



Invasive Exotic Plant Monitoring at Colorado National Monument, 2009

Natural Resource Technical Report NPS/NCPN/NRTR—2010/354



ON THE COVER

Yellow sweetclover (*Melilotus officinalis*). Photo ©Patrick J. Alexander.

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Abstract

Invasive exotic plant (IEP) species are a significant threat 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 at Colorado National Monument (COLM) during 2009. On July 10–14 and August 9, 2009, 16 IEP species were detected on monitoring routes and plots at COLM. Of these, 11 were Priority 1 species that were consistently recorded in each year. IEPs were most prevalent along riparian areas. There were almost no Priority 1 IEPs found along trails. Many IEPs were present in small, localized invasions that have a promising chance of successful management control and eradication. Network staff will return to COLM in 2011, to re-sample all monitoring routes.

Acronyms

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

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1 Introduction

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

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

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

Because regular, comprehensive monitoring of the distribution and abundance of all exotic plant species within NCPN units is beyond the fiscal capabilities of the network and parks, the NCPN is focusing on the most likely areas where a broad range of invasive exotic plants may occur: riparian corridors, roads, trails, areas of high visitor impact (e.g., campgrounds), and park boundaries. This approach is cost-effective for finding many new invasions in areas where they are most likely to occur, but it may miss exotic plants dispersed to the interior areas of large parks by wind and/or animals. This report summarizes the 2009 field season at Colorado National Monument (COLM).

Specific objectives of NCPN invasive exotic plant monitoring are:

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

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 COLM 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 target IEPs located along the park's invasive pathways (i.e., the monitoring routes) and allow us to estimate trends in selected 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 park target invasive exotic plant list

NCPN and COLM staff reviewed the list of high-priority target IEPs for COLM (see Appendix A). 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.

2.2 Monitoring routes

2.2.1 Minimum Detection Target Size

The minimum detection target size (MDTS) rep-

resented 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 saltcedar (*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 COLM was between 5 and 50 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 10–100 m at COLM.

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

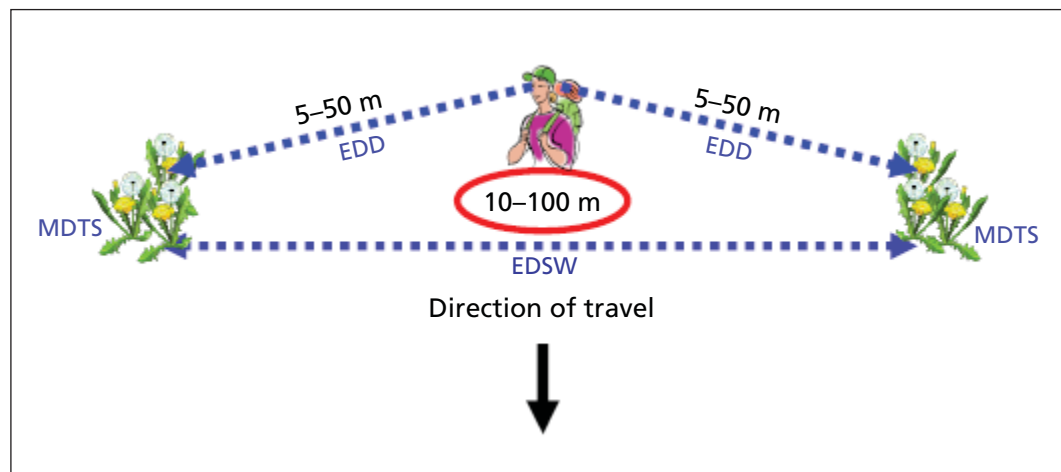


Figure 2-1. The maximum Effective Detection Distance (EDD) at Colorado NM ranged from 5 to 50 meters, making the Effective Detection Swath Width (EDSW) 10–100 meters.

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 allow electronic tracking of the user's route. The GPS unit was set to automatically generate these positions at a distance equal to the EDSW. Each time a surveyor walked the equivalent of one EDSW, the GPS unit created a point.

2.2.6 Data collection methods

For Rim Rock Drive and East Glade 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 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 selected IEPs by visually scanning (side-to-side) all of the land within the borders of the swath. However, if the terrain was uneven or steep, and the observer

had to glance frequently at the ground to ensure safe foot placement, then searchers stopped approximately every 10–100 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 five-meter accuracy.

Only species that were designated as Priority 1 were consistently recorded during monitoring routes. 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 were recorded with a separate point.

Infestation size class was estimated as follows:

- 1) 1—a few plants (used for isolated single plants or very small patches (2×2 m))
- 2) few plants— 40 m^2 (48 yd^2)
- 3) $40\text{--}400 \text{ m}^2$ ($48\text{--}478 \text{ yd}^2$)
- 4) $400\text{--}1,000 \text{ m}^2$ ($0.1\text{--}0.25$ acre)
- 5) $1,000\text{--}2,000 \text{ m}^2$ ($0.25\text{--}0.5$ 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 et al. (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 Rim Rock Drive and East Glade Park Road), we established plots only on the way out. A 1-m² sampling frame was used to sample cover of vegetation and soil surface features by placing it on the right side of the transect line as the technician walks from the monitoring route. The sampling frame was leveled in some cases by propping up quadrat corners.

2.3.2 Data collection methods

In the monitoring plots, all Priority 1 IEP species observed were recorded as well as cheatgrass (*Bromus tectorum*). 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 (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 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 (<1, 11–25, 26–50, and >50% cover), midpoints were used (0.5, 18, 38, and 78%) when calculating the mean and standard error.

