National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

Invasive Exotic Plant Monitoring at Fossil Butte National Monument

2014 Field Season

Natural Resource Report NPS/NCPN/NRR—2015/988



ON THE COVER

Japanese chess (*Bromus japonicus*). Photo by Patrick J. Alexander.

Invasive Exotic Plant Monitoring at Fossil Butte National Monument

2014 Field Season

Natural Resource Report NPS/NCPN/NRR—2015/988

Prepared by
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

July 2015

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, http://www.nature.nps.gov/im/units/ncpn, as well as at the Natural Resource Publications Management web site, http://www.nature.nps.gov/publications/nrpm. To receive this report in a format optimized for screen readers, please email irma@nps.gov.

Please cite this publication as:

Perkins, D. W. 2015. Invasive exotic plant monitoring at Fossil Butte National Monument: 2014 field season. Natural Resource Report NPS/NCPN/NRR—2015/988. National Park Service, Fort Collins, Colorado.

NPS 174/129002, July 2015

Contents

Figures v
Tables v
Abstract vii
Acknowledgements ix

1 Introduction 1

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

3 Results 7
3.1 Monitoring routes 7
3.2 Monitoring transects 7
3.3 Priority patches over time 7

4 Discussion 23
4.1 Possibilities for management control 23
4.2 Future monitoring efforts 24

5 Literature Cited 25

Appendices 27

Figures

Figure 2-1. The maximum effective detection distance (EDD) in 2012 at Fossil Butte National Monument was 3 to 7.5 meters, making the effective detection swath width (EDSW) 6–15 meters. 4

Figure 3-1. Invasive plant monitoring routes by figure number, Fossil Butte National Monument, July 19–22, 2014. 16

Figure 3-2. Invasive plant monitoring routes and invasive patches detected along monitoring routes, northern section of Fossil Butte National Monument, July 19–22, 2014. 17

Figure 3-3. Invasive plant monitoring routes and invasive patches detected along monitoring routes, central section of Fossil Butte National Monument, July 19–22, 2014. 18

Figure 3-4. Invasive plant monitoring routes and invasive patches detected along monitoring routes, southern section of Fossil Butte National Monument, July 19–22, 2014. 19

Figure 3-5. Invasive plant monitoring transects, Fossil Butte National Monument, July 19–22, 2014. . 20

Figure 3-6. Invasive plant patches per kilometer, by area, of priority invasive species that were consistently recorded on monitoring routes in all years, Fossil Butte National Monument, 2008–2014. 21

Figure 3-7. Invasive plant patches, recorded in the highest densities per kilometer, of priority invasive species that were consistently searched for on monitoring routes in most years, Fossil Butte National Monument, 2008–2014. 21

Tables

Table 2-1. Priority invasive plant list, Fossil Butte National Monument, 2008–2014. 3

Table 3-1. Invasive exotic plants detected at Fossil Butte National Monument, July 19–22, 2014. 7

Table 3-2. Number of priority IEP patches per route, and number per kilometer by route type, Fossil Butte National Monument, July 19–22, 2014. 9

Table 3-3. Number of patches by species patch size class detected along monitoring routes, Fossil Butte National Monument, July 19–22, 2014. 10

Table 3-4. Species observed and patch size detected along the Main Park Road, Fossil Butte National Monument, 2008–2012. 11

Table 3-5. Total number of patches (number per km) detected on the southern and northern drainages and roads, Fossil Butte National Monument, 2008–2014. 13

Table 3-6. Total number of patches (number per km) detected on trails and parkwide, Fossil Butte National Monument, August 6–8, 2009, July 24–28, 2010, August 2–5, 2012, and July 19–22, 2014. 15

Abstract

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 2014 field season at Fossil Butte National Monument (NM). From July 19 to 22, 2014, ten priority IEP species in 574 patches were detected on monitoring routes that covered all major roads, trails, and riparian areas at Fossil Butte NM. The highest densities of IEP patches were recorded in the drainages; specifically, South Millet Canyon (22.0/km), North Dam Fork of Chicken Creek (17.8/km), East Red Hill (15.0/km), and Millet Canyon (12.7/km). Cheatgrass (*Bromus tectorum*), flixweed (*Descurainia sophia*), and creeping foxtail (*Alopecurus arundinaceus*) were the most widespread species. All three of those species also increased substantially from 2012 to 2014. We found invasive plants in six formerly weedless routes (East Fork of Chicken Creek, East Red Hill Drainage, Fossil Butte Middle Drainage, Northeast Fork of Chicken Creek, West Fork of Chicken Creek and West Red Hill Drainage). Percent cover of cheatgrass along the Main Park Road was higher than in previous years. The network will return to Fossil Butte NM for a fifth year of monitoring in 2016.

Acknowledgements

A. Cohens and J. Doucette conducted field work. A. Wight was extremely helpful in generating routes, quadrats, and other GIS information. A. Aase assisted with reviewing the park target invasive plant list and arranging site logistics. D. Thoma and A. Aase improved this report with their thoughtful review. Data management was provided by H. Thomas and B. Campbell. K. Lund, S. Karinen, and D. Perry 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 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 2014 field season and fourth complete monitoring visit at Fossil Butte National Monument (NM).

2 Methods

We followed the invasive plant monitoring protocol developed by the NCPN (Perkins et al. 2013). 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 were surveyed previously with monitoring routes and quadrats in 2008–2009, 2010, and 2012 (Perkins 2010, 2011, 2013).

2.1 Developing a park target invasive exotic plant list

Prior to beginning monitoring in 2014, 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 2009, 2011, and 2013. Cheatgrass (*Bromus tectorum*) was mapped throughout the park in 2012 with relatively few patches, so it was added to the priority list in 2014. 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 priority 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. Eradicating these target species, or containing them within a park, is possible. 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 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 (0.01 acres, or approximately 20 × 20 ft) for all IEPs. Use of the MDTS is necessary because field

Table 2-1. Priority invasive plant list, Fossil Butte National Monument, 2008–2014.

Scientific name	Common name
Alopecurus arundinaceus[1]	creeping foxtail
Arctium minus	burdock
Bromus tectorum[2]	cheatgrass
Cardaria chalepensis	orbicular whitetop
Cardaria pubescens	hairy whitetop
Carduus nutans	musk thistle
Centaurea diffusa	diffuse knapweed
Centaurea maculosa	spotted knapweed
Centaurea repens	Russian knapweed
Cirsium arvense	Canada thistle
Cirsium vulgare	bull thistle
Convolvulus arvensis	field bindweed
Cynoglossum officinale	common houndstongue
Descurainia sophia[3]	flixweed
Elymus repens	quackgrass
Hyoscyamus niger	black henbane
Isatis tinctoria	Dyer's woad
Kochia scoparia	kochia
Lepidium latifolium	perennial pepperweed
Linaria dalmatica	Dalmatian toadflax
Melilotus officinalis	yellow sweetclover
Sonchus arvensis/S. ulginosis	perennial sowthistle
Tamarix ramosissima	tamarisk
Verbascum thapsus	woolly mullein

[1]2010–2014 only, [2]2014 only, [3]2012–2014 only

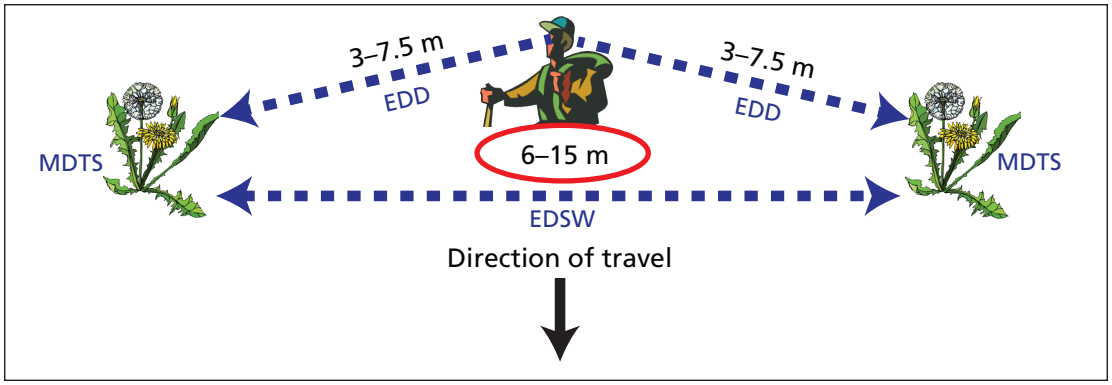


Figure 2-1. The maximum effective detection distance (EDD) in 2012 at Fossil Butte National Monument was 3 to 7.5 meters, making the effective detection swath width (EDSW) 6–15 meters.

