



Invasive Exotic Plant Monitoring in Fossil Butte National Monument

Field Seasons 2008–2012

Natural Resource Technical Report NPS/NCPN/NRTR—2013/751



ON THE COVER

Chicken Creek Nature Trail, Fossil Butte National Monument. National Park Service/A. Wondrak Biel.

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May 2013

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

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Please cite this publication as:

Perkins, D. 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.

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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 10 monitoring protocols to be implemented as part of its long-term monitoring program. This report represents work completed during 2012 at Fossil Butte National Monument (FOBU) and compares these results with monitoring conducted in 2008, 2009, and 2010. We detected nine priority IEP and five non-priority IEP species on monitoring routes and quadrats in 2012 at FOBU. Almost all priority IEPs had fewer infestations in 2012 than in 2010, with one exception: creeping foxtail (*Alopecurus arundinaceus*) increased along Chicken Creek and the North Dam Fork of Chicken Creek. No new priority species were detected along monitoring routes in 2012. Generally, the further a route was from areas of high visitation, the fewer IEPs were detected on it. Seventy-seven percent of IEPs were present in small (<40m²), localized invasions that have a promising chance of successful management control and eradication. NCPN staff will return to FOBU to revisit all monitoring routes in 2014.

Acknowledgements

J. Doucette and D. Block 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 exotic plant list, arranging site logistics, and providing history of the site. R. Weissinger, N. Skinner, and A. Aase improved this report with their thoughtful review. Data management was provided by A. Wight, R. DenBleyker, and H. Thomas. R. Weissinger 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 (National Research Council 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, national parks of the Northern Colorado Plateau Network (NCPN) 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 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 2012 field season at Fossil Butte National Monument (NM) and makes comparisons to data collected from 2008 to 2010 (Perkins and Weissinger 2009; Perkins 2010, 2011). All roads, trails, and major drainages have been surveyed at least three times.

2 Methods

We followed the invasive exotic plant monitoring protocol developed by the NCPN (in review), adapted from Andersen and Dewey (2007). The protocol emphasizes the 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).

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.

2.1 Developing a priority invasive exotic plant list

Prior to beginning monitoring in 2012, NCPN and park staff reviewed the list of high-priority target IEPs for Fossil Butte NM (Table 2-1) that was initially developed in 2008. 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 IEP list includes existing IEPs and potential IEPs of high management concern. Because these methods are designed to be rapid, field crews are 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. Fossil Butte NM staff recommended that flixweed (*Descurainia sophia*) be added to the priority list in 2010, but it was inadvertently left off. It was added to the priority list for 2012.

2.2 Monitoring routes

2.2.1 Minimum detection target size

The minimum detection target size (MDTS) represents the patch size that is large enough to be detected 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. We establish an MDTS of 40 m² (0.01 acres or approximately 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 tamarisk (*Tamarix ramosissima*), is possible due to their large size, single plants of other species, such as field

Table 2-1. Priority invasive plant list, Fossil Butte NM, 2008–2012.

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

*2012 only

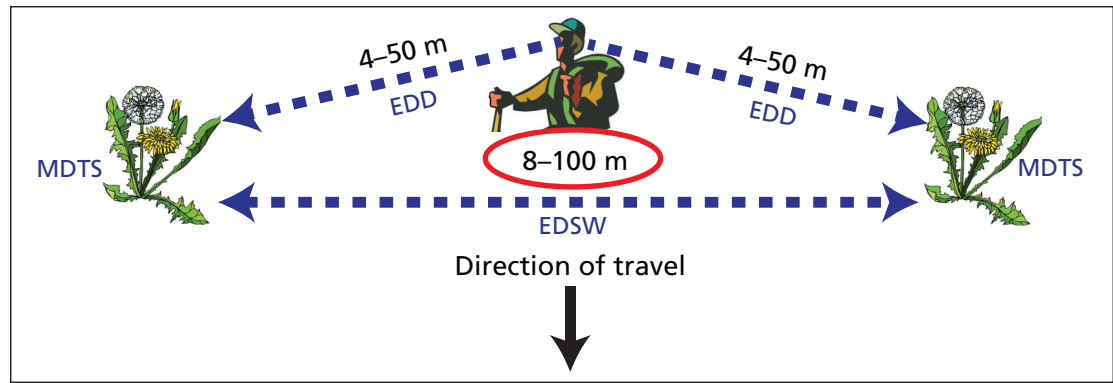


Figure 2-1. The maximum effective detection distance (EDD) in 2012 at FOBU was 4–50 meters, making the effective detection swath width (EDSW) 8–100 meters.

bindweed (*Convolvulus arvensis*), are nearly impossible to detect in most field conditions.

2.2.2 Effective detection distance

The effective detection distance (EDD) is the maximum distance from which a searcher can consistently detect (i.e., see and recognize) the MDTs of the least-visible targeted species with at least 90% detection efficiency (Figure 2-1). Using fake plants of a targeted size, crew members are trained by walking away and determining the maximum distance from which they can 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 in 2012 was 4–50 m, 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 EDSW is equal to two times the EDD, because the surveyor is able to effectively detect weeds for one EDD on either side of his/her search route. The EDSW ranged from 8 to 100 m at FOBU in 2012.

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 or infestations. Individuals or clusters of a target species separated by the PSR

distance or more were recorded as separate patches. We consider plants separated by less than the PSR to be a single patch or infestation. The PSR is set at 50 m, based on the assumption that most plants or groups of plants separated by less than 50 m are typically considered to be one infestation during planning and implementation of weed-control operations. If an infestation is continuous for more than 50 m, cover estimates were made every 50 m to aid in developing an effective management strategy for the entire infestation.

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

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 8–100 m (the length of one EDSW) and visually scanned the area in all directions. As we traversed monitoring routes, we documented locations

