



Invasive Exotic Plant Monitoring at Fossil Butte National Monument

Annual Report 2009

Natural Resource Technical Report NPS/NCPN/NRTR—2010/322



ON THE COVER

NCPN crew members conduct invasive plant monitoring at Fossil Butte National Monument. NPS photo.

Invasive Exotic Plant Monitoring at Fossil Butte National Monument

Annual Report 2009

Natural Resource Technical Report NPS/NCPN/NRTR—2010/322

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

May 2010

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

The National Park Service, Natural Resource Program Center publishes a range of reports that address natural resource topics 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 Technical Report Series is used to disseminate results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service mission. The series provides contributors with a forum for displaying comprehensive data that are often deleted from journals because of 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 are those of the author(s) and 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 National Park Service.

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>.

Please cite this publication as:

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.

Contents

- Figures v
- Tables v
- Executive Summary vii
- Acronyms ix
- Acknowledgements xi
- 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 Plots 6
 - 2.4 Analyses 6
- 3 Results..... 9
 - 3.1 Park target IEP list 9
 - 3.2 Monitoring routes..... 9
 - 3.3 Monitoring plots 10
- 4 Discussion 21
 - 4.1 Changes to protocol based on 2008 and 2009 pilot field seasons..... 21
 - 4.2 Priority 1 IEP List..... 21
 - 4.3 Possibilities for management control 21
 - 4.4 Future monitoring efforts 22
- 5 Literature Cited 23
- Appendices 25
 - Appendix A. Fossil Butte National Monument Target Invasive Exotic Plant List 25
 - Appendix B. Exotic Plant Invasions Detected on Monitoring Routes at Fossil Butte NM, August 6–8, 2009..... 26
 - Appendix C. Invasive Exotic Plant Percent Cover Detected by Monitoring Plots at Fossil Butte NM, July 14–15 2008 and August 6–8, 2009 33

Figures

Figure 2-1. The maximum Effective Detection Distance (EDD) at Fossil Butte NM ranged from 15 to 37.5 meters, making the Minimum Detection Target Size (MDTS) 30–75 meters.....	4
Figure 2-2. Overview of invasive plant monitoring routes and extra areas surveyed at Fossil Butte National Monument, July 14–15, 2008, and August 6–8, 2009.	5
Figure 2-3. Monitoring plots established at Fossil Butte National Monument, July 14–15, 2008 and August 6–8, 2009.	7
Figure 3-1. Invasive plants detected along monitoring routes, monitoring plots, and extra-area surveys at Fossil Butte National Monument, July 14–15, 2008 and August 6–8, 2009.	13
Figure 3-2. Invasive plants detected along monitoring routes and monitoring plots in the northern portion of Fossil Butte National Monument, July 14–15, 2008 and August 6–8, 2009.....	14
Figure 3-3. Invasive plants detected along monitoring routes and monitoring plots in the middle portion of Fossil Butte National Monument, July 14–15, 2008 and August 6–8, 2009.....	15
Figure 3-4. Invasive plants detected along monitoring routes and monitoring plots in the southern portion of Fossil Butte National Monument, July 14–15, 2008 and August 6–8, 2009.....	16
Figure 3-5. Areas monitored in both July 14-15, 2008 and August 6–8, 2009 along the southern portion of the Main Park Road.	17
Figure 3-6. Areas monitored in both July 14-15, 2008 and August 6-8, 2009 along the northern portion of the Main Park Road.	18

Tables

Table 3-1. Invasive exotic plants detected at Fossil Butte National Monument, July 12–13, 2008 and August 6–8, 2009.	10
Table 3-2. Number of IEP infestations per route surveyed, Fossil Butte NM, July 14–15, 2008 and August 6–8, 2009.	11
Table 3-3. Species observed and size of infestation detected along monitoring routes at Fossil Butte NM on July 14–15, 2008 and August 6–8, 2009.....	12
Table 3-4. Species observed and size of infestations detected at Chicken Creek, Fossil Butte NM on July 14–15, 2008 and August 6–8, 2009.....	19
Table 3-5. Species observed and size of infestation detected along the Main Park Road, Fossil Butte NM on July 14–15, 2008 and August 6–8, 2009.....	20

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 2009 at Fossil Butte National Monument (FOBU). Some portions of work completed in 2008 are combined with 2009 data for a complete survey of all roads, trails, and riparian areas at FOBU. We detected 26 IEP species on monitoring routes and plots in 2008 and 2009 at FOBU. Of these, 11 were Priority 1 species for the park that were consistently recorded in each year. IEPs were widespread along the Main Park Road at FOBU in 2008, but were reduced significantly in 2009, after weed control efforts took place. IEPs were less prevalent elsewhere. Generally, the further a route was from areas of high visitation, the fewer IEPs detected. Many IEPs were present in small, localized invasions that have a promising chance of successful management control and eradication. In 2010, the NCPN will return to FOBU to re-sample all of monitoring routes.

Acronyms

BFP	Between Feature Position
EDD	effective detection distance
EDSW	effective detection swath width
FOBU	Fossil Butte National Monument
IEP	invasive exotic plants
MDTS	minimum detection target size
NCPN	Northern Colorado Plateau Network
NPS	National Park Service
PSR	patch separation resolution

Acknowledgements

S. Dewey assisted with questions on methods. S. Shoemaker, A. Lowe, and R. Houk conducted field work. A. Wight was extremely helpful in generating routes, plots, and other GIS information. A. Aase and D. Worthington assisted with reviewing the park target invasive plant list, arranging site logistics, providing history of the site, and reviewing this report. D. Witwicki and A. Aase improved this report with their thoughtful review. Data management was provided by H. Thomas. D. Perry assisted with 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 2009 field season at Fossil Butte National Monument (FOBU). Some portions of work completed in 2008 are combined with 2009 data for a complete survey of all roads, trails, and riparian areas at FOBU.

Two sections of the Main Park Road and Chicken Creek were surveyed in both years. Different management practices were applied to these two areas. On May 26–28, 2009, the Northern Rockies Exotic Plant Management Team and park staff sprayed bull thistle (*Cirsium vulgare*), musk thistle (*Carduus nutans*), and Canada thistle (*Cirsium arvense*), and pulled yellow sweetclover (*Melilotus officinalis*), primarily along the Main Park Road. Some control efforts took place in Chicken Creek, but the crews had limited time after focusing most of their efforts on the Main Park Road. In July 2009, Lincoln County Weed and Pest mowed and treated the Main Park Road with Te-lar® herbicide to reduce cheatgrass (*Bromus tectorum*) and lens-pod whitetop (*Cardaria chalapensis*). This gave the NCPN a unique opportunity to watch how these invasive communities changed before and after two different levels of management control.

2 Methods

Field work followed the invasive exotic plant monitoring protocol developed by the NCPN (in prep.), 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 will capture the greatest amount of information (i.e., benefit) with the least amount of time and effort (i.e., cost).

The first step was to have FOBU and NCPN staff review and update the list of target invasive plants for the park (see below). Next, we established a series of co-located monitoring routes and plots along all roads, major drainages, and trails in the park. The plots, 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. Between 2008 and 2009, all roads, trails, and riparian areas were surveyed with monitoring routes and plots.

2.1 Developing a park target invasive exotic plant list

NCPN and FOBU staff reviewed the list of high-priority target IEPs for FOBU (see Appendix A) that was 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 target IEP list includes existing IEPs and potential IEPs of high management concern. Because these methods were designed to be rapid, field crews were trained to develop a focused search image on the target plants, instead of looking for every possible invasive plant species. The likelihood of eradicating these target species, or containing them within a park, is generally high. No changes to the Priority 1 list were made between 2008 and 2009.

2.2 Monitoring routes

2.2.1 Minimum Detection Target Size

The minimum detection target size (MDTS) represented the patch size that was 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 established an MDTS of 40 m² (0.01 acres or approximately 20 × 20 ft) for all IEPs. Use of the MDTS was necessary because field technicians were not expected to find every single plant of every targeted weed species during route surveys. Although searching for single mature plants of some species, such as Russian olive (*Elaeagnus angustifolia*) and tamarisk (*Tamarix ramosissima*), is possible due to their large size, single plants of other species, such as field bindweed (*Convolvulus arvensis*), are nearly impossible to detect in most field conditions.

2.2.2 Effective Detection Distance

The effective detection distance (EDD) was 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. Crew members calibrated themselves by walking away from a targeted patch size of the least-visible species and determining the maximum distance from which they could consistently see and recognize the patch with complete confidence. The distance was measured either by pacing or using a laser rangefinder. The EDD for FOBU was between 15 and 37.5 m, depending on vegetation.

2.2.3 Effective Detection Swath Width

Effective detection swath width (EDSW) was defined as the maximum width of a linear search swath (band transect) in which a walking observer is confident of visually detecting 90% of all target species of the MDTS (Figure 2-1). The effective detection swath width (EDSW) is equal to two times the EDD, because the surveyor is able to effectively detect weeds for one EDD on either side of his/her search route. The EDSW ranged from 30 to 75 m at FOBU.

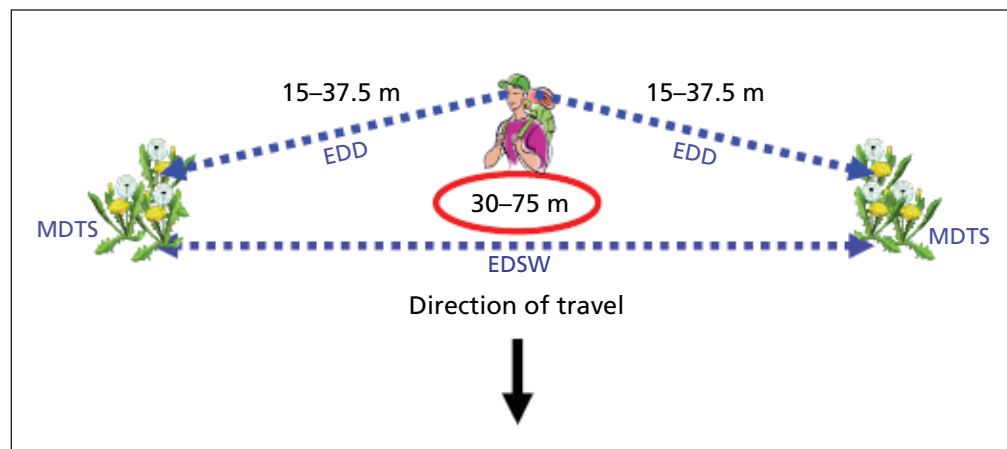


Figure 2-1. The maximum Effective Detection Distance (EDD) at Fossil Butte NM ranged from 15 to 37.5 meters, making the Minimum Detection Target Size (MDTS) 30–75 meters.