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 unless the observer is very close to the patch.

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 Fossil Butte NM was between 3 and 7.5 m in 2014, depending on surrounding 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 the search route. The EDSW ranged from 6 to 15 m at Fossil Butte NM in 2014.

2.2.4 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.

2.2.5 Patch separation resolution

We define patch separation resolution (PSR) as the minimum distance between plants that must be considered members of separate infestations, or 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 m are typically considered to be one patch during planning and implementation of weed-control operations. If a patch is continuous for more than 50 m, then cover estimates are made every 50 m to aid in developing an effective management strategy for the entire patch.

2.2.6 Data collection methods

For the Main Park Road, we walked one EDD out from one side of the road and then returned to the starting point by walking back one EDD from the road on the other

side. For secondary roads, single-track trails, and drainages, we walked the center of the trail or drainage in only one direction (Figure 2-2). 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 6–15 m (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 GPS units with at least 5-meter accuracy. Only species designated as priority were consistently recorded during monitoring routes.

When a priority IEP was discovered, we recorded the following information: (1) the monitoring route, (2) the 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 m (55 yards) apart were considered separate patches 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

We established transects with three vegetation quadrats every 500 m along monitoring routes. If no IEPs were detected for four consecutive transects (12 quadrats), then transects were established every 1,000 m. 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 m.

2.3.1 Quadrat establishment

From 2010 to 2014, we centered vegetation quadrats at 0.5, 5, and 10 m away from the edge of a road on the same side as the route that was being walked and on alternating sides for riparian areas, small roads, or trails. We placed a 1-m^2 sampling frame to sample vegetation cover and soil surface features on the right side of the transect line as the technician walked the monitoring route. In some cases, we leveled the sampling frame by propping up quadrat corners.

Quadrat-sampling methods differed slightly from 2008 to 2009–2012. In 2008, we used three 1-m^2 vegetation quadrats, placed in a circular macroplot (Perkins and Weissinger 2009). In 2009, quadrats were placed at 3, 8, and 13 m away from the monitoring route. In 2008, all invasive species were recorded in monitoring quadrats. From 2009 to 2014, only priority species and cheatgrass were recorded in quadrats and along routes. Observers could make additional species observations, but non-priority species, and cheatgrass in locations other than along the Main Park Road, were not reliably recorded.

2.3.2 Data collection methods

In the monitoring quadrats, we recorded all priority IEP species observed. 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, 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 100 m for monitoring routes. Percent cover estimates for monitoring routes or groups of monitoring routes were generated from the monitoring transect data. We calculated the mean and standard error of percent cover by species for monitoring quadrats. For classes representing a range of percent cover values (11–25, 26–50, and 51–100), midpoints were used (18, 38, and 76%) 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 66.6 km (41.4 miles) along 27 monitoring routes in 2014 (Figure 3-1). We recorded a total of 10 priority species and one additional IEP species in 597 patches (574 patches of priority species) in 2014 (Tables 3-1, 3-2, 3-3, Figures 3-1, 3-2, 3-3, 3-4, Appendix A). Of the 574 priority patches, 237 (41%) were larger than 40 m^2 (Table 3-3). The highest densities of plant patches were recorded in the drainages; specifically, South Millet Canyon (22.0/km), North Dam Fork of Chicken Creek (17.8/km), East Red HiIl (15.0/km), and Millet Canyon (12.7/km) Table 3-2. The Main Park Road had the highest density (12.2/km) of patches of any road or trail. Roads other than the Main Park Road (2.4/km), and trails (4.4/km), generally had lower patch densities.

Cheatgrass, flixweed (*Descurainia sophia*), and creeping foxtail (*Alopecurus arundinaceus*) were by far the most widespread species, with over 100 patches each and representing 85% of all priority patches detected (Table 3-3). The next-most widespread was musk thistle (*Carduus nutans*), with 30 patches. 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

A total of 122 transects were sampled in 2014 (Figure 3-5, Appendix B). Only priority species and cheatgrass have been reliably recorded in all years. In 2014, four priority species and one additional, non-priority invasive species were detected in transects. Creeping foxtail and Japanese chess (*Bromus japonicus*) each occurred in one transect each along Chicken Creek and the Main Park Road, respectively. Yellow sweetclover (*Melilotus officinalis*) occurred in one transect each along the Chicken Creek Nature Trail and the Main Park Road. Flixweed occurred in one transect each along Chicken Creek, Eagle Nest Point Road, East Red Hill Drainage, North Dam Fork of Chicken Creek, and Smallpox Creek, as well as three transects along the Main Park Road. Total percent cover for any of the above species per monitoring route was less than 0.4%. Cheatgrass occurred in one transect along Fossil Butte East Drainage and 10 transects along the Main Park Road, with a mean percent cover of 0.94% (0.5 SE). Estimated percent covers of cheatgrass along the Main Park Road in 2009, 2010, and 2012 were 0.44% (0.30 SE), 0.36% (0.17 SE), and 0.06% (0.06 SE), respectively.

3.3 Priority patches over time

In 2014, the number of priority IEP patches consistently recorded across the sampling periods was similar to that in 2012, and the

Table 3-1. Invasive exotic plants detected at Fossil Butte National Monument, July 19–22, 2014.

Scientific name	Common name	Method detected		Park priority?
		Routes	Transects	
Alopecurus arundinaceus	creeping foxtail	X	X	Yes
Bromus tectorum	cheatgrass	X	X	Yes
Cardaria sp.	whitetop	X		Yes
Carduus nutans	musk thistle	X		Yes
Centaurea maculosa	spotted knapweed	X		Yes
Cirsium arvense	Canada thistle	X		Yes
Convolvulus arvensis	field bindweed	X		Yes
Descurainia sophia	flixweed	X	X	Yes
Elymus repens	quackgrass	X		Yes
Hyoscyamus niger	black henbane	X		Yes
Melilotus officinalis	yellow sweetclover	X	X	Yes
Bromus japonicus	Japanese chess	X	X	No

second-lowest of the four sample periods (Figure 3-6). When examined by area, patch density was also similar to that in 2012 (Tables 3-4, 3-5, 3-6, Figure 3-6).

However, three species that have not been on the priority list in all years (cheatgrass, flixweed, and creeping foxtail) increased substantially. Creeping foxtail had large increases from 2012 in both northern and southern drainages. Cheatgrass and flixweed had substantial increases in patch density along the Main Park Road, which has been consistently monitored for cheatgrass since 2009 and flixweed since 2012 (Tables 3-4, 3-5, Figure 3-7). Flixweed also showed large increases in northern drainages and trails since 2012 (Tables 3-5, 3-6). Other species with notable increases from 2012 to 2014 included yellow sweetclover along the Main Park Road (Table 3-4), Canada thistle (*Cirsium arvense*) in southern drainages, and musk thistle in northern drainages. There was a notable decrease in quackgrass (*Elymus repens*) along the Main Park Road from 2012 to 2014.