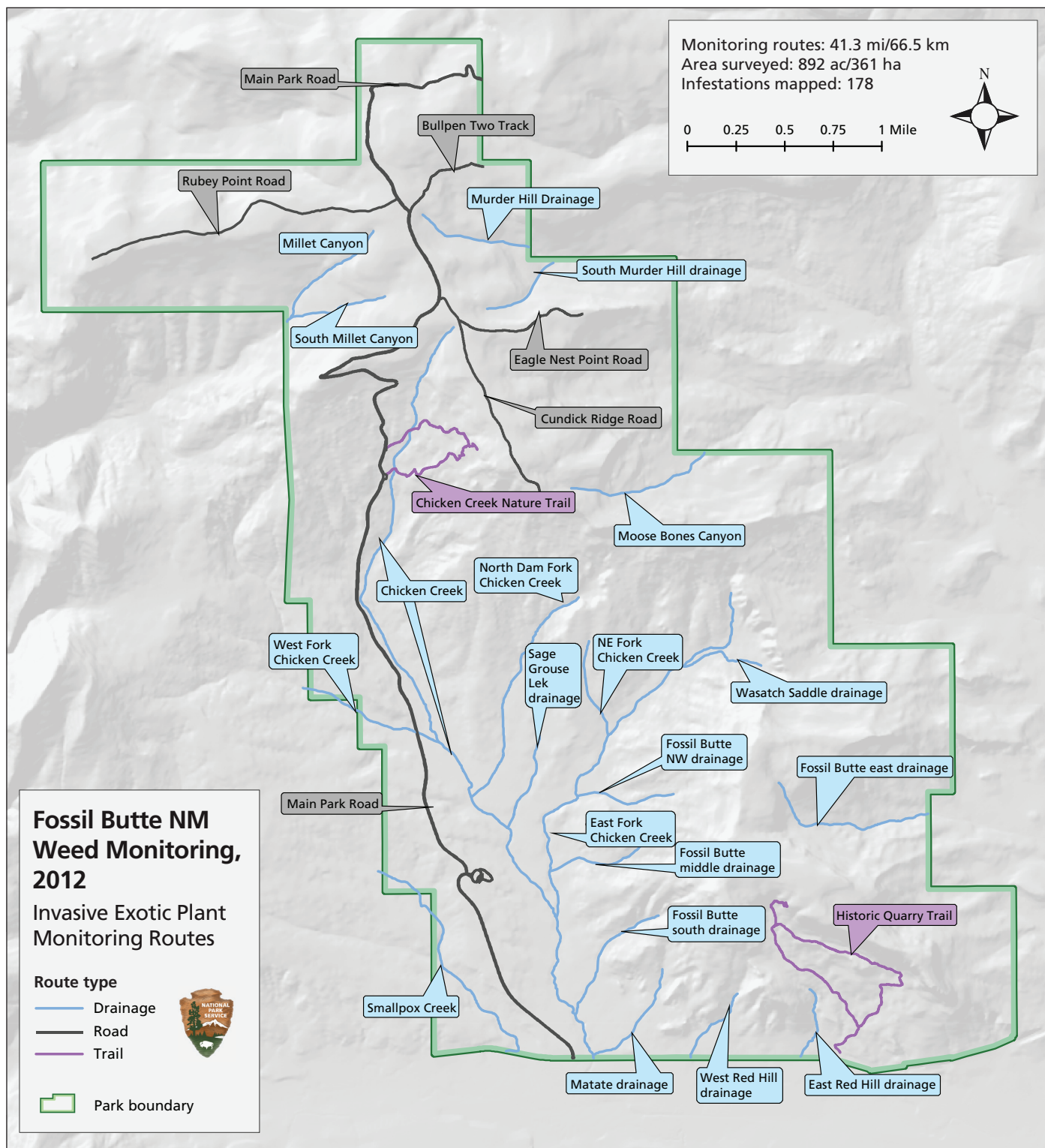


Figure 2-2. Invasive plant monitoring routes at Fossil Butte National Monument, August 2–5, 2012.

of all target species using global positioning system (GPS) units with at least five-meter accuracy.

Only species designated as priority were consistently recorded on monitoring routes, with the exception of cheatgrass (*Bromus tectorum*), which park staff requested we map along the Main Park Road. Survey crew members were permitted to record additional species if they were noteworthy (e.g., a highly invasive species that is not known to the local area).

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) infestation 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, 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 invasions and recorded with separate points.

Infestation size class was estimated as follows:

1. 1–a few plants (used for isolated single plants or very small patches ($\leq 2 \times 2$ m),
2. few plants–40 m² (48 yd²),
3. 40–400 m² (48–478 yd²),
4. 400–1,000 m² (0.1–0.25 acre), and
5. 1,000–2,000 m² (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. We recorded canopy cover of a patch 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 infestation: 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

Our methods for sampling the monitoring quadrats were based on Stohlgren and others (2005). We established transects with three vegetation quadrats every 500 m along monitoring routes (Figures 2-3, 2-4, starting on page 8). If no invasives 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 infestation size class, then we went back to establishing transects every 500 m.

2.3.1 Quadrat establishment

In 2010 and 2012, 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-m² 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.¹

Quadrat-sampling methods differed slightly from 2008 to 2009–2012. In 2008, all invasive species were recorded in monitoring quadrats. From 2009 to 2012, only priority species and cheatgrass were recorded in the 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 cheatgrass and all priority IEP species observed. For each quadrat, we recorded per-

¹In 2008, we used three 1-m² vegetation quadrats, placed in a circular macroplot [see Perkins and Weissinger 2009]. In 2009, quadrats were placed at 3, 8, and 13 m away from the monitoring route.

cent 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 infestations per 100 m for monitoring routes. Per-

cent 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 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 and cheatgrass mapped along the Main Park Road should be used when comparing results from year to year.

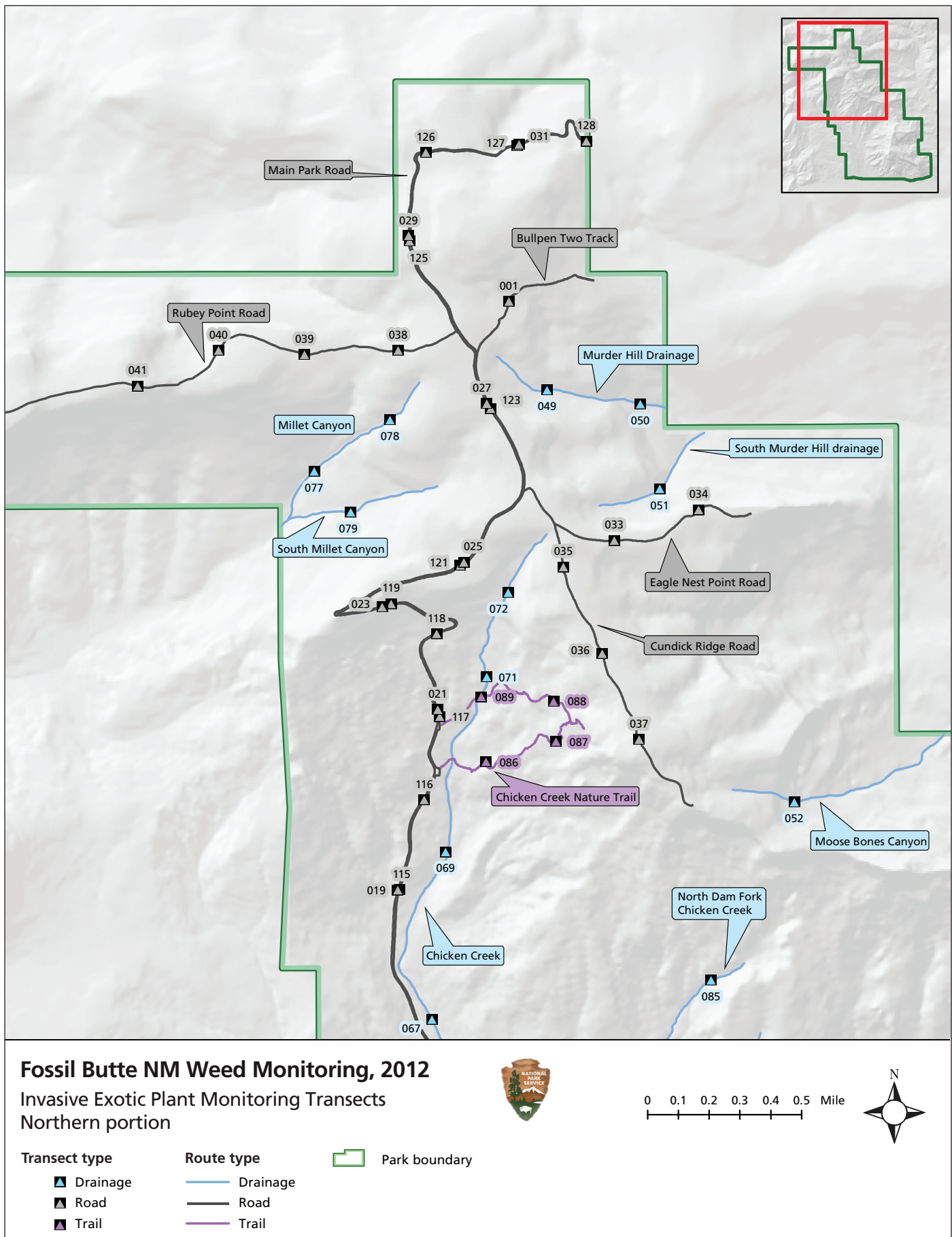


Figure 2-3. Monitoring quadrats established in the northern portion of Fossil Butte National Monument, August 2–5, 2012.

