National Park Service
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Natural Resource Stewardship and Science

Invasive Exotic Plant Monitoring in Colorado National Monument

2013 Field Season

Natural Resource Technical Report NPS/NCPN/NRTR—2014/859



ON THE COVER

Field bindweed (*Convolvulus arvensis*). Photo by Steve Dewey, Utah State University, Bugwood.org

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Executive Summary

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 during 2013. During the monitoring conducted between July 31 and August 16, 2013, a total of 14 IEP species were detected in the combined monitoring routes and transects at the monument. Of these, 11 were priority species that accounted for 335 separate infestations. IEPs were most prevalent along riparian areas. Yellow sweetclover (*Melilotus officinale*), woolly mullein (*Verbascum thapsus*), field bindweed (*Convolvulus arvensis*), and Siberian elm (*Ulmus pumila*) were the most widespread species found along monitoring routes. Cheatgrass (*Anisantha tectorum*) had the highest percent cover (1.4%) and highest frequency (48%) of all transects. Fewer priority IEPs were found along Rim Rock Drive from the intersection with East Glade Park Road to the Ute Canyon Overlook than along East Glade Park Road and Rim Rock Drive from the intersection with East Glade Park Road to the East Entrance, where there is a higher rate of transportation of livestock and livestock food (hay). Invasive species were found in reduced numbers than in previous years, presumably due to park eradication and control efforts. In areas that were monitored in all four years, Russian olive (*Elaeagnus angustifolia*) declined to its lowest levels in 2013, after increasing in 2009 and 2011. Russian-olive infestations dropped by 77% between 2011 and 2013, and declined on every route that was monitored in all years. Tamarisk continued its decline, to just four infestations in 2013. This decline represents an 81% reduction in tamarisk infestations since 2011, and a 96% reduction since 2003. Yellow sweetclover also showed a 68% reduction from 2011. Many IEPs were present in small, localized invasions that have a promising chance of successful control and eradication. Network staff will return to re-sample all monitoring routes in 2015.

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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 (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 (see Loope 1992). 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, the NCPN 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. This report summarizes the 2013 field season at Colorado National Monument (NM).

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.

In discussions with network staff, Colorado NM staff also sought to know if infestation densities differed along roads that are commonly used to transport livestock and associated hay through the park, compared to roads where levels of livestock and feed transport are much lower. The vast majority of livestock and feed traffic occurs along Rim Rock Drive, from the East Entrance to the intersection of and then along East Glade Park Road. Very little livestock and hay are transported along Rim Rock Drive north of the intersection with East Glade Park Road. In 2011, monument staff requested that we add this objective:

3. Determine if there are differences between infestation densities along Rim Rock Drive from the East Entrance to East Glade Park Road (Rim Rock South) and East Glade Park Road compared to Rim Rock Drive north of the intersection with East Glade Park Road to Ute Canyon Overlook (Rim Rock Ute).

2 Methods

Field work followed the invasive exotic plant monitoring protocol developed by the NCPN (Perkins et al. 2013), 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 monument and NCPN staff review and update the list of priority invasive exotic plants for the park (Table 2-1). Next, we established a series of co-located monitoring routes and quadrats along all roads, major drainages, and trails in the park. The quadrats, which are sampled in a quantitative manner, are used to make inference to the percent cover of priority 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 priority invasive exotic plant list

Prior to the start of monitoring, NCPN and monument staff reviewed the list of priority IEPs (Table 2-1). The original list was developed by reviewing past park literature and state and county weed lists and consulting with park staff and county weed managers. Our priority IEP list includes existing IEPs and potential IEPs of high management concern. Because these methods were designed to be rapid, field crews were trained to develop a focused search image on the priority IEPs, instead of looking for every possible invasive plant species. The likelihood of eradicating these priority 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) 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 m^2 (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 priority IEP species during route surveys. Although searching for single

Table 2-1. Priority invasive exotic plant list, Colorado National Monument.

Scientific name	Common name
Acosta diffusa	diffuse knapweed
Acosta maculosa	spotted knapweed
Acroptilon repens	Russian knapweed
Arctium minus	burdock
Breea arvensis	Canada thistle
Cardaria draba	hoary cress
Cardaria latifolia	broad-leaf pepperwort*
Carduus acanthoides	plumeless thistle
Carduus nutans var. *macrolepis*	musk thistle
Centaurea solstitialis	yellow starthistle
Cirsium vulgare	bull thistle
Convolvulus arvensis	field bindweed
Cylindropyrum cylindricum	jointed goatgrass
Elaeagnus angustifolia	Russian olive
Isatis tentoria	Dyer's woad
Linaria vulgaris	butter-and-eggs
Lythrum salicaria	purple loosestrife
Melilotus officinale	yellow sweetclover
Onopordum acanthium	Scotch thistle
Tamarix ramosissima	tamarisk
Tithymalus esula	leafy spurge
Tribulus terrestris	puncturevine
Ulmus pumila	Siberian elm
Verbascum thapsus	woolly mullein

*referred to in previous reports as perennial pepperweed

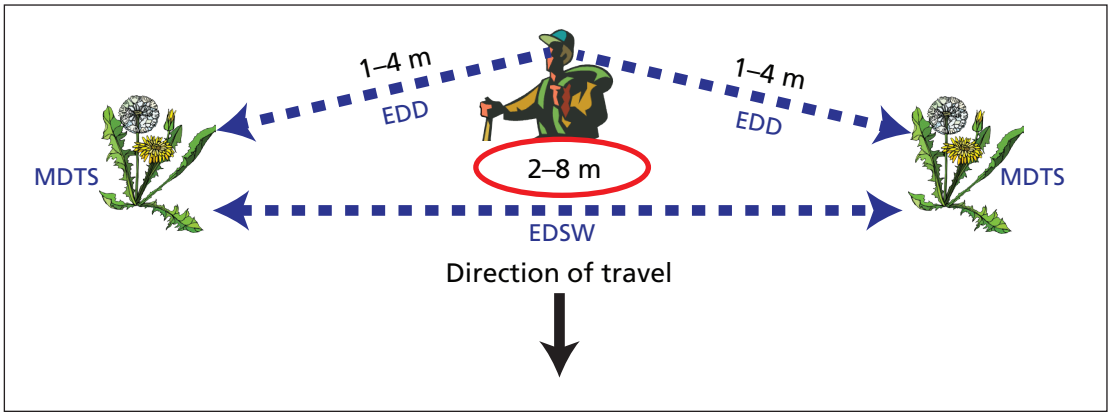


Figure 2-1. The maximum effective detection distance (EDD) at Colorado NM ranged from 1 to 4 meters, making the effective detection swath width (EDSW) 2–8 meters.

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*) or even seedlings of the aforementioned species, 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 priority 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 Colorado NM in 2013 was between 1 and 4 m, depending on vegetation that could obscure infestations (Figure 2-1).

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 priority species of the MDTS. The effective detection swath width (EDSW) is equal to two times the EDD, because the surveyor is able to effectively detect IEPs for one EDD on either side of his/her search route. The EDSW for the monument in 2013 ranged from 2 to 8 m (Figure 2-1).

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 priority 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 IEP-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 South, Rim Rock Ute, and East Glade Park Road, we walked 5 m out from one side of the road and then returned to the starting point by walking back 5 m from the road on the other side. In some cases, due to topography and property boundaries, it was not possible to walk 5 m from the road. For single-track trails and drainages, we walked the center of the trail or drainage in only one direction (Figure 2-2).