We found invasive plants in six formerly weedless routes (East Fork of Chicken Creek, East Red Hill Drainage, Fossil Butte Middle Drainage, Northeast Fork of Chicken Creek, West Fork of Chicken Creek and West Red Hill Drainage), leaving the Fossil Butte Northwest Drainage and Wasatch Saddle Drainage as the only remaining weedless monitoring routes.

Table 3-2. Number of priority IEP patches per route, and number per kilometer by route type, Fossil Butte National Monument, July 19–22, 2014.

Route	Length (m)	ha	Patches	Patches/km
Road				
Main Park Road	*23,490*	*14.5*	*288*	*12.3*
Bullpen Two Track	829	1.0	5	6.0
Cundick Ridge Road	1,968	4.0	6	3.0
Eagle Nest Point Road	1,126	2.3	2	1.8
Rubey Point Road	2,737	5.5	3	1.1
Roads other than Main Park Road	*6,660*	*12.8*	*16*	*2.4*
Riparian				
Chicken Creek	7,197	15.1	85	11.8
East Fork Chicken Creek*	3,617	7.2	21	5.8
East Red Hill Drainage*	666	1.1	10	15.0
Fossil Butte East Drainage	1,552	4.7	19	12.2
Fossil Butte Middle Drainage*	1,012	2.0	1	1.0
Fossil Butte Northwest Drainage	837	1.7	0	0.0
Fossil Butte South Drainage	1,162	2.3	3	2.6
Matate Drainage	996	2.0	3	3.0
Millet Canyon	1,101	2.2	14	12.7
Moose Bones Canyon	1,286	2.6	8	6.2
Murder Hill Drainage	960	1.9	4	4.2
Northeast Fork Chicken Creek*	879	1.8	3	3.4
North Dam Fork Chicken Creek	2,028	4.1	36	17.8
Sage Grouse Lek Drainage	1,188	2.4	4	3.4
Smallpox Creek	2,266	4.6	21	9.3
South Millet Canyon	818	1.6	18	22.0
South Murder Hill Drainage	719	1.5	6	8.3
Wasatch Saddle Drainage	719	1.4	0	0.0
West Fork Chicken Creek*	1,286	3.0	9	7.0
West Red Hill Drainage*	703	0.8	3	4.3
All Riparian	*30,992*	*64.1*	*269*	*8.7*
Trails				
Chicken Creek Nature Trail	1,990	3.9	18	9.0
Historic Quarry Trail	3,483	6.9	6	1.7
All trails	*5,474*	*10.8*	*24*	*4.4*
Total	**66,616**	**102.0**	**597**	**9.0**

*Route previously weed-free
Numbers have been rounded.

Table 3-3. Number of patches by species patch size class detected along monitoring routes, Fossil Butte National Monument, July 19–22, 2014.

Scientific name	Common name	Total patches	Patch size class (number per class)				
			1	2	3	4	5
Alopecurus arundinaceus	creeping foxtail	123	17	49	40	10	7
Bromus tectorum	cheatgrass	199	5	89	66	22	17
Cardaria sp.	whitetop	1	0	1	0	0	0
Carduus nutans	musk thistle	30	18	10	1	1	0
Centaurea maculosa	spotted knapweed	6	1	4	1	0	0
Cirsium arvense	Canada thistle	19	2	12	4	1	0
Convolvulus arvensis	field bindweed	2	0	2	0	0	0
Descurainia sophia	flixweed	165	7	103	26	8	21
Elymus repens	quackgrass	5	1	4	0	0	0
Hyoscyamus niger	black henbane	4	1	3	0	0	0
Melilotus officinalis	yellow sweetclover	20	9	9	2	0	0
Total priority species		**574**	**61**	**286**	**140**	**42**	**45**
Bromus japonicus	Japanese chess	23	3	10	9	0	1
Total all species		**597**	**64**	**296**	**149**	**42**	**46**

*Non-priority species may not have been recorded on all routes.

Table 3-4. Species observed and patch size detected along the Main Park Road, Fossil Butte National Monument, 2008–2014.

Scientific name	Common name	Year[1]	Patches/km	Patch size class				
				1	2	3	4	5
Alopecurus arundinaceus[2]	creeping foxtail	2010	6 (0.26)	3	3	0	0	0
		2012	2 (0.08)	0	2	0	0	0
		2014	9 (0.38)	5	4	0	0	0
Bromus tectorum	cheatgrass	2008	37 (1.97)	15	12	9	1	0
		2010	95 (4.10)	2	35	44	13	1
		2012	15 (0.64)[3]	-	-	-	-	-
		2014	139 (5.91)	3	58	49	18	11
Cardaria chalepensis	orbicular whitetop	2008	2 (0.11)	1	1	0	0	0
		2010	0 (0.00)	0	0	0	0	0
		2012	0 (0.00)	0	0	0	0	0
		2014	1 (0.04)	0	1	0	0	0
Carduus nutans	musk thistle	2008	6 (0.32)	4	2	0	0	0
		2010	13 (0.56)	11	1	1	0	0
		2012	2 (0.08)	1	1	0	0	0
		2014	9 (0.38)	8	1	0	0	0
Centaurea maculosa	spotted knapweed	2008	0 (0.00)	0	0	0	0	0
		2010	0 (0.00)	0	0	0	0	0
		2012	4 (0.17)	2	2	0	0	0
		2014	6 (0.26)	1	4	1	0	0
Cirsium arvense	Canada thistle	2008	29 (1.54)	12	16	1	0	0
		2010	12 (0.52)	7	5	0	0	0
		2012	2 (0.08)	1	1	0	0	0
		2014	2 (0.09)	0	1	1	0	0
Cirsium vulgare	bull thistle	2008	1 (0.05)	0	1	0	0	0
		2010	1 (0.04)	1	0	0	0	0
		2012	3 (0.13)	1	2	0	0	0
		2014	0 (0.00)	0	0	0	0	0
Convolvulus arvensis	field bindweed	2008	4 (0.21)	0	4	0	0	0
		2010	1 (0.04)	0	1	0	0	0
		2012	0 (0.00)	0	0	0	0	0
		2014	2 (0.09)	0	2	0	0	0
Descurainia sophia[4]	flixweed	2012	2 (0.08)	2	0	0	0	0
		2014	75 (3.19)	6	51	10	5	3
Elymus repens	quackgrass	2008	49 (2.61)	19	16	12	2	0
		2010	69 (2.98)	5	23	19	15	7
		2012	21 (0.89)	0	17	3	1	0
		2014	4 (0.17)	1	3	0	0	0
Hyoscyamus niger	black henbane	2008	16 (0.85)	15	0	1	0	0
		2010	2 (0.09)	2	0	0	0	0
		2012	4 (0.17)	0	4	0	0	0
		2014	4 (0.17)	1	3	0	0	0

Table 3-4. Species observed and patch size detected along the Main Park Road, Fossil Butte National Monument, 2008–2014, cont.

Melilotus officinalis	yellow sweetclover	2008	48 (2.55)	38	7	3	0	0
		2010	35 (1.51)	18	14	3	0	0
		2012	6 (0.25)	2	4	0	0	0
		2014	15 (0.64)	9	5	1	0	0
Overall annual totals for species searched for in all four sampling years[5]								
		2008	155 (8.25)	89	47	17	2	0
		2010	133 (5.73)	44	44	23	15	7
		2012	42 (1.78)	7	31	3	1	0
		2014	43 (1.83)	20	20	3	0	0

[1]Distances surveyed were 18,793 m (July 14–15, 2008), 23,192 m (July 24–28, 2010), 23,531 m (August 2–5, 2012), and 23,490 m (July 19–22, 2014).

[2]Species not searched for in 2008

[3]13 plants were pulled, no size class recorded

[4]Species not searched for in 2008–2010

[5]These totals do not include cheatgrass, creeping foxtail, or flixweed, which were not searched for in all four years.

Table 3-5. Total number of patches (number per km) detected on the southern and northern drainages and roads, Fossil Butte National Monument, 2008–2014.