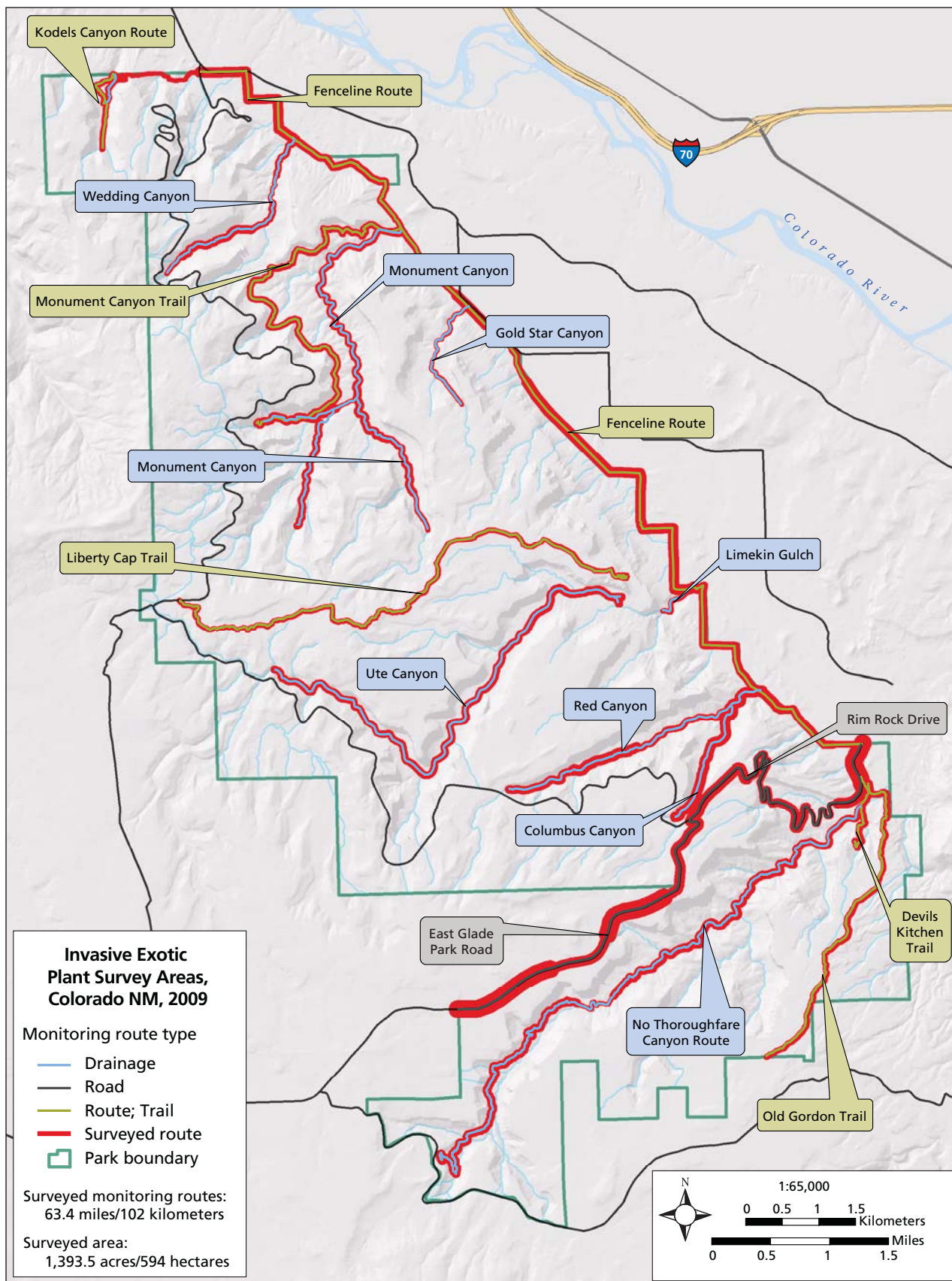


Figure 2-2. Overview of invasive plant monitoring routes and extra areas surveyed at Colorado National Monument, July 10–14, and August 9, 2009.

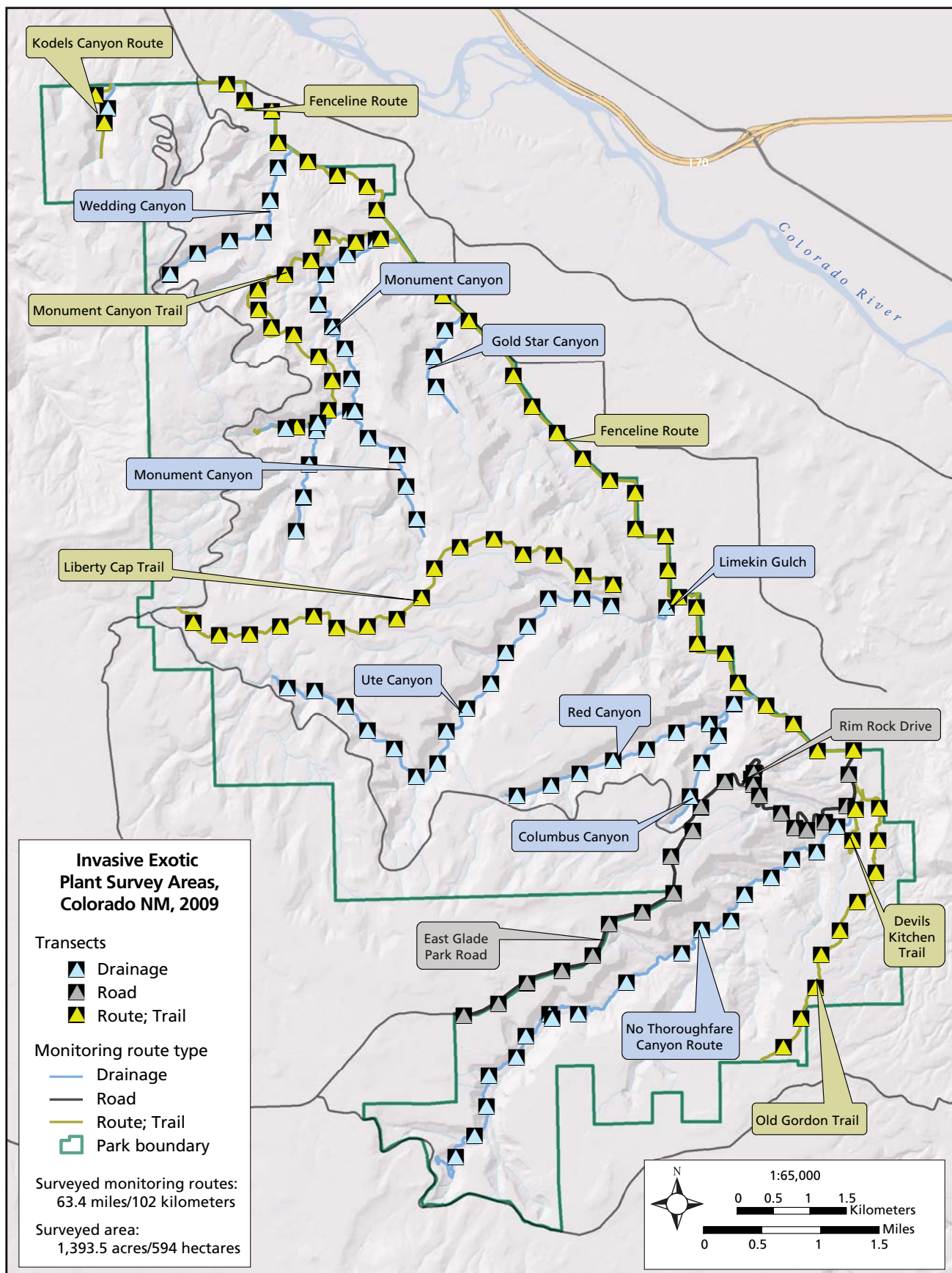


Figure 2-3. Monitoring plots established at Colorado National Monument, July 10–14 and August 9, 2009.

3 Results

3.1 Target invasive exotic plant list

Twenty-three IEP species were identified as Priority 1 for COLM (Appendix A). An additional four species were identified as Priority 2. We also recorded cheatgrass in monitoring plots. Observers were trained to recognize Priority 1 species, but were given the freedom to map additional species; therefore, presence and absence data for Priority 1 species are reliable, but absence data for other species are suspect. A total of 16 IEP species were recorded on monitoring routes and plots in 2009. Fifteen IEP species were recorded on monitoring routes and four in monitoring plots. Of the 16 IEP species detected, 11 were Priority 1, three were Priority 2, and two were not identified as priority species (Table 3-1). We covered 594 hectares (1,394 acres) along monitoring routes in 2009, representing 7.1% of the entire park.

3.2 Monitoring routes

The survey crew walked a total of 102 km (63.4 miles) along 22 monitoring routes in 2009. With the EDSW, this represented a total of 561 hectares (1,386 acres) surveyed. A total of 188 infestations, 150 of which were Priority 1, were detected along monitoring routes. Eleven Priority 1 species, three Priority 2 species, and one species not on either list were recorded (Tables 3-2 and 3-3, Figures 3-1, 3-2, 3-3, and 3-4, Appendix B).