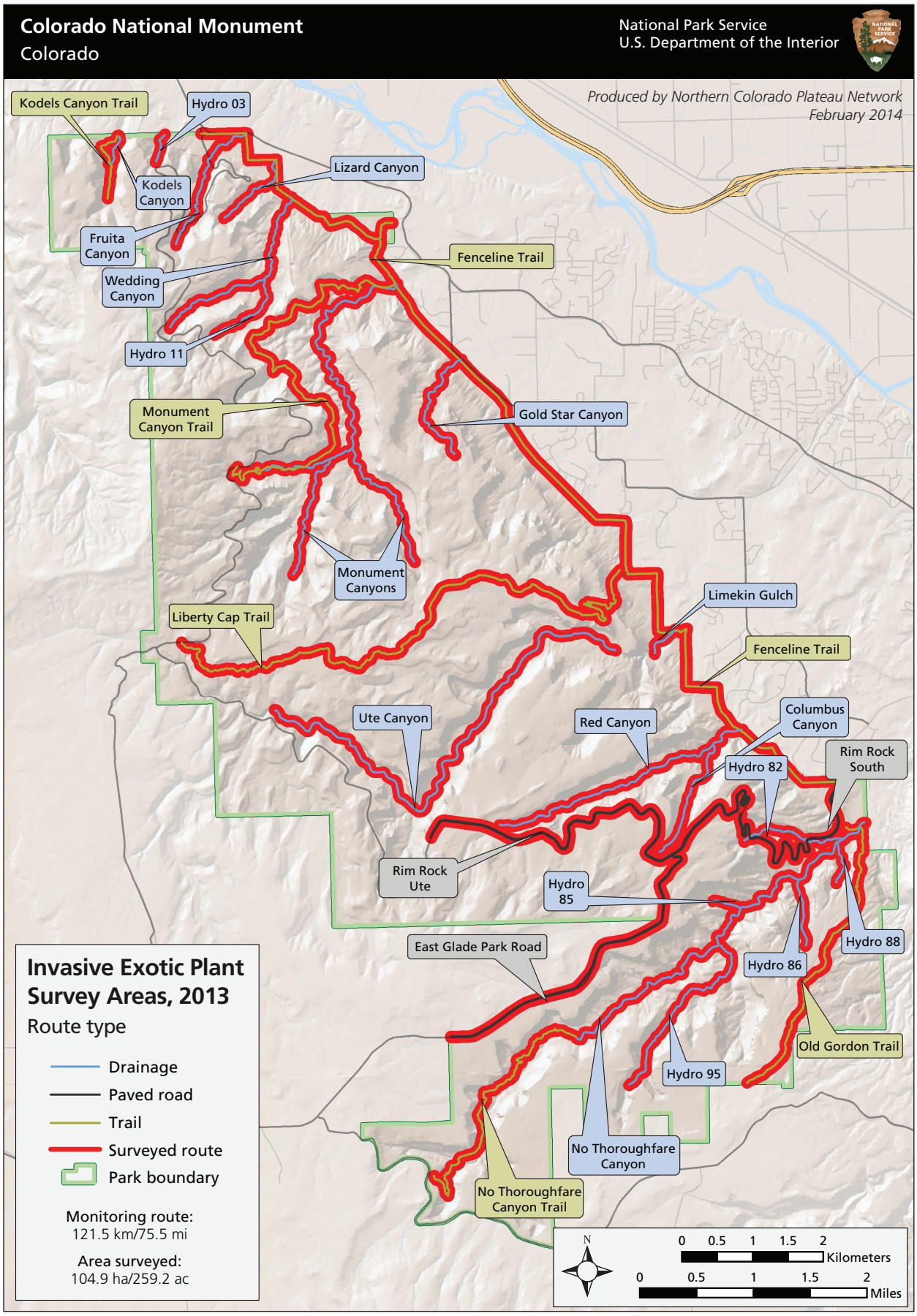


Figure 2-2. Overview of invasive exotic plant monitoring routes and extra areas surveyed at Colorado National Monument, July 31–August 16, 2013.

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 2-8 m (the length of one EDSW) and visually scanned the area in all directions. As monitoring routes were traversed, locations of all priority species were documented using global positioning system (GPS) units with at least five-meter accuracy.

Only IEPs that were designated as priority were consistently recorded during monitoring routes. Survey crew members were given the latitude to record additional IEP species if they were noteworthy. When a priority IEP was discovered, we recorded the following information: (1) the monitoring route, (2) the sequential number of the invasion per monitoring route, (3) infestation size class (see below), (4) whether the plant was pulled by the observer, 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. 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) 40–400 m^2 (48–478 yd^2)
4) 400–1,000 m^2 (0.1–0.25 acre)
5) 1,000–2,000 m^2 (0.25–0.5 acre).

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), the growth stage of exotic trees (i.e., sapling, pole, mature), evidence of prior treatment, and evidence of disturbances (e.g., recent fire, flood, small mammal disturbance).

2.3 Monitoring transects

We established transects with three vegetation quadrats every 500 m along monitoring routes (Figure 2-3). If no invasives were detected for four consecutive transects (12 quadrats), then transects were established every 1,000 m. If invasive plants were found in categories greater than 1 for canopy cover class or infestation size class, then we reverted back to establishing transects every 500 m. Our methods for sampling the quadrats were based on Stohlgren et al. (2005).

2.3.1 Quadrat establishment

We centered vegetation quadrats at 0.5, 5, and 10 m away from the edge of a road on the same side as the route that was being walked and on alternating sides for riparian areas, small roads, or trails. This differed slightly from 2009, when quadrats were placed at 3, 8, and 13 m from the route. If there was not enough space between the route and a topographic feature or property boundary, the three quadrats were evenly spaced between the route and the boundary. A 1-m^2 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 quadrats, observers recorded all priority IEP species observed, as well as cheatgrass (*Anisantha tectorum*). For each quadrat, we recorded percent cover of

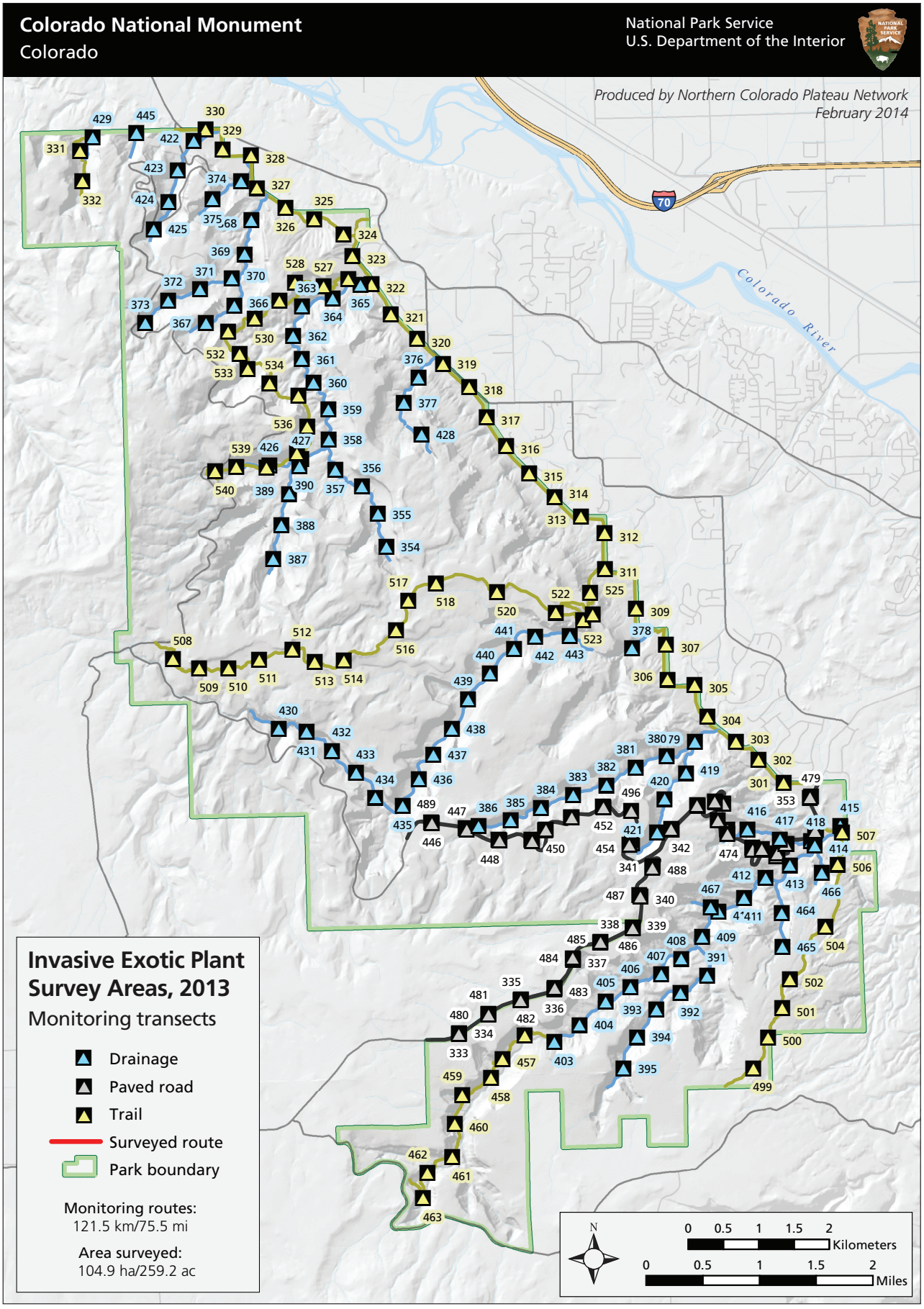


Figure 2-3. Monitoring transects established at Colorado National Monument, July 31–August 16, 2013.

each IEP using the following classes: <1, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, 40, 50, 60, 70, 80, 90, or 100%. This differed slightly from 2009, when cover classes were <1, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11–25, 26–50, 51–75, or >75%. However, only three transects would have been recorded differently in 2009 had the 2011 framework been used in that year. 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 number of infestations per 100 linear meters for monitoring routes (see Table 3-3). Percent cover estimates were generated from the quadrat data, from which we calculated the mean and standard error of percent cover by species (see Tables 3-5 and 3-6).