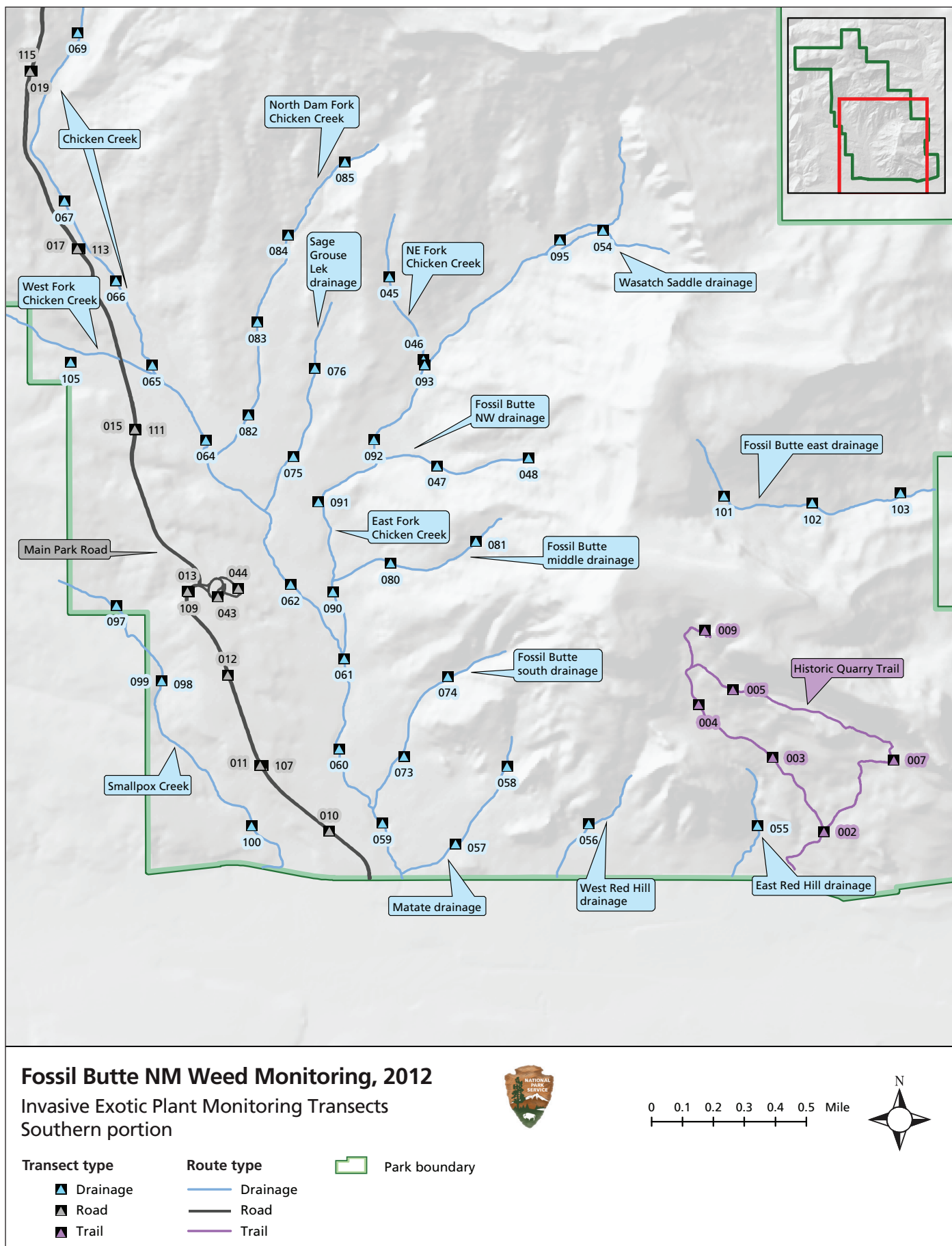


Figure 2-4. Monitoring quadrats established in the southern portion of Fossil Butte National Monument, August 2–5, 2012.

3 Results

3.1 Target invasive exotic plant list

Twenty-three IEP species were identified as priority for the Fossil Butte NM target IEP list (see Table 2-1). From 2008 to 2010, at the request of park staff, we also mapped cheatgrass along the Main Park Road; in 2012, it was mapped parkwide. We also recorded cheatgrass in monitoring quadrats from 2009 to 2012. A total of nine priority IEP species and five non-priority species were recorded on monitoring routes and quadrats in 2012 (Table 3-1). Nine priority species (plus 3 additional IEPs) were recorded on monitoring routes; two priority species (plus 3 additional IEPs) were recorded in monitoring quadrats in 2012. We covered 361.0 hectares (892 acres) along monitoring routes in 2012.

3.2 Monitoring routes

The survey crew walked a total of 66.5 km (41.3 miles) along 27 monitoring routes in 2012 (Figures 3-1, 3-2, 3-3, 3-4; figures start on page 19). A total of 178 infestations, 136 of which were priority species, were detected along monitoring routes (Table 3-2, Electron-

ic Appendix A). Field bindweed and lenspod whitetop (*Cardaria chalepensis*) were the only priority species found along routes in previous years (1 infestation for each species in 2010) but not found in 2012. Of the 136 priority infestations, 105 (77%) were classified as infestations that were less than 40 m² in size (Table 3-3). No new priority species were detected along monitoring routes in 2012.

Creeping foxtail (*Alopecurus arundinaceus*), quackgrass (*Elymus repens*), and musk thistle (*Carduus nutans*) were the most commonly detected priority IEPs. Only priority species throughout the park, and cheatgrass along the Main Park Road, should be examined when comparing years and areas, as these were the only species recorded consistently by all observers and in all years. In 2012, IEPs were most prevalent in the North Dam Fork of Chicken Creek, Chicken Creek, Small Pox Creek, and South Millet Canyon.

Routes or sections of routes located away from roads and areas of high visitation generally had lower numbers of IEP invasions. No priority IEPs were detected on the Bullpen Two Track, Cundick Ridge Road, Eagle Nest

Table 3-1. Invasive exotic plants detected at Fossil Butte National Monument, August 2–5, 2012.

Scientific name	Common name	Method detected		Priority?*
		Routes	Quadrats	
<i>Alopecurus arundinaceus</i>	creeping foxtail	X	X	Yes
<i>Carduus nutans</i>	musk thistle	X		Yes
<i>Centaurea maculosa</i>	spotted knapweed	X		Yes
<i>Cirsium arvense</i>	Canada thistle	X		Yes
<i>Cirsium vulgare</i>	bull thistle	X		Yes
<i>Descurainia sophia</i>	flixweed	X		Yes
<i>Elymus repens</i>	quackgrass	X	X	Yes
<i>Hyoscyamus niger</i>	black henbane	X		Yes
<i>Melilotus officinalis</i>	yellow sweetclover	X		Yes
<i>Agropyron cristatum</i>	crested wheatgrass		X	No
<i>Agrostis stolonifera</i>	creeping bentgrass		X	No
<i>Bromus tectorum</i>	cheatgrass	X	X	No
<i>Salsola</i> sp.	Russian thistle	X		No
<i>Tragopogon dubius</i>	yellow salsify	X		No

*Only priority species were mapped and recorded in quadrats throughout FOBU. Species not on the list were opportunistic observations.