Saltcedar, yellow sweetclover (*Melilotus officinalis*), Russian olive, and field bindweed were the most commonly detected IEPs. Only Priority 1 species should be examined when comparing across areas, as these were the only species recorded consistently by all observers. Priority 1 IEPs were most prevalent along riparian areas, specifically Red, No Thoroughfare, and Monument canyons. Relatively few Priority 1 IEPs were found on trails and the park boundary. No Priority 1 IEPs were detected in Columbus Canyon, Kodel's Canyon, Limekin Gulch, Devil's Kitchen Trail, Liberty Cap Trail, Old Gordon Trail, or the Ute Canyon Trail. Of the 150 Priority 1 infestations, 96% were classified as infestations in size classes 1 (1–a few plants) or 2 (few plants–40 m²). Ninety-three percent of all IEP infestations were also classified in the smallest two size classes (Table 3-3).

Three invasive tree species were detected: Russian olive, saltcedar, and Siberian elm (*Ulmus*

pumila). Of the 66 tree infestations detected, 22 were seedlings, 39 were in the sapling stage, and only 5 were mature trees.

3.3 Monitoring plots

A total of 169 plots were sampled in 2009 (see Figure 2-3, Appendix C). Perennial pepperweed (*Cardaria latifolia*) was recorded in one plot in Red Canyon, and Canada thistle (*Breca arvensis*) was located in one plot along Hydro 25. These were the only Priority 1 species found in plots. Yellow sweetclover was found in two plots in Ute Canyon. Cheatgrass dominated one plot along the fenceline. Priority 1 species and cheatgrass were the only species recorded consistently among all plots by all observers. Percent cover of all of these species together was 0.51% for all plots combined. Without the plot dominated by cheatgrass, this number would drop to 0.06% cover.

3.4 Results comparison, 2009 and 2003

Colorado NM was last surveyed extensively for IEPs in 2003 (Dewey and Anderson 2005). The only species that were on both the 2009 Priority 1 list and the 2003 target list are Russian knapweed (*Acroptilon repens*), field bindweed, Russian olive, saltcedar, and woolly mullein (*Verbascum thapsus*). Dewey and Anderson (2005) also surveyed for cheatgrass, redstem fillaree (*Erodium cicutarium*), curly dock (*Rumex crispus*), Russian thistle (*Salsola australis*), tumblemustard (*Sisymbrium altissimum*), and yellow salsify (*Tragopogon dubius*) on their target list, which are not on the Priority 1 list. While Dewey and Anderson did not provide specific route lengths, the following areas were essentially the same as those surveyed in 2009: No Thoroughfare Canyon, Ute Canyon, and Gold Star Canyon. In addition, coverage of Monument Canyon and Independence Monument in 2003 equate to that of Monument Canyon in 2009.

Saltcedar has been greatly reduced since 2003 at all four sites that were monitored in both years. Russian olive increased from 2003 to 2009, particularly at Monument and No Thoroughfare canyons. Woolly mullein also increased at No Thoroughfare Canyon (Table 3-4).

Table 3-1. Invasive exotic plants detected at Colorado National Monument, July 10–14 and August 9, 2009.

Scientific name	Common name	Method detected		Park priority
		Routes	Plots	
<i>Acroptilon repens</i>	Russian knapweed	X		1
<i>Breea arvensis</i>	Canada thistle	X	X	1
<i>Carduus nutans</i>	musk thistle	X		1
<i>Centaurea solstitialis</i>	yellow starthistle	X		1
<i>Cardaria latifolia</i>	perennial pepperweed	X	X	1
<i>Cirsium vulgare</i>	bull thistle	X		1
<i>Convolvulus arvensis</i>	field bindweed	X		1
<i>Elaeagnus angustifolia</i>	Russian olive	X		1
<i>Tamarix</i> spp.	saltcedar	X		1
<i>Ulmus pumila</i>	Siberian elm	X		1
<i>Verbascum thapsus</i>	woolly mullein	X		1
<i>Melilotus officinalis</i>	yellow sweetclover	X	X	2
<i>Salsola australis</i>	Russian thistle	X		2
<i>Tragopogon dubius</i>	yellow salsify	X		2
<i>Asparagus</i> spp.	asparagus	X		Not on list
<i>Bromus tectorum</i>	cheatgrass		X	Not on list

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

Table 3-2. Monitoring routes surveyed, route type, length, number of IEP infestations, and number of infestations/100 m, Colorado NM, July 10–14 and August 9, 2009.

Route	Type of route	Length (m)	Infestations		Infestations/100 m	
			Total	Priority 1	Total	Priority 1
Columbus Canyon	Riparian	1,883	0	0	0.00	0.00
Gold Star Canyon	Riparian	1,867	2	2	0.11	0.11
Kodel's Canyon	Riparian	463	0	0	0.00	0.00
Limekin Gulch	Riparian	503	0	0	0.00	0.00
Monument Canyon	Riparian	9,837	35	34	0.36	0.35
No Thoroughfare	Riparian	10,302	39	39	0.38	0.38
Red Canyon	Riparian	4,014	19	19	0.47	0.47
Ute Canyon	Riparian	7,171	18	18	0.25	0.25
Wedding Canyon	Riparian	2,994	7	7	0.23	0.23
<i>Total Riparian</i>		<i>39,034</i>	<i>120</i>	<i>119</i>	<i>0.31</i>	<i>0.30</i>
Devil's Kitchen	Trail	1,227	0	0	0.00	0.00
Kodel's Canyon	Trail	1,819	4	4	0.22	0.22
Liberty Cap	Trail	8,308	0	0	0.00	0.00
Monument Canyon Trail	Trail	8,095	1	1	0.01	0.01
Old Gordon	Trail	4,770	1	0	0.02	0.00
Ute Canyon Trail	Trail	287	0	0	0.00	0.00
<i>Total Trails</i>		<i>24,506</i>	<i>6</i>	<i>5</i>	<i>0.02</i>	<i>0.02</i>
East Glade Park Road	Road	9,677	5	3	0.05	0.03
Rim Rock Drive	Road	12,438	48	22	0.39	0.18
<i>Total Roads</i>		<i>22,115</i>	<i>53</i>	<i>25</i>	<i>0.24</i>	<i>0.12</i>
Fenceline	Boundary	16,428	9	1	0.05	0.01
Total all types		102,083	188	150	0.19	0.15

Table 3-3. Species observed and infestation size class detected along monitoring routes, Colorado NM, July 10–14 and August 9, 2009.

Scientific name	Common name	Total infestations	Infestation size class Number of infestations			
			1	2	3	4
<i>Acroptilon repens</i>	Russian knapweed	4	1	2	1	0
<i>Asparagus</i> spp.*	asparagus	1	1	0	0	0
<i>Breia arvensis</i>	Canada thistle	2	2	0	0	0
<i>Cardaria latifolia</i>	perennial pepperweed	16	10	5	1	0
<i>Carduus nutans</i>	musk thistle	4	3	1	0	0
<i>Centaurea solstitialis</i>	yellow starthistle	2	1	1	0	0
<i>Cirsium vulgare</i>	bull thistle	3	1	2	0	0
<i>Convolvulus arvensis</i>	field bindweed	22	11	9	2	0
<i>Elaeagnus angustifolia</i>	Russin olive	31	23	6	2	0
<i>Melilotus officinalis</i> *	yellow sweetclover	28	14	12	2	0
<i>Salsola australis</i> *	Russian thistle	8	1	2	1	4
<i>Tamarix</i> spp.	saltcedar	38	37	1	0	0
<i>Tragopogon dubius</i> *	yellow salsify	1	1	0	0	0
<i>Ulmus pumila</i>	Siberian elm	9	9	0	0	0
<i>Verbascum thapsus</i>	woolly mullein	19	11	8	0	0
Priority 1 Species		150	109	35	6	0
All species		188	126	49	9	4

*Not a priority 1 species, so may not have been recorded by all observers.