Scientific name	Common name	Southern drainages[1]		Northern drainages[2]		Roads[3]	
		Year	Total patches (per km)	Year	Total patches (per km)	Year	Total patches (per km)
Alopecurus arundinaceus[4]	creeping foxtail	2009	NA	2009	NA	2008	0 (0.00)
		2010	43 (1.64)	2010	8 (1.75)	2010	2 (0.30)
		2012	55 (1.97)	2012	1 (0.23)	2012	0 (0.00)
		2014	95 (3.64)	2014	15 (3.07)	2014	2 (0.30)
Bromus tectorum[5]	cheatgrass	2009	NA	2009	NA	2008	NA
		2010	NA	2010	NA	2010	NA
		2012	NA	2012	NA	2012	NA
		2014	31 (1.19)	2014	13 (2.66)	2014	1 (0.15)
Cardaria chalepensis	orbicular whitetop	2009	0 (0.00)	2009	0 (0.00)	2008	0 (0.00)
		2010	1 (0.04)	2010	0 (0.00)	2010	0 (0.00)
		2012	0 (0.00)	2012	0 (0.00)	2012	0 (0.00)
		2014	0 (0.00)	2014	0 (0.00)	2014	0 (0.00)
Carduus nutans	musk thistle	2009	13 (0.50)	2009	7 (1.45)	2008	1 (0.15)
		2010	16 (0.61)	2010	7 (1.53)	2010	1 (0.15)
		2012	11 (0.39)	2012	5 (1.15)	2012	0 (0.00)
		2014	11 (0.42)	2014	9 (1.84)	2014	1 (0.15)
Centaurea maculosa	spotted knapweed	2009	0 (0.00)	2009	0 (0.00)	2008	0 (0.00)
		2010	1 (0.04)	2010	0 (0.00)	2010	0 (0.00)
		2012	0 (0.00)	2012	0 (0.00)	2012	0 (0.00)
		2014	0 (0.00)	2014	0 (0.00)	2014	0 (0.00)
Cirsium arvense	Canada thistle	2009	26 (1.00)	2009	10 (2.06)	2008	0 (0.00)
		2010	22 (0.84)	2010	13 (2.84)	2010	3 (0.44)
		2012	1 (0.04)	2012	5 (1.15)	2012	0 (0.00)
		2014	11 (0.42)	2014	6 (1.23)	2014	0 (0.00)
Cirsium vulgare	bull thistle	2009	4 (0.15)	2009	1 (<.21)	2008	0 (0.00)
		2010	3 (0.11)	2010	4 (0.87)	2010	0 (0.00)
		2012	2 (0.07)	2012	1 (0.23)	2012	0 (0.00)
		2014	0 (0.00)	2014	0 (0.00)	2014	0 (0.00)
Descurainia sophia[6]	flixweed	2009	NA	2009	NA	2008	NA
		2010	NA	2010	NA	2010	NA
		2012	1 (0.04)	2012	0 (0.00)	2012	0 (0.00)
		2014	65 (2.49)	2014	6 (1.23)	2014	1 (0.15)

Table 3-5. Total number of patches (number per km) detected on the southern and northern drainages and roads, Fossil Butte National Monument, 2008–2014, cont.

Scientific name	Common name	Southern drainages[1]		Northern drainages[2]		Roads[3]	
		Year	Total patches (per km)	Year	Total patches (per km)	Year	Total patches (per km)
Elymus repens	quackgrass	2009	3 (0.12)	2009	0 (0.00)	2008	1 (0.15)
		2010	0 (0.00)	2010	13 (2.84)	2010	8 (1.18)
		2012	2 (0.07)	2012	0 (0.00)	2012	0 (0.00)
		2014	0 (0.00)	2014	1 (0.20)	2014	0 (0.00)
Hyoscyamus niger	black henbane	2009	2 (0.08)	2009	1 (0.21)	2008	0 (0.00)
		2010	2 (0.08)	2010	1 (0.21)	2010	0 (0.00)
		2012	0 (0.00)	2012	0 (0.00)	2012	0 (0.00)
		2014	0 (0.00)	2014	0 (0.00)	2014	0 (0.00)
Isatis tinctoria	Dyer's woad	2009	2 (0.08)	2009	0 (0.00)	2008	0 (0.00)
		2010	0 (0.00)	2010	0 (0.00)	2010	0 (0.00)
		2012	0 (0.00)	2012	0 (0.00)	2012	0 (0.00)
		2014	0 (0.00)	2014	0 (0.00)	2014	0 (0.00)
Melilotus officinalis	yellow sweetclover	2009	6 (0.23)	2009	0 (0.00)	2008	0 (0.00)
		2010	18 (0.69)	2010	0 (0.00)	2010	0 (0.00)
		2012	3 (0.11)	2012	0 (0.00)	2012	0 (0.00)
		2014	5 (0.19)	2014	0 (0.00)	2014	0 (0.00)
Total priority species		**2009**	**78 (3.00)**	**2009**	**21 (4.34)**	**2008**	**2 (0.30)**
		2010	**106 (4.05)**	**2010**	**46 (10.04)**	**2010**	**14 (2.07)**
		2012	**75 (2.68)**	**2012**	**12 (2.77)**	**2012**	**0 (0.00)**
		2014	**218 (8.35)**	**2014**	**50 (10.23)**	**2014**	**5 (0.75)**
Total species monitored all years		**2009**	**56 (2.16)**	**2009**	**19 (3.92)**	**2008**	**2 (0.30)**
		2010	**62 (2.37)**	**2010**	**38 (8.29)**	**2010**	**14 (2.07)**
		2012	**19 (0.68)**	**2012**	**11 (2.54)**	**2012**	**0 (0.00)**
		2014	**27 (1.03)**	**2014**	**16 (3.27)**	**2014**	**4 (0.60)**
Meters monitored		2009	25,983	2009	4,844	2008	6,638
		2010	26,173	2010	4,580	2010	6,774
		2012	27,942	2012	4,335	2012	6,745
		2014	26,108	2014	4,884	2014	6,660

[1]All Chicken Creek tributaries, Small Pox Creek, Matate, Sage Grouse Lek, Wasatch Saddle, Red Hill, and Fossil Butte drainages

[2]Millet Canyon, Murder Hill, South Millet Canyon, South Murder Hill and Moose Bones

[3]Rubey Point, Bullpen 2-Track, Eagle Nest, and Cundick Ridge

[4]Species not searched for in 2008; [5]Species not searched for in 2008–2012; [6]Species not searched for in 2008–2010

Table 3-6. Total number of patches (number per km) detected on trails and parkwide, Fossil Butte National Monument, July 14–16, 2008, August 6–8, 2009, July 24–28, 2010, August 2–5, 2012, and July 19–22, 2014.