3 Results

3.1 Priority invasive exotic plant list

Twenty-four IEP species were identified as "priority" for Colorado NM (Table 2-1). The priority list has been the same since 2009, except for the addition of yellow sweetclover (*Melilotus officinale*) in 2011. We also recorded cheatgrass in monitoring quadrats. A total of 14 IEP species were recorded on monitoring routes and transects in 2013, eleven of which were priority species (Table 3-1; tables start on page 10). Thirteen IEP species were recorded on monitoring routes and four species were recorded in monitoring quadrats. Of these, 11 and 3 were priority species, respectively. We monitored along 121.5 km (75.5 miles) of monitoring routes in 2013.

Two priority species were found in 2009 but not detected in 2011 or 2013: Canada thistle (*Breea arvensis*) and yellow starthistle (*Centaurea solstitialis*). One priority species was detected in 2011 but not in 2013: jointed goatgrass (*Cylindropyrum cylindricum*). Broad-leaf pepperwort (*Cardaria latifolia*) was not detected in 2011, but was detected in 2009 and 2013. Burdock (*Arctium minus*) was detected in 2013 for the first time (Table 3-2).

3.2 Monitoring routes

A total of 345 infestations, 335 of which were priority species, were detected along 20 monitoring routes in 2013 (Tables 3-3 and 3-4; Figures 3-1, 3-2, 3-3, 3-4, 3-5, and 3-6; Appendix A, available with the electronic version of this report. Figures start on page 13).

Yellow sweetclover, woolly mullein (*Verbascum thapsus*), field bindweed (*Convolvulus arvensis*), and Siberian elm (*Ulmus pumila*) were the most commonly detected priority IEPs, representing 87% of all priority infestations. Yellow sweetclover represented 66% of all priority infestations. Only priority species should be examined when comparing across areas, as these were the only species recorded consistently by all observers.

Priority IEPs were most prevalent along riparian areas and roads. They were found in highest numbers along Columbus Canyon, Red Canyon, and No Thoroughfare Canyon (Table 3-3). Only five priority IEPs were found along the 43.4 km of trail sampled in 2013. No priority IEPs were detected along the Fruita Canyon, Gold Star Canyon, Kodels Canyon, Lizard Canyon, Rim Rock Ute, Kodels Canyon Trail, Liberty Cap Trail, Monument Canyon Trail, or Old Gordon Trail monitoring routes.

Of the 335 priority infestations, 28.1% were classified as infestations in size classes larger than 40 m^2 (size classes 3–5; Table 3-4). This percentage was largely driven by yellow sweetclover, for which 40% of infestations were larger than 40 m^2. Of all other priority species, only 4% were larger than 40 m^2. Infestation densities of priority species were higher along the East Glade Park Road (0.20 infestations per 100 m) and Rim Rock South (0.29/100 m) routes, respectively, than along the Rim Rock Ute route, where no priority species were found.

Three priority invasive tree species were detected: Russian olive, tamarisk, and Siberian elm. Of the 44 tree infestations detected, 15 were seedlings, 18 were in the sapling stage, 7 were mature trees, and growth stage was not noted for 4 infestations.

3.3 Monitoring transects

A total of 220 transects were sampled in 2013 (see Figure 2-3; Appendix B, available with the electronic version of this report). Cheatgrass and yellow sweetclover were the only target species present in more than one transect (Tables 3-5, 3-6). Cheatgrass was widespread (found in 48% of all transects), with a percent cover of 1.4% of the total monitored area. Along routes with at least five transects, cheatgrass had the highest percent cover along No Thoroughfare Trail, at 2.5%, and the highest frequency along Monument Canyon, occurring in 83.3% of those transects (Table 3-5). Yellow sweetclover was present most often (37.5% of transects) and had the highest percent cover, at 0.18%, on No Thoroughfare Canyon Trail. Percent cover of cheatgrass and yellow sweetclover was higher along Rim Rock South (0.12% and 0.1%, respectively) and East Glade Park Road (0.36% and 0.01%) than along Rim Rock Ute (0.8% and 0.0%).

3.4 Results comparison: 2003, 2009, 2011, and 2013

Colorado NM was previously surveyed for IEPs in 2003 (Dewey and Anderson 2005), 2009 (Perkins 2010), and 2011 (Perkins 2012). The only species included in the 2003, 2009, 2011, and 2013 target (2003) and priority (2009–2013) lists were Russian knapweed (*Acroptilon repens*), field bindweed, Russian olive, tamarisk, and woolly mullein. However, between 2009, 2011, and 2013, the lists were the same (except that yellow sweetclover was added in 2011). While Dewey and Anderson did not provide specific route lengths, the following areas were essentially the same as those surveyed in 2009, 2011, and 2013: No Thoroughfare Canyon, Ute Canyon, and Gold Star Canyon. In addition, coverage of Monument Canyon and Independence Monument in 2003 was approximately equal to the coverage of Monument Canyon in 2009, 2011, and 2013.

In areas that were monitored in all four years, Russian olive declined to its lowest levels in 2013, after increasing in 2009 and 2011 (Table 3-7, Figure 3-7). Russian-olive infestations dropped by 77% between 2011 and 2013, and declined on every route that was monitored in all years. Tamarisk continued its decline, to just four infestations in 2013. This decline represents an 81% reduction in tamarisk infestations since 2011, and a 96% reduction since 2003. Yellow sweetclover showed a 68% reduction from 2011 to 2013 (Table 3-7). Red Canyon and Ute Canyon were the only locations where infestations increased for all species from 2011 to 2013. Frequency of cheatgrass in transects has been variable, from 1% of transects in 2009 to 68% frequency and 1.4% cover in 2011, to 48% frequency and 1.4% cover in 2013.

The size of infestations also decreased. In 2011, 64% of infestations were larger than 40 m^2 (Perkins 2012). In 2013, only 28% were larger than 40 m^2.

Table 3-1. Invasive exotic plants detected at Colorado National Monument, July 31–August 16, 2013.

Scientific name	Common name	Method detected		Priority?
		Routes	Transects	
Acroptilon repens	Russian knapweed	X	X	Yes
Arctium minus	burdock	X		Yes
Cardaria latifolia	broad-leaf pepperwort	X		Yes
Cirsium vulgare	bull thistle	X		Yes
Convolvulus arvensis	field bindweed	X		Yes
Elaeagnus angustifolia	Russian olive	X		Yes
Melilotus officinale	yellow sweetclover	X	X	Yes
Tamarix spp.	tamarisk	X		Yes
Tribulus terrestris	puncturevine	X	X	Yes
Ulmus pumila	Siberian elm	X		Yes
Verbascum thapsus	woolly mullein	X		Yes
Anisantha tectorum	cheatgrass		X	No
Medicago sativa	alfalfa	X		No
Poa bulbosa	bulbous bluegrass	X		No

Table 3-2. Changes in detection status of selected priority invasive exotic plants, Colorado National Monument, 2009–2013.

Scientific name	Common name	Year(s) detected		
		2009	2011	2013
Arctium minus	burdock	-	-	X
Breea arvensis	Canada thistle	X	-	-
Cardaria latifolia	broad-leaf pepperwort	X	-	X
Centaurea solstitialis	yellow starthistle	X	-	-
Cylindropyrum cylindricum	jointed goatgrass	-	X	-

Table 3-3. Number of invasive exotic plant infestations and infestations/100 m by route and route type, Colorado National Monument, July 31–August 16, 2013.