Point Road, East Fork of Chicken Creek, East Red Hill Drainage, Historic Quarry Trail, Fossil Butte Middle Drainage, Fossil Butte NW Drainage, Fossil Butte South Drainage, Northeast Fork of Chicken Creek, Rubey Point Road, Wasatch Saddle Drainage, West Fork of Chicken Creek, or West Red Hill Drainage. A large area along the eastern tributaries of Chicken Creek in the southern portion of the park, as well as the roads other than the Main Park Road, appear to be mostly free of priority species (Figure 3-4).

3.3 Monitoring quadrats

A total of 100 quadrats were sampled in 2012 (Figure 3-2, 3-3, 3-4, Electronic Appendix B). Only priority species and cheatgrass have been reliably recorded in all years. In 2012, two priority species and cheatgrass were detected in quadrats. Only four and one priority species, respectively, and cheatgrass were detected in the last comprehensive surveys of park quadrats, done in 2008–2009 and 2010. In 2012, creeping foxtail occurred in two plots along Chicken Creek. Quackgrass (*Elymus repens*) occurred in one plot along Smallpox Creek. Cheatgrass occurred in two plots along the Main Park Road and one in Fossil Butte East Drainage. Parkwide percent cover for any species was all less than 0.5%.

3.4 Comparisons to prior monitoring

The monitoring mapping methods are subjective. For example, one observer may identify two small infestations separated by 45 m (the patch separation rule is 50 m, but exact measurements are not made in the field) as two infestations, while another observer may identify them one large infestation. Therefore, although general comparisons and species with major differences between the two survey periods are useful (if somewhat problematic) and likely represent biological differences, smaller changes may not reflect actual conditions.

Monitoring was conducted along the entire Main Park Road in 2008, 2010, and 2012, and along portions of the road in 2009. Almost all priority IEP species had lower numbers of infestations in 2012 than 2010 (Table 3-4). Large declines between 2010 and 2012 occurred for cheatgrass (95 to 15), quackgrass (69 to 21), yellow sweetclover (*Melilotus officinalis*) (35 to 6), musk thistle (*Carduus nutans*) (13 to 2), and Canada thistle (*Cirsium arvense*) (12 to 2). Overall, priority IEP infestations declined from 133 to 42 between 2010 and 2012 along the Main Park Road. Ninety percent of the remaining infestations were less than 40m² in size (Table 3-4). The exceptions were four infestations of quackgrass in the northern and central portions of the Main Park Road (Figures 3-2, 3-3).

Declines were evident in several other areas from 2010 to 2012, as well. In 2012, there were 14 monitoring routes with no priority IEPs detected, compared to just 7 routes with no priority IEPs in 2010. Canada thistle and yellow sweetclover declined from 22 to 1 and 18 to 2 infestations, respectively, in the southern drainages. Creeping foxtail (8 to 1), Canada thistle (13 to 5), and quackgrass (13 to 0) all declined in the northern drainages (Table 3-5). No IEP infestations were observed on any of the secondary roads in 2012, compared to 14 infestations in 2010 (Table 3-5). Creeping foxtail (4 to 0), Canada thistle (4 to 1), and quackgrass (5 to 0) all declined along the two hiking trails (Table 3-6). Parkwide, priority IEP infestations declined from 320 in 2010 to 133 in 2012 (Table 3-6).

Only one increase in IEP presence was noted: in the southern drainages, creeping foxtail increased from 43 in 2010 to 55 in 2012 (Table 3-5). These increases occurred along Chicken Creek and the North Dam Fork of Chicken Creek (Figure 3-5).

Table 3-2. Number of IEP infestations per route and route type, Fossil Butte NM, August 2–5, 2012.

Route	Length (m)	Area (ha)	Infestations		Infestations/ha	
			Total	Priority only	Total	Priority only
Riparian						
Chicken Creek	7,200	28.86	52	49	1.80	1.70
East Fork Chicken Creek	3,619	29.00	0	0	0.00	0.00
East Red Hill Drainage	653	4.40	0	0	0.00	0.00
Fossil Butte East Drainage	1,514	9.21	3	2	0.33	0.22
Fossil B. Middle Drainage	1,018	8.01	0	0	0.00	0.00
Fossil Butte NW Drainage	838	6.65	0	0	0.00	0.00
Fossil Butte S. Drainage	1,167	4.59	0	0	0.00	0.00
Matate Drainage	1,000	1.92	1	1	0.52	0.52
Millet Canyon	1,090	9.00	3	3	0.33	0.33
Moose Bones Canyon	739	1.82	3	2	1.65	1.10
Murder Hill Drainage	967	1.96	1	1	0.51	0.51
NE Fork Chicken Creek	841	6.62	0	0	0.24	0.00
N. Dam Fork Chicken Cr.	2,037	6.08	16	16	2.63	2.63
Sage Grouse Lek Drainage	1,192	3.56	2	2	0.56	0.56
Smallpox Creek	2,228	5.33	7	5	1.31	0.94
South Millet Canyon	822	4.41	5	5	1.13	1.13
S. Murder Hill Drainage	717	4.58	1	1	0.22	0.22
Wasatch Saddle Drainage	727	4.36	0	0	0.00	0.00
West Fork Chicken Creek	1,249	8.76	0	0	0.00	0.00
West Red Hill Drainage	541	4.59	0	0	0.00	0.00
All Riparian	30,159	153.71	94	87	0.55	0.49
Roads						
Bullpen Two Track	890	6.66	0	0	0.00	0.00
Cundick Ridge Road	1,981	11.69	0	0	0.00	0.00
Eagle Nest Point Road	1,134	11.43	0	0	0.00	0.00
Rubey Point Road	2,740	27.26	0	0	0.00	0.00
All Roads (other than Main Park Road)	6,745	57.04	0	0	0.00	0.00
Main Park Road	23,531	115.72	80	46	0.69	0.40
Trails						
Chicken Creek Nature Trail	2,118	4.40	3	3	0.68	0.68
Historic Quarry Trail	3,903	30.12	1	1	0.03	0.00
All Trails	6,021	34.52	4	3	0.36	0.34
Total	66,456	361.00	178	136	0.46	0.41

Table 3-3. Number of infestations by species and infestation size class detected along monitoring routes, Fossil Butte NM, August 2–5, 2012.