2.2.4 Patch Separation Resolution

We defined 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 considered plants separated by less than the PSR to be a single patch or infestation. The PSR was 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 was 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 (BFPs) allow electronic tracking of a user's route. A GPS unit was set to automatically generate these positions at a distance equal to the EDSW, or 75 m. Each time a surveyor walked the equivalent of one EDSW, the GPS unit created 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 30–75 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 global positioning system (GPS) units with at least 5-meter accuracy.

Only species designated as Priority 1 were consistently recorded during monitoring routes, with the exception of cheatgrass, which park staff requested we map along the Main Park Road. Survey crew members were given the latitude to record additional species if they were noteworthy.

When a Priority 1 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 a separate point.

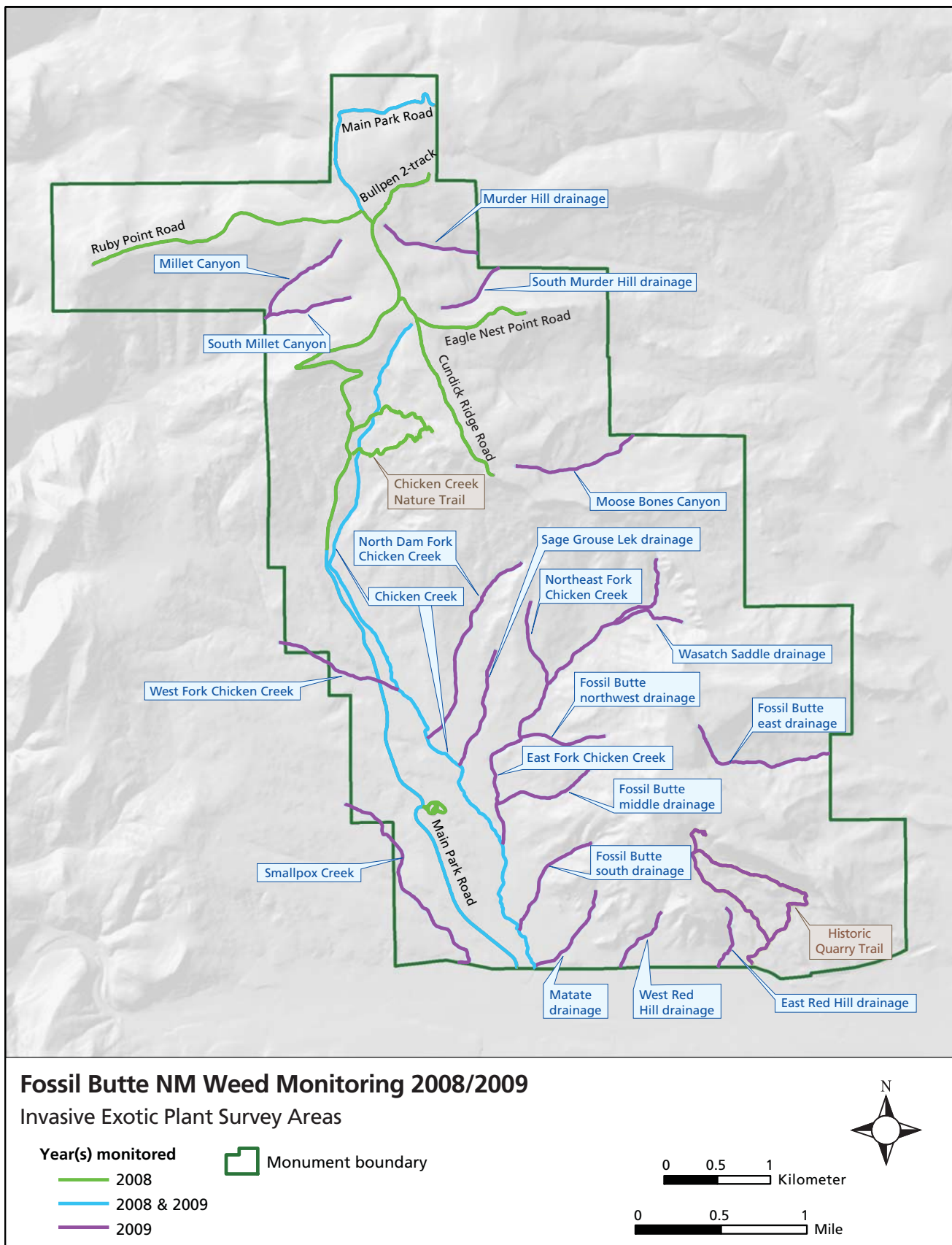


Figure 2-2. Overview of invasive plant monitoring routes and extra areas surveyed at Fossil Butte National Monument, July 14–15, 2008, and August 6–8, 2009.

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. 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 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, whether it was pulled, and evidence of disturbances (e.g., recent fire, flood, small mammal disturbance).

2.3 Monitoring Plots

Our methods for sampling the monitoring plots were based on Stohlgren and others (2005). We established plots with three 1-m² vegetation quadrats every 500 m along all routes (Figure 2-3).

2.3.1 Plot establishment

We centered vegetation quadrats at 3, 8, and 13 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.

For routes along roads, where observers walked on one side on the way out and returned on the opposite side (only at Main Park Road), we established plots only on the way out. A 1-m² sampling frame, placed on the right side of the transect line as the technician walked the monitoring route, was used to sample vegetation cover and soil surface features. In some cases, we leveled the sampling frame by propping up quadrat corners. In 2008, we used three 1-m² vegetation quadrats, placed in a circular macroplot (see Perkins and Weissinger 2009).

2.3.2 Data collection methods

In the monitoring plots, all Priority 1 IEP species observed were recorded, as well as cheatgrass. For each quadrat, we recorded percent cover of each IEP using the following classes: <1, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11–25, 26–50, 51–75, or >75%. 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. Percent cover estimates were generated from the monitoring plot data (see below). We calculated the mean and standard error of percent cover by species for monitoring plots. For classes represented by a range of percent cover values (11–25, 26–50, 51–75, and >75% cover), midpoints were used (18, 38, 63, and 88%) when calculating the mean and standard error. Due to differences in observers’ knowledge, only Priority 1 species and cheatgrass along the Main Park Road should be used when comparing results from year to year.

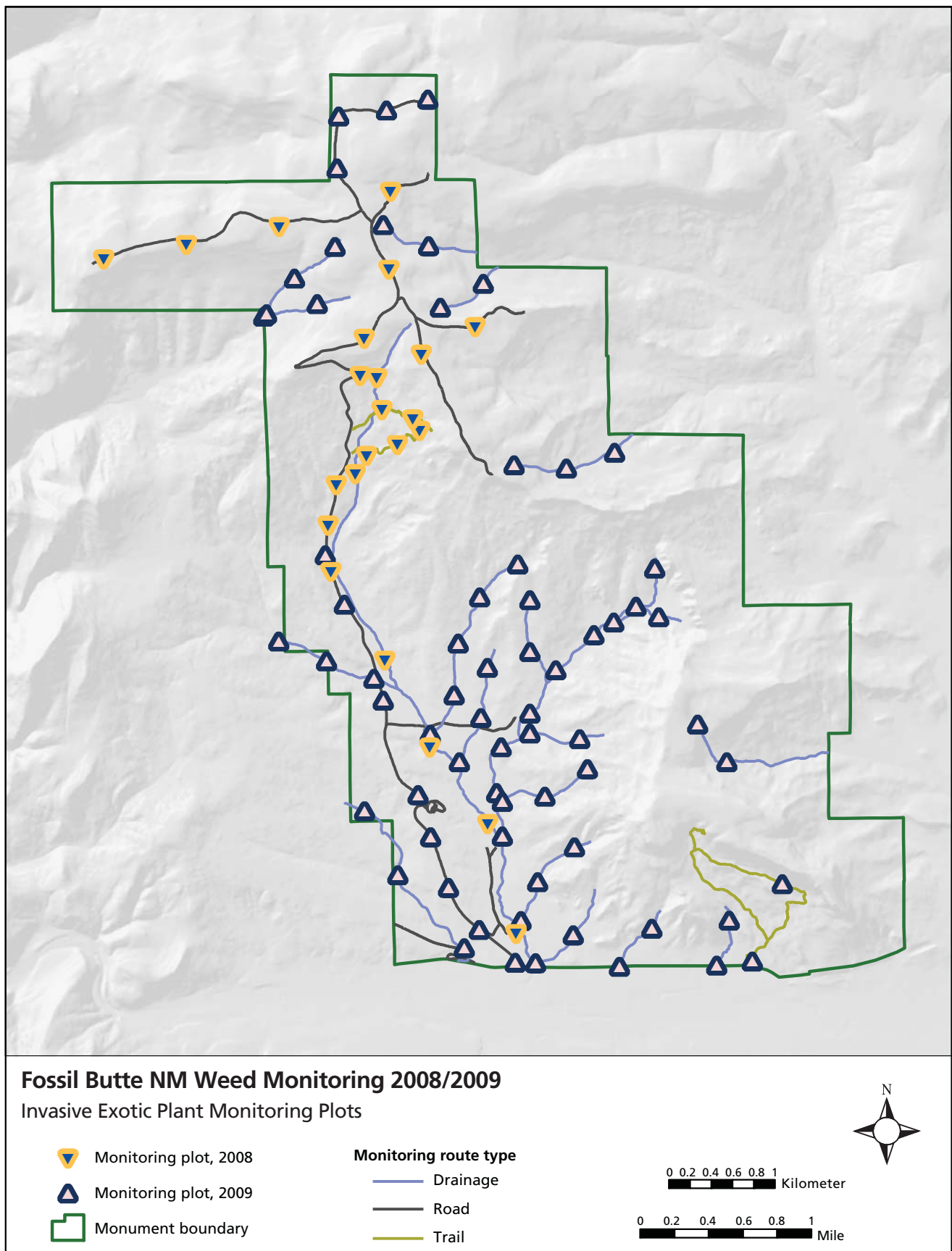


Figure 2-3. Monitoring plots established at Fossil Butte National Monument, July 14–15, 2008 and August 6–8, 2009.

3 Results

3.1 Park target IEP list

Twenty-two IEP species were identified as Priority 1 for the FOBU target IEP list (Appendix A). An additional 14 species were identified as Priority 2. At the request of park staff, we also mapped cheatgrass along the main park road in 2008 and 2009, and recorded it in monitoring plots in 2009. A total of 26 IEP species were recorded on monitoring routes and plots in 2008 and 2009 (Table 3-1).