Scientific name	Common name	Trails				Parkwide			
		2008–2009	2010	2012	2014	2008–2009	2010	2012	2014
Alopecurus arundinaceus[1]	creeping foxtail	NA	4 (0.66)	0 (0.00)	1 (0.18)	NA	63 (0.94)	58 (0.87)	123 (1.85)
Bromus tectorum[2]	cheatgrass	NA	NA	NA	13 (2.38)	NA	NA	NA	199 (2.99)
Cardaria chalepensis	orbicular whitetop	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	2 (0.03)	1 (0.01)	0 (0.00)	1 (0.02)
Carduus nutans	musk thistle	0 (0.00)	0 (0.00)	1 (0.17)	0 (0.00)	27 (0.44)	37 (0.55)	19 (0.24)	30 (0.45)
Centaurea maculosa	spotted knapweed	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.01)	4 (0.06)	6 (0.09)
Cirsium arvense	Canada thistle	1 (0.18)	4 (0.66)	1 (0.17)	0 (0.00)	66 (1.07)	54 (0.81)	9 (0.14)	19 (0.29)
Cirsium vulgare	bull thistle	1 (0.18)	1 (0.17)	0 (0.00)	0 (0.00)	7 (0.11)	9 (0.13)	6 (0.09)	0 (0.00)
Convolvulus arvensis	field bindweed	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	4 (0.06)	1 (0.01)	0 (0.00)	2 (0.03)
Descurainia sophia[3]	flixweed	NA	NA	0 (0.00)	10 (1.83)	NA	NA	3 (0.05)	165 (2.48)
Elymus repens	quackgrass	0 (0.00)	5 (0.83)	0 (0.00)	0 (0.00)	53 (0.86)	95 (1.42)	23 (0.35)	5 (0.08)
Hyoscyamus niger	black henbane	2 (0.36)	0 (0.00)	0 (0.00)	0 (0.00)	21 (0.34)	5 (0.07)	4 (0.06)	4 (0.06)
Isatis tinctoria	Dyer's woad	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	2 (0.03)	0 (0.00)	0 (0.00)	0 (0.00)
Melilotus officinalis	yellow sweetclover	0 (0.00)	1 (0.17)	1 (0.17)	0 (0.00)	54 (0.87)	54 (0.81)	10 (0.15)	20 (0.30)
Total priority species		**4 (1.07)**	**15 (2.49)**	**3 (0.50)**	**24 (4.39)**	**260 (4.20)**	**320 (4.79)**	**133 (2.00)**	**574 (8.62)**
Total priority species recorded in all years		**4 (1.07)**	**11 (1.83)**	**3 (0.50)**	**0 (0.00)**	**236 (3.82)**	**257 (3.85)**	**75 (1.13)**	**87 (1.31)**
Meters monitored		5,597	6,021	6,021	5,473	61,855	66,739	66,456	66,616

[1]Species not searched for in 2008

[2]Species not searched for in 2008–2012

[3]Species not searched for in 2008–2014

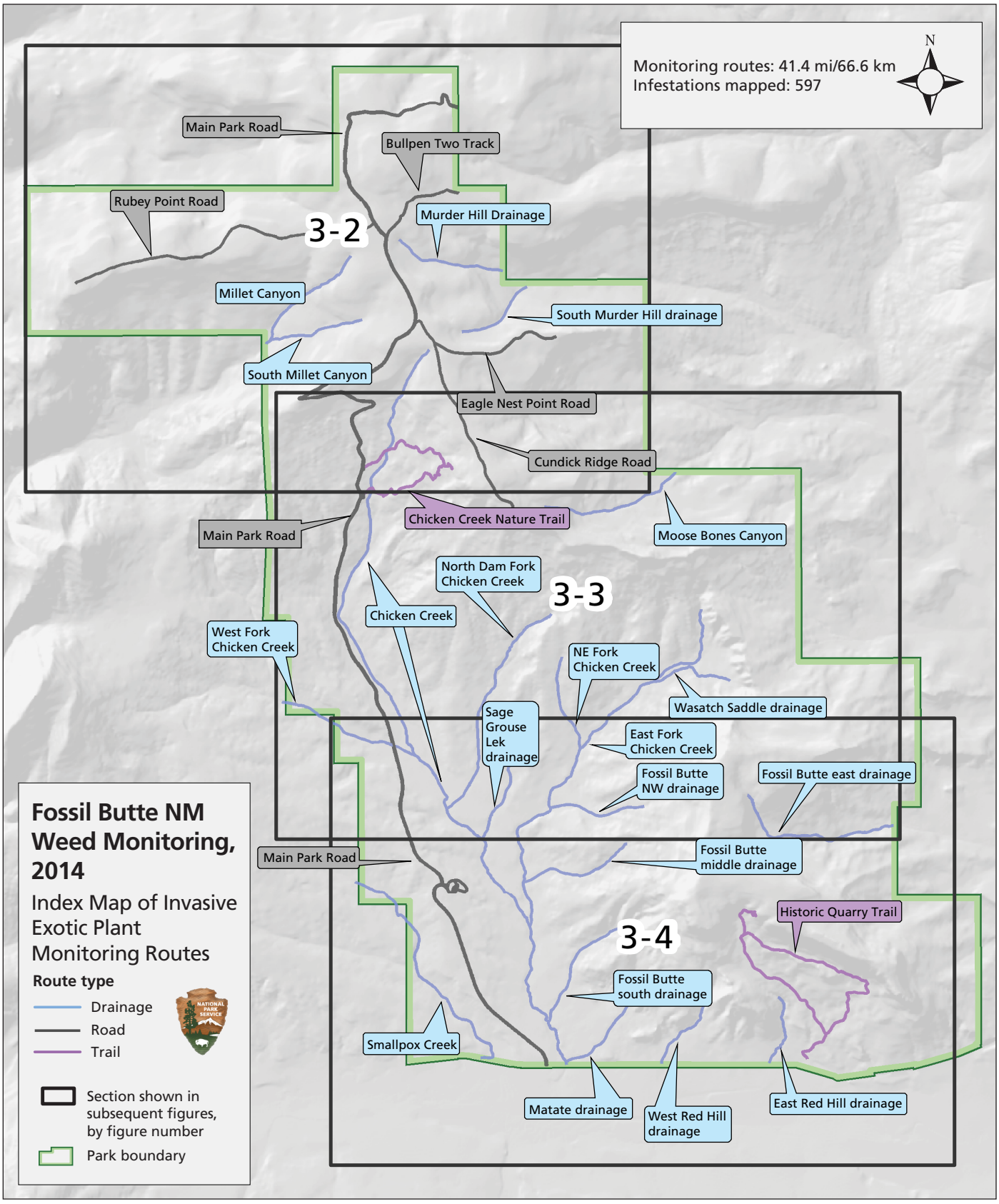


Figure 3-1. Invasive plant monitoring routes by figure number, Fossil Butte National Monument, July 19–22, 2014.