Scientific name	Common name	Total infestations	Infestation size class				
			1	2	3	4	5
Priority species							
<i>Alopecurus arundinaceus</i>	creeping foxtail	58	1	35	17	4	1
<i>Elymus repens</i>	quackgrass	23	1	18	3	1	0
<i>Carduus nutans</i>	musk thistle	19	6	11	1	1	0
<i>Melilotus officinalis</i>	yellow sweetclover	10	3	6	1	0	0
<i>Cirsium arvense</i>	Canada thistle	9	1	6	1	1	0
<i>Cirsium vulgare</i>	bull thistle	6	2	4	0	0	0
<i>Centaurea maculosa</i>	spotted knapweed	4	2	2	0	0	0
<i>Descurainia sophia</i>	flixweed	3	2	1	0	0	0
<i>Hyoscyamus niger</i>	black henbane	4	0	4	0	0	0
	<i>Priority species</i>	136	18	87	23	7	1
Non-priority species**							
<i>Bromus tectorum</i> *	cheatgrass	17	Size was not noted for most non-priority infestations.				
<i>Agropyron cristatum</i>	crested wheatgrass	10					
<i>Tragopogon dubius</i>	yellow salsify	10					
<i>Agrostis stolonifera</i>	creeping bentgrass	4					
<i>Salsola</i> sp.	Russian thistle	1					
	<i>Non-priority species</i>	42					
All species		178					

Infestation size classes: 1 = 1–a few plants ($\leq 2 \times 2$ m), 2 = few plants–40 m² (48 yd²), 3 = 40–400 m² (48–478 yd²), 4 = 400–1,000 m² (0.1–0.25 acre), 5 = 1,000–2,000 m² (0.25–0.5 acre).

**Bromus tectorum* was reliably recorded only along the Main Park Road in 2008, but was recorded everywhere in 2009, 2010, and 2012.

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

Table 3-4. Species observed and size of infestation detected along the Main Park Road, Fossil Butte NM, 2008, 2010, and 2012.

Scientific name	Common name	Year	Infestations		Infestation size class				
			Total	Per km	1	2	3	4	5
Priority species									
<i>Cardaria chalapensis</i>	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
<i>Carduus nutans</i>	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
<i>Centaurea maculosa</i>	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
<i>Cirsium arvense</i>	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
<i>Cirsium vulgare</i>	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
<i>Convolvulus arvensis</i>	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
<i>Elymus repens</i>	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
<i>Hyoscyamus niger</i>	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
<i>Melilotus officinalis</i>	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
Total (priority)		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

Table 3-4. Species observed and size of infestation detected along the Main Park Road, Fossil Butte NM, 2008, 2010, and 2012, cont.

Scientific name	Common name	Year	Infestations		Infestation size class				
			Total	Per km	1	2	3	4	5
Non-priority (or not searched for in all years) species									
<i>Alopecurus arundinaceus</i> [^]		2010	6	(0.26)	3	3	0	0	0
		2012	2	(0.08)	0	2	0	0	0
<i>Bromus tectorum</i> *	cheatgrass	2008	37	(1.97)	15	12	9	1	0
		2010	95	(4.10)	2	35	44	13	1
		2012	15	(0.64)	13 pulled and no size class recorded				
Total (non-priority)		2008	37		15	12	9	1	0
		2010	101		5	38	44	13	1
		2012	17				**		

Infestation size classes: 1 = 1–a few plants ($\leq 2 \times 2$ m), 2 = few plants–40 m² (48 yd²), 3 = 40–400 m² (48–478 yd²), 4 = 400–1,000 m² (0.1–0.25 acre), 5 = 1,000–2,000 m² (0.25–0.5 acre).

The Main Park Road was surveyed on the following dates at the following distances: July 14–15, 2008 (18,793 m); July 24–28, 2010 (23,192 m), August 2–5, 2012 (23,531 m).

[^]*Alopecurus arundinaceus* was a priority species in 2008, but was not reliably recorded.

*Not a priority species, but was searched for along the Main Park Road in both years.

**Can't be calculated due to absence of *B. tectorum* data for 2012

Table 3-5. Total number of priority infestations (number per km) detected on the southern drainages, northern drainages, and roads, Fossil Butte NM, 2008, 2009, 2010, and 2012.

Scientific name	Common name	Northern drainages ^b		Southern drainages ^a		Roads ^c	
		Year	Infestations (per km)	Year	Infestations (per km)	Year	Infestations (per km)
<i>Alopecurus arundinaceus</i>	creeping foxtail	2009	2 (0.41)	2009	22 (0.85)	2008	---
		2010	8 (1.75)	2010	43 (1.64)	2010	2 (0.30)
		2012	1 (0.23)	2012	55 (1.97)	2012	0 (0.00)
<i>Cardaria chalapensis</i>	orbicular whitetop	2009	0 (0.00)	2009	0 (0.00)	2008	0 (0.00)
		2010	0 (0.00)	2010	1 (0.04)	2010	0 (0.00)
		2012	0 (0.00)	2012	0 (0.00)	2012	0 (0.00)
<i>Carduus nutans</i>	musk thistle	2009	7 (1.45)	2009	13 (0.50)	2008	1 (0.15)
		2010	7 (1.53)	2010	16 (0.61)	2010	1 (0.15)
		2012	5 (1.15)	2012	11 (0.39)	2012	0 (0.00)
<i>Centaurea maculosa</i>	spotted knapweed	2009	0 (0.00)	2009	0 (0.00)	2008	0 (0.00)
		2010	0 (0.00)	2010	1 (0.04)	2010	0 (0.00)
		2012	0 (0.00)	2012	0 (0.00)	2012	0 (0.00)
<i>Cirsium arvense</i>	Canada thistle	2009	10 (2.06)	2009	26 (1.00)	2008	0 (0.00)
		2010	13 (2.84)	2010	22 (0.84)	2010	3 (0.44)
		2012	5 (1.15)	2012	1 (0.04)	2012	0 (0.00)
<i>Cirsium vulgare</i>	bull thistle	2009	1 (<.21)	2009	4 (0.15)	2008	0 (0.00)
		2010	4 (0.87)	2010	3 (0.11)	2010	0 (0.00)
		2012	1 (0.23)	2012	2 (0.07)	2012	0 (0.00)
<i>Elymus repens</i>	quackgrass	2009	0 (0.00)	2009	3 (0.12)	2008	1 (0.15)
		2010	13 (2.84)	2010	0 (0.00)	2010	8 (1.18)
		2012	0 (0.00)	2012	2 (0.07)	2012	0 (0.00)
<i>Hyoscyamus niger</i>	black henbane	2009	1 (0.21)	2009	2 (0.08)	2008	0 (0.00)
		2010	1 (0.21)	2010	2 (0.08)	2010	0 (0.00)
		2012	0 (0.00)	2012	0 (0.00)	2012	0 (0.00)
<i>Isatis tinctoria</i>	Dyer's woad	2009	0 (0.00)	2009	2 (0.08)	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)
<i>Melilotus officinalis</i>	yellow sweetclover	2009	0 (0.00)	2009	6 (0.23)	2008	0 (0.00)
		2010	0 (0.00)	2010	18 (0.69)	2010	0 (0.00)
		2012	0 (0.00)	2012	3 (0.11)	2012	0 (0.00)
Total		2009	21 (4.34)	2009	78 (3.00)	2008	2 (0.30)
		2010	46 (10.04)	2010	106 (4.05)	2010	14 (2.07)
		2012	12 (2.77)	2012	74 (2.65)	2012	0 (0.00)

^aIn the southern drainages, the following distances were surveyed on the following dates: August 6–8, 2009 (25,983 m), July 24–28, 2010 (26,173 m), August 2–5, 2012 (27,942 m).

^bIn the northern drainages, the following distances were surveyed on the following dates: August 6–8, 2009 (4,844 m), July 24–28, 2010 (4,580 m), August 2–5, 2012 (4,335 m).

^cOn roads, the following distances were surveyed on the following dates: July 14–15, 2008 (6,638 m), July 24–28, 2010 (6,774 m), August 2–5, 2012 (6,745 m).

