



Invasive Exotic Plant Monitoring in Colorado National Monument

2011 Field Season

Natural Resource Technical Report NPS/NCPN/NRTR—2012/556



ON THE COVER

Russian olive (*Elaeagnus angustifolia*). Photo by Patrick Breen, Oregon State University, Bugwood.org.

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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 2011. In monitoring conducted between June 22 and August 21, 2011, twenty-four IEP species were detected on monitoring routes and transects at COLM. Of these, 11 were priority species that accounted for 696 separate infestations. IEPs were most prevalent along riparian areas and roads. Yellow sweetclover (*Melilotus officinale*), field bindweed (*Convolvulus arvensis*), Russian olive (*Elaeagnus angustifolia*), and tamarisk (*Tamarix* spp.) were the most widespread species found along monitoring routes. Cheatgrass (*Anisantha tectorum*) and yellow sweetclover had the highest percent cover (1.4 and 0.1%) and highest frequency (68% and 18%) of all transects, respectively. 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). Russian olive has generally increased, while tamarisk has decreased in the time since surveys were conducted in 2003 and 2009. 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 2013.

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
NM	national monument
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 priority 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 2011 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.

COLM staff also sought to know if infestation rates were different along roads that are and are not commonly used to transport livestock and associated hay through the park. The vast majority of this 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, COLM staff requested that we add this objective:

3. Determine if there are differences between infestation rates 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 (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 priority invasive plants for the park (see below). 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 COLM staff reviewed the list of priority 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 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 plants, 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 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 priority 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 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 range-finder. The EDD for COLM in 2011 was between 2.5 and 20 m, depending on vegetation (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

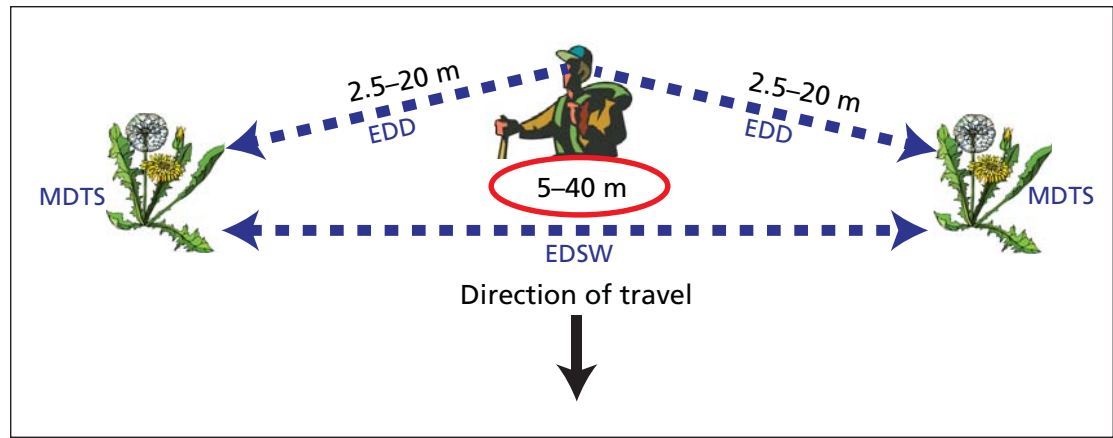


Figure 2-1. The maximum effective detection distance (EDD) at Colorado NM ranged from 2.5 to 20 meters, making the effective detection swath width (EDSW) 5–40 meters.

(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 for COLM in 2011 ranged from 5 to 40 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 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 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).

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 5–40 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 species that were designated as priority were consistently recorded during monitoring routes. Survey crew members were given the latitude to record additional 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, 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.