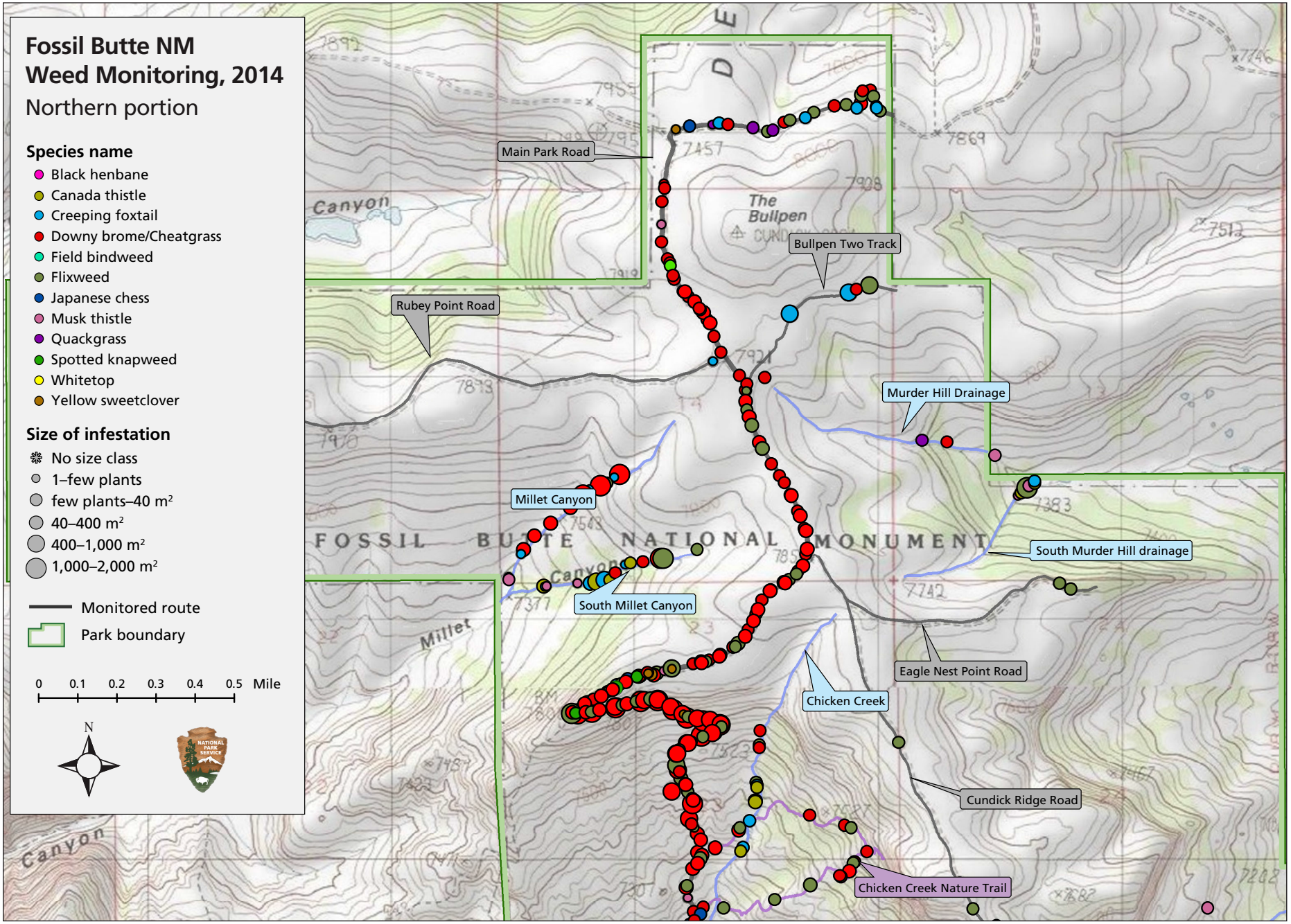


Figure 3-2. Invasive plant monitoring routes and invasive patches detected along monitoring routes, northern section of Fossil Butte National Monument, July 19–22, 2014.

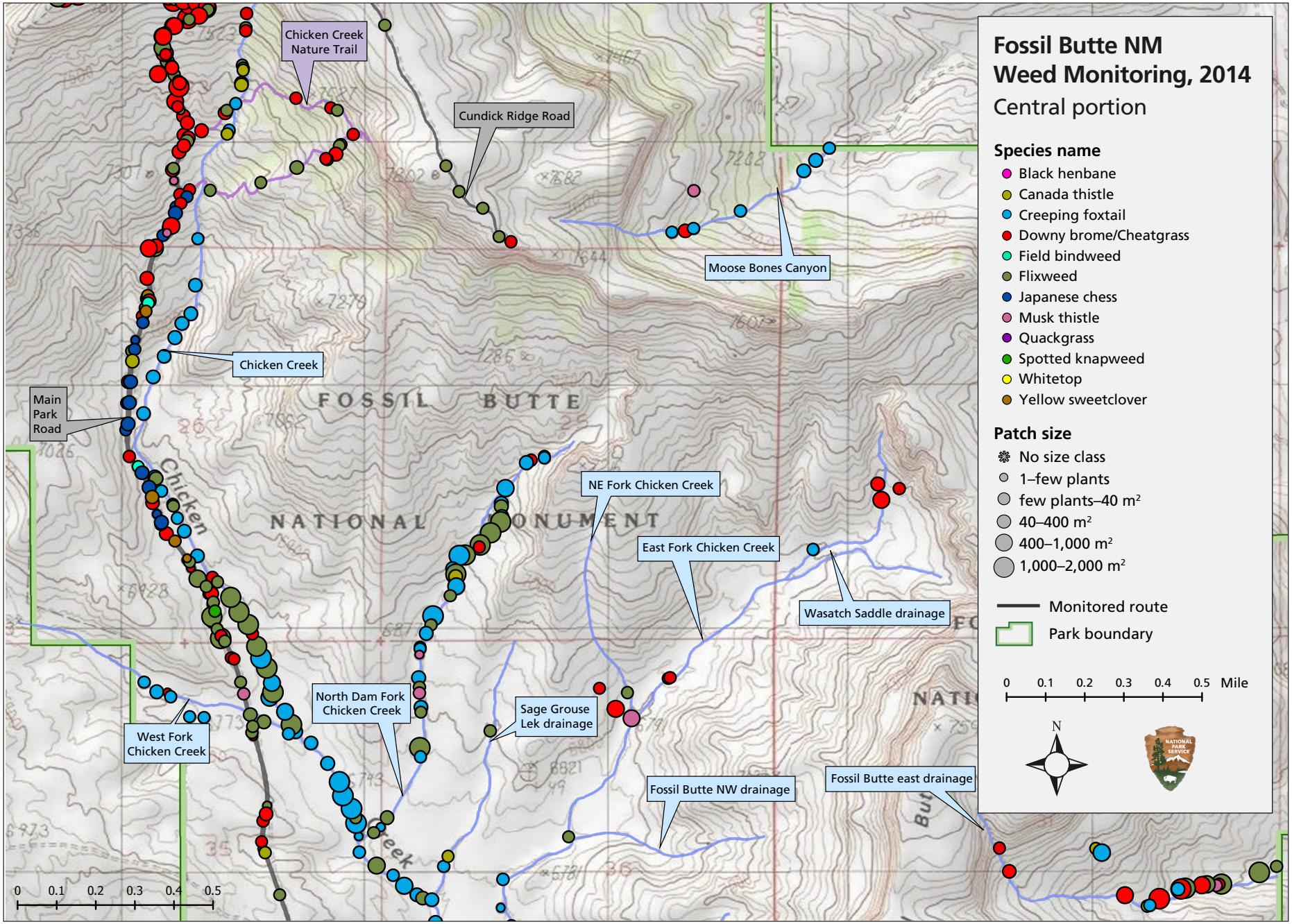


Figure 3-3. Invasive plant monitoring routes and invasive patches detected along monitoring routes, central section of Fossil Butte National Monument, July 19–22, 2014.