Plot-sampling methods changed slightly from 2008 to 2009, to increase efficiency. In 2008, all invasive species were recorded in monitoring plots. In 2009, only Priority 1 species and cheatgrass were recorded in the plots and along routes. Observers could make additional species observations, but species other than Priority 1 and cheatgrass were not thoroughly mapped.

Seventeen IEP species were recorded on monitoring routes and 16 in monitoring plots in 2008 and 2009. Of the 26 IEP species detected, 11 were Priority 1, 4 were Priority 2, and 11 were not identified as priority species (Table 3-1). We covered 202.4 hectares (500 acres) and 316.8 hectares (783 acres) along monitoring routes in 2008 and 2009, respectively. We covered an additional 79.2 hectares (196 acres) in extra-area surveys that were reported previously (Perkins and Weissinger 2009). Together, these efforts covered 598 hectares (1,479 acres), representing 18.0% of the entire park.

3.2 Monitoring routes

The survey crew walked a total of 47.9 km (29.8 miles) along 21 monitoring routes in 2009, and 34.7 km (21.6 miles) along seven monitoring routes in 2008. Given the EDSW, this represents a total of 519 hectares (1,283 acres) surveyed. A total of 426 infestations, 315 of which were Priority 1, were detected along monitoring routes. There were 10 Priority 1 species and 3 Priority 2 species recorded (Tables 3-2 and 3-3, Figures 3-1, 3-2, 3-3, and 3-4, Appendix B).

Canada thistle, quackgrass (*Elymus repens*), cheatgrass, and yellow sweetclover were the most commonly detected IEPs. Only Priority 1 species 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 both years. IEPs were most prevalent along South Millet Canyon and the Main Park Road in 2008, and the East Red Hill Drainage, North Dam Fork of Chicken Creek, and Chicken Creek in 2009.

Routes or sections of routes located away from areas of high visitation generally had lower numbers of IEP invasions. No Priority 1 IEPs were detected on Eagle Nest Point Road, Bullpen Two-Track, or Ruby Point Road in 2008, or on the east, northwest, south, and middle drainages of Chicken Creek, Wasatch Saddle Drainage, or West Red Hill Drainage in 2009. There appears to be a large, Priority 1 weed-free area around Fossil Butte in the southern portion of the park (Figure 3-4) along the major invasive pathways, but we cannot be certain that the areas away from roads, trails, and riparian corridors are weed-free in this area. Of the 426 infestations, 81% were classified as infestations in either the “1–a few plants” (1) or “few plants–40 m²” (2) size classes. Eighty-four percent of Priority 1 infestations were classified in these two smallest size classes (Table 3-3).

Creeping foxtail (*Alopecurus arundinaceus*) was not recorded anywhere in the park in 2008. This may have been due to inadequate training of field staff, but was more likely attributable to a control effort that cut seedheads off of the plants, making the plants hard to identify with rapid methods. Crews received extra training on creeping foxtail in 2009, and recorded it in several places.

Chicken Creek and two sections of the Main Park Road were surveyed in both 2008 and 2009 (Figures 3-5, 3-6). In Chicken Creek, where little IEP control occurred between monitoring, the number of infestations present for Canada thistle, bull thistle, Russian thistle, and yellow sweetclover all increased (Table 3-4). In sum, Priority 1 species increased from 0.19 infestations per 100 m in 2008 to 0.51 in 2009 (Table 3-2).

Along the Main Park Road, where park and EPMT staff performed several IEP control efforts in between monitoring field seasons, total Priority 1 species decreased from 0.95 infestations per 100 m in 2008 to 0.41 infestations per 100 m in 2009 (Table 3-2). Cheatgrass, Canada thistle, yellow sweetclover, lens-pod whitetop, and quackgrass all decreased along the Main Park Road from 2008 to 2009 (Table 3-5). Quackgrass appears to have expanded into some areas where weed-control efforts took place on the southern

portion of the Main Park Road (Figure 3-5). Although it was reduced in the southern portion of the Main Park Road, cheatgrass appears to have expanded its presence on the northern portion of the Main Park Road (Figure 3-6).

3.3 Monitoring plots

A total of 23 and 79 plots were sampled in 2008 and 2009, respectively (see Figure 2-3, Appendix C). Only cover in 1-m² quadrats is presented here from 2008 and 2009. A circular macroplot was used in 2008, but not in 2009. In 2008, all IEP species were recorded in plots, whereas in 2009, only Priority 1 species and cheatgrass were recorded. Quackgrass was the only Priority 1 species detect-

ed in a plot in either year, and it was only recorded in three plots along the Main Park Road in 2009. Estimated cover of quackgrass for the entire area monitored in the park is only 0.04%; along the Main Park Road, it is 0.20%. Only two Priority 2 species were detected in plots: halogeton (*Halogeton glomeratus*), in one plot along Chicken Creek in 2008; and yellow salsify (*Tragopogon dubius*), in one plot in along Chicken Creek in 2008, and in one plot in Millet Canyon in 2009. Cheatgrass was only recorded in plots in 2009, where it was detected in three of 79 plots (two along the Main Park Road and one along the Historic Quarry Trail). Cheatgrass had 0.10% cover throughout the areas sampled with plots, and 0.33% cover along the Main Park Road in 2009.

Table 3-1. Invasive exotic plants detected at Fossil Butte National Monument, July 12–13, 2008 and August 6–8, 2009.

Scientific name	Common name	Method detected		Park priority
		Routes	Plots	
<i>Alopecurus arundinaceus</i>	creeping foxtail	X		1
<i>Cardaria chalapensis</i>	lens-pod whitetop	X		1
<i>Carduus nutans</i>	musk thistle	X		1
<i>Centaurea maculosa</i>	spotted knapweed	X		1
<i>Cirsium arvense</i>	Canada thistle	X		1
<i>Cirsium vulgare</i>	bull thistle	X		1
<i>Convolvulus arvensis</i>	field bindweed	X		1
<i>Elymus repens</i>	quackgrass	X	X	1
<i>Hyoscyamus niger</i>	black henbane	X		1
<i>Isatis tinctoria</i>	Dyer's woad	X		1
<i>Melilotus officinalis</i>	yellow sweetclover	X		1
<i>Halogeton glomeratus</i>	halogeton		X	2
<i>Onopordum acanthium</i>	Scotch thistle	X		2
<i>Salsola tragus</i>	Russian thistle	X		2
<i>Tragopogon dubius</i>	yellow salsify	X	X	2
<i>Bromus tectorum</i>	cheatgrass	X	X	Not on list
<i>Descurainia sophia</i>	flixweed	X	X	Not on list
<i>Lepidium perfoliatum</i>	clasping pepperweed		X	Not on list
<i>Medicago sativa</i>	alfalfa	X		Not on list
<i>Phleum pratense</i>	timothy grass		X	Not on list
<i>Poa bulbosa</i>	bulbous bluegrass		X	Not on list
<i>Poa pratensis</i>	Kentucky bluegrass		X	Not on list
<i>Polygonum aviculare</i>	prostrate knotweed		X	Not on list
<i>Ranunculus testiculatus</i>	curveseed butterwort		X	Not on list
<i>Thlaspi arvense</i>	field pennycress		X	Not on list
<i>Trifolium repens</i>	white clover		X	Not on list

Only Priority 1 species were mapped and recorded in plots throughout FOBU. Priority 2 and species not on the list were opportunistic observations.

Table 3-2. Number of IEP infestations per route surveyed, Fossil Butte NM, July 14–15, 2008 and August 6–8, 2009.

Route	Type of route	Length (m)	Number of infestations (Priority 1)	Number of infestations/100 m (Priority 1)
2008				
Bullpen Two-Track	Road	783	3 (0)	0.38 (0.00)
Chicken Creek	Riparian	7,200	14 (14)	0.19 (0.19)
Chicken Creek Nature Trail	Trail	2,118	9 (1)	0.42 (0.05)
Cundick Ridge Road	Road	1,981	9 (1)	0.45 (0.05)
Eagle Nest Point Road	Road	1,134	0 (0)	0.00 (0.00)
Main Park Road	Road	18,793	223 (159)	1.19 (0.85)
Ruby Point Road	Road	2,740	2 (0)	0.07 (0.00)
2009				
Chicken Creek	Riparian	7,200	42 (37)	0.58 (0.51)
East Fork Chicken Creek	Riparian	3,619	4 (3)	0.11 (0.08)
East Red Hill Drainage	Riparian	653	6 (5)	0.91 (0.77)
Historic Quarry Trail	Trail	3,476	3 (3)	0.09 (0.09)
Fossil Butte East Drainage	Riparian	1,514	0 (0)	0.00 (0.00)
Fossil B. Middle Drainage	Riparian	1,018	0 (0)	0.00 (0.00)
Fossil Butte NW Drainage	Riparian	838	0 (0)	0.00 (0.00)
Fossil Butte S. Drainage	Riparian	1,167	0 (0)	0.00 (0.00)
Main Park Road	Road	13,623	57 (41)	0.41 (0.30)
Matate Drainage	Riparian	1,000	1 (1)	0.10 (0.10)
Millet Canyon	Riparian	1,090	4 (3)	0.37 (0.28)
Moose Bones Canyon	Riparian	1,248	4 (3)	0.32 (0.24)
Murder Hill Drainage	Riparian	967	2 (2)	0.21 (0.21)
NE Fork Chicken Creek	Riparian	841	1 (1)	0.12 (0.12)
N. Dam Fork Chicken Cr.	Riparian	2,037	15 (15)	0.74 (0.74)
Sage Grouse Lek Drainage	Riparian	1,192	1 (1)	0.08 (0.08)
Smallpox Creek	Riparian	2,228	8 (8)	0.36 (0.36)
South Millet Canyon	Riparian	822	10 (10)	1.21 (1.21)
S. Murder Hill Drainage	Riparian	717	4 (3)	0.56 (0.42)
Wasatch Saddle Drainage	Riparian	727	0 (0)	0.00 (0.00)
West Fork Chicken Creek	Riparian	1,249	4 (4)	0.32 (0.32)
West Red Hill Drainage	Riparian	700	0 (0)	0.00 (0.00)
All Riparian 2009		30,827	106 (97)	0.34 (0.31)
All Trails		5,594	12 (4)	0.21 (0.07)
Roads Other Than Main Park Road		6,638	14 (1)	0.21 (0.02)
Main Park Rd. 2008		9,102	119 (86)	1.31 (0.95)
Main Park Rd. 2009		9,102	55 (37)	0.60 (0.41)

Table 3-3. Species observed and size of infestation detected along monitoring routes at Fossil Butte NM on July 14–15, 2008 and August 6–8, 2009.