Route type	Route	Length (m)	Area (ha)	Infestations		Infestations/100 m	
				Total	Priority only	Total	Priority only
Riparian	Columbus Canyon	1,881.5	2.27	20	19	1.06	1.01
	Fruita Canyon	2,156.5	2.03	0	0	0.00	0.00
	Gold Star Canyon	1,922.0	2.31	0	0	0.00	0.00
	Hydro 03	445.6	0.43	4	4	0.90	0.90
	Kodels Canyon	461.9	0.37	0	0	0.00	0.00
	Lizard Canyon	1273.7	1.01	0	0	0.00	0.00
	Monument Canyon	9,259.6	10.43	43	43	0.46	0.46
	No Thoroughfare Canyon	12,633.9	11.20	117	117	0.93	0.93
	Red Canyon	4,014.2	3.72	40	40	1.00	1.00
	Ute Canyon	7,949.6	6.35	51	51	0.64	0.64
	Wedding Canyon	4,250.9	5.07	2	2	0.05	0.05
	subtotal	*46,249.4*	*45.19*	*277*	*276*	*0.60*	*0.60*
Road	East Glade Park Road	9,537.8	4.07	25	19	0.26	0.20
	Rim Rock South	12,112.5	3.62	38	35	0.31	0.29
	Rim Rock Ute	10,204.9	3.57	0	0	0.00	0.00
	subtotal	*31,855.2*	*11.26*	*63*	*54*	*0.20*	*0.17*
Trail	Kodels Canyon Trail	1150.7	0.92	0	0	0.00	0.00
	Liberty Cap Trail	9,653.7	8.06	0	0	0.00	0.00
	Monument Canyon Trail	8,014.8	10.01	0	0	0.00	0.00
	No Thoroughfare	4,361.6	3.49	1	1	0.02	0.02
	Old Gordon Trail	4,770.3	3.81	0	0	0.00	0.00
	Fenceline Trail	15,403.7	22.14	4	4	0.03	0.03
	subtotal	*43,354.8*	*48.43*	*5*	*5*	*0.01*	*0.01*
Totals		**121,459.4**	**104.88**	**345**	**335**	**0.28**	**0.28**

Hydros 82, 85, 88, 86, and 95 are all included in No Thoroughfare Canyon totals. Hydro 11 is included in Wedding Canyon and Limekin Gulch is included in Ute Canyon totals.

Table 3-4. Number of infestations by species and infestation size class detected along monitoring routes, Colorado National Monument, July 31–August 16, 2013.

Scientific name	Common name	Total infestations	Infestation size class				
			1	2	3	4	5
Acroptilon repens	Russian knapweed	1	0	1	0	0	0
Arctium minus	burdock	7	3	3	1	0	0
Cardaria latifolia	broad-leaf pepperwort	2	1	1	0	0	0
Cirsium vulgare	bull thistle	4	2	1	1	0	0
Convolvulus arvensis	field bindweed	23	10	12	1	0	0
Elaeagnus angustifolia	Russian olive	11	7	3	0	1	0
Melilotus officinale	yellow sweetclover	220	25	106	55	33	1
Tamarix spp.	tamarisk	16	13	2	0	1	0
Tribulis terrestris	puncturevine	4	2	2	0	0	0
Ulmus pumila	Siberian elm	17	16	1	0	0	0
Verbascum thapsus	woolly mullein	30	18	12	0	0	0
*Medicago sativa**	alfalfa	1	1	0	0	0	0
*Poa bulbosa**	bulbous bluegrass	9	1	8	0	0	0
Priority species		**335**	**97**	**144**	**58**	**35**	**1**
All species		**345**	**99**	**152**	**58**	**35**	**1**

*Infestation size classes: 1 = 1–a few plants (≤2 × 2 m), 2 = few plants–40 m^2 (48 yd^2), 3 = 40–400 m^2 (48–478 yd^2), 4 = 400–1,000 m^2 (0.1–0.25 acre), 5 = 1,000–2,000 m^2 (0.25–0.5 acre).

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

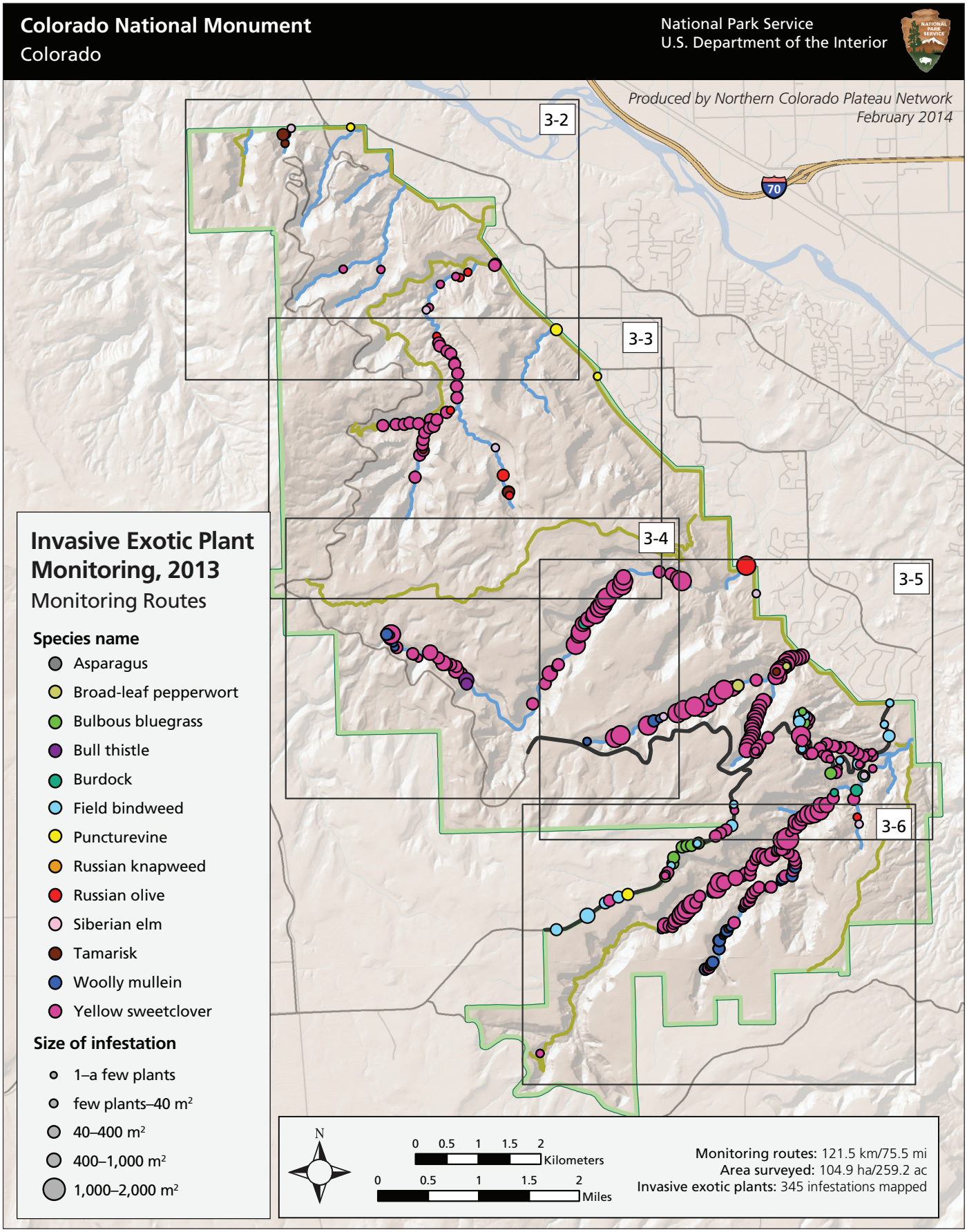


Figure 3-1. Invasive exotic plants detected on monitoring routes, Colorado National Monument, July 31–August 16, 2013.