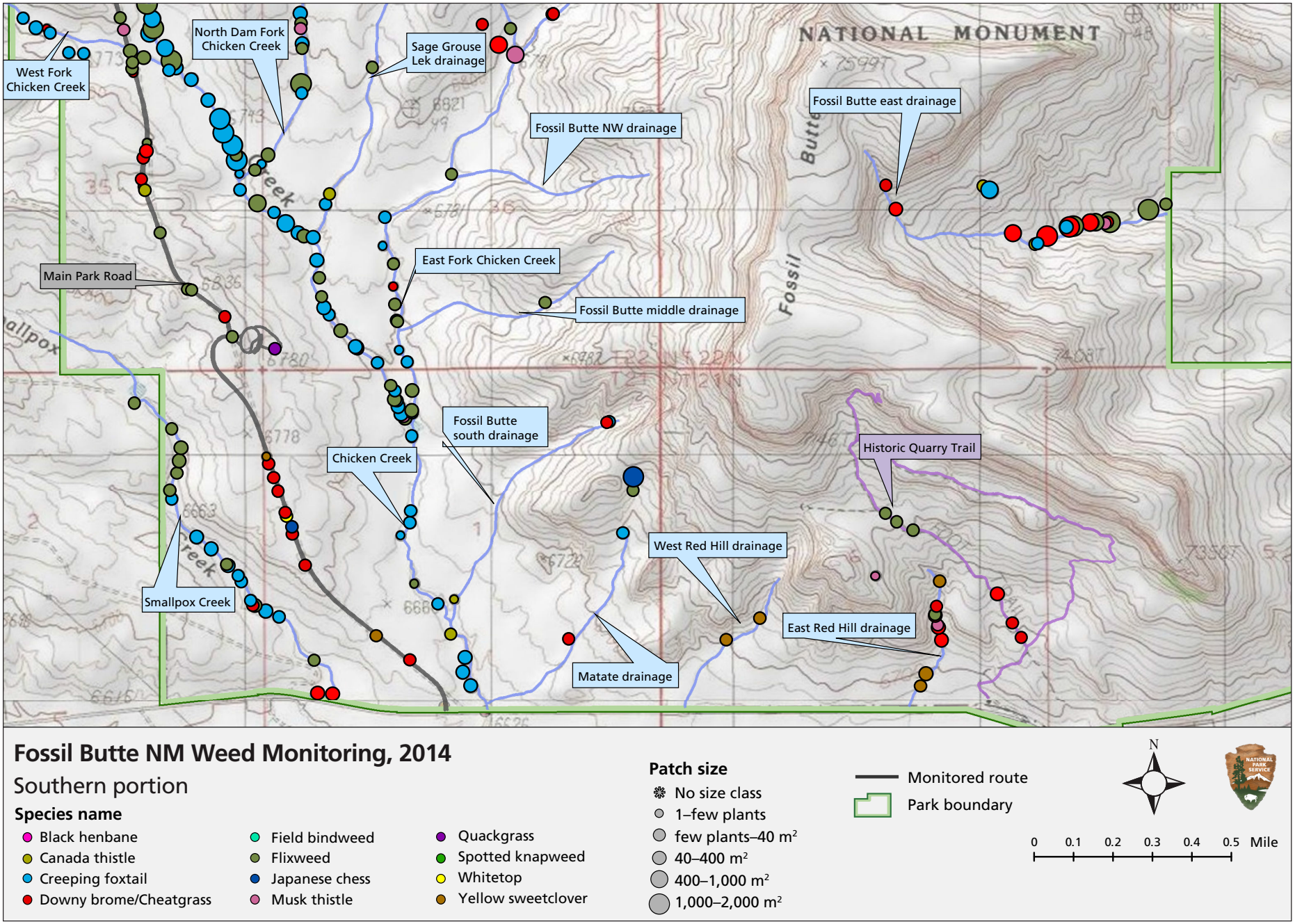


Figure 3-4. Invasive plant monitoring routes and invasive patches detected along monitoring routes, southern section of Fossil Butte National Monument, July 19–22, 2014.

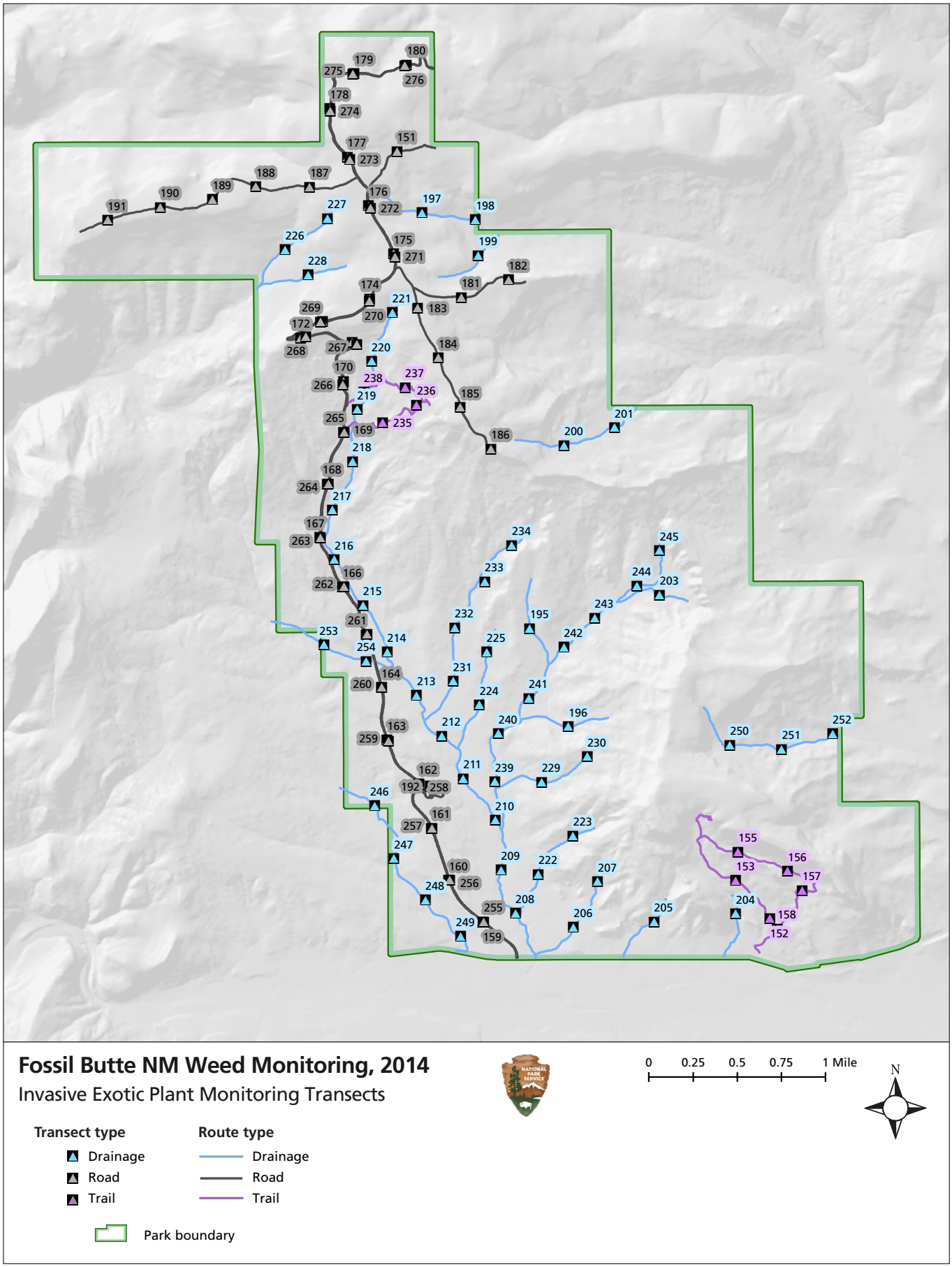


Figure 3-5. Invasive plant monitoring transects, Fossil Butte National Monument, July 19–22, 2014.

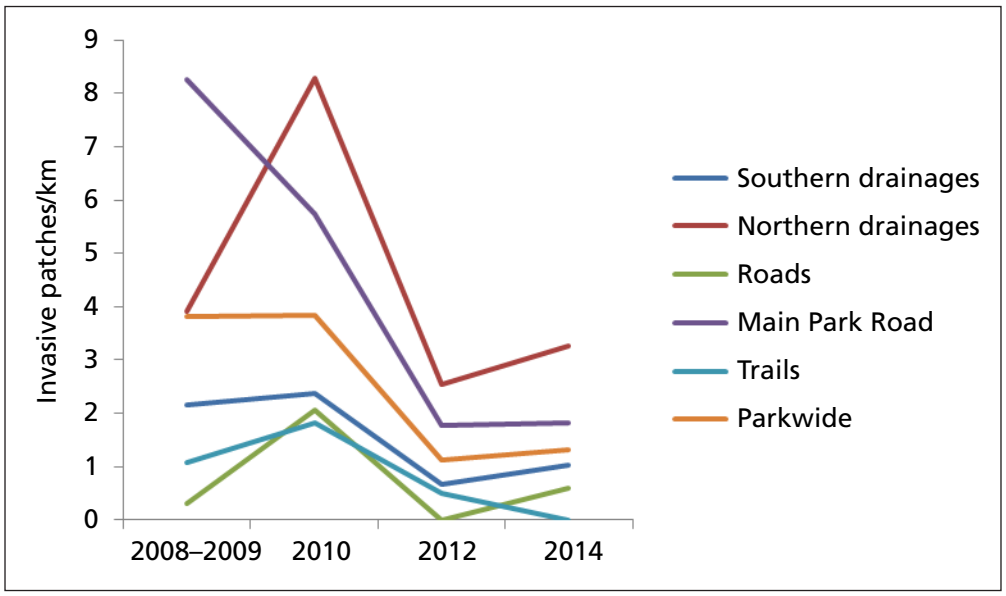


Figure 3-6. Invasive plant patches per kilometer, by area, of priority invasive species that were consistently recorded on monitoring routes in all years, Fossil Butte National Monument, 2008–2014.