Species	Common name	Total infestations	Infestation size class Number of infestations			
			1	2	3	4
<i>Alopecurus arundinaceus</i> [^]	creeping foxtail	26	12	10	2	2
<i>Bromus tectorum</i> *	cheatgrass	57	19	18	15	5
<i>Cardaria chalepensis</i>	lens-pod whitetop	2	1	1	0	0
<i>Carduus nutans</i>	musk thistle	33	22	11	0	0
<i>Centaurea maculosa</i>	spotted knapweed	1	0	0	1	0
<i>Cirsium arvense</i>	Canada thistle	89	35	40	11	3
<i>Cirsium vulgare</i>	bull thistle	8	6	2	0	0
<i>Convolvulus arvensis</i>	field bindweed	5	0	5	0	0
<i>Descurainia sophia</i> **	flixweed	39	20	9	8	2
<i>Elymus repens</i>	quackgrass	73	20	29	15	9
<i>Hyoscyamus niger</i>	black henbane	19	17	1	1	0
<i>Isatis tinctoria</i>	Dyer's woad	2	2	0	0	0
<i>Medicago sativa</i> **	alfalfa	1	1	0	0	0
<i>Melilotus officinalis</i>	yellow sweetclover	56	39	10	5	2
<i>Poa bulbosa</i> **	bulbous bluegrass	1	0	0	1	0
<i>Salsola tragus</i> **	Russian thistle	1	0	1	0	0
<i>Tragopogon dubius</i> **	yellow salsify	13	11	1	1	0
Priority 1 species		315	154	109	35	16
All species		426	205	138	60	23

For areas along the Main Park Road that were surveyed in 2008 and 2009, only the 2009 data was used for this table.

**Bromus tectorum* was only regularly recorded along the Main Park Road in 2008, but was recorded everywhere in 2009.

**Not a Priority 1 species, so may not have been recorded during all routes in both years.

[^]Species was not searched for in 2008.

Infestation size classes:

- 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).

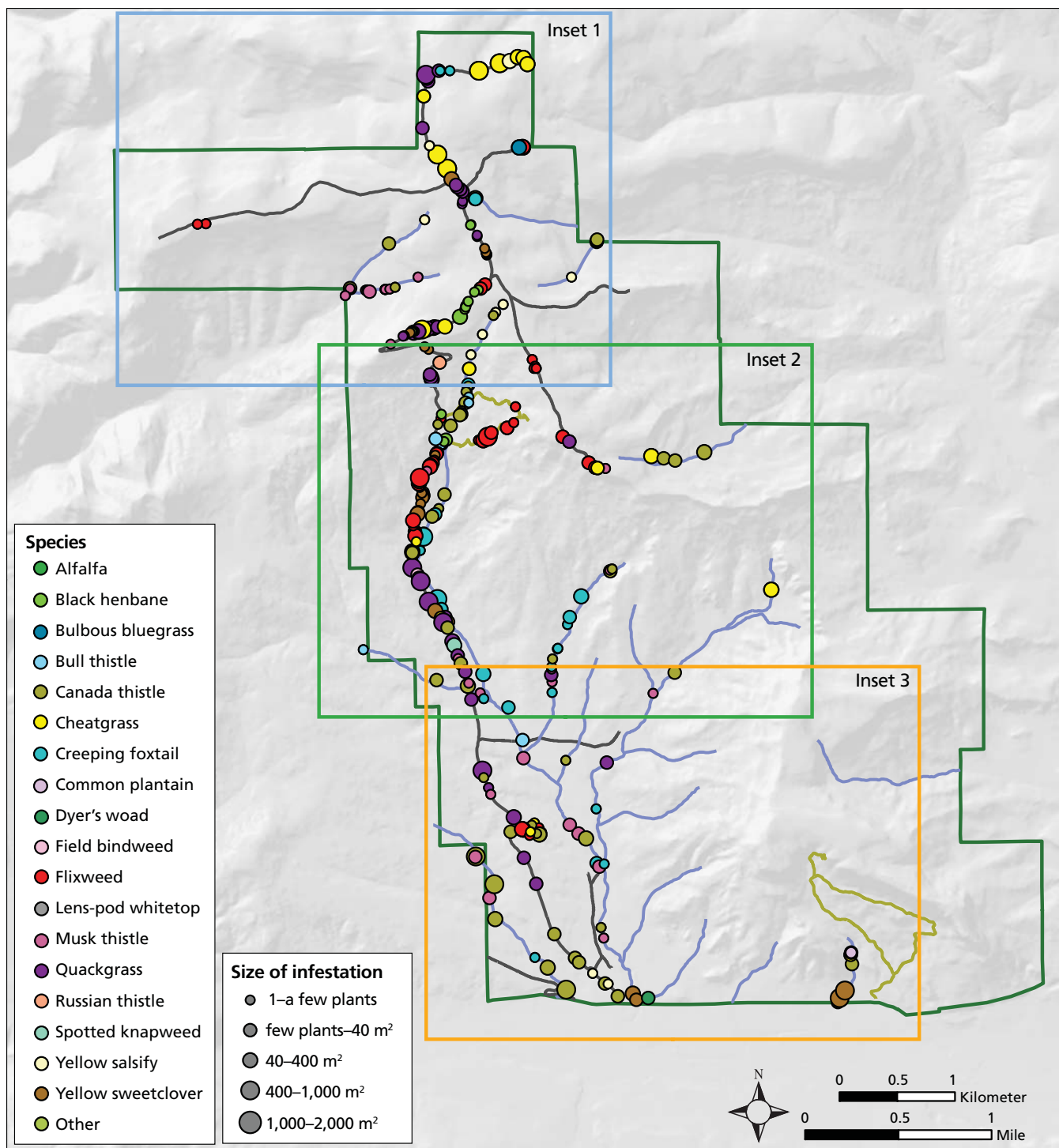


Figure 3-1. Invasive plants detected along monitoring routes, monitoring plots, and extra-area surveys at Fossil Butte National Monument, July 14–15, 2008 and August 6–8, 2009. In areas where surveys were conducted on both years, only 2009 data are shown.

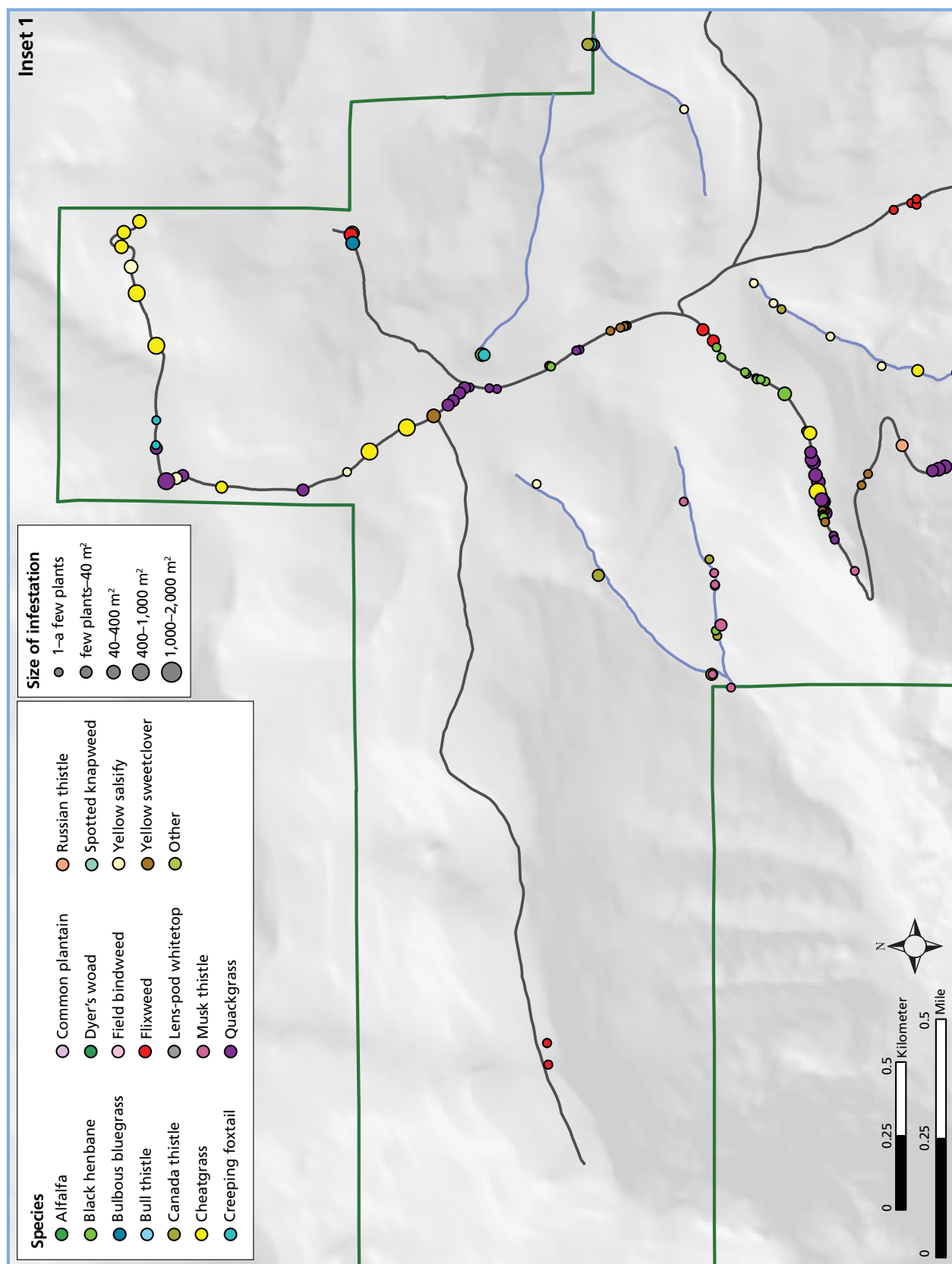


Figure 3-2. Invasive plants detected along monitoring routes and monitoring plots in the northern portion of Fossil Butte National Monument, July 14–15, 2008 and August 6–8, 2009. In areas where surveys were conducted on both years, only 2009 data are shown.