Infestation size classes:

- 1) 1–a few plants (used for isolated single plants or very small patches (2 × 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 3-4. Number of infestations detected in areas that were surveyed in 2003 and 2009.

Scientific name	Common name	Gold Star Canyon		No Thoroughfare Canyon		Ute Canyon		Monument Canyon		Total	
		2003	2009	2003	2009	2003	2009	2003	2009	2003	2009
<i>Acroptilon repens</i>	Russian knapweed	0	0	0	0	0	0	0	3	0	3
<i>Convolvulus arvensis</i>	field bindweed	0	0	1	1	3	0	1	2	5	3
<i>Elaeagnus angustifolia</i>	Russian olive	0	2	2	14	6	4	1	9	9	29
<i>Tamarix</i> spp.	saltcedar	6	4	17	8	37	8	33	11	93	31
<i>Verbascum thapsus</i>	woolly mullein	0	0	0	11	5	4	0	0	5	15
Totals		6	6	20	34	51	16	35	25	112	81

Only species that were on the 2003 target list and the 2009 Priority 1 list are included. Data were collected in June 2003, July 10–14, and August 9, 2009 at Colorado National Monument.

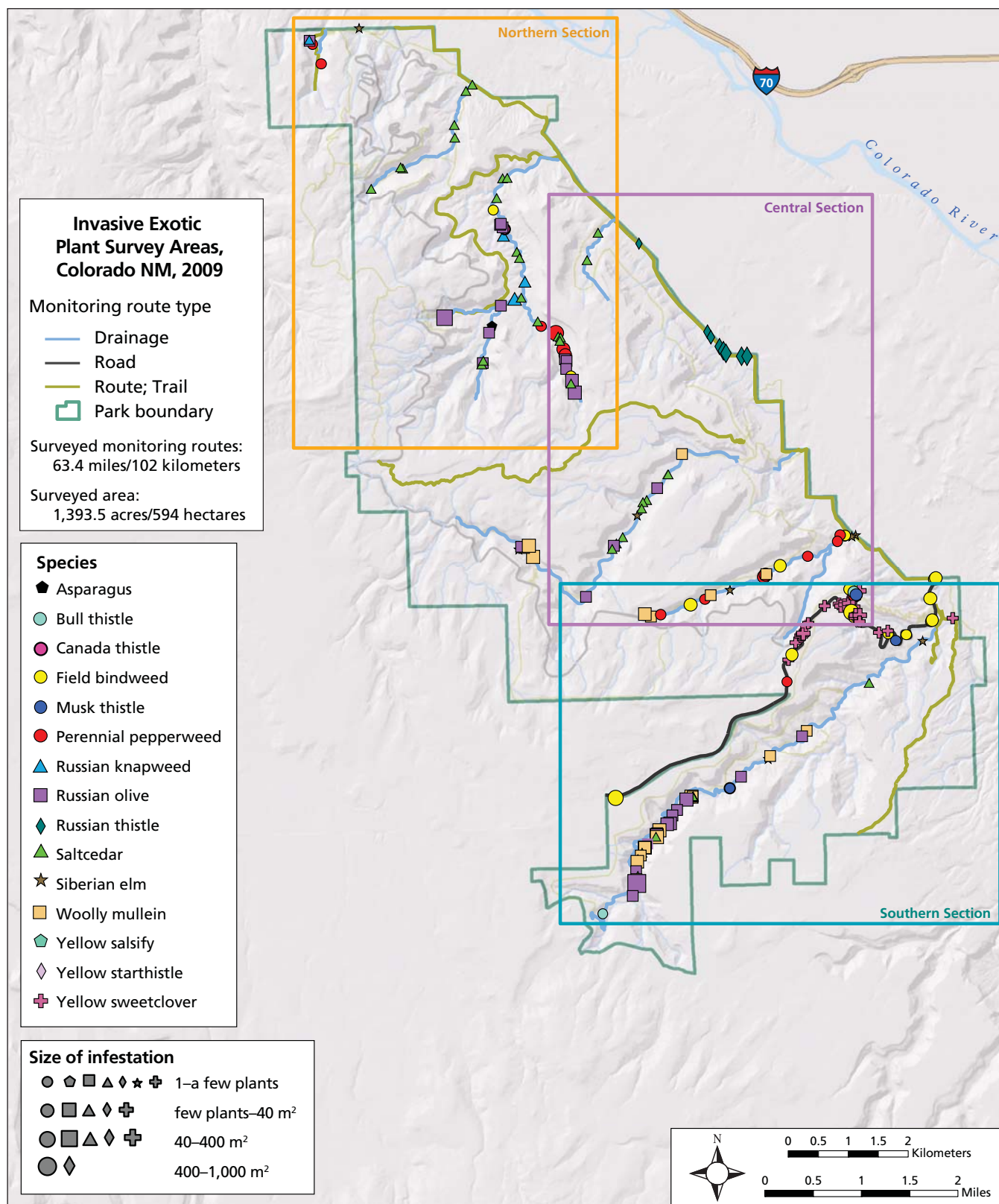


Figure 3-1. Invasive plants detected on monitoring routes, Colorado NM, July 10–14 and August 9, 2009.