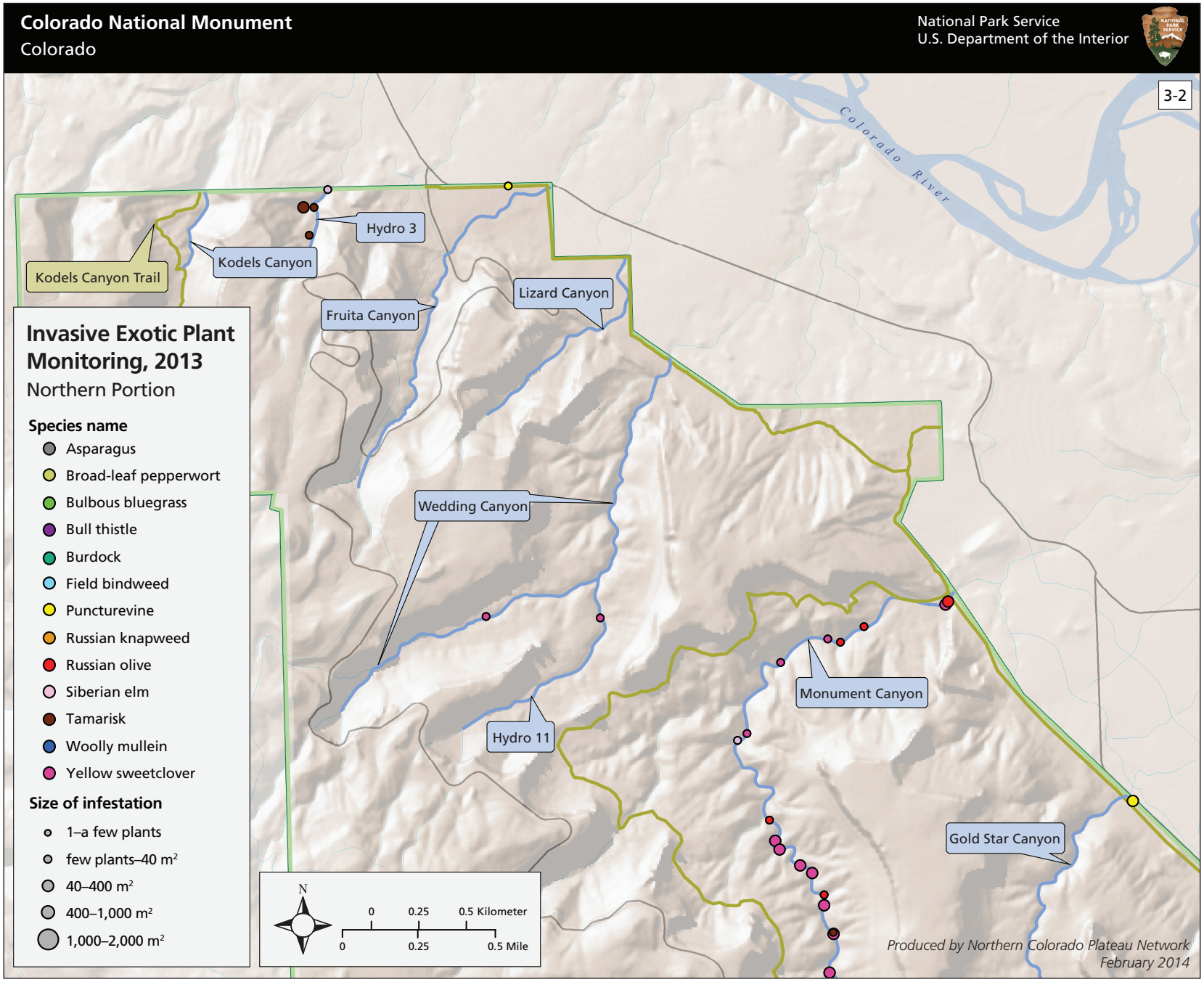


Figure 3-2. Invasive exotic plants detected on monitoring routes in the northern portion of Colorado National Monument, July 31–August 16, 2013.

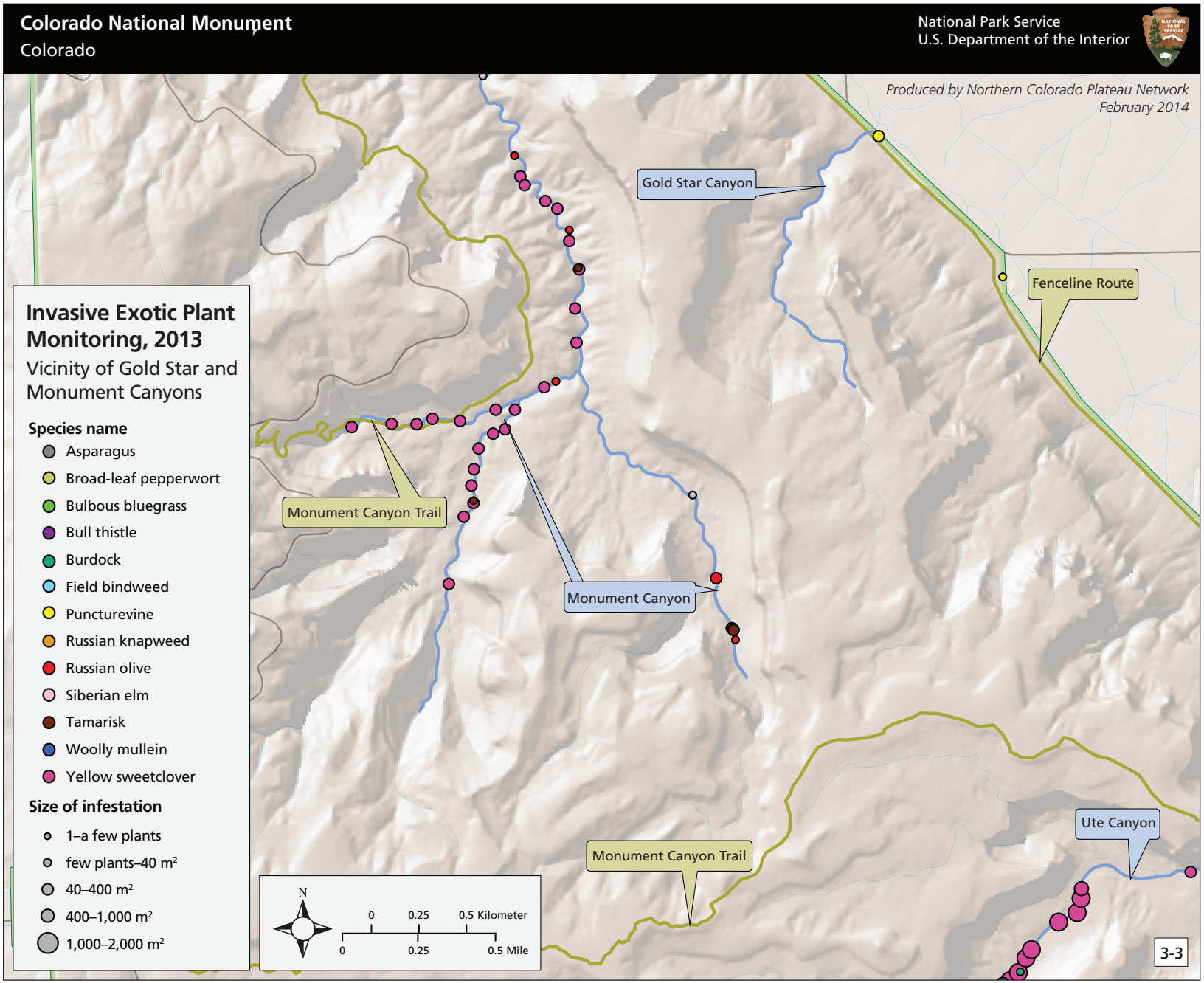


Figure 3-3. Invasive exotic plants detected on monitoring routes in the vicinity of Gold Star and Monument canyons, Colorado National Monument, July 31–August 16, 2013.