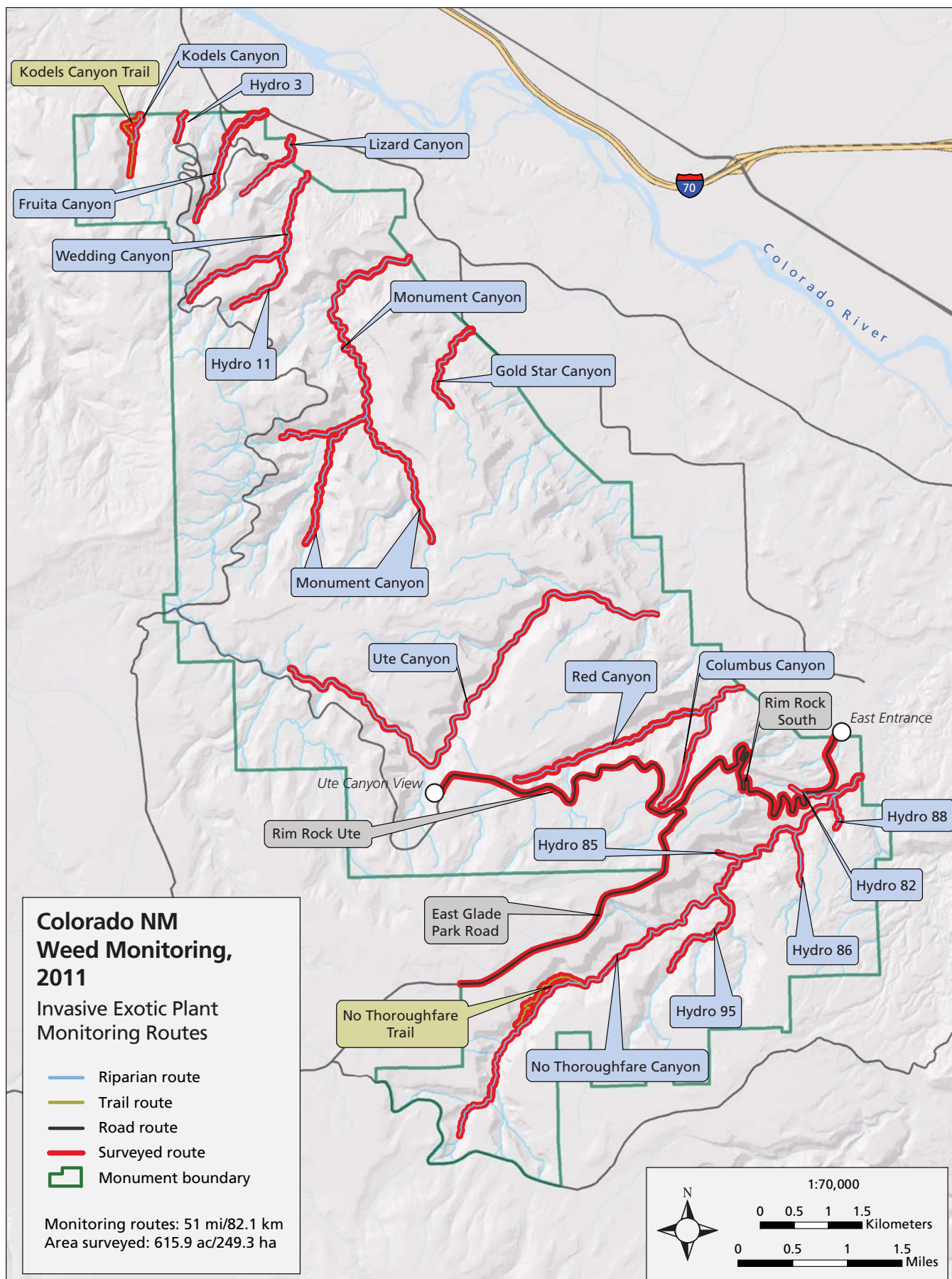


Figure 2-2. Overview of invasive plant monitoring routes and extra areas surveyed at Colorado National Monument, June 22–August 21, 2011. Results from the Hydro 88, 86, 85, and 95 routes were combined with No Thoroughfare Canyon.

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 m² (48 yd²)
- 3) 40–400 m² (48–478 yd²)
- 4) 400–1,000 m² (0.1–0.25 acre)
- 5) 1,000–2,000 m² (0.25–0.5 acre).

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, 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-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 quadrats, observers recorded all priority IEP species observed, as well as cheatgrass (*Anisantha 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, 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 hectare for monitoring routes (see Table 3-2). Percent cover estimates were generated from the quadrat data, from which we calculated the mean and standard error of percent cover by species (see Table 3-4).

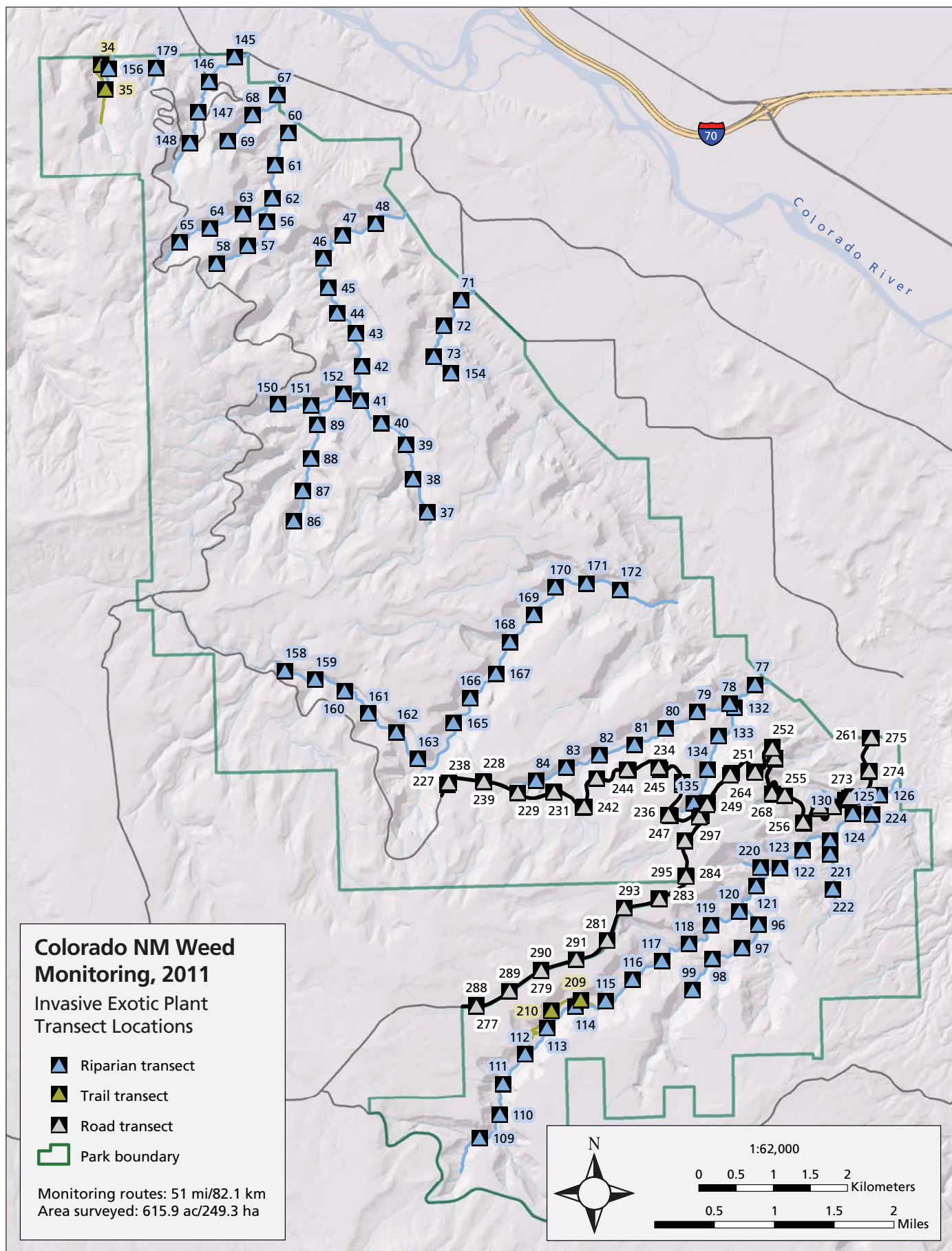


Figure 2-3. Monitoring routes and transects surveyed, Colorado National Monument, June 22–August 21, 2011.