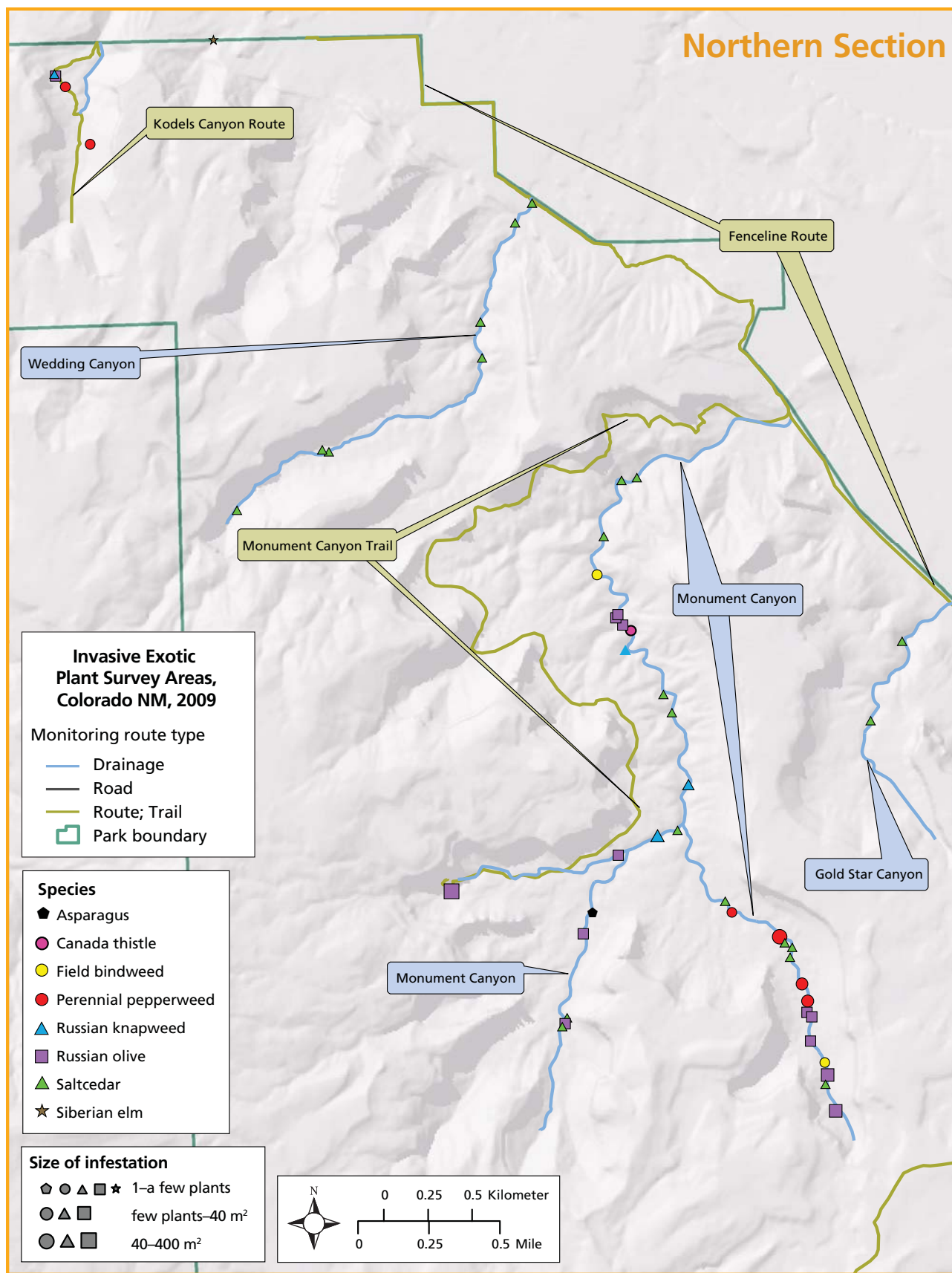


Figure 3-2. Invasive plants detected on monitoring routes in the northern portion of Colorado NM, July 10–14 and August 9, 2009.

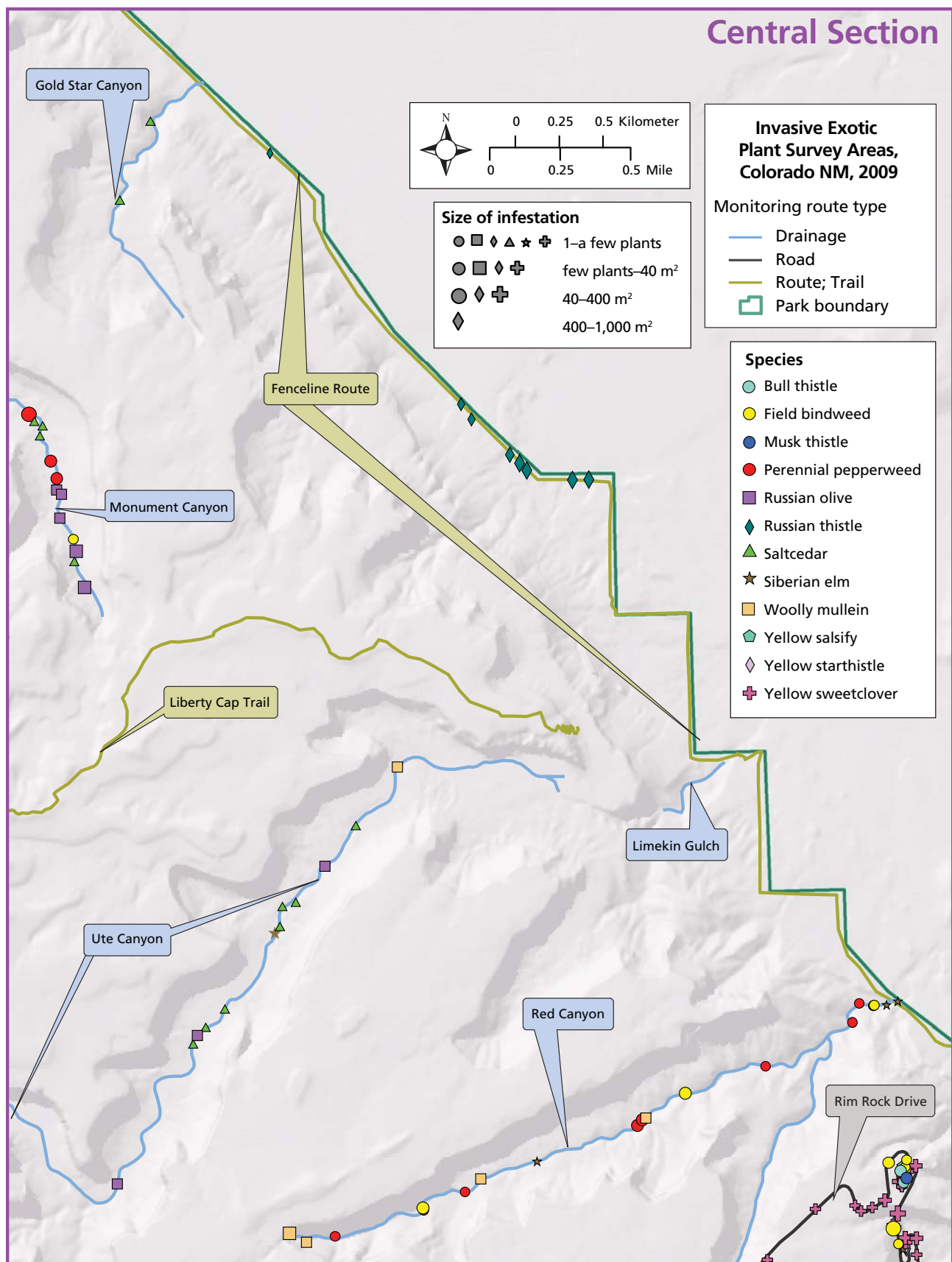


Figure 3-3. Invasive plants detected on monitoring routes in the middle portion of Colorado NM, July 10–14 and August 9, 2009.