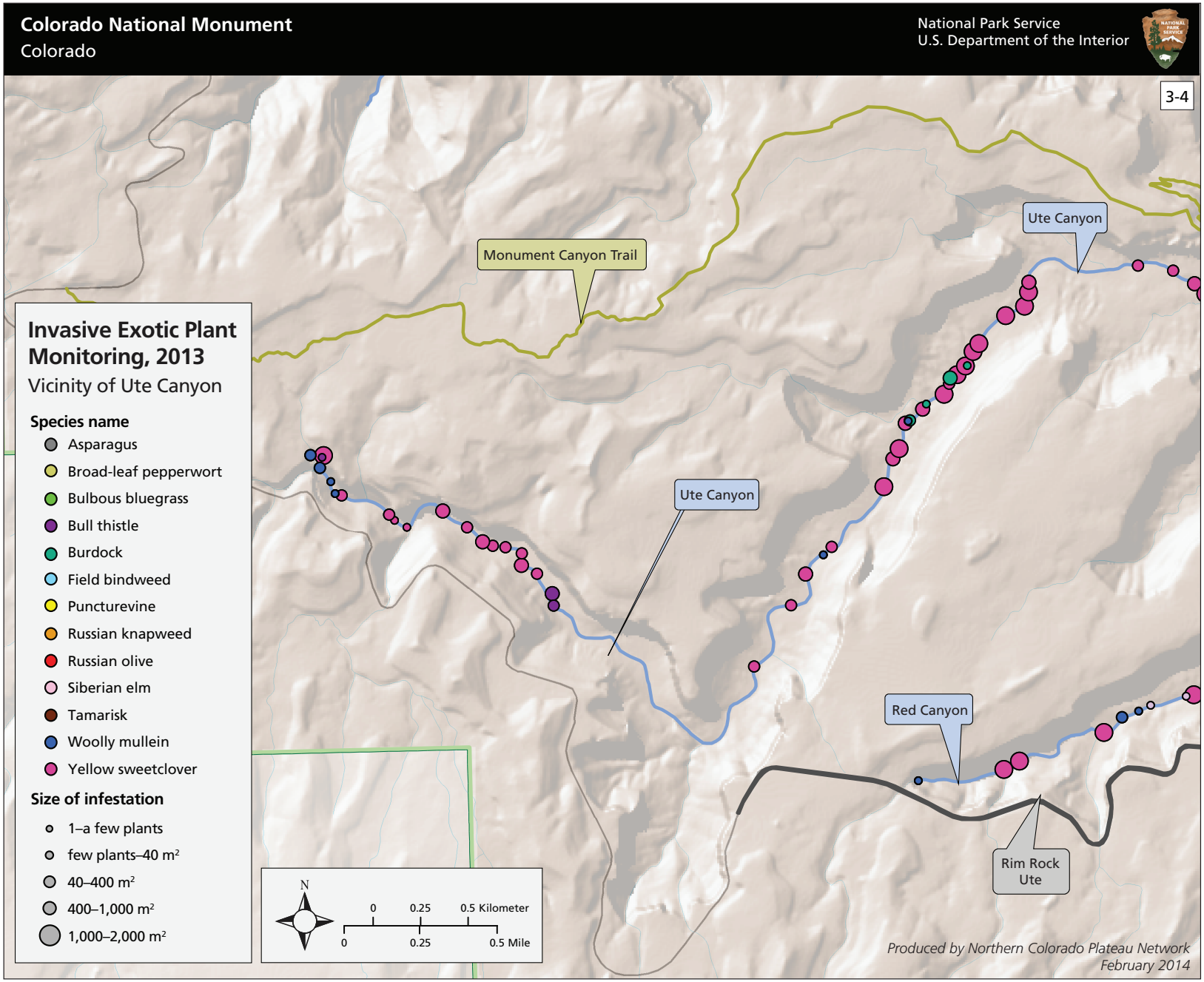


Figure 3-4. Invasive exotic plants detected on monitoring routes and monitoring plots in the vicinity of Ute Canyon, Colorado National Monument, July 31–August 16, 2013.

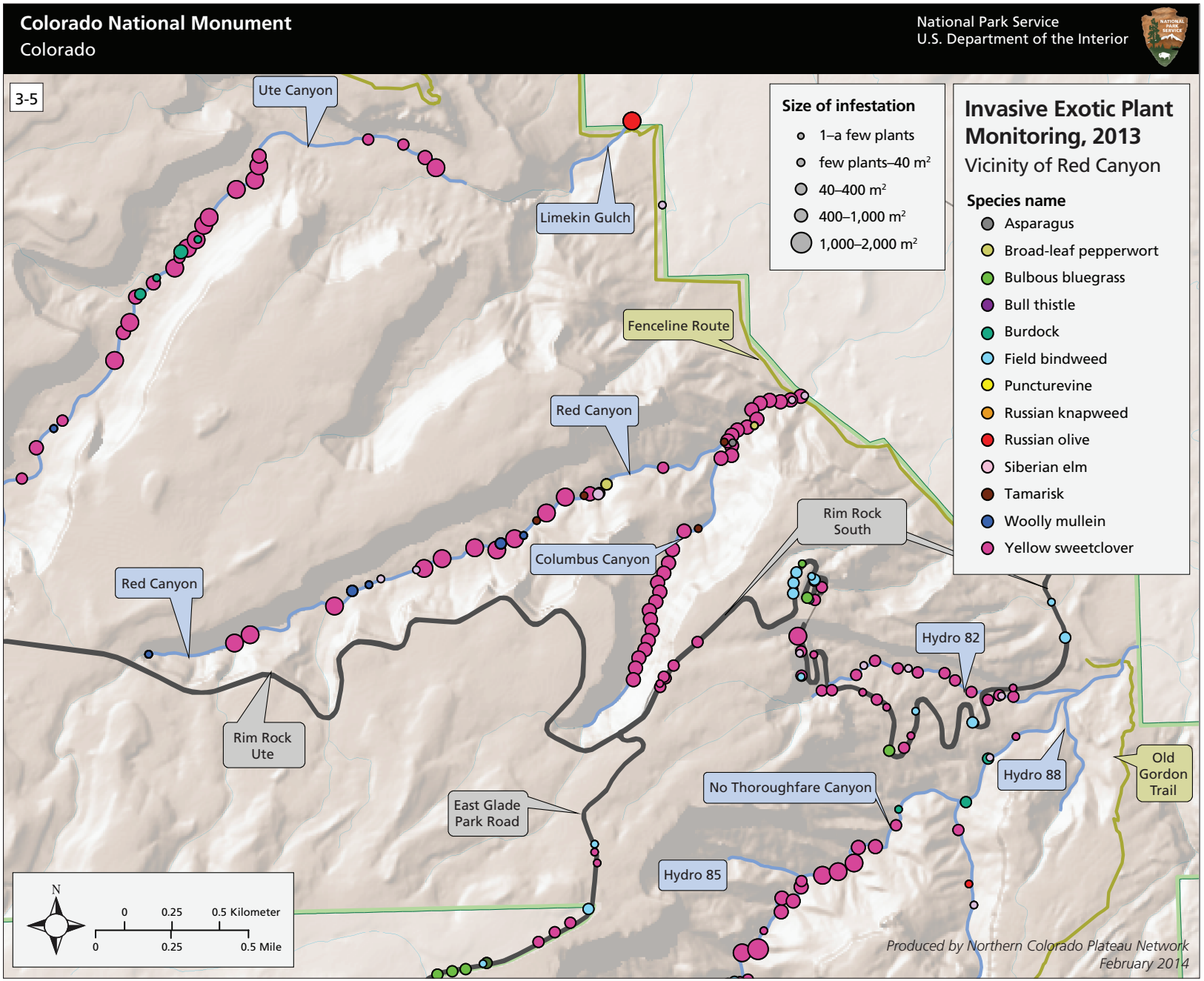


Figure 3-5. Invasive exotic plants detected on monitoring routes and monitoring plots in the vicinity of Red Canyon, Colorado National Monument, July 31–August 16, 2013.