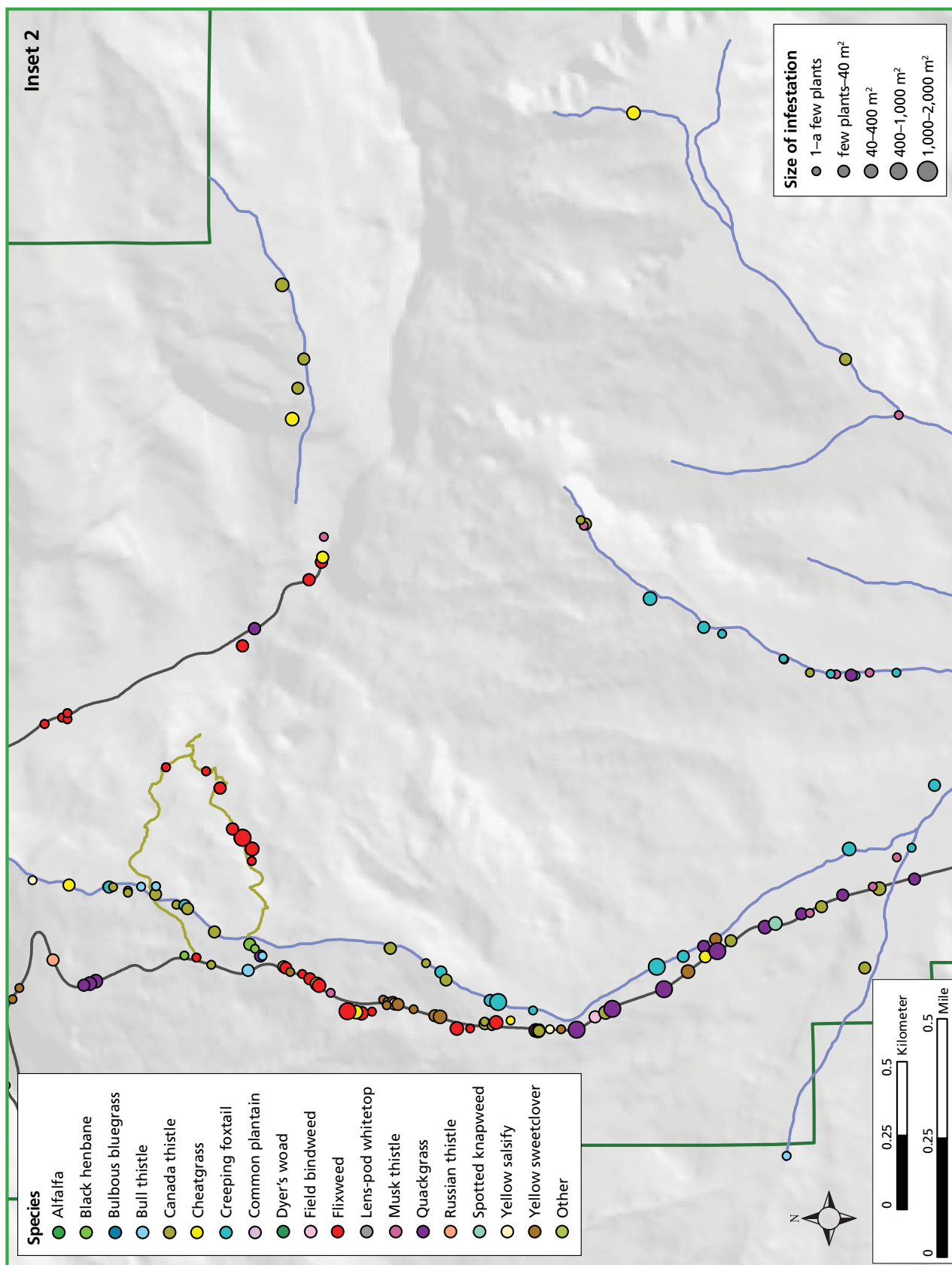


Figure 3-3. Invasive plants detected along monitoring routes and monitoring plots in the middle portion of Fossil Butte National Monument, July 14–15, 2008 and August 6–8, 2009. In areas where surveys were conducted on both years, only 2009 data are shown.

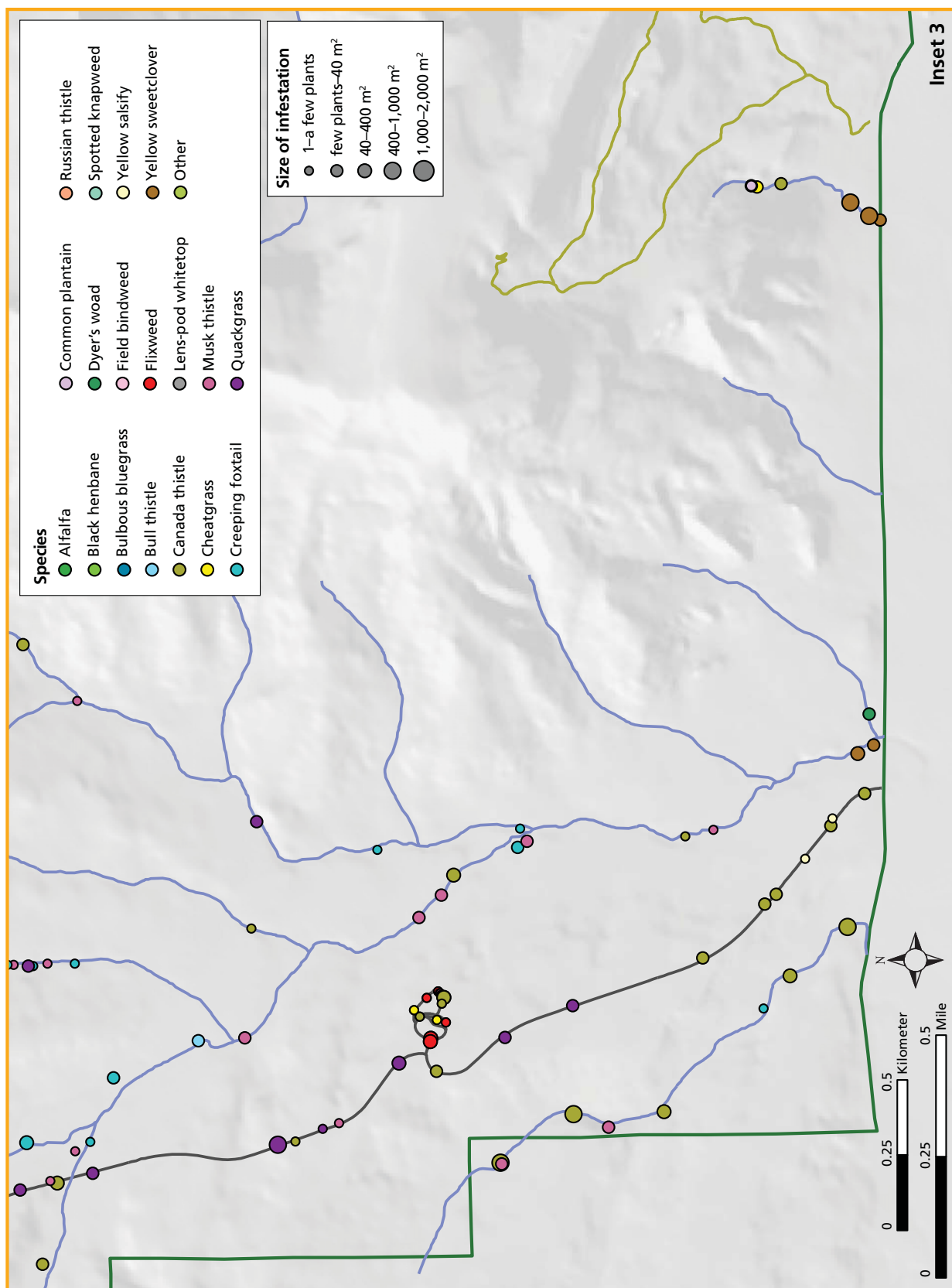


Figure 3-4. Invasive plants detected along monitoring routes and monitoring plots in the southern portion of Fossil Butte National Monument, July 14–15, 2008 and August 6–8, 2009. In areas where surveys were conducted on both years, only 2009 data are shown. Note the large, Priority 1 weed-free area in the area surrounding Fossil Butte within the park unit.

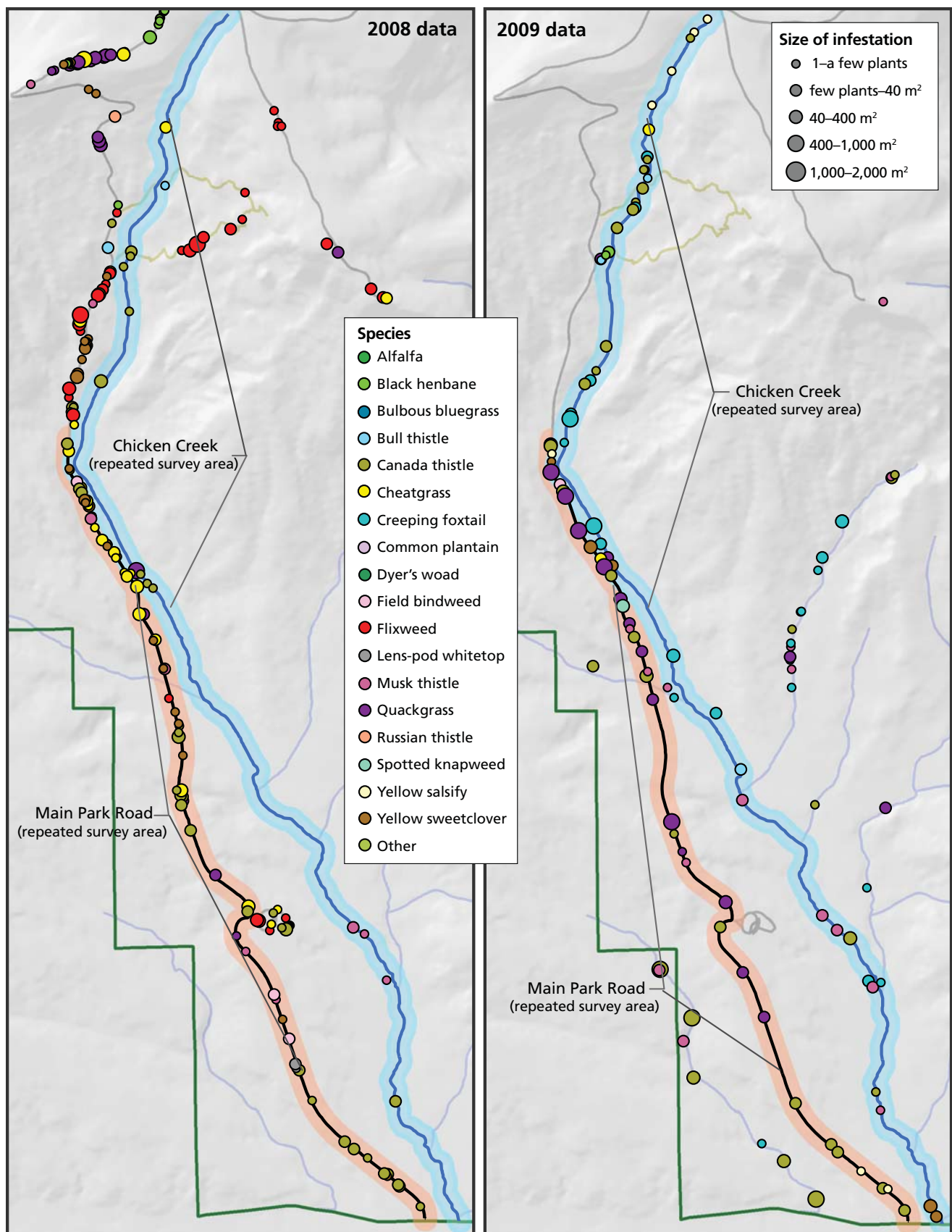


Figure 3-5. Areas monitored in both July 14-15, 2008 and August 6-8, 2009 (highlighted in blue and pink) along the southern portion of the Main Park Road.

