Data Detected at Golden Spike NHS, July 5–6, 2016, cont.

Route	Transect	Area	E_Coord	N_Coord	Species	Master_Common_Name	Alive?	AverageCover
Poulsons Road	128	Big Fill	374350.369	4609888.361	Sisymbrium altissimum	Tumble mustard	Y	1
Big Fill Section County Road	134	Big Fill	377023.934	4610725.636	Sisymbrium altissimum	Tumble mustard	Y	0.167
Big Fill Section County Road	138	Big Fill	375127.388	4610380.94	Sisymbrium altissimum	Tumble mustard	Y	5
County Road	102	Last Spike	370973.205	4608577.77	Agropyron cristatum	crested wheatgrass	Y	16.833
Witkers Service Road	103	Last Spike	370911.998	4608852.973	Agropyron cristatum	crested wheatgrass	Y	20.667
Residence Service Road	104	Last Spike	371331.46	4608590.273	Agropyron cristatum	crested wheatgrass	Y	1.333
Water Tank Road	105	Last Spike	371076.279	4608416.73	Agropyron cristatum	crested wheatgrass	Y	2
Pacific Track Grade	106	Last Spike	370992.836	4608699.874	Agropyron cristatum	crested wheatgrass	Y	1.167
Pacific Track Grade	107	Last Spike	371413.22	4608970.94	Agropyron cristatum	crested wheatgrass	Y	24.333
Hydro 1	108	Last Spike	370792.929	4608891.192	Agropyron cristatum	crested wheatgrass	Y	8.333
Retired Service Road	109	Last Spike	370784.843	4608641.459	Agropyron cristatum	crested wheatgrass	Y	14.333
County Road	132	Last Spike	370979.811	4608577.735	Agropyron cristatum	crested wheatgrass	Y	10.333
County Road	133	Last Spike	370598.298	4608327.812	Agropyron cristatum	crested wheatgrass	Y	18
Facility Road	101	Last Spike	371336.7	4608711.267	Bromus tectorum	Cheatgrass	Y	1.5
County Road	102	Last Spike	370973.205	4608577.77	Bromus tectorum	Cheatgrass	Y	13.333
Residence Service Road	104	Last Spike	371331.46	4608590.273	Bromus tectorum	Cheatgrass	Y	0.667
Water Tank Road	105	Last Spike	371076.279	4608416.73	Bromus tectorum	Cheatgrass	Y	0.667
Pacific Track Grade	106	Last Spike	370992.836	4608699.874	Bromus tectorum	Cheatgrass	Y	1.167
Pacific Track Grade	107	Last Spike	371413.22	4608970.94	Bromus tectorum	Cheatgrass	Y	0.167
Hydro 1	108	Last Spike	370792.929	4608891.192	Bromus tectorum	Cheatgrass	Y	0.667
County Road	132	Last Spike	370979.811	4608577.735	Bromus tectorum	Cheatgrass	Y	1.333
County Road	133	Last Spike	370598.298	4608327.812	Bromus tectorum	Cheatgrass	Y	4
County Road	102	Last Spike	370973.205	4608577.77	Sisymbrium altissimum	Tumble mustard	Y	16.833
Residence Service Road	104	Last Spike	371331.46	4608590.273	Sisymbrium altissimum	Tumble mustard	Y	0.333
Water Tank Road	105	Last Spike	371076.279	4608416.73	Sisymbrium altissimum	Tumble mustard	Y	2.333
Pacific Track Grade	106	Last Spike	370992.836	4608699.874	Sisymbrium altissimum	Tumble mustard	Y	13.333
Retired Service Road	109	Last Spike	370784.843	4608641.459	Sisymbrium altissimum	Tumble mustard	Y	0.667
County Road	133	Last Spike	370598.298	4608327.812	Sisymbrium altissimum	Tumble mustard	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.

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