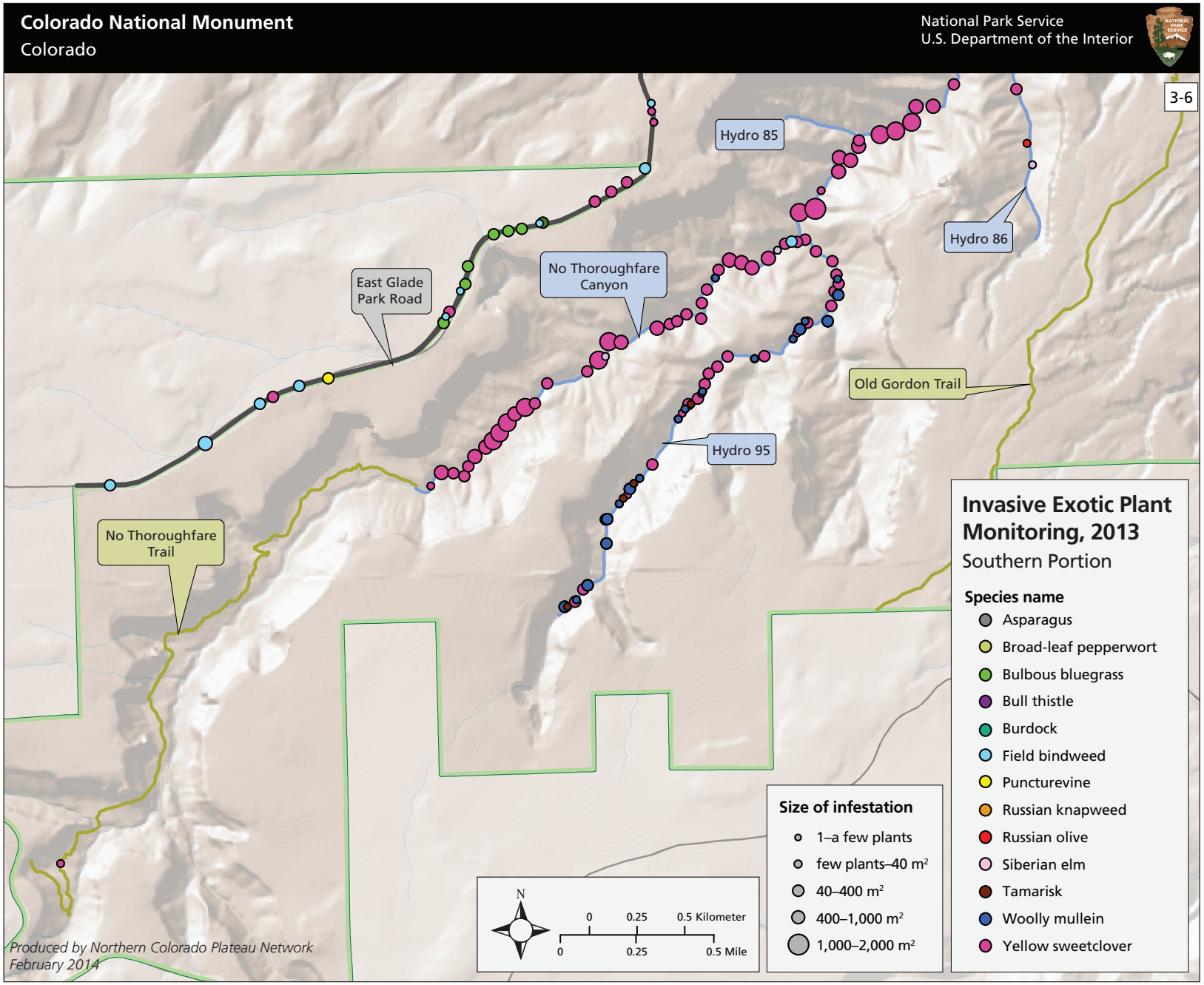


Figure 3-6. Invasive exotic plants detected on monitoring routes and monitoring plots in the southern portion of Colorado National Monument, July 31–August 16, 2013.

Table 3-5. Number of monitoring transects where exotic plant species were detected per route, with percent cover, Colorado National Monument, July 31–August 16, 2013.

Route	Scientific name	Common name	# of transects		Percent cover	SE
			# with IEPs	Total		
Riparian						
Columbus Canyon	*Melilotus officinale*	yellow sweetclover	1	3	0.06	0.06
Fruita Canyon	*Anisantha tectorum*	cheatgrass	3	4	0.46	0.25
Gold Star Canyon	*Anisantha tectorum*	cheatgrass	2	3	0.28	0.15
Hydro 3	*Anisantha tectorum*	cheatgrass	1	1	0.50	0.50
Kodels Canyon	*Anisantha tectorum*	cheatgrass	1	1	0.67	0.67
Lizard Canyon	*Anisantha tectorum*	cheatgrass	1	2	0.08	0.08
Monument Canyon	*Anisantha tectorum*	cheatgrass	15	18	0.30	0.06
No Thoroughfare Canyon	*Anisantha tectorum*	cheatgrass	8	25	0.47	0.40
	Melilotus officinale	yellow sweetclover	3	25	0.09	0.08
Red Canyon	*Anisantha tectorum*	cheatgrass	6	8	1.60	0.85
	Melilotus officinale	yellow sweetclover	2	8	0.04	0.03
Ute Canyon	*Anisantha tectorum*	cheatgrass	5	14	0.92	0.46
	Melilotus officinale	yellow sweetclover	2	14	0.02	0.02
Wedding Canyon	*Anisantha tectorum*	cheatgrass	6	8	0.71	0.43
Road						
East Glade Park Road	*Anisantha tectorum*	cheatgrass	10	18	0.52	0.36
	Acroptilon repens	Russian knapweed	1	18	0.01	0.01
	Tribulus terrestris	puncturevine	1	18	0.02	0.02
	Melilotus officinale	yellow sweetclover	1	18	0.01	0.01
Rim Rock South	*Anisantha tectorum*	cheatgrass	16	23	0.47	0.12
	Melilotus officinale	yellow sweetclover	1	23	0.01	0.01
Rim Rock Ute	*Anisantha tectorum*	cheatgrass	5	17	0.12	0.08
Trail						
No Thoroughfare Trail	*Anisantha tectorum*	cheatgrass	3	8	2.52	1.75
	Melilotus officinale	yellow sweetclover	3	8	0.18	0.15
Kodels Canyon Trail	*Anisantha tectorum*	cheatgrass	1	2	0.08	0.08
Liberty Cap Trail	*Anisantha tectorum*	cheatgrass	2	14	0.02	0.02
Monument Canyon Trail	*Anisantha tectorum*	cheatgrass	11	15	0.27	0.10
Fenceline Route	*Anisantha tectorum*	cheatgrass	9	28	0.26	0.12

Hydros 82, 85, 88, 86, and 95 are all included in No Thoroughfare Canyon totals. Hydro 11 is included in Wedding Canyon and Limekin Gulch is included in Ute Canyon totals.

Table 3-6. Number of transects (of total number) where priority exotic plant species were detected by route type, with percent cover, Colorado National Monument, July 31–August 16, 2013.

		Riparian		Roads		Trails		Parkwide	
Scientific name	Common name	Transects with IEPs (of 88)	Percent cover (SE)	Transects with IEPs (of 58)	Percent cover (SE)	Transects with IEPs (of 74)	Percent cover (SE)	Transects with IEPs (of 220)	Percent cover (SE)
Anisantha tectorum	cheatgrass	43	0.49 (0.12)	31	0.39 (0.13)	31	0.49 (0.20)	105	0.46 (0.09)
Tribulus terrestris	puncturevine	0	0.00 (0.00)	1	0.01 (0.01)	0	0.00 (0.00)	1	<0.01 (<0.01)
Acroptilon repens	Russian knapweed	0	0.00 (0.00)	1	<0.01 (<0.01)	0	0.00 (0.00)	1	<0.01 (<0.01)
Melilotus officinale	yellow sweetclover	5	0.01 (<0.01)	2	0.01 (<0.01)	3	0.03 (0.03)	10	0.01 (<0.01)
Total priority species on transects		46	0.50 (0.12)	37	0.40 (0.12)	33	0.49 (0.20)	116	0.47 (0.09)

Table 3-7. Number of infestations of selected invasive exotic plants detected in areas surveyed in 2003, 2009, 2011, and 2013, Colorado National Monument.

Year surveyed	Routes surveyed in all four years					Routes surveyed only in 2009, 2011, and 2013							Totals, 2009–2013[2]
	Gold Star Canyon	Monument Canyon	No Thoroughfare Canyon[1]	Ute Canyon	*subtotal*	Columbus Canyon	Kodels Canyon	Red Canyon	Wedding Canyon[1]	East Glade Park	Rim Rock South	*subtotal*	
Convolvulus arvensis (field bindweed)													
2003	0	1	1	3	*5*	-	-	-	-	-	-	-	-
2009	0	2	1	0	*3*	0	0	3	0	2	14	*19*	22
2011	1	4	1	0	*6*	0	0	0	0	15	28	*43*	49
2013	0	1	1	0	*2*	0	0	0	0	9	12	*21*	23
Elaeagnus arvensis (Russian olive)													
2003	0	1	2	6	*9*	-	-	-	-	-	-	-	-
2009	2	9	14	4	*29*	0	1	0	0	0	0	1	30
2011	0	21	19	4	*44*	0	0	1	0	0	3	4	48
2013	0	9	0	1	*10*	0	0	0	0	0	0	0	10
Tamarix (tamarisk)													
2003	6	33	17	37	93	-	-	-	-	-	-	-	-
2009	4	11	8	8	31	0	0	0	7	0	0	7	38
2011	1	9	8	0	18	2	1	4	0	0	0	7	25
2013	0	3	0	1	4	1	0	3	0	0	0	4	8
Verbascum thapsus (woolly mullein)													
2003	0	0	0	5	5	-	-	-	-	-	-	-	-
2009	0	0	11	4	15	0	0	4	0	0	0	4	19
2011	0	0	4	1	5	0	0	1	0	0	0	1	6
2013	0	0	1	6	7	0	0	5	0	0	0	5	12
Melilotus officinale (yellow sweetclover)													
2003	-	-	-	-	-	-	-	-	-	-	-	-	-
2009	-	-	-	-	-	-	-	-	-	-	-	-	-
2011	0	49	94	73	216	18	0	43	17	75	68	221	-
2013	0	28	47	36	111	18	0	24	1	8	22	73	-
Others*													
2003	-	-	-	-	-	-	-	-	-	-	-	-	-
2009	1	4	5	10	20	0	4	4	0	1	8	17	37
2011	0	3	8	4	15	0	0	3	0	1	2	6	21
2013	0	2	3	3	8	0	0	8	0	2	1	11	19

Table 3-7. Number of infestations of selected invasive exotic plants detected in areas surveyed in 2003, 2009, 2011, and 2013, Colorado National Monument, cont.