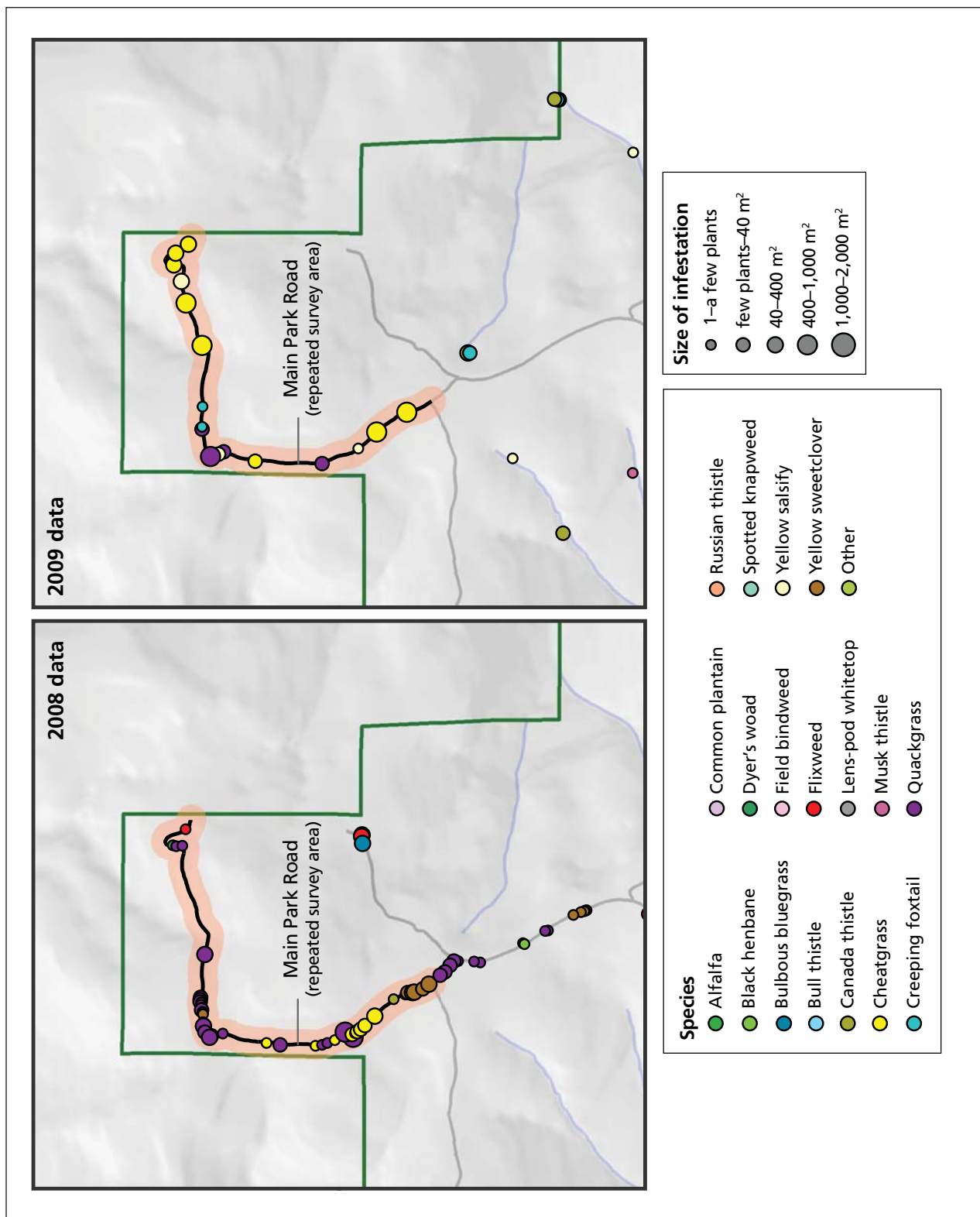


Figure 3-6. Areas monitored in both July 14-15, 2008 and August 6-8, 2009 (highlighted in pink) along the northern portion of the Main Park Road.

Table 3-4. Species observed and size of infestations detected at Chicken Creek, Fossil Butte NM on July 14–15, 2008 and August 6–8, 2009.

Species	Common name	Year	Total infestations	Infestation size class Number of infestations			
				1	2	3	4
Species recorded in both years							
<i>Bromus tectorum</i> *	cheatgrass	2008	1	0	1	0	0
		2009	1	0	1	0	0
<i>Carduus nutans</i>	musk thistle	2008	3	2	1	0	0
		2009	5	1	4	0	0
<i>Cirsium arvense</i>	Canada thistle	2008	9	6	2	1	0
		2009	13	8	4	1	0
<i>Cirsium vulgare</i>	bull thistle	2008	0	0	0	0	0
		2009	3	2	1	0	0
<i>Elymus repens</i>	quackgrass	2008	1	0	0	1	0
		2009	1	0	1	0	0
<i>Melilotus officinalis</i>	yellow sweetclover	2008	0	0	0	0	0
		2009	3	0	2	1	0
Species not searched for in both years							
<i>Alopecurus arundinaceus</i> ^	creeping foxtail	2008	0	0	0	0	0
		2009	12	2	7	1	2
<i>Tragopogon dubius</i> *	yellow salsify	2008	0	0	0	0	0
		2009	4	4	0	0	0
Total Priority 1		2008	13	8	3	2	0
		2009	37	13	19	3	2
Total Priority 1, no <i>A. arundinaceus</i>		2009	25	11	12	2	0

[^]Species was not searched for in 2008.

*Not a Priority 1 species so may not have been searched for by all observers in both years.

Infestation size classes:

- 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).

Table 3-5. Species observed and size of infestation detected along the Main Park Road, Fossil Butte NM on July 14–15, 2008 and August 6–8, 2009.

Species	Common name	Year	Total infestations	Infestation size class Number of infestations			
				1	2	3	4
Species recorded in both years							
<i>Bromus tectorum</i> *	cheatgrass	2008	30	13	11	6	0
		2009	9	1	4	4	0
<i>Cardaria chalepensis</i>	lens-pod whitetop	2008	2	1	1	0	0
		2009	0	0	0	0	0
<i>Carduus nutans</i>	musk thistle	2008	4	2	2	0	0
		2009	3	3	0	0	0
<i>Cirsium arvense</i>	Canada thistle	2008	25	9	15	1	0
		2009	12	1	8	3	0
<i>Centaurea maculosa</i>	spotted knapweed	2008	0	0	0	0	0
		2009	1	0	0	1	0
<i>Convolvulus arvensis</i>	field bindweed	2008	3	0	3	0	0
		2009	1	0	1	0	0
<i>Elymus repens</i>	quackgrass	2008	27	12	10	3	2
		2009	18	1	8	3	6
<i>Melilotus officinalis</i>	yellow sweetclover	2008	25	19	4	2	0
		2009	2	1	1	0	0
Species not searched for in both years							
<i>Alopecurus arundinaceus</i> ^	creeping foxtail	2008	0	0	0	0	0
		2009	2	2	0	0	0
<i>Descurainia sophia</i> *	flixweed	2008	2	2	0	0	0
		2009	0	0	0	0	0
<i>Medicago sativa</i> *	alfalfa	2008	1	1	0	0	0
		2009	0	0	0	0	0
<i>Tragopogon dubius</i> *	yellow salsify	2008	0	0	0	0	0
		2009	7	5	1	1	0
Totals All Species		2008	119	59	46	12	2
		2009	55	14	23	12	6
Total Priority 1		2008	86	43	35	6	2
		2009	39	8	18	7	6
Priority 1, no <i>A. arundinaceus</i>		2009	37	6	18	7	6

[^]Species was not searched for in 2008, but was Priority 1 in 2009.

*Not a Priority 1 species so may not have been searched for by all observers in both years.

Infestation size classes:

- 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).

4 Discussion

4.1 Changes to protocol based on 2008 and 2009 pilot field seasons

In 2008, we estimated that observers spent more than half of their field time establishing and collecting data from the monitoring plots and nested quadrats. In order to make the collection of quantitative data more efficient, we eliminated the circular macroplot with three nested 1-m² quadrats and alternatively collected data from three 1-m² quadrats at set distances of 3, 8, and 13 m away from the monitoring route. We also decided to only collect data on the Priority 1 IEPs and other widespread IEPs (like cheatgrass) about which the park has requested information. By requiring observers to only learn target and dominant IEPs, data collection takes less time and requires less botanical expertise. These changes decreased the time required to monitor a set of three quadrats from an average of 21 minutes in 2008 to an average of 7 minutes in 2009, allowing more areas to be searched throughout the park.

Based on work at other NCPN parks, a few additional protocol changes will be made for 2010. In order to better capture the roadside verge, where many invasives colonize, we will establish our three quadrats at 0.5, 5, and 10 m from the monitoring route. We will continue to establish transects with three quadrats every 500 m along monitoring routes. However, if no Priority 1 IEPs or other park-requested widespread species are detected for four consecutive transects (12 quadrats), then transects will then be established every 1,000 m. If invasive plants are found in categories greater than 1% in subsequent quadrats, the observer will revert to establishing transects every 500 m.

When the level of invasives is very low (<1% cover), it will be difficult to detect trends based on the monitoring quadrats. However, we will maintain them to establish a baseline, should invasives ever expand. This report demonstrates that the monitoring routes, while not as quantitative, clearly showed the effects of different management actions along the Main Park Road and Chicken Creek.