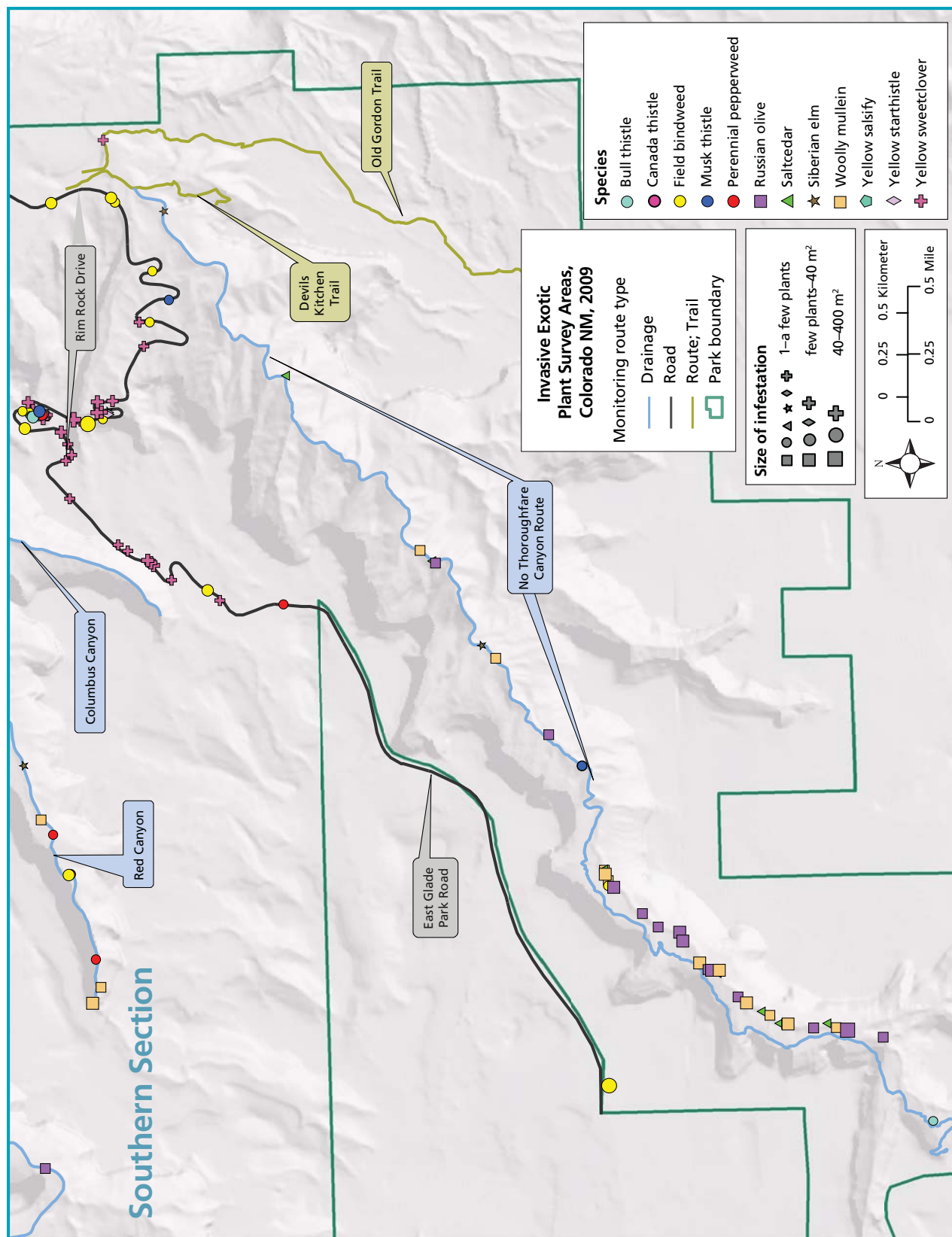


Figure 3-4. Invasive plants detected on monitoring routes and monitoring plots in the southern portion of Colorado NM, July 10–14 and August 9, 2009.

4 Discussion

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

Based on work at other NCPN parks, a few changes will be made to the IEP monitoring protocol for 2010. To better capture the roadside verge, where many invasions occur, we will establish the three quadrats at 0.5, 5, and 10 m from the monitoring route, and will establish plots on both sides of the road, instead of just one side, as was done in 2009. We will continue to establish plots with the 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 plots (12 quadrats), then plots will then be established every 1,000 m. If invasive plants are found in categories greater than 1% in subsequent quadrats, the observer will resume establishing plots every 500 m. When the level of invasives is very low (<1% cover), it will be very hard to detect trends based on the monitoring quadrats. However, we will continue monitoring plots to establish a baseline, should invasives ever expand.

4.2 Priority 1 IEP List

The NCPN will continue to work with COLM staff and area weed experts to review and update the list of priority species each year. The park may want to consider adding yellow sweetclover to the Priority 1 list for 2010, due to its wide prevalence. Presence and absence data for most Priority 1 species, and presence data for other species, should be reliable; however, absence data for non-Priority 1 species are suspect, because not all observers recorded all of these species.

4.3 Possibilities for management control

Invasive exotic plants were most widespread along riparian areas. There were almost no IEPs along trails. IEPs were present in intermediate amounts along the roads. Most IEP control currently takes place along Rim Rock Drive and the East Glade Park Road. The results of this report suggest that COLM should consider focusing control efforts on riparian areas in 2010. Also, in the future, the park may want to have the NCPN devote more attention to the remaining unsurveyed sections of Rim Rock Drive or on addition-

al canyon bottoms, and reduce the frequency of monitoring along upland trails.

It is encouraging that 96% 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. Ninety-two percent of the invasive tree infestations for which growth stage was noted were either in the seedling or sapling stage. This is likely due to extensive previous eradication efforts by COLM staff and volunteers. The four areas surveyed in both 2003 and 2009 illustrate the success of eradication efforts performed between the survey dates. Saltcedar has been reduced in these areas, and 97% of the saltcedar detected were seedlings or saplings. Russian olive and woolly mullein have increased in No Thoroughfare Canyon, and Russian olive has increased in Monument Canyon. These species may have increased by filling voids left by the saltcedar removal, or they may not have been targeted by eradication crews.

It will be much easier for COLM to contain invasive species if eradication efforts continue. In just a few years, these small infestations could become large, and the seedlings and saplings will become mature trees, requiring chainsaws instead of loppers. Preventing additional species from invading will give the native species a better chance to persist.

It should be noted that estimates of percent cover in this report (see Table 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.

4.4 Future monitoring efforts

IEPs at COLM 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 through September is not expected to drastically alter the chances of detecting invasive species larger than the minimum detection target size. In 2011, the NCPN will re-survey all monitoring routes. Because detections from one

year may be eradicated by park staff before the next sampling period, the monitoring quadrats are re-located each 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

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Appendix A. Target invasive plant list, Colorado National Monument

Species name (Colorado)	Common name
Priority 1	
<i>Acosta diffusa</i>	diffuse knapweed
<i>Acosta maculosa</i>	spotted knapweed
<i>Acroptilon repens</i> *	Russian knapweed
<i>Aegilops cylindrica</i>	jointed goatgrass
<i>Arctium minus</i>	burdock
<i>Breea arvensis</i>	Canada thistle
<i>Cardaria draba</i>	hoary cress, whitetop
<i>Cardaria latifolia</i>	perennial pepperweed
<i>Carduus acanthoides</i>	plumeless thistle
<i>Carduus nutans</i> var. <i>macrolepis</i>	musk thistle
<i>Centaurea solstitialis</i>	yellow starthistle
<i>Cirsium vulgare</i>	bull thistle
<i>Convolvulus arvensis</i> *	field bindweed
<i>Elaeagnus angustifolia</i> *	Russian olive
<i>Isatis tinctoria</i>	Dyer's woad
<i>Linaria vulgaris</i>	butter-and-eggs
<i>Lythrum salicaria</i>	purple loosestrife
<i>Onopordum acanthium</i>	Scotch thistle
<i>Tamarix ramosissima</i> *	saltcedar
<i>Tithymalus esula</i>	leafy spurge
<i>Tribulus terrestris</i>	puncturevine
<i>Ulmus pumila</i>	Siberian elm
<i>Verbascum thapsus</i> *	woolly mullein
Priority 2	
<i>Melilotus officinalis</i>	yellow sweetclover
<i>Salsola australis</i> *	Russian thistle
<i>Sisymbrium altissimum</i>	tumblemustard
<i>Tragopogon dubius</i> *	yellow salsify, goatsbeard

*Also on Dewey and Anderson (2005) target plant list.