Year surveyed	Routes surveyed in all four years					Routes surveyed only in 2009, 2011, and 2013							Totals, 2009–2013[2]
	Gold Star Canyon	Monument Canyon	No Thoroughfare Canyon[1]	Ute Canyon	*subtotal*	Columbus Canyon	Kodels Canyon	Red Canyon	Wedding Canyon[1]	East Glade Park	Rim Rock South	*subtotal*	
Total (excluding yellow sweetclover)[3]													
2003	6	35	20	51	112	-	-	-	-	-	-	-	-
2009	7	26	39	26	98	0	5	11	7	3	22	48	146
2011	2	37	40	9	88	2	1	9	0	16	33	61	149
2013	0	15	5	11	31	1	0	16	0	11	13	41	72

**Acroptilon repens, Arctium minus, Breea arvensis, Cardaria latifolia, Carduus nutans, Centaurea solstitialis, Cirsium vulgare, Tribulus terrestris,* and *Ulmus pumila* (Russian knapweed, burdock, Canada thistle, broad-leaf pepperwort, musk thistle, yellow starthistle, bull thistle, puncturevine, and Siberian elm).

- No data collected for that species in that year.

[1]Although tributaries to these canyons were added in 2011 (Hydros 11, 82, 85, 88, 86, and 95), only areas that were surveyed in 2009, 2011, and 2013 were compared in this table. Thus, total infestations for Wedding and No Thoroughfare Canyons are not equal to those found in Table 3-3.

[2] Totals in this column only represent areas monitored in 2009, 2011, and 2013. Subtotals for 2003 are not included in these totals. *Melilotus officinale* is not included in these totals because it was not searched for in 2009.

[3] *Melilotus officinale* is not included in these totals because it was not searched for in 2003 or 2009.

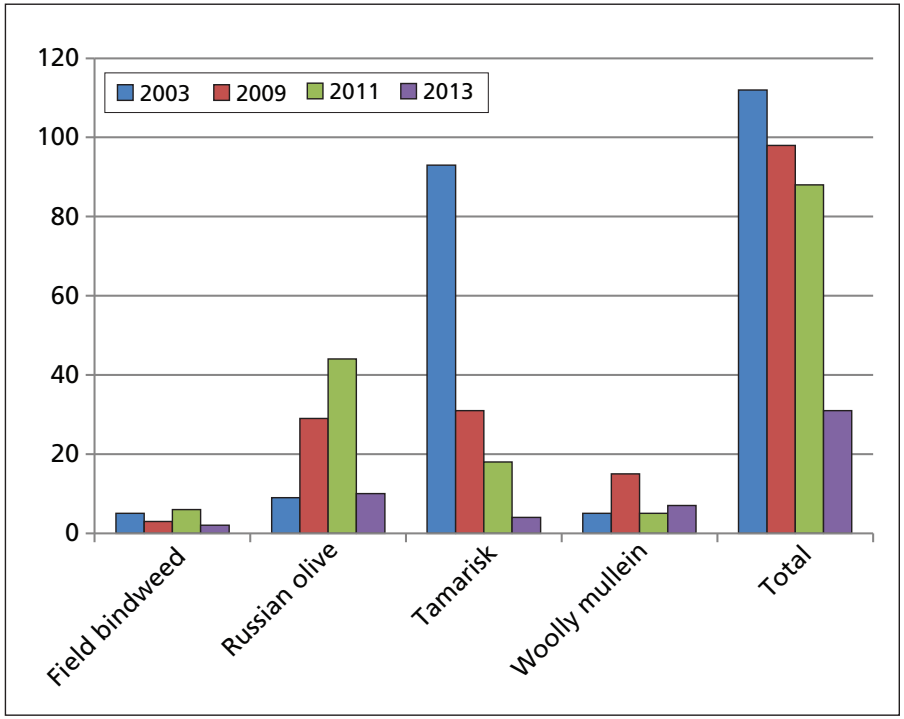


Figure 3-7. Infestation numbers for species searched for at sites in 2003, 2009, 2011, and 2013, Colorado National Monument (see Table 3-7 for sites). Infestations for most species declined from 2011 to 2013.

4 Discussion

4.1 Priority invasive exotic plant list

The NCPN will continue to work with Colorado NM staff and area IEP experts to review and update the list of priority species each year. At this time, the network has no recommendations for additions or deletions to the current priority list. Monument staff has suggested we add western tansymustard (*Descurainia pinnata*), tumble mustard (*Sisymbrium altissimum*), blue mustard (*Chorispora tenella*), and western salsify (*Tragopogon dubius*) to the priority IEP list for 2015. Russian thistle (*Salsola australis*), curly dock (*Rumex crispus*), alfalfa (*Medicago sativa*), curveseed butterwort (*Ceratocephala testiculata*), and halogeton (*Halogeton glomeratus*) are all species for which the park currently manages; they may be added in 2015. To maximize monitoring accuracy and efficiency, it is ideal for the priority IEP list to include fewer than 30 species, so crews may easily identify the priority species.

In this report, presence and absence data for most priority species (and presence data for other species) should be reliable. However, absence data for non-priority species should be considered suspect, because not all observers recorded all of those species.

4.2 Possibilities for management control

Over the past two years, the number of infestations has decreased for almost all species on all monitoring routes due to IEP control efforts by monument staff. Because monitoring was conducted at approximately the same time each year, phenology differences between years should be minimal. Priority invasive exotic plants were most widespread along riparian and road areas. Almost no priority IEPs were recorded along trails. While infestations have declined, the most problematic remaining areas are Columbus Canyon, Red Canyon, and No Thoroughfare Canyon. These areas should be targeted for control efforts.

While overall numbers were lower along all three routes than in 2011, there were more IEPs along the Rim Rock South and East Glade Park Road routes than along Rim Rock Ute, as was shown by both route and transect data. Possible explanations for this include (1) the higher volumes of livestock and hay that are transported on the former two roads compared to Rim Rock Ute (K. Hartwig, pers. comm.), or (2) the higher volume of general traffic that the Rim Rock South and East Glade Park Road routes receive. In either case, monument staff should implement measures to control the transportation of hay through the park, such as allowing only weed-free hay or mandating that hay be covered during transport.

The size and maturity of tree infestations indicated that the infestations present were generally recent. It is worth noting that IEP control efforts are typically more successful during early stages of an infestation. Excluding yellow sweetclover, 96% of priority infestations detected on monitoring routes were less than 40 m^2 in size, and the percentage of yellow-sweetclover infestations larger than 40 m^2 declined from 81% in 2011 to 40% in 2013. Tree infestations consist largely of seedlings and saplings, which are easier to control than mature trees. In 2009, 2011, and 2013, 92%, 75%, and 83% of infestations, respectively, were seedlings and saplings. Continued control efforts should be made before more seedlings and saplings grow into mature trees.

The decrease in tamarisk infestations is likely the result of efforts by volunteers to control this species. These efforts have focused on tamarisk but will expand to include Russian olive in the coming years. A Youth Conservation Corps crew focused on yellow sweetclover over the past two seasons. The wet spring of 2011 may have contributed to the increases seen in cheatgrass (on transects) from 1% frequency on transects in 2009 to 68% frequency in 2011. That cheatgrass has appeared to persist, with 48% frequency in 2013. Cheatgrass percent cover was 1.4% in both 2011 and 2013.

It will be much easier for monument staff to contain invasive species if eradication efforts continue. In just a few years, small infestations could become large, and seedlings and saplings will become mature trees, requiring removal aided by chainsaws instead of loppers or pruning shears. Preventing the invasion of additional species should give native species a better chance to persist.

It should be noted that estimates of percent cover in this report (see Tables 3-5 and 3-6) 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 may be lower in the interior of the park than along the monitoring routes.

4.3 Future monitoring efforts

IEPs at Colorado NM will generally be monitored at the same time of year in alternating years. 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 2015, 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 (1) trends in species distribution and percent cover of individual species, and (2) changes in IEP percent cover of priority species and cheatgrass by monitoring route. Extra-area surveys will also be considered for inventories at the park's request. The NCPN invasive plant monitoring protocol was finalized in September 2013.

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Appendix A. Invasive Exotic Plant Invasions Detected on Monitoring Routes, Colorado National Monument, July 31–August 16, 2013

See electronic appendix

Appendix B. Invasive Exotic Plant Percent Cover Detected by Monitoring Plots, July 31–August 16, 2013

See electronic appendix

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