4.2 Priority 1 IEP List

The NCPN will continue to work with FOBU staff and area weed experts to review and update

the list of priority species each year. The park has suggested adding flaxweed to the Priority 1 list for 2010. Presence and absence data for most Priority 1 species and cheatgrass along the Main Park Road should be reliable; however, absence data for other species are suspect due to the changes in techniques and training of observers between the 2008 and 2009 sampling effort. Quackgrass is a problematic Priority 1 species, as it is very similar to native *Elymus* species and hybridizes with some of them. In 2008, we were reluctant to record thistle rosettes because of the difficulty in accurately distinguishing between the exotics and several native thistle species.

4.3 Possibilities for management control

Invasive exotic plants were widespread along the Main Park Road in 2008, but were reduced in 2009 after control efforts. However, quackgrass and cheatgrass may have invaded some of the areas where IEPs were removed. Areas with lower human visitation had few IEPs. Efforts should be made to ensure that a Priority 1 weed-free area around the geologic feature, Fossil Butte, is maintained. Infestations at Chicken Creek increased between 2008 and 2009, and should be targeted for control in 2010. Efforts should also continue along the Main Park Road. South Millet Canyon, East Red Hill Drainage, and the North Dam Fork of Chicken Creek are all areas where park staff may not regularly traverse, but these areas had some of the highest infestation rates and are also areas that should be targeted for control. The latter two areas are near the large weed-free area. The northern portion of Chicken Creek had several infestations of cheatgrass, making it one of the few areas in the park in addition to the Main Park Road where this species was present. Because these infestations are at the head of the drainage, it is likely that they could spread further down into the park.

It is encouraging that 84% of infestations by Priority 1 species detected on monitoring routes were less than 40 m² in size, indicating that rapid control of these infestations may limit their expansion. Preventing additional species from invading will give native species a better chance to persist.

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.

NCPN staff does not regularly control invasives while monitoring; however, they are instructed to pull IEPs found in areas that require a significant amount of time to access. NCPN crews pulled a single musk thistle each in Millet Canyon and in South Millet Canyon. Other than two infestations of Canada thistle near the confluence with South Millet Canyon, this was the only Priority 1 IEP in Millet Canyon, although there was one small infestation of yellow salsify at the head of the canyon. Even though only one musk thistle was pulled in South Millet Canyon, this area should still be targeted for control because several other Priority 1 IEPs were detected here.

4.4 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 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 2010, the NCPN will re-survey all of the areas covered in 2008 and 2009. The monitoring quadrats are re-located each year because any detections from a previous year could have been eradicated by park staff. A complete second sample of monitoring plots will be collected in 2010; these will be compared to the samples collected in 2008 and 2009. The NCPN will then begin monitoring the park every other year. 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 1 species and cheatgrass by monitoring route. Extra-area surveys will also be considered for inventories at the park's request. It is anticipated that the NCPN invasive plant monitoring protocol will be submitted for peer review in 2010.

5 Literature Cited

- Andersen, K. A., and S. A. Dewey. 2007. USU Wildland weed mapping methods training supplement. Master's thesis. Utah State University, Logan, Utah. 107 pp. plus appendix.
- Elzinga, C. L., D. W. Salzer, and J. W. Willoughby. 1998. Measuring and monitoring plant populations. USDI-BLM Technical Ref. 1730-1. Bureau of Land Management, Denver, Colorado. 477 pp.
- Mooney, H., and R. J. Hobbs, eds. Invasive species in a changing world. Washington, D.C.: Island Press. 457 pp.
- National Research Council. 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.
- Scott, J. M., and D. S. Wilcove. 1998. Improving the future for endangered species. *BioScience* 48(8):579–580.
- Stohlgren, T. J., D. T. Barnett, and S. E. Simonson. 2005. Beyond North American Weed Management Association standards. <http://www.nawma.org/documents/Mapping%20Standards/BEYOND%20NAWMA%20STANDARDS.pdf>.

Appendix A. Fossil Butte National Monument Target Invasive Exotic Plant List

Species name (Utah)	Common name
Priority 1	
<i>Alopecurus arundinaceus</i>	creeping foxtail
<i>Arctium minus</i>	burdock
<i>Cardaria chalepensis</i>	lens-pod 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 hound's-tongue
<i>Elymus repens</i>	quackgrass
<i>Hyoscyamus niger</i>	black henbane
<i>Isatis tintoria</i>	Dyer's woad
<i>Kochia scorpioides</i>	kochia
<i>Lepidium latifolium</i>	broad-leaf pepperwort
<i>Linaria dalmatica</i>	Dalmatian toadflax
<i>Melilotus officinalis</i>	yellow sweetclover
<i>Sonchus arvensis</i> / <i>S. uliginosus</i>	perennial sowthistle
<i>Tamarix</i> spp.	tamarisk
<i>Verbascum thapsus</i>	woolly mullein
Priority 2	
<i>Cardaria draba</i>	hoary cress
<i>Carduus acanthoides</i>	plumeless thistle
<i>Centaurea solstitialis</i>	yellow starthistle
<i>Condrilla juncea</i>	rush skeltonweed
<i>Elaeagnus angustifolia</i>	Russian olive
<i>Euphorbia esula</i>	leafy spurge
<i>Halogeton glomeratus</i>	halogeton
<i>Hypericum perforatum</i>	common St. Johnswort
<i>Linaria vulgaris</i>	butter-and-eggs
<i>Lythrum salicaria</i>	purple loosertrife
<i>Marrubium vulgare</i>	common horehound
<i>Onopordum acanthium</i>	Scotch thistle
<i>Salsola tragus</i>	Russian thistle
<i>Tragopogon dubius</i>	yellow salsify

Appendix B. Exotic Plant Invasions Detected on Monitoring Routes at Fossil Butte NM, August 6–8, 2009

Monitoring route	Species	Common name	Infestation size class	Canopy cover class	Pulled?	Northing	Easting
Chicken Creek	<i>Cirsium vulgare</i>	bull thistle	1	5	No	4635409.535	518455.75
			1	3	No	4634573.697	518248.091
			2	5	No	4632444.288	518922.008
	<i>Cirsium arvense</i>	Canada thistle	1	4	No	4635453.027	518442.074
			1	3	No	4635453.478	518435.331
			1	5	No	4635289.751	518394.378
			2	4	No	4635252.38	518380.223
			2	3	No	4635160.837	518301.983
			2	3	No	4634566.931	518246.472
			1	4	No	4634445.325	518196.944
			2	3	No	4634378.024	518139.359
			1	5	No	4636114.068	518668.455
			3	4	No	4631596.241	519471.593
			1	4	No	4630826.701	519600.005
			1	5	No	4635523.43	518454.665
			1	4	No	4635504.197	518453.245
	<i>Bromus tectorum</i>	cheatgrass	2	5	No	4635653.248	518461.231
	<i>Alopecurus arundinaceus</i>	creeping foxtail	2	3	No	4635261.776	518392.089
			2	3	No	4634395.314	518166.08
			2	3	No	4634228.482	518069.933
			4	3	No	4634202.055	518064.655
			1	5	No	4634084.107	518036.747
			4	4	No	4633664.87	518184.707
			2	5	No	4633576.171	518219.375
			3	5	No	4633014.787	518583.155

Appendix B. Exotic Plant Invasions Detected on Monitoring Routes at Fossil Butte NM, August 6–8, 2009, cont.

Monitoring route	Species	Common name	Infestation size class	Canopy cover class	Pulled?	Northing	Easting
Chicken Creek, cont.	<i>Alopecurus arundinaceus</i>	creeping foxtail	2	5	No	4632726.437	518798.429
			2	4	No	4631383.629	519563.629
			2	3	No	4635517.456	518453.619
			1	4	No	4631375.831	519626.137
	<i>Carduus nutans</i>	musk thistle	2	2	No	4632290.267	518931.147
			2	5	No	4631711.598	519331.09
			2	3	No	4631637.398	519404.822
			2	4	No	4631352.403	519583.838
	<i>Elymus repens</i>	quackgrass	1	5	No	4630734.195	519622.577
			2	5	No	4633507.128	518254.034
Cundick Ridge Road	<i>Tragopogon dubius</i>	yellow salsify	1	5	No	4636207.917	518755.827
			1	5	No	4636142.096	518688.163
			1	5	No	4635948.667	518575.952
			1	5	No	4635775.983	518476.348
	<i>Mellilotus officinalis</i>	yellow sweetclover	2	5	No	4633466.347	518277.333
			3	3	No	4630253.561	519875.024
			2	3	No	4630201.128	519903.752
	<i>Carduus nutans</i>	musk thistle	1	4	No	4634791.797	519637.141
	<i>Cirsium arvense</i>	Canada thistle	2	4	No	4633027.325	520237.658
			3	4	No	4633743.483	521071.46
East Fork Chicken Creek	<i>Bromus tectorum</i>	cheatgrass	1	3	No	4631849.98	519556.206
	<i>Alopecurus arundinaceus</i>	creeping foxtail	2	3	No	4632251.38	519649.569
	<i>Elymus repens</i>	quackgrass	2	3	No	4630509.46	521767.616
	<i>Cirsium arvense</i>	Canada thistle	2	3	No	4630589.018	521757.284
	<i>Bromus tectorum</i>	cheatgrass	2	5	No	4630607.744	521761.049
	<i>Isatis tinctoria</i>	Dyer's woad	1	5	No	4630180.086	521648.007
	<i>Mellilotus officinalis</i>	yellow sweetclover	2	3	No	4630216.78	521661.572
	<i>Mellilotus officinalis</i>	yellow sweetclover	4	3	No	4630279.018	521705.978
			4	3	No		
	<i>Mellilotus officinalis</i>	yellow sweetclover	4	3	No		

Appendix B. Exotic Plant Invasions Detected on Monitoring Routes at Fossil Butte NM, August 6–8, 2009, cont.