Table 3-6. Total number of priority infestations (number per km) detected at Historic Quarry and Chicken Creek Nature Trails and parkwide at Fossil Butte NM by year (meters monitored).

Scientific name	Common name	Trails			Parkwide		
		2008–2009 (5,597 m)	2010 (6,021 m)	2012 (6,021 m)	2008–2009 (61,855 m)	2010 (66,739 m)	2012 (66,456 m)
<i>Alopecurus arundinaceus</i> [^]	creeping foxtail	0 (0.00)	4 (0.66)	0 (0.00)	24 (0.39)	63 (0.94)	58 (0.87)
<i>Cardaria chalepensis</i>	orbicular whitetop	0 (0.00)	0 (0.00)	0 (0.00)	2 (0.03)	1 (0.01)	0 (0.00)
<i>Carduus nutans</i>	musk thistle	0 (0.00)	0 (0.00)	1 (0.17)	27 (0.44)	37 (0.55)	19 (0.24)
<i>Centaurea maculosa</i>	spotted knapweed	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (0.01)	4 (0.06)
<i>Cirsium arvense</i>	Canada thistle	1 (0.18)	4 (0.66)	1 (0.17)	66 (1.07)	54 (0.81)	9 (0.14)
<i>Cirsium vulgare</i>	bull thistle	1 (0.18)	1 (0.17)	0 (0.00)	7 (0.11)	9 (0.13)	6 (0.09)
<i>Convolvulus arvensis</i>	field bindweed	0 (0.00)	0 (0.00)	0 (0.00)	4 (0.06)	1 (0.01)	0 (0.00)
<i>Elymus repens</i>	quackgrass	0 (0.00)	5 (0.83)	0 (0.00)	53 (0.86)	95 (1.42)	23 (0.35)
<i>Hyoscyamus niger</i>	black henbane	2 (0.36)	0 (0.00)	0 (0.00)	21 (0.34)	5 (0.07)	4 (0.06)
<i>Isatis tinctoria</i>	Dyer's woad	0 (0.00)	0 (0.00)	0 (0.00)	2 (0.03)	0 (0.00)	0 (0.00)
<i>Melilotus officinalis</i>	yellow sweetclover	0 (0.00)	1 (0.17)	1 (0.17)	54 (0.87)	54 (0.81)	10 (0.15)
Total		4 (1.07)	15 (2.49)	3 (0.50)	260 (4.20)	320 (4.79)	133 (2.00)
Total (no <i>A. arundinaceus</i>)		4 (1.07)	11 (1.83)	3 (0.50)	236 (3.82)	257 (3.85)	75 (1.13)

[^]Species not searched for in 2008.

Surveys were conducted on July 14–15, 2008, August 6–8, 2009, July 24–28, 2010, and August 2–5, 2012.

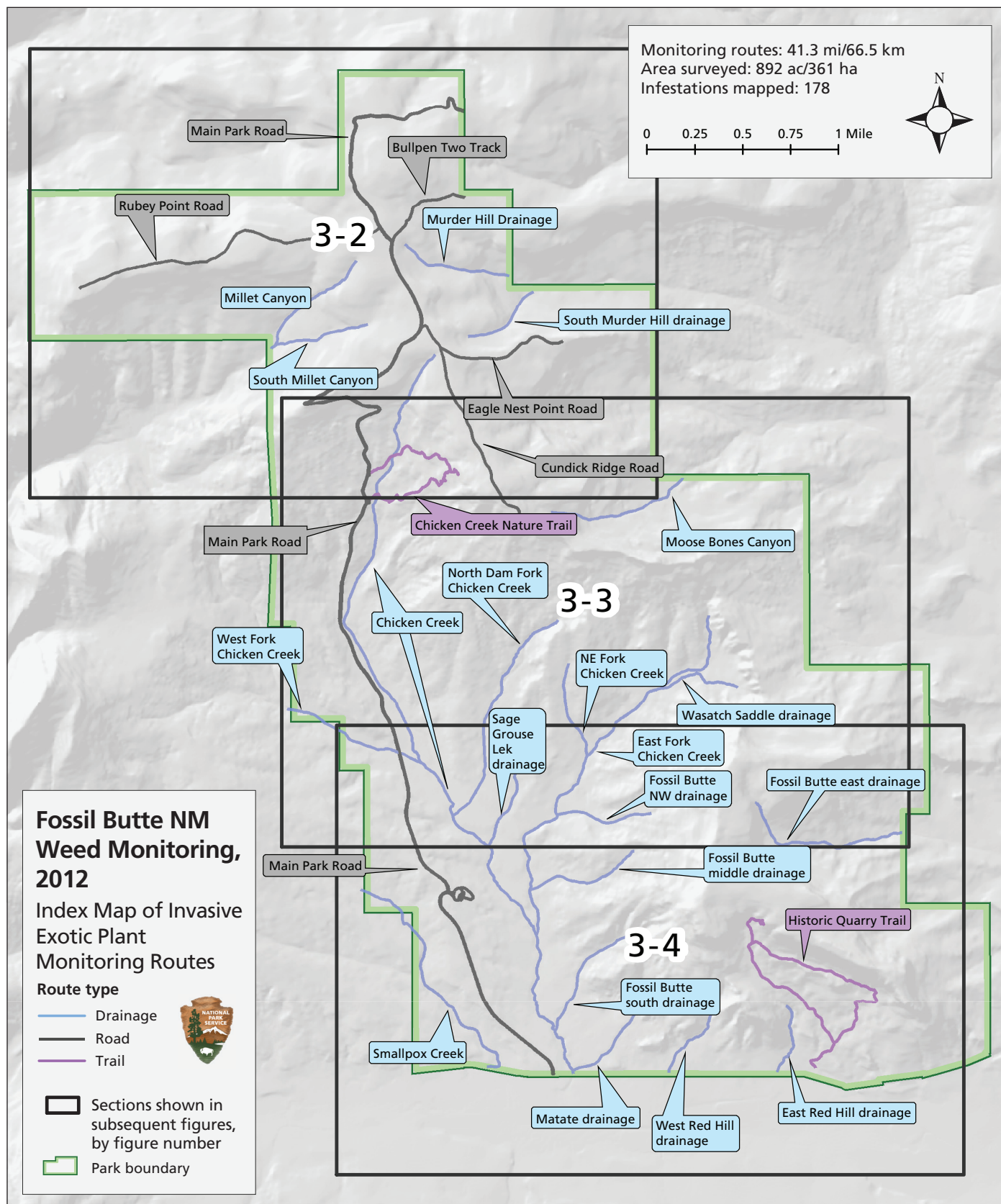


Figure 3-1. Index map of invasive plant monitoring routes, Fossil Butte National Monument, August 2–5, 2012.