Appendix B. Exotic plant invasions detected on monitoring routes, Colorado NM, July 10–14 and August 9, 2009

Route name	Scientific name	Common name	Infestation size class	Canopy cover class	Pulled?	Growth stage	Northing	Easting
access to Kodels Canyon E. Glade Park Road/DS Rd	<i>Ulmus pumila</i>	Siberian elm	1	1	No	Sapling(s)	4332605.452	695545.257
	<i>Lepidium latifolium</i>	perennial pepperweed	1	5	No		4321696.461	702607.475
	<i>Convolvulus arvensis</i>	field bindweed	3	5	No		4319770.643	699751.232
	<i>Melilotus officinalis</i>	yellow sweetclover	2	4	No		4322158.81	702699.899
Fenceline Route			1	5	No		4322093.195	702642.329
			1	5	No		4322381.005	702763.359
	<i>Salsola kali</i>	Russian thistle	1	5	No		4329025.892	700139.118
			3	3	No		4327301.052	701505.567
			4	3	No		4327249.879	701557.574
			4	3	No		4327209.491	701599.339
			4	4	No		4327155.152	701860.427
			4	4	No		4327155.526	701952.711
			2	5	No		4327584.265	701218.757
			2	5	No		4327497.262	701278.047
Gold Star Canyon	<i>Tamarix ramosissima</i>	saltcedar	1	5	Yes	Seedling(s)	4329201.208	699445.254
			1	5	No	Seedling(s)	4328750.729	699266.305
Hydro 18	<i>Centaurea repens</i>	Russian knapweed	4	4	No		4328096.694	698056.862
	<i>Elaeagnus angustifolia</i>	Russian olive	1	2	No		4327985.851	697833.999
Hydro 25	<i>Asparagus</i> sp.	asparagus	1	3	No		4327663.758	697689.637
	<i>Elaeagnus angustifolia</i>	Russian olive	1	4	No	Mature Tree(s)	4327539.848	697635.848
			1	4	No	Sapling(s)	4327031.646	697532.49
	<i>Tamarix ramosissima</i>	saltcedar	1	4	No	Sapling(s)	4327064.014	697544.384
			1	3	No	Seedling(s)	4327014.391	697518.359
Kodels Canyon Route	<i>Lepidium latifolium</i>	perennial pepperweed	1	1	No		4332017.055	694842.712
	<i>Centaurea repens</i>	Russian knapweed	1	1	No		4332341.821	694700.216
	<i>Elaeagnus angustifolia</i>	Russian olive	1	1	No		4332415.613	694636.742
			1	1	No	Seedling(s)	4332406.267	694644.227

Appendix B. Exotic plant invasions detected on monitoring routes, Colorado NM, July 10–14 and August 9, 2009, cont.

Route name	Scientific name	Common name	Infestation size class	Canopy cover class	Pulled?	Growth stage	Northing	Easting
Monument Canyon	<i>Cirsium arvense</i>	Canada thistle	1	4	No		4329257.448	697907.237
	<i>Convolvulus arvensis</i>	field bindweed	1	2	No		4326808.085	699007.122
			1	4	No		4329574.406	697717.109
	<i>Lepidium latifolium</i>	perennial pepperweed	1	2	No		4327659.217	698481.287
			3	1	No		4327521.515	698751.609
			2	2	No		4327253.892	698878.993
			2	2	No		4327155.701	698912.737
	<i>Centaurea repens</i>	Russian knapweed	2	4	No		4328387.399	698231.816
			2	4	No		4329152.887	697876.232
	<i>Elaeagnus angustifolia</i>	Russian olive	1	2	No	Mature Tree(s)	4327093.983	698904.327
			1	2	No	Sapling(s)	4326932.252	698926.154
			1	2	No	Mature Tree(s)	4327068.514	698932.459
			1	4	No	Seedling(s)	4329292.081	697861.282
			1	4	No	Seedling(s)	4329333.365	697820.889
			1	4	No	Seedling(s)	4329350.054	697833.328
Monument Canyon Trail			2	2	No	Seedling(s)	4326739.189	699021.467
			2	3	No	Sapling(s)	4326533.774	699067.185
	<i>Tamarix ramosissima</i>	saltcedar	1	2	No		4328127.199	698170.046
			1	3	No		4327725.238	698440.137
			1	2	No		4327490.052	698779.543
			1	2	No	Sapling(s)	4327411.753	698809.181
			1	2	No	Sapling(s)	4326688.372	699009.85
			1	2	No	Sapling(s)	4327464.25	698822.97
			1	4	No	Sapling(s)	4328796.683	698139.825
			1	4	No	Sapling(s)	4328899.06	698091.243
			1	4	No	Sapling(s)	4329795.558	697753.665
			1	4	No	Mature Tree(s)	4330113.36	697853.665
			1	4	No	Seedling(s)	4330127.437	697939.195
	<i>Elaeagnus angustifolia</i>	Russian olive	3	3	No		4327778.12	696887.441

Appendix B. Exotic plant invasions detected on monitoring routes, Colorado NM, July 10–14 and August 9, 2009, cont.

Route name	Scientific name	Common name	Infestation size class	Canopy cover class	Pulled?	Growth stage	Northing	Easting
No Thoroughfare Drainage	<i>Cirsium vulgare</i>	bull thistle	1	2	No		4317840.784	699542.096
	<i>Cirsium arvense</i>	Canada thistle	1	5	No		4319929.901	701656.967
	<i>Convolvulus arvensis</i>	field bindweed	1	5	No		4319774.943	700941.317
	<i>Carduus nutans</i>	musk thistle	1	5	No		4319930.987	701655.424
	<i>Elaeagnus angustifolia</i>	Russian olive	1	1	Yes	Seedling(s)	4319573.337	700772.973
			1	2	No	Sapling(s)	4319479.327	700693.305
			1	4	No	Sapling(s)	4319184.219	700439.188
			1	2	No	Sapling(s)	4319004.765	700278.05
			1	2	No	Sapling(s)	4318714.454	700115.16
			1	3	No	Sapling(s)	4318555.213	700091.822
			1	1	No	Sapling(s)	4318139.99	700037.132
			1	3	No		4320132.192	701839.699
			1	4	No	Sapling(s)	4320806.941	702861.467
			3	3	No	Sapling(s)	4318349.054	700076.318
			2	2	No	Seedling(s)	4319744.265	700929.458
			2	2	No	Sapling(s)	4319349.199	700662.219
			2	2	No	Sapling(s)	4319332.671	700609.658
			2	4	No	Sapling(s)	4319159.736	700435.874
<i>Tamarix ramosissima</i>	saltcedar		1	2	No	Seedling(s)	4319131.104	700419.712
			1	2	No	Seedling(s)	4318867.318	700189.877
			1	2	No	Sapling(s)	4318762.057	700120.754
			1	3	No	Seedling(s)	4318476.89	700120.396
			1	5	Yes	Seedling(s)	4319778.692	700966.182
			1	5	Yes	Seedling(s)	4319804.729	701037.711
			1	3	No	Sapling(s)	4321699.472	703976.204
			1	3	No	Sapling(s)	4320829.359	702872.87
			1	4	No	Sapling(s)	4322413.388	704971.354
			1	3	No		4320503.218	702366.315
<i>Ulmus pumila</i>	Siberian elm							

Appendix B. Exotic plant invasions detected on monitoring routes, Colorado NM, July 10–14 and August 9, 2009, cont.