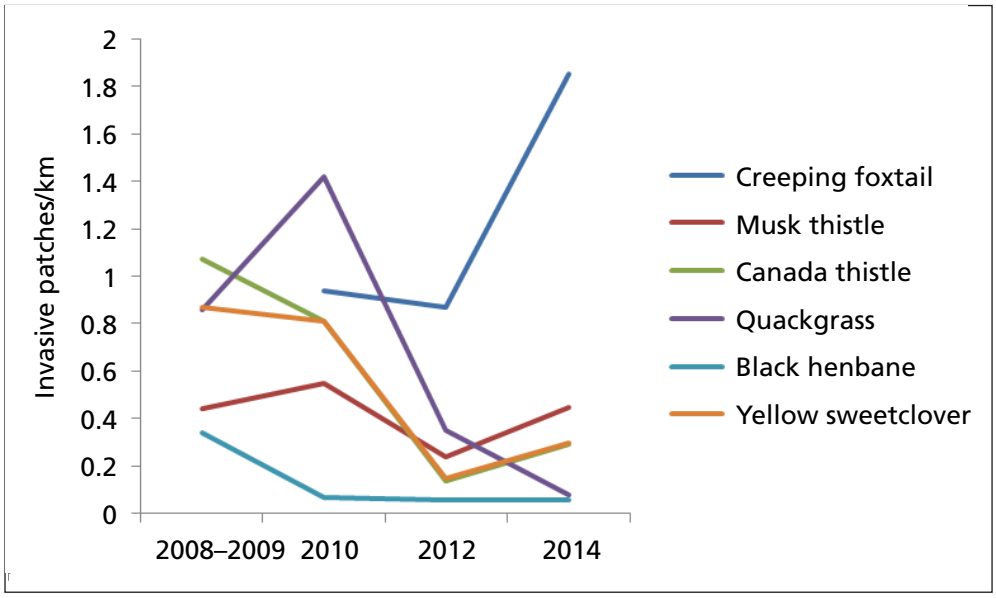


Figure 3-7. Invasive plant patches, recorded in the highest densities per kilometer, of priority invasive species that were consistently searched for on monitoring routes in most years, Fossil Butte National Monument, 2008–2014.

4 Discussion

The NCPN will continue to work with Fossil Butte NM 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. After this season's monitoring cycle, Fossil Butte NM staff requested that NCPN begin to monitor Japanese chess. This species will be added to the list for future visits.

Priority IEPs that have been consistently recorded from 2008 to 2014 stayed relatively similar in 2014, and many have declined since monitoring started in 2008. Park staff believe the efforts of a seasonal biotechnician may have contributed to the decreases seen in many species from 2010 to 2012 (A. Aase, pers. comm.). However, new species to the priority list, such as cheatgrass, flixweed, and creeping foxtail, all had large increases from 2012 to 2014. Additionally, several areas that were formerly weedless now have invasive patches in them. These areas should be targeted for control before these new invasive plants become more widespread.

4.1 Possibilities for management control

Cheatgrass, which can be very hard to control, increased substantially along the Main Park Road from 2012 to 2014. However, park managers should be congratulated for even being able to consider controlling cheatgrass, as its levels at many parks are too high for control efforts to be effective. Park staff removed 113 bags (appx. 30 gallons each) of cheatgrass in fiscal year 2012 (NPS 2012). They continued these efforts in 2013, with 60 bags removed by mowing along the Main Park Road and County Road 300. In 2014, the cheatgrass matured exceptionally early; thus, only the Main Park Road was mowed, resulting in 65 bags collected. By the time the park road was mowed, the cheatgrass along County Road 300 had fully matured and dropped its seed (A. Aase, pers. comm). This may be the reason for the increase in cheatgrass in 2014, after a reduction from 2012 to 2014.

In 2013, park staff sprayed 62 acres, mowed 25 acres, and pulled invasives from 18 acres, for a total of 105 acres treated. Spraying efforts focused on musk thistle and Canada thistle along the Chicken Creek picnic area and trails, Millet Canyon, Murder Hill Drainage, and below the repeater. In 2014, there were no musk thistle or Canada thistle patches detected along the Chicken Creek Nature Trail, and only one musk thistle patch each in Millet Canyon and Murder Hill Drainage, which is the same number or a reduction of thistle patches in these areas since 2012. In 2014, park staff mechanically and chemically treated 33 acres. Weed-pulling efforts for 2013 and 2014 focused on burdock (*Arctium minus*), cut-leaf nightshade (*Solanum triflorum*), flixweed, halogeton (*Halogeton glomeratus*), black henbane (*Hyoscyamus niger*), houndstoungue (*Cynoglossum officinale*), knapweed (*Centaruea* sp.), lambsquarters (*Chenopodium* sp.), musk thistle, Russian thistle, and yellow sweetclover. Parkwide, Canada thistle, yellow sweetclover, and musk thistle had small increases despite these control efforts, while black henbane remained approximately the same since 2012. Other species listed above are either not on the priority list or were present in numbers too low to determine if they had increased or decreased.

Areas away from riparian areas and the Main Park Road continued to have fewer IEPs. The area around Fossil Butte had been largely free of priority IEPs in 2012, but in 2014, invasive plant patches were found on six routes in this area that had previously been weed-free since monitoring began. Efforts should be made to eliminate these patches and keep this area weed-free. This area had no priority infestations in 2009, and two each in 2010 and 2012, but had 27 (plus an explosion of creeping foxtail, which was not monitored in all years) in 2014 (Figure 3-7). Efforts should be made to control these patches, particularly those at the upper end of drainages, before they become widespread.

It should be noted that estimates of percent cover in this report (see Section 3.3) 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. Data from monitoring routes are meant to provide information for control efforts. Unlike the monitoring transects and associated quadrats, the routes are not designed to make statistical

comparisons between years and areas. However, large changes in patches are likely to represent biological realities.

4.2 Future monitoring efforts

IEPs at Fossil Butte NM 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 June to August is not expected to drastically alter the chances of detecting invasive species larger than the minimum detection target size. A complete fifth sample of monitoring routes will occur in 2016. 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

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

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

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., and R. Weissinger. 2009. Invasive exotic plant monitoring at Fossil Butte National Monument: 2008 pilot field season. Natural Resource Technical Report NPS/NCPN/NRTR—2009/234. National Park Service, Fort Collins, Colorado.

Perkins, D. W. 2010. Invasive exotic plant monitoring at Fossil Butte National Monument: Annual report 2009. Natural Resource Technical Report NPS/NCPN/NRTR—2010/322. National Park Service, Fort Collins, Colorado.

——. 2011. Invasive exotic plant monitoring at Fossil Butte National Monument: 2010 field season. Natural Resource Technical Report NPS/NCPN/NRTR—2011/466. National Park Service, Fort Collins, Colorado.

——. 2013. Invasive exotic plant monitoring in Fossil Butte National Monument: Field seasons 2008–2012. Natural Resource Technical Report NPS/NCPN/NRTR—2013/751. National Park Service, Fort Collins, Colorado.

Perkins, D. W., K. Edvarchuk, S. Dewey, H. Thomas and A. Wight. 2013. Invasive plant protocol for Northern Colorado Plateau parks.

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

Appendix A. Exotic plant patches detected on monitoring routes at Fossil Butte NM, July 19–22, 2014.

See electronic appendices.

Appendix B. Exotic plant transect data detected at Fossil Butte NM, July 19–22, 2014.

See electronic appendices.

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 174/129002, July 2015

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™