3 Results

3.1 Priority invasive exotic plant list

Twenty-four IEP species were identified as “priority” for COLM (Appendix A). One species was added after the end of the 2009 field season: yellow sweetclover (*Melilotus officinale*). We also recorded cheatgrass in monitoring quadrats. A total of 22 IEP species were recorded on monitoring routes and transects in 2011, eleven of which were priority species (Table 3-1). Thirteen IEP species were recorded on monitoring routes and 14 in monitoring quadrats. Of these, 11 and 4 were priority species, respectively. We covered 249 hectares (615 acres) along 82.1 km (51.0 miles) of monitoring routes in 2011, representing 7.1% of the entire park. Three priority species (Canada thistle [*Breca arvensis*], perennial pepperweed [*Cardaria latifolia*], and yellow starthistle [*Centaurea solstitialis*]) that were found in 2009 were not found in 2011. Two priority species (jointed goatgrass [*Cylindropyrum cylindricum*] and puncture vine [*Tribulus terrestris*]) not found in 2009 were found in 2011.

3.2 Monitoring routes

A total of 701 infestations, 696 of which were priority species, were detected along 20 monitoring routes in 2011 (Tables 3-2 and 3-3, Figures 3-1, 3-2, 3-3, 3-4, 3-5, and 3-6; electronic Appendix B).

Yellow sweetclover, field bindweed (*Convolvulus arvensis*), Russian olive (*Elaeagnus angustifolia*), and tamarisk (*Tamarix* spp.) were the most commonly detected priority IEPs. Only priority species should be examined when comparing across areas, as these were the only species recorded consistently by all observers. Priority IEPs, most prevalent along riparian areas and along roads, were found in highest numbers along East Glade Park Road, No Thoroughfare Canyon, Rim Rock South, and Ute Canyon (Table 3-2). Only one priority IEP was found on trails in 2011 (only 2.7 km of trail were monitored). No priority IEPs were detected in the Fruita Canyon, Lizard Canyon, or Kodel’s Canyon routes.

Of the 696 priority infestations, 64% were classified as infestations in size classes larg-

er than 40 m² (Table 3-3). This was largely driven by yellow sweetclover, for which 81% of infestations were larger than 40 m². Of all other priority species, only 12% were larger than 40 m². Priority species infestation rates were 137% and 56% higher along the East Glade Park Road and Rim Rock South routes, respectively, than along the Rim Rock Ute route.

Three priority invasive tree species were detected: Russian olive, tamarisk, and Siberian elm (*Ulmus pumila*). Of the 92 tree infestations detected, 25 were seedlings, 41 were in the sapling stage, and 26 were mature trees.

3.3 Monitoring transects

A total of 155 transects were sampled in 2011 (see Figure 2-3; electronic Appendix C). Cheatgrass and yellow sweetclover were the only target species present in more than one transect (Tables 3-4, 3-5). Cheatgrass was widespread, found in 68% of all transects with a percent cover of 1.4% of the total monitored area. Along routes with more than 10 transects, cheatgrass had the highest percent cover along Rim Rock South, at 2.8%, and was found in 79% of transects (Table 3-4). Yellow sweetclover was present most often in No Thoroughfare Canyon (58% of transects), at 0.21% cover. Percent cover of cheatgrass and yellow sweetclover was higher along Rim Rock South (2.8% and 0.1%) and East Glade Park Road (0.9% and 0.03%) than along Rim Rock Ute (0.2% and 0.0%). Percent cover of cheatgrass was considerably higher than in 2009, when it was present in only one of 169 transects sampled (Perkins 2010).

3.4 Results comparison: 2003, 2009 and 2011

Colorado NM was surveyed for IEPs in 2003 (Dewey and Anderson 2005) and 2009 (Perkins 2010). The only species included in the 2003, 2009, and 2011 target lists were Russian knapweed (*Acroptilon repens*), field bindweed, Russian olive, tamarisk, and woolly mullein (*Verbascum thapsus*). However, the lists between 2009 and 2011 were the same, with the exception of the addition of yellow sweetclover in 2011. While Dewey and Anderson did not provide specific route lengths, the following areas were essentially

the same as those surveyed in 2009 and 2011: 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 and 2011.

In areas that were monitored in all three years, Russian olive has continued to increase when compared to 2003 and 2009, while tamarisk has continued to decline (Table 3-6); both findings were reported by Perkins (2010). The Russian olive increase is most notable at Monument and No Thoroughfare canyons, while the tamarisk decline is noted at Monument, Ute, No Thoroughfare, and Gold Star

canyons. Most other species remained constant or were variable at low levels.

When data only from 2009 and 2011 are compared, there is a similar pattern of Russian-olive increase and tamarisk decrease (Table 3-6). In addition, the number of field-bindweed infestations more than doubled between those years, most notably along East Glade Park Road and Rim Rock South. Woolly-mullein infestations showed the opposite pattern—decreasing since 2009, particularly along No Thoroughfare, Ute, and Red canyons. Overall, the total number of priority infestations was very similar in 2009 and 2011 (Table 3-6).

Table 3-1. Invasive exotic plants detected at Colorado National Monument, June 22–August 21, 2011.

Scientific name	Common name	Method detected		Park priority
		Route	Transects	
<i>Acroptilon repens</i>	Russian knapweed	X		Yes
<i>Carduus nutans</i>	musk thistle	X		Yes
<i>Cirsium vulgare</i>	bull thistle	X		Yes
<i>Convolvulus arvensis</i>	field bindweed	X	X	Yes
<i>Cylindropyrum cylindricum</i>	jointed goatgrass	X	X	Yes
<i>Elaeagnus angustifolia</i>	Russian olive	X		Yes
<i>Melilotus officinale</i>	yellow sweetclover	X	X	Yes
<i>Tamarix</i> spp.	tamarisk	X		Yes
<i>Tribulus terrestris</i>	puncture vine	X		Yes
<i>Ulmus pumila</i>	Siberian elm	X		Yes
<i>Verbascum thapsus</i>	woolly mullein	X	X	Yes
<i>Agropyron cristatum</i>	crested wheatgrass		X	No
<i>Alyssum desertorum</i>	desert madwort		X	No
<i>Anisantha tectorum</i>	cheatgrass		X	No
<i>Bassia sieversiana</i>	summer cypress		X	No
<i>Bromus inermis</i>	smooth brome		X	No
<i>Erodium cicutarium</i>	stork's bill		X	No
<i>Halogeton glomeratus</i>	halogeton	X	X	No
<i>Orthoceras</i> spp.	bur buttercup		X	No
<i>Salsola australis</i>	Russian thistle		X	No
<i>Populus alba</i>	white popular	X		No
<i>Tragopogon dubius</i>	yellow salsify		X	No

Table 3-2. Monitoring routes surveyed, route type, length, hectares covered along the route, number of IEP infestations, and number of infestations/100 m, Colorado NM, June 22–August 21, 2011.