Route name	Scientific name	Common name	Infestation size class	Canopy cover class	Pulled?	Growth stage	Northing	Easting
No Thoroughfare Drainage, cont.	<i>Verbascum thapsus</i>	woolly mullein	1	2	No		4318815.335	700167.681
			1	3	No		4318420.335	700094.119
			1	5	No		4319776.966	700969.742
			1	2	No		4319801.308	701031.428
			1	3	No		4320447.228	702293.578
			1	3	No		4320897.5	702937.41
			2	2	No		4319231.472	700478.971
			2	2	No		4319113.835	700434.539
			2	2	No		4318951.353	700240.66
			2	2	No		4318705.992	700114.428
			2	2	No		4319793.994	701007.287
Old Gordon Trail	<i>Melilotus officinalis</i>	yellow sweetclover	1	1	Yes		4322787.817	705381.745
Red Canyon	<i>Convolvulus arvensis</i>	field bindweed	1	1	Yes		4324147.519	703581.62
			2	4	No		4323646.181	702502.375
			2	2	No		4322988.105	701005.056
			1	1	Yes		4324145.164	703576.241
	<i>Lepidium latifolium</i>	perennial pepperweed	1	2	No		4323798.121	702960.824
			1	2	Yes		4322825.596	700501.732
			1	1	No		4322975.357	701008.87
			1	1	No		4324157.886	703496.232
			1	1	No		4323080.354	701245.235
			1	3	No		4324049.875	703456.953
			2	1	No		4323460.823	702229.936
			2	2	No		4323492.635	702256.627
Old Gordon Trail	<i>Ulmus pumila</i>	Siberian elm	1	5	No	Mature Tree(s)	4324179.634	703711.524
			1	1	No		4323266.547	701669.194
			1	4	No	Sapling(s)	4324158.778	703646.764
			1	1	Yes		4322796.861	700334.56
Red Canyon	<i>Verbascum thapsus</i>	woolly mullein	1	2	No		4323155.022	701331.797

Appendix B. Exotic plant invasions detected on monitoring routes, Colorado NM, July 10–14 and August 9, 2009, cont.

Route name	Scientific name	Common name	Infestation size class	Canopy cover class	Pulled?	Growth stage	Northing	Easting
Red Canyon, cont.	<i>Verbascum thapsus</i>	woolly mullein	1	2	No		4323506.506	702262.092
			2	2	No		4322845.238	700238.416
Rim Rock Drive	<i>Cirsium vulgare</i>	bull thistle	2	4	No		4323137.107	703750.773
			2	2	No		4323200.499	703731.373
	<i>Convolvulus arvensis</i>	field bindweed	1	5	No		4323182.185	703761.073
			1	4	No		4323222.255	703759.005
			1	2	No		4323262.415	703766.539
			1	3	No		4322784.233	703720.638
			1	3	No		4322504.693	704297.313
			1	3	No		4322489.665	704599.887
			1	3	No		4322712.283	705010.732
			3	3	No		4322873.077	703690.265
			2	5	No		4323213.385	703759.042
			2	3	No		4322735.806	705036.447
			2	3	No		4323091.533	705006.038
			2	3	No		4323416.173	705072.504
			2	3	No		4323441.903	705092.009
			2	4	No		4323247.921	703662.725
			1	5	No		4322391.544	704429.753
			2	3	No		4323159.811	703766.389
	<i>Carduus nutans</i>	musk thistle	2	4	No		4323146.139	703747.614
			1	3	No		4322772.975	703761.017
	<i>Lepidium latifolium</i>	perennial pepperweed	1	4	No		4323228.347	703746.71
	<i>Ulmus pumila</i>	Siberian elm	1	3	No		4322760.955	703764.576
	<i>Tragopogon dubius</i>	yellow salsify	2	3	No		4322769.834	703758.485
	<i>Centaurea solstitialis</i>	yellow starthistle	1	3	No		4323009.292	703474.397
	<i>Melilotus officinalis</i>	yellow sweetclover	1	4	No		4322976.472	703508.374
			1	4	No		4322997.678	703571.709
			1	4	No		4323116.801	703740.945
			1	4	No			

Appendix B. Exotic plant invasions detected on monitoring routes, Colorado NM, July 10–14 and August 9, 2009, cont.

Route name	Scientific name	Common name	Infestation size class	Canopy cover class	Pulled?	Growth stage	Northing	Easting
Rim Rock Drive, cont.	<i>Melilotus officinalis</i>	yellow sweetclover	1	4	No		4323202.574	703772.173
			1	3	No		4322728.777	703826.495
			1	3	No		4322546.562	704154.942
			1	3	No		4322572.643	704298.546
			1	5	No		4322642.218	702936.007
			1	3	No		4322699.689	702972.32
			1	4	No		4322987.944	703246.183
			3	3	No		4322957.928	703710.371
			3	3	No		4322879.877	703694.201
			2	4	No		4323033.981	703639.427
			2	4	No		4323194.794	703751.473
			2	4	No		4323142.269	703720.626
			2	4	No		4323179.119	703756.951
			2	3	No		4323231.207	703815.382
			2	3	No		4322893.669	703687.612
			2	3	No		4322795.804	703759.123
			2	3	No		4322819.74	703757.096
			2	3	No		4322817.645	703822.078
			2	4	No		4322484.378	702847.59
			2	4	No		4322500.996	702863.42
			2	4	No		4322518.774	702877.398
Ute Canyon	<i>Elaeagnus angustifolia</i>	Russian olive	1	4	No	Sapling(s)	4323978.462	699714.782
			1	4	No	Seedling(s)	4323129.694	699254.76
			1	4	No	Seedling(s)	4323968.39	698168.445
			1	4	No		4324942.459	700441.817
	<i>Tamarix ramosissima</i>	saltcedar	1	4	No	Sapling(s)	4324604.591	700184.459
			1	4	No	Sapling(s)	4324127.103	699863.618
			1	4	No	Sapling(s)	4324019.909	699759.39
			1	4	No	Sapling(s)	4323929.754	699692.817

Appendix B. Exotic plant invasions detected on monitoring routes, Colorado NM, July 10–14 and August 9, 2009, cont.							
Route name	Scientific name	Common name	Infestation size class	Canopy cover class	Pulled?	Growth stage	Northing Easting
Ute Canyon, cont.	<i>Tamarix ramosissima</i>	saltcedar	1	4	Yes		4325177.413 700618.848
			1	4	Yes		4325176.566 700620.581
			1	4	No	Sapling(s)	4324745.443 700267.861
			1	4	No	Sapling(s)	4324711.309 700202.005
	<i>Ulmus pumila</i>	Siberian elm	1	4	No	Sapling(s)	4324564.611 700155.841
			1	4	No	Sapling(s)	4323969.48 698175.249
	<i>Verbascum thapsus</i>	Woolly mullein	1	4	No		4323945.669 698220.411
			1	4	No		4325511.338 700856.553
			2	4	No		4323792.826 698364.949
			2	3	No		4323922.844 698269.059
Wedding Canyon	<i>Tamarix ramosissima</i>	saltcedar	1	1	Yes	Seedling(s)	4331686.267 697345.905
			1	1	No	Seedling(s)	4331574.293 697249.223
			1	1	No	Seedling(s)	4331011.417 697053.812
			1	1	Yes	Seedling(s)	4330807.317 697062.452
			1	2	No	Sapling(s)	4330275.141 696192.928
			1	2	No	Sapling(s)	4329943.017 695673.171
			2	2	No	Sapling(s)	4330288.672 696159.136

Appendix C. Invasive exotic plant percent cover detected by monitoring plots

Plot #	Scientific name	Common name	Mean cover	Northing	Easting
W124	<i>Bromus tectorum</i>	cheatgrass	76.00	4330868.617	698523.31
HO36-2	<i>Breea arvensis</i>	Canada thistle	9.33	4326924.454	697516.043
HO18-4	<i>Melilotus officinalis</i>	yellow sweetclover	12.67	4324787.564	700294.388
HO18-14	<i>Melilotus officinalis</i>	yellow sweetclover	12.67	4324297.903	697297.895
HO29-4	<i>Cardaria latifolia</i>	perennial pepperweed	0.67	4323459.261	702230.181

Only plots where invasives were detected are listed. There were a total of 169 plots sampled at Colorado NM, July 10–14, and August 9, 2009.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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