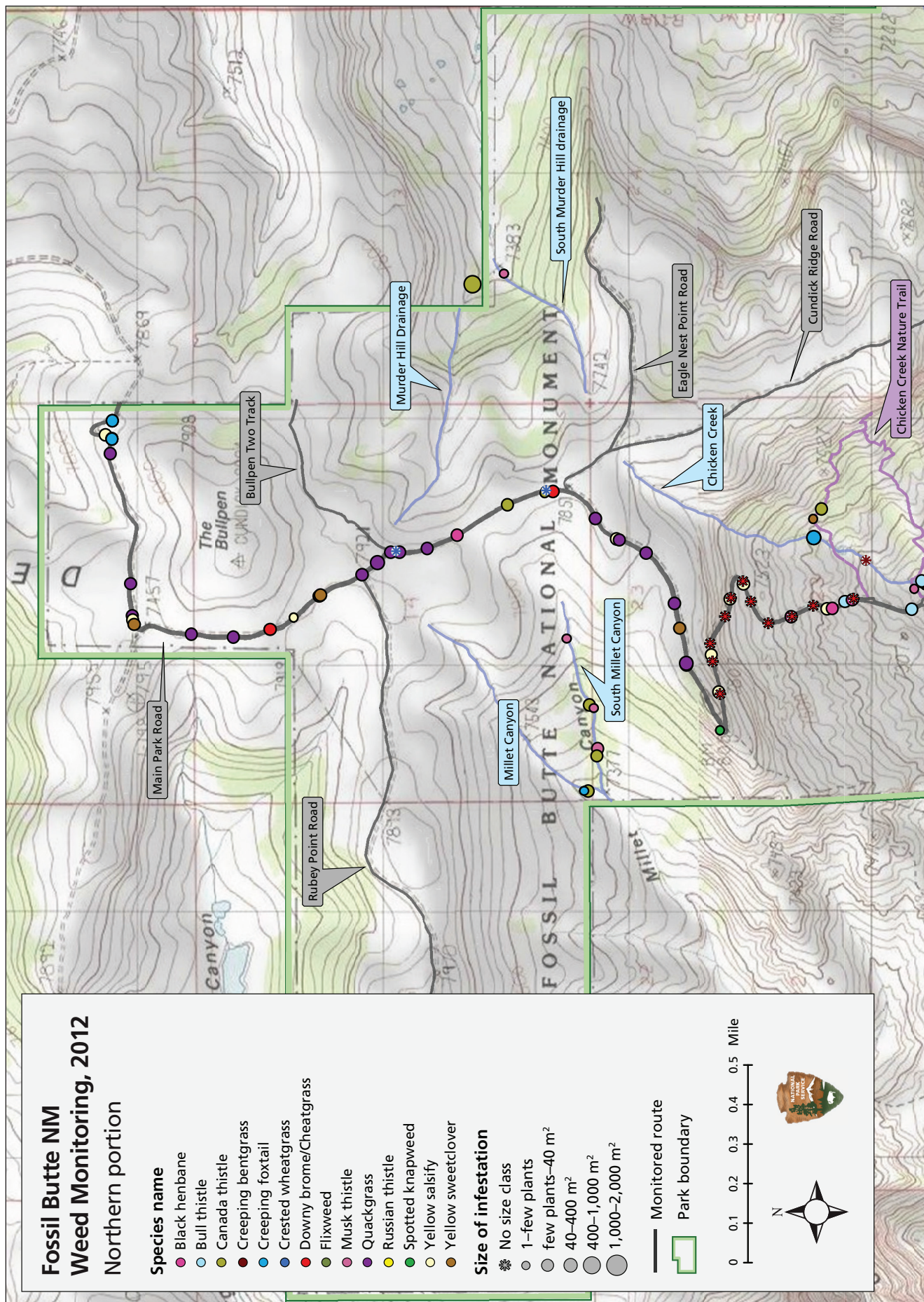


Figure 3-2. Invasive plants detected along monitoring routes and monitoring quadrats in the northern portion of Fossil Butte National Monument, August 2–5, 2012.

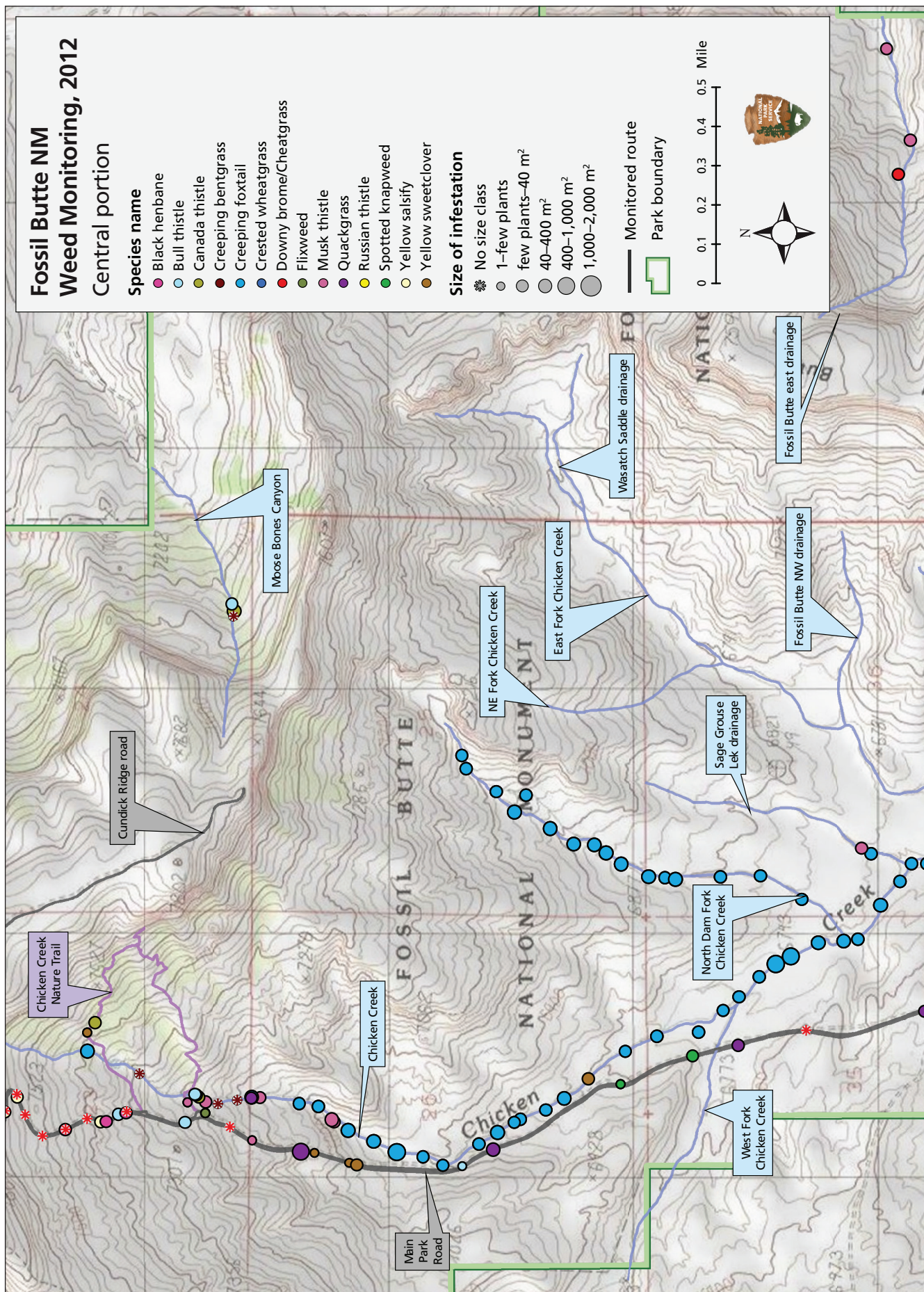


Figure 3-3. Invasive plants detected along monitoring routes and monitoring quadrats in the central portion of Fossil Butte National Monument, August 2-5, 2012.

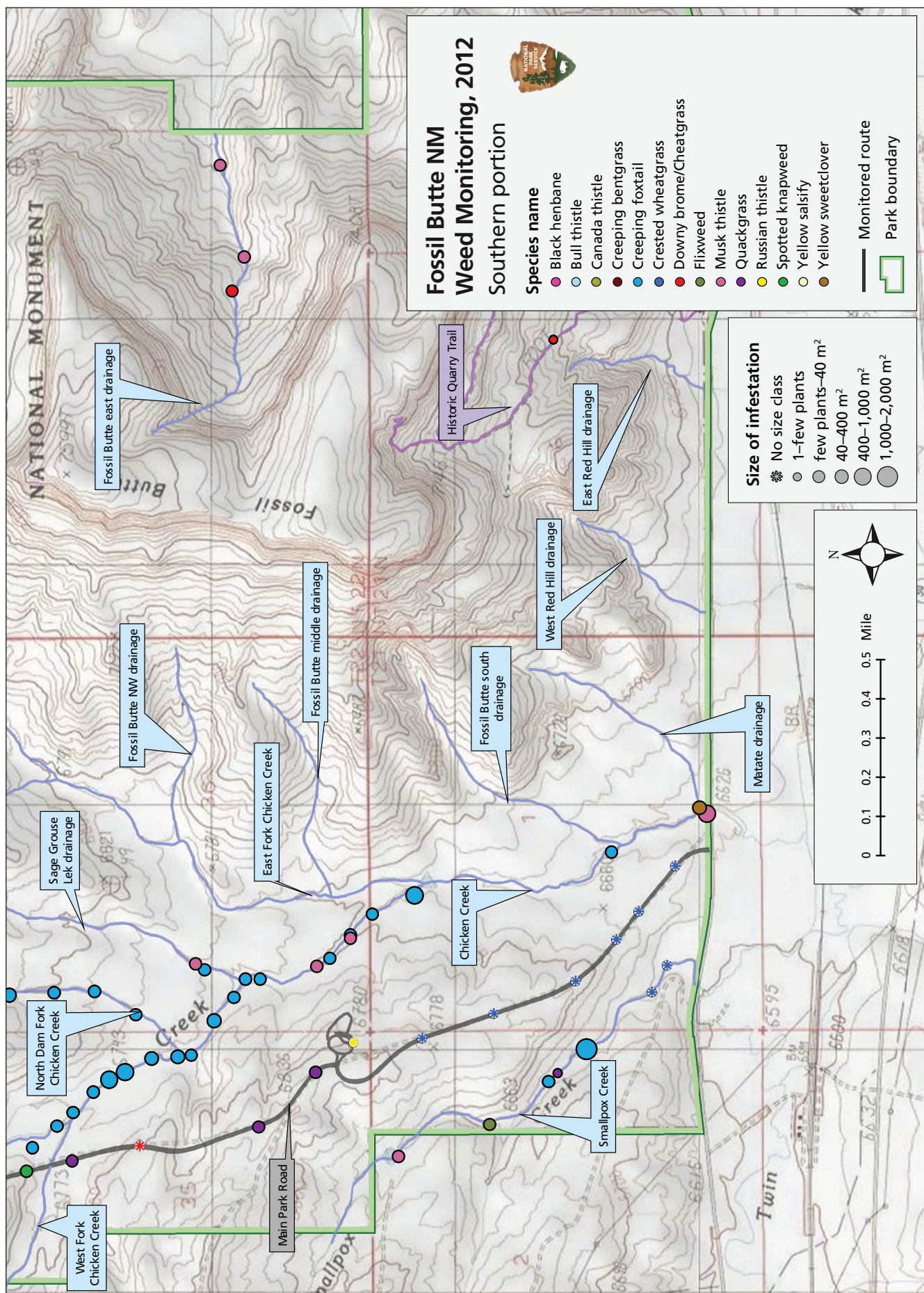


Figure 3-4. Invasive plants detected along monitoring routes and monitoring quadrats in the southern portion of Fossil Butte National Monument, August 2–5, 2012.

4 Discussion

4.1 Target invasive exotic plant list

The NCPN will continue to work with park staff and area weed experts to review and update the list of priority species each year. Presence and absence data for most priority species and cheatgrass along the Main Park Road should be reliable; however, absence data for other species is suspect, because they are not consistently recorded from year to year. We mapped cheatgrass parkwide in 2012 with relatively few infestations; therefore, it will be added to the priority list in 2014.

4.2 Possibilities for management control

Control efforts for targeted species have resulted in large declines of several invasive species throughout the park. Invasive exotic plants were widespread along the Main Park Road in 2008, but declined in 2010 and 2012 after control efforts. Cheatgrass, which can be very hard to control, decreased dramatically along monitoring routes between 2010 and 2012. Continued vigilance will be needed to eradicate or keep this species at low levels. 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 and the Northern Rocky Mountain Exotic Plant Management team removed 113 bags (appx. 30 gallons each) of cheatgrass in fiscal year 2012 (NPS 2012).

In most cases, crews performing control efforts document the total species removed for the park, but do not designate the specific areas from which they were removed. For example, in 2012, park staff and the Northern Rocky Mountain Exotic Plant Management team personnel mechanically removed 8,959 yellow sweetclover plants, 1,149 knapweeds (*Centaurea* spp.), approximately 500 musk thistles, 306 black henbanes (*Hyoscyamus niger*), and 26 bull thistles (*Cirsium vulgare*). In addition, they treated 9.7 hectares (24 acres) of Canada thistle and 0.10 hectares (0.25 acres) of white top (*Cardaria* spp.) (A. Aase, personal communication).

These control efforts are reflected in the monitoring data. Priority IEPs have declined from 2010 numbers along roads, trails, southern drainages, and northern drainages. All IEP species have either declined or remained constant along all routes, with the exception of creeping foxtail, which increased along Chicken Creek and the North Dam Fork of Chicken Creek. Thistles, black henbane, and yellow sweetclover, all species of focused control efforts (NPS 2012), have had large declines throughout the park. This is in contrast to increases in priority IEPs from 2008–2009 to 2010 (Perkins 2011).

Areas away from roads and with lower human visitation continued to have fewer IEPs. Efforts should be made to ensure that the area around Fossil Butte, which is largely free of priority IEPs, is maintained. This area had no priority infestations in 2009, but had two in 2010 and 2012, so efforts should be made to control the few infestations present. Park managers may also want to focus efforts on Chicken Creek, North Dam Fork of Chicken Creek, Moose Bones Canyon, Small Pox Creek, and South Millet Canyon, as these were the areas with the highest infestation rates.

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 infestations are likely to represent biological realities.

4.3 Future monitoring efforts

IEPs at FOBU 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 larger than the minimum detection target size.

In 2014, the NCPN will re-survey all of the areas covered in 2008–2012. The monitoring quadrats are re-located each year because any detections from a previous year could have been eradicated by park staff. A complete fourth sample of monitoring quadrats will be collected in 2014; these will be compared to the samples collected in 2008–2012. 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 and cheatgrass by monitoring route. Extra-area surveys will also be considered for inventories at the park's request. The park's stock-trailing routes are not currently monitored, and might be good candidates for extra-area surveys. Peer review comments on the NCPN's invasive plant monitoring protocol were received in September 2012 and NCPN's responses were completed in March 2013. It is anticipated that this protocol will be finalized in 2013.

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NPS 174/120887, May 2013

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