Route type	Route name	Length (m)	Area covered (ha)	Infestations		Infestations/ha	
				Total	Priority only	Total	Priority only
Riparian	No Thoroughfare	13,678.7	46.22	198	196	4.28	4.24
	Ute Canyon	8,032.5	23.53	82	82	3.49	3.49
	Columbus Canyon	1,881.5	6.11	20	20	3.27	3.27
	Red Canyon	3,873.6	19.10	52	52	2.72	2.72
	Monument Canyon	9,591.3	41.00	86	86	2.10	2.10
	Hydro 03	445.6	1.91	2	2	1.05	1.05
	Wedding Canyon	4,250.9	17.08	18	18	1.05	1.05
	Kodel's Canyon	461.9	1.34	1	1	0.74	0.74
	Gold Star Canyon	1,531.0	7.00	2	2	0.29	0.29
	Fruita Canyon	2,156.5	12.03	0	0	0.00	0.00
	Lizard Canyon	1,273.7	5.32	0	0	0.00	0.00
	<i>subtotal</i>	<i>47,177.4</i>	<i>180.62</i>	<i>461</i>	<i>459</i>	<i>2.65</i>	<i>2.54</i>
Road	East Glade Park Road	9,537.8	14.72	91	91	6.18	6.18
	Rim Rock South	12,470.1	24.81	104	101	4.19	4.07
	Rim Rock Ute	10,204.9	16.84	44	44	2.61	2.61
	<i>subtotal</i>	<i>32,212.8</i>	<i>56.37</i>	<i>239</i>	<i>236</i>	<i>4.33</i>	<i>4.19</i>
Trail	No Thoroughfare Trail	1585.4	7.59	1	1	0.13	0.13
	Kodel's Canyon Trail	1150.7	4.69	0	0	0.00	0.00
	<i>subtotal</i>	<i>2736.1</i>	<i>12.28</i>	<i>1</i>	<i>1</i>	<i>0.07</i>	<i>0.07</i>
Totals		82,126.3	249.27	701	696	2.65	2.79

Numbers have been rounded.

Table 3-3. Species observed and infestation size class detected along monitoring routes, Colorado NM, June 22–August 21, 2011.

Scientific name	Common name	Total infestations	Infestation size class			
			1	2	3	4
<i>Acroptilon repens</i>	Russian knapweed	1	0	1	0	0
<i>Carduus nutans</i>	musk thistle	1	1	0	0	0
<i>Cirsium vulgare</i>	bull thistle	3	2	1	0	0
<i>Convolvulus arvensis</i>	field bindweed	49	14	21	14	0
<i>Cylindropyrum cylindricum</i>	jointed goatgrass	3	0	1	2	0
<i>Elaeagnus angustifolia</i>	Russian olive	46	40	5	1	0
<i>Melilotus officinale</i>	yellow sweetclover	524	38	63	402	21
<i>Tamarix</i> spp.	tamarisk	29	27	0	2	0
<i>Tribulus terrestris</i>	puncture vine	2	0	2	0	0
<i>Ulmus pumila</i>	Siberian elm	19	17	1	1	0
<i>Verbascum thapsus</i>	woolly mullein	19	13	5	1	0
<i>Halogeton glomeratus</i> *	halogeton	3	2	1	0	0
<i>Populus alba</i> *	white poplar	2	2	0	0	0
Priority species		696	152	100	423	21
All species		701	156	101	423	21

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

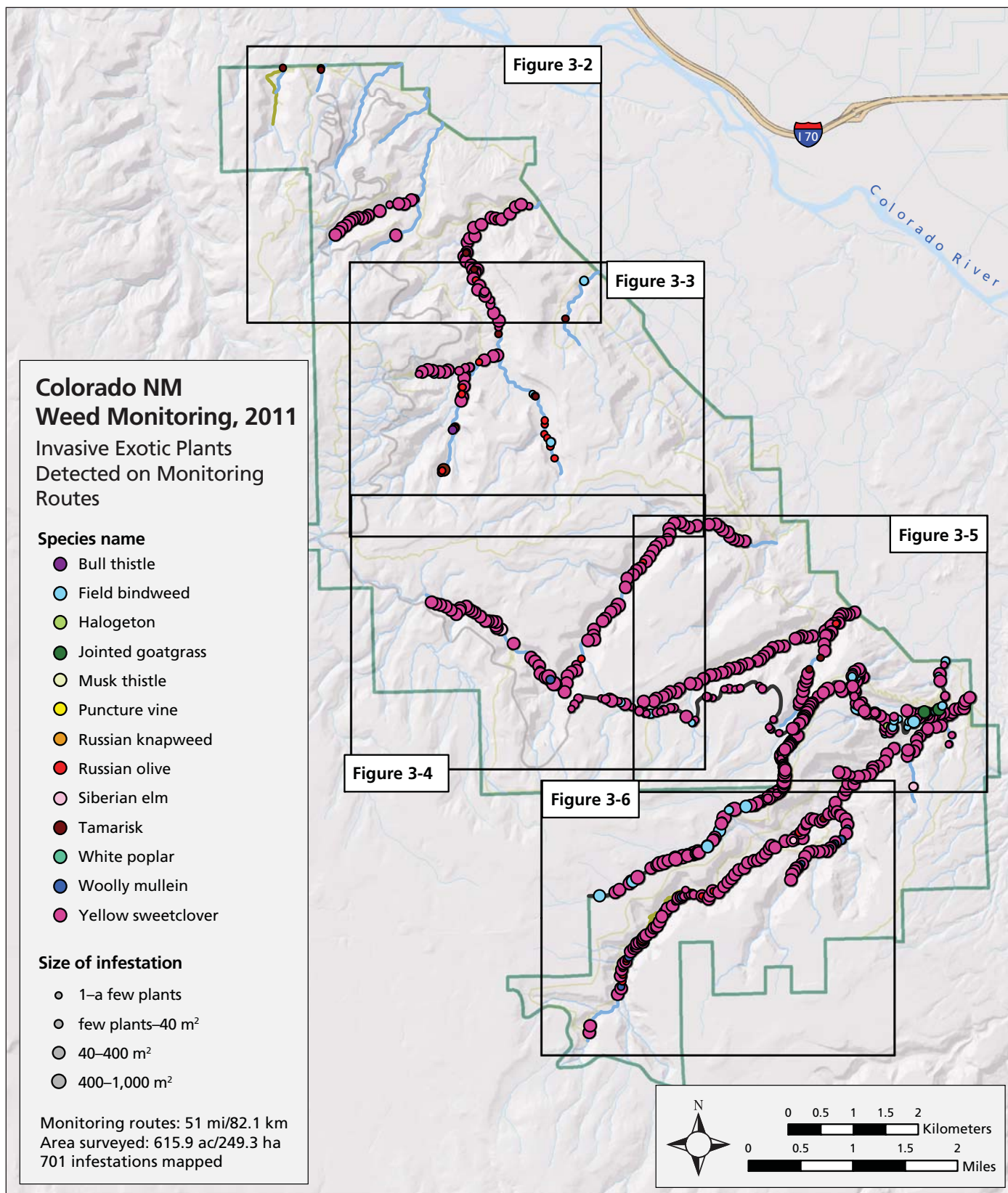


Figure 3-1. Invasive plants detected on monitoring routes, Colorado NM, June 22–August 21, 2011.

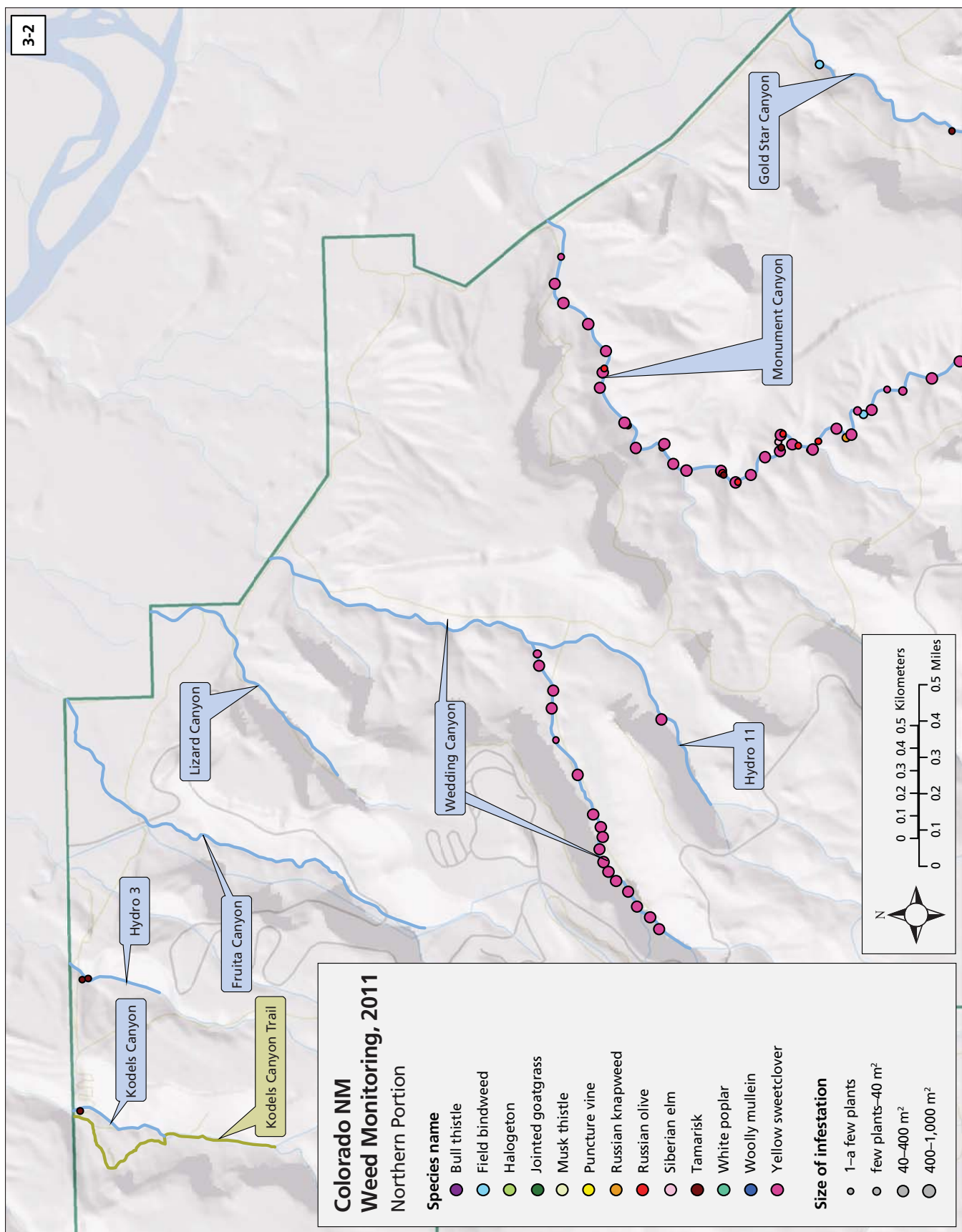


Figure 3-2. Invasive plants detected on monitoring routes in the northern portion of Colorado NM, June 22–August 21, 2011.

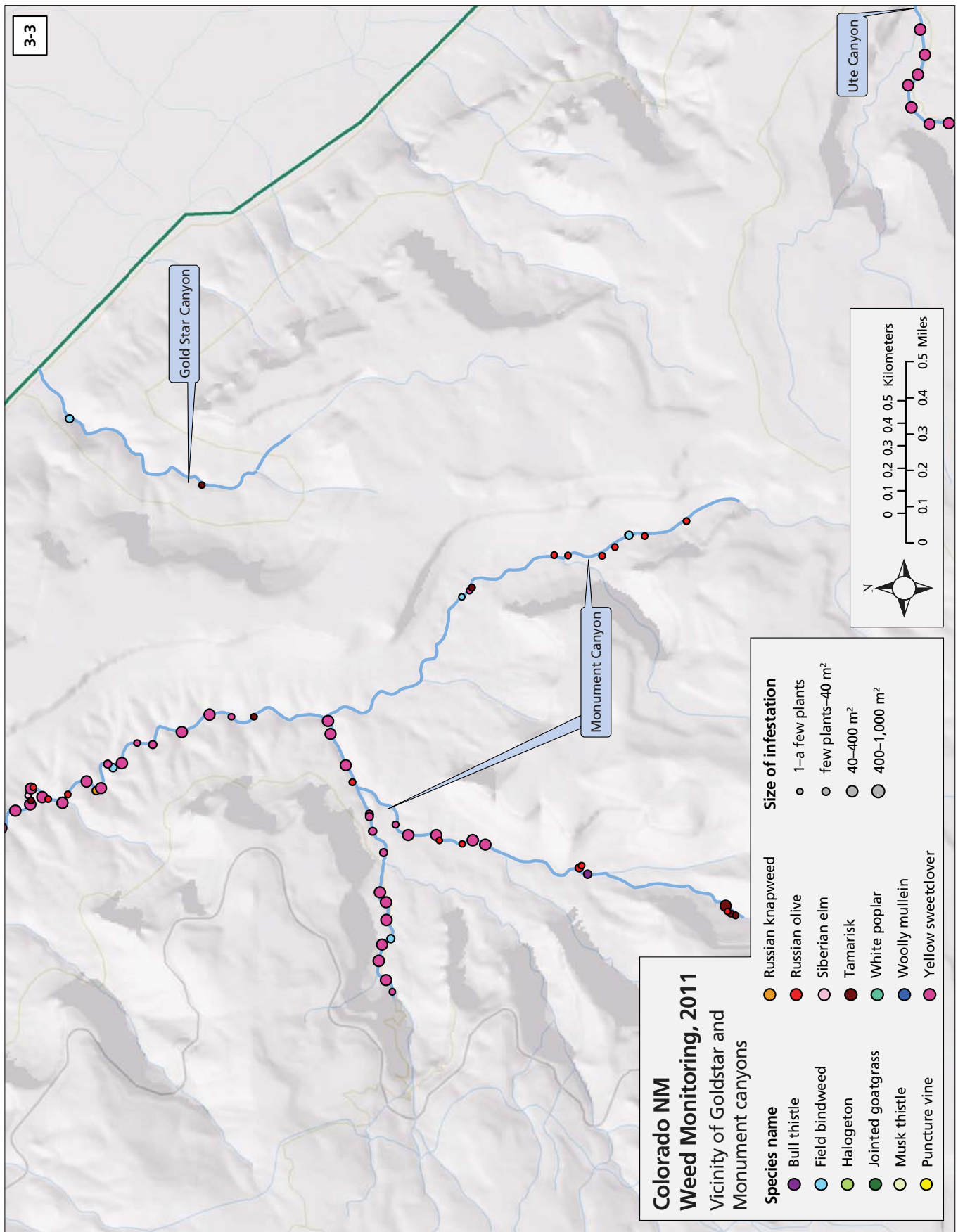


Figure 3-3. Invasive plants detected on monitoring routes in the vicinity of Gold Star and Monument canyons, Colorado NM, June 22–August 21, 2011.

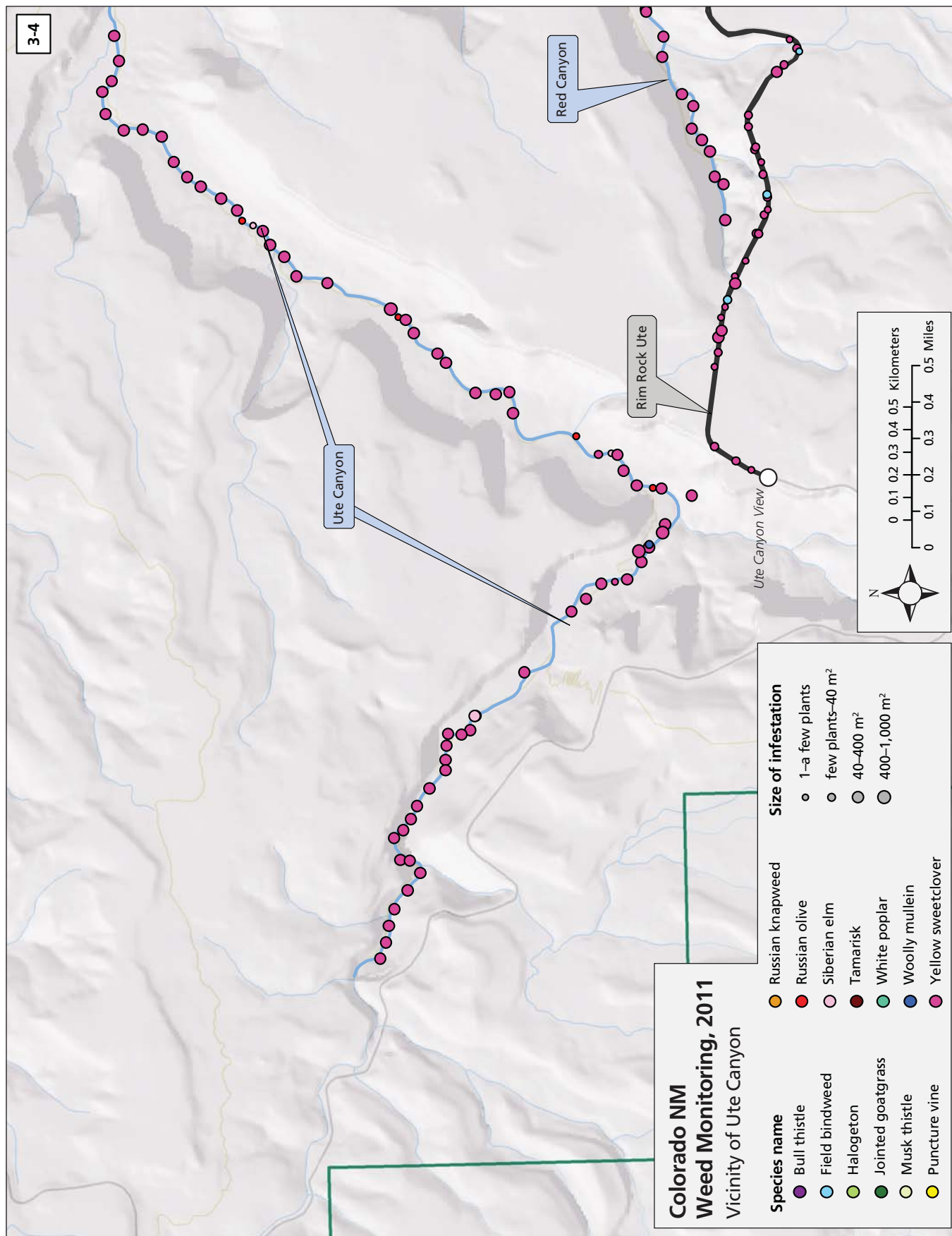


Figure 3-4. Invasive plants detected on monitoring routes and transects in the vicinity of Ute Canyon, Colorado NM, June 22–August 21, 2011.

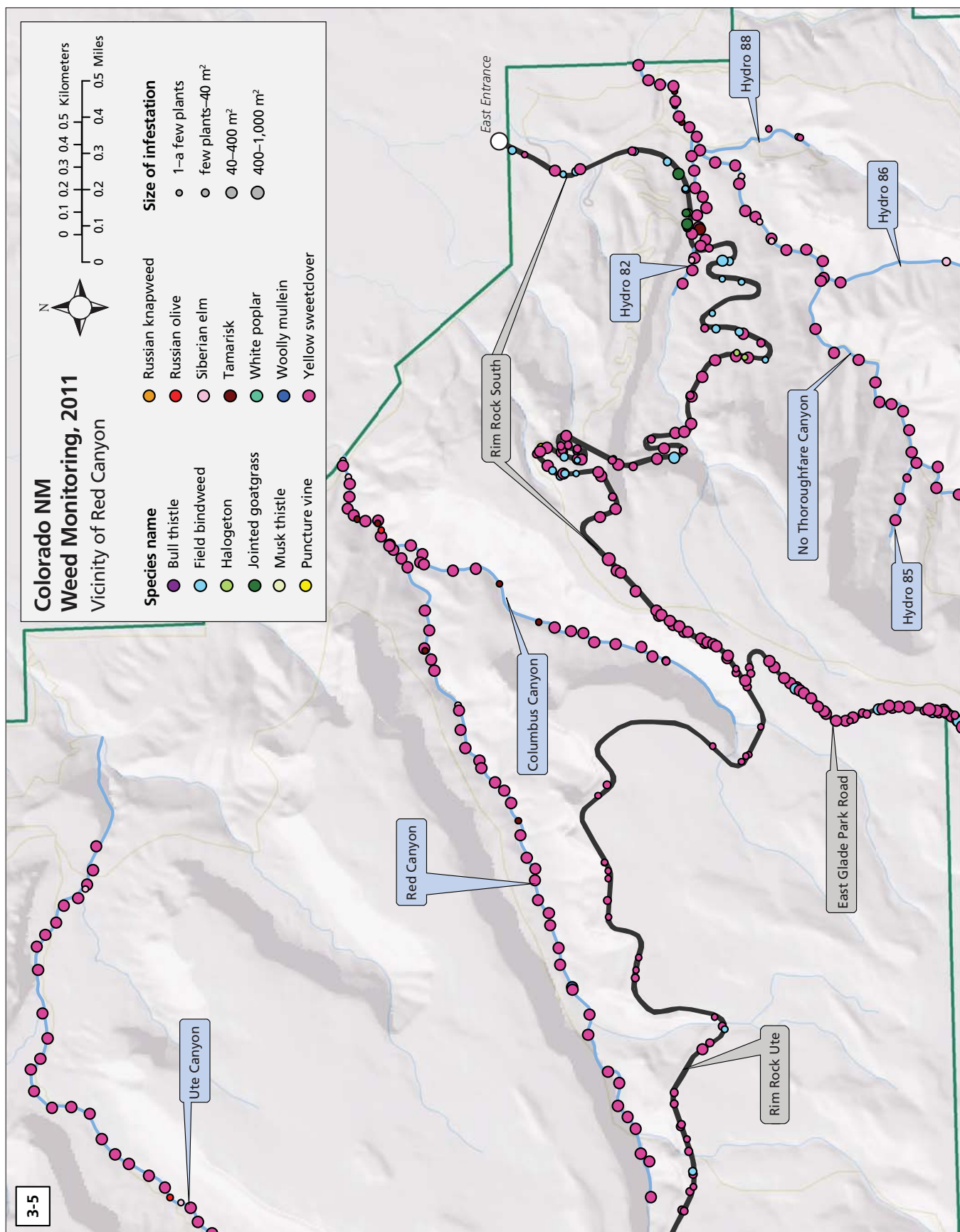


Figure 3-5. Invasive plants detected on monitoring routes and transects in the vicinity of Red Canyon, Colorado NM, June 22-August 21, 2011.

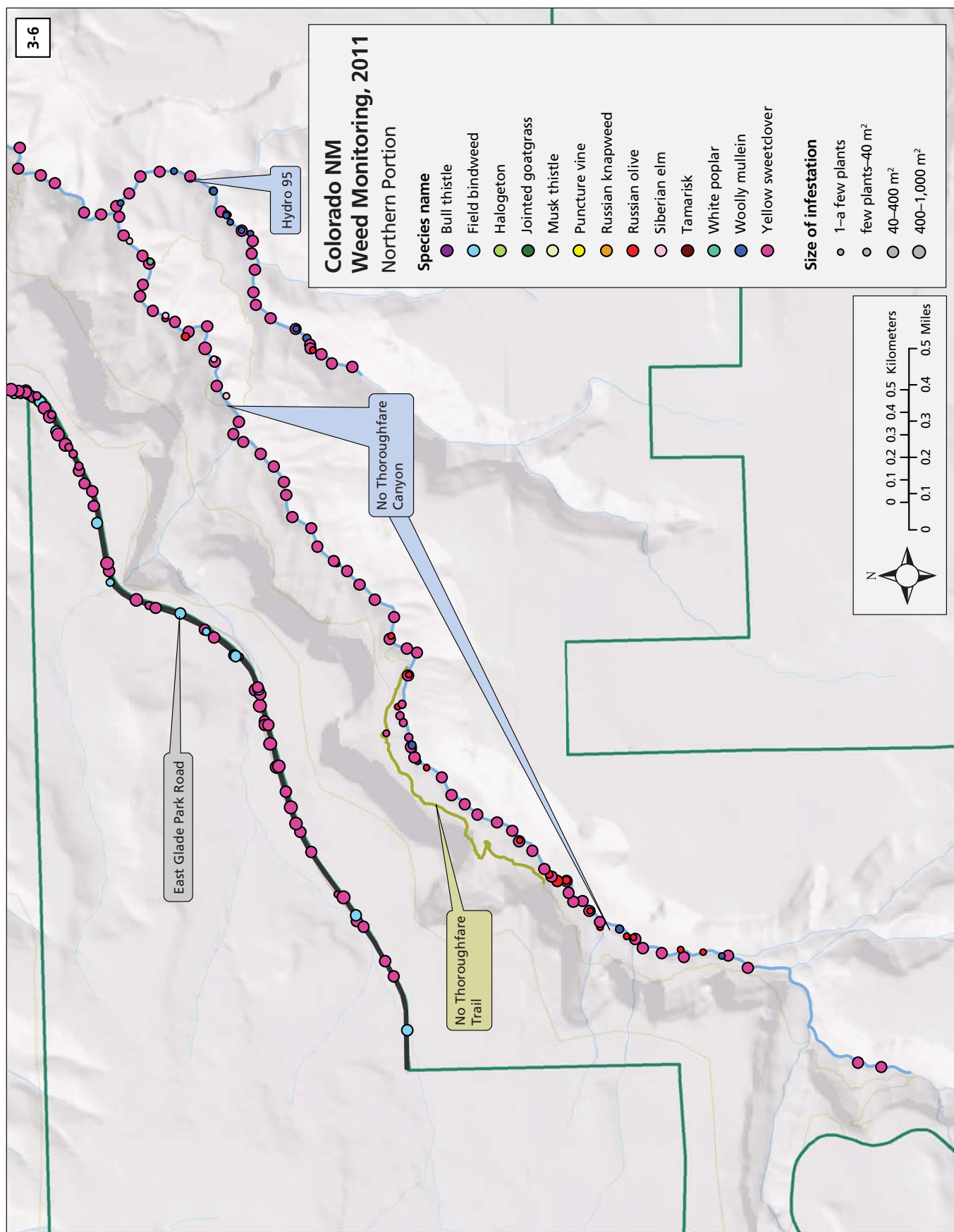


Figure 3-6. Invasive plants detected on monitoring routes and transects in the southern portion of Colorado NM, June 22–August 21, 2011.

Table 3-4. Total number of transects per route, number of transects where exotic plant species were detected, mean percent cover, and standard error by sampling area (management unit or monitoring route), Colorado NM, June 22–August 21, 2011.

Route	Scientific name	Common name	# of transects		Percent cover	SE
			Total	# with IEPs		
Riparian						
Columbus Canyon	<i>Anisantha tectorum</i>	cheatgrass	4	2	0.08	0.05
Fruita Canyon	<i>Anisantha tectorum</i>	cheatgrass	4	4	11.17	7.41
	<i>Orthoceras</i> spp.	bur buttercup	4	3	0.54	0.38
	<i>Bromus inermis</i>	smooth brome	4	3	0.25	0.14
Gold Star Canyon	<i>Anisantha tectorum</i>	cheatgrass	4	4	0.79	0.23
Hydro 3	<i>Anisantha tectorum</i>	cheatgrass	1	1	0.17	0.17
Kodel's Canyon	<i>Anisantha tectorum</i>	cheatgrass	1	1	0.67	0.67
Lizard Canyon	<i>Anisantha tectorum</i>	cheatgrass	3	3	1.67	1.02
Monument Canyon	<i>Anisantha tectorum</i>	cheatgrass	19	15	0.84	0.41
	<i>Bromus inermis</i>	smooth brome	19	5	0.29	0.18
	<i>Alyssum desertorum</i>	desert madwort	19	6	0.19	0.11
	<i>Melilotus officinale</i>	yellow sweetclover	19	3	0.04	0.02
	<i>Tragopogon dubius</i>	yellow salsify	19	1	0.01	0.01
No Thoroughfare Canyon	<i>Anisantha tectorum</i>	cheatgrass	26	20	0.37	0.13
	<i>Melilotus officinale</i>	yellow sweetclover	26	15	0.21	0.09
	<i>Agropyron cristatum</i>	crested wheatgrass	26	4	0.10	0.06
	<i>Bromus inermis</i>	smooth brome	26	3	0.07	0.05
	<i>Salsola australis</i>	Russian thistle	26	1	0.02	0.02
	<i>Alyssum desertorum</i>	desert madwort	26	1	0.01	0.01
	<i>Verbascum thapsus</i>	woolly mullein	26	1	0.01	0.01
Red Canyon	<i>Anisantha tectorum</i>	cheatgrass	8	5	0.92	0.40
	<i>Melilotus officinale</i>	yellow sweetclover	8	1	0.17	0.17
Ute Canyon	<i>Alyssum desertorum</i>	desert madwort	14	11	2.05	1.27
	<i>Anisantha tectorum</i>	cheatgrass	14	6	1.36	1.22
	<i>Melilotus officinale</i>	yellow sweetclover	14	5	0.21	0.11
	<i>Agropyron cristatum</i>	crested wheatgrass	14	2	0.17	0.14
	<i>Bromus inermis</i>	smooth brome	14	2	0.14	0.10
	<i>Tragopogon dubius</i>	yellow salsify	14	1	0.01	0.01
	<i>Erodium cicutarium</i>	stork's bill	14	1	0.01	0.01
Wedding Canyon	<i>Anisantha tectorum</i>	cheatgrass	9	8	1.37	0.47
	<i>Bromus inermis</i>	smooth brome	9	5	0.19	0.09
	<i>Alyssum desertorum</i>	desert madwort	9	2	0.13	0.11

Table 3-4. Total number of transects per route, number of transects where exotic plant species were detected, mean percent cover, and standard error by sampling area (management unit or monitoring route), Colorado NM, June 22–August 21, 2011, cont.

			# of transects			
Route	