Monitoring route	Species	Common name	Infestation size class	Canopy cover class	Pulled?	Northing	Easting
Fossil Lake Trail	<i>Hyoscyamus niger</i>	black henbane	2	5	No	4635041.154	518259.843
			1	5	No	4635024.473	518245.315
	<i>Cirsium arvense</i>	Canada thistle	2	4	No	4635359.661	518428.875
Main Park Road	<i>Cirsium vulgare</i>	bull thistle	1	5	No	4634998.738	518220.924
	<i>Cirsium arvense</i>	Canada thistle	2	1	No	4633415.298	518272.465
			2	2	No	4633109.013	518387.601
			3	2	No	4634065.901	517967.652
			3	3	No	4632913.468	518448.556
			1	2	No	4632121.599	518587.038
			2	2	No	4631653.615	518819.602
			2	3	No	4630768.573	519196.697
			2	3	No	4630562.671	519375.406
			2	3	No	4630524.999	519408.374
			2	2	No	4630343.405	519635.199
			2	2	No	4630231.73	519743.337
			3	3	No	4633839.219	518030.158
	<i>Bromus tectorum</i>	cheatgrass	2	3	No	4633501.709	518218.45
			4	3	No	4637381.922	518268.788
			4	3	No	4637506.845	518187.422
			2	3	No	4638007.982	518066.411
			4	2	No	4638228.004	518545.308
			4	2	No	4638294.25	518721.94
			3	2	No	4638345.584	518879.706
			3	2	No	4638338.275	518928.236
			3	2	No	4638285.815	518965.153
	<i>Alopecurus arundinaceus</i>	creeping foxtail	1	3	No	4638229.162	518209.457
			1	3	No	4638227.802	518292.548

Appendix B. Exotic Plant Invasions Detected on Monitoring Routes at Fossil Butte NM, August 6–8, 2009, cont.

Monitoring route	Species	Common name	Infestation size class	Canopy cover class	Pulled?	Northing	Easting
Main Park Road, cont.	<i>Convolvulus arvensis</i>	field bindweed	2	3	No	4633874.183	518014.733
	<i>Carduus nutans</i>	musk thistle	1	2	Yes	4633148.397	518365.768
			1	2	No	4631977.463	518647.788
			1	2	No	4632935.969	518455.864
	<i>Elymus repens</i>	quackgrass	3	2	No	4634074.628	517968.857
			4	1	No	4633460.775	518237.698
			3	2	No	4633300.148	518317.759
			2	4	No	4633177.009	518363.205
			2	3	No	4633036.939	518426.348
			2	2	No	4632794.919	518481.281
			4	2	No	4632181.053	518576.081
			1	2	No	4632031.76	518628.857
			3	3	No	4631777.503	518846.75
			2	2	No	4631426.309	518932.689
			2	2	No	4631201.234	519038.782
			4	2	No	4633936.085	517970.927
			4	2	No	4633815.992	518041.368
			2	2	No	4637732.545	518056.911
			2	3	No	4638138.939	518105.277
			4	3	No	4638193.88	518086.829
			4	2	No	4633641.737	518109.007
			2	3	No	4638228.194	518197.976
			2	5	No	4635005.484	518220.318
<i>Centaurea maculosa</i>	spotted knapweed		3	3	No	4633264.752	518330.103
<i>Tragopogon dubius</i>	yellow salsify		1	2	No	4634027.22	517973.051
			1	1	No	4630428.952	519526.478
			1	2	No	4630338.495	519659.602
			1	1	No	4637582.739	518118.73

Appendix B. Exotic Plant Invasions Detected on Monitoring Routes at Fossil Butte NM, August 6–8, 2009, cont.

Monitoring route	Species	Common name	Infestation size class	Canopy cover class	Pulled?	Northing	Easting
Main Park Road, cont.	<i>Tragopogon dubius</i>	yellow salsify	1	2	No	4638002.705	518067.216
			2	3	No	4638160.05	518096.461
			3	2	No	4638313.568	518811.605
Matate drainage	<i>Melilotus officinalis</i>	yellow sweetclover	3	2	No	4633559.481	518167.998
			1	5	No	4630216.73	520006.413
			2	3	No	4636733.713	517768.62
Millet Canyon	<i>Cirsium arvense</i>	Canada thistle	2	2	No	4636350.692	517433.576
			1	2	Yes	4636347.876	517433.792
			1	1	No	4636942.454	518077.212
Moose Bones Canyon	<i>Tragopogon dubius</i>	Canada thistle	2	4	No	4634878.949	520140.239
			2	4	No	4634859.311	520239.699
			3	4	No	4634932.224	520490.166
Murder Hill drainage	<i>Bromus tectorum</i>	cheatgrass	3	4	No	4634897.818	520036.199
			3	4	No	4637127.245	518514.579
			2	2	No	4637119.491	518513.613
NE Fork Chicken Creek	<i>Alopecurus arundinaceus</i>	creeping foxtail	1	4	No	4632847.341	520050.098
			2	4	No	4633906.037	519680.798
			1	4	No	4633922.239	519694.879
North Dam Fork Chicken Creek	<i>Carduus nutans</i>	musk thistle	1	4	No	4633147.744	519179.095
			1	4	No	4632855.35	519178.102
			1	4	No	4633444.052	519310.027
	<i>Alopecurus arundinaceus</i>	creeping foxtail	2	4	No	4633507.644	519331.223
			3	4	No	4633688.339	519429.742
			1	4	No	4632993.353	519169.125
	<i>Carduus nutans</i>	musk thistle	1	4	No	4633078.051	519174.291
			1	4	No	4633236.919	519226.672
			1	4	No	4633912.663	519675.244
			1	4	No	4632946.131	519178.438

Appendix B. Exotic Plant Invasions Detected on Monitoring Routes at Fossil Butte NM, August 6–8, 2009, cont.

Monitoring route	Species	Common name	Infestation size class	Canopy cover class	Pulled?	Northing	Easting
North Dam Fork Chicken Creek, cont.	<i>Carduus nutans</i>	musk thistle	1	4	No	4633058.837	519173.406
			1	4	No	4633234.352	519223.133
	<i>Elymus repens</i>	quackgrass	2	4	No	4633009.11	519170.099
Sage Grouse Lek drainage	<i>Cirsium arvense</i>	Canada thistle	1	4	No	4632267.989	519293.918
Smallpox Creek	<i>Cirsium arvense</i>	Canada thistle	4	4	No	4630287.929	519299.528
			3	2	No	4630478.775	519137.716
			4	5	No	4631198.144	518677.914
			4	5	No	4631440.473	518516.663
			3	3	No	4630897.905	518685.488
	<i>Alopecurus arundinaceus</i>	creeping foxtail	1	3	No	4630567.523	519028.496
South Millet Canyon	<i>Carduus nutans</i>	musk thistle	2	2	No	4631081.539	518634.819
			2	2	No	4631436.922	518513.329
	<i>Hyoscyamus niger</i>	black henbane	1	2	No	4636335.997	517581.195
	<i>Cirsium vulgare</i>	bull thistle	1	2	No	4636339.781	517732.945
	<i>Cirsium arvense</i>	Canada thistle	1	3	No	4636331.729	517564.198
			1	2	No	4636339.408	517735.549
			1	2	No	4636358.45	517822.458
	<i>Carduus nutans</i>	musk thistle	1	2	Yes	4636284.88	517389.352
			2	3	No	4636319.652	517600.161
			1	2	No	4636339.873	517736.997
South Murder Hill drainage	<i>Cirsium arvense</i>	Canada thistle	2	2	No	4636342.01	517776.666
	<i>Alopecurus arundinaceus</i>	creeping foxtail	2	3	No	4636445.22	518018.428
	<i>Carduus nutans</i>	musk thistle	2	3	No	4636768.681	519564.265
	<i>Tragopogon dubius</i>	yellow salsify	1	2	No	4636757.753	519563.334
West Fork Chicken Creek	<i>Cirsium vulgare</i>	bull thistle	1	3	No	4636749.611	519562.601
	<i>Cirsium arvense</i>	Canada thistle	2	3	No	4636444.272	519344.122
			1	3	No	4633226.971	517545.556
			2	3	No	4632962.407	518179.691

Appendix B. Exotic Plant Invasions Detected on Monitoring Routes at Fossil Butte NM, August 6–8, 2009, cont.						
Monitoring route	Species	Common name	Infestation size class	Canopy cover class	Pulled?	Northing Easting
West Fork Chicken Creek, cont.	<i>Alopecurus arundinaceus</i>	creeping foxtail	1	2	No	4632803.7 518586.544
	<i>Carduus nutans</i>	musk thistle	1	2	No	4632854.31 518554.556
Infestation size classes: 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). Canopy cover classes: 1) Trace ($< 1\%$) 2) Low (1–5%) 3) Moderate (6–25%) 4) High (26–50%) 5) Majority (51–100%).						

Appendix C. Invasive Exotic Plant Percent Cover Detected by Monitoring Plots at Fossil Butte NM, July 14–15 2008 and August 6–8, 2009

Plot #	Species	Common name	Mean cover	Easting	Northing
2008 Plots					
CHCR 4	<i>Tragopogon dubius</i>	yellow salsify	0.17	4633070.582	518543.651
	<i>Polygonum aviculare</i>	prostrate knotweed	0.67		
	<i>Lepidium perfoliatum</i>	clasping pepperweed	1.33		
	<i>Halogeton glomeratus</i>	halogeton	1.33		
	<i>Descurainia sophia</i>	flixweed	6.00		
	<i>Ranunculus testiculatus</i>	curvseed butterwort	0.17		
CHCR 5	<i>Poa pratensis</i>	Kentucky bluegrass	1.50	4633906.531	518036.673
CHCR 6	<i>Poa pratensis</i>	Kentucky bluegrass	5.67	4634824.750	518262.692
	<i>Phleum pratense</i>	timothy grass	0.33		
CHTR 1	<i>Poa pratensis</i>	Kentucky bluegrass	0.83	4634996.348	518372.330
	<i>Trifolium repens</i>	white clover	1.00		
CHTR 2	<i>Ranunculus testiculatus</i>	curvseed butterwort	0.33	4635098.083	518658.917
	<i>Trifolium repens</i>	white clover	4.33		
CHTR 5	<i>Poa pratensis</i>	Kentucky bluegrass	2.00	4635427.452	518515.038
2009 Plots					
HR2	<i>Tragopogon dubius</i>	yellow salsify	0.67	4636645.098	517678.697
RA4	<i>Elymus repens</i>	quackgrass	0.67	4631388.916	518959.34
RA9	<i>Elymus repens</i>	quackgrass	0.67	4633578.395	518147.046
RA10	<i>Elymus repens</i>	quackgrass	2.67	4634043.032	517966.717
RA31	<i>Bromus tectorum</i>	cheatgrass	3.33	4637255.367	518331.59
RA32	<i>Bromus tectorum</i>	cheatgrass	3.33	4637682.959	518079.164
TB1	<i>Bromus tectorum</i>	cheatgrass	1.00	4630218.705	521984.188

Only plots where invasives were detected are listed. There were a total of 102 plots sampled over the two years.

CHCR = Chicken Creek; RA = Main Park Road; HR = Millet Canyon; CHTR = Chicken Creek Nature Trail; TB = Historic Quarry Trail

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 174/102092, May 2010

National Park Service
U.S. Department of the Interior



Natural Resource Program Center

1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525

www.nature.nps.gov

EXPERIENCE YOUR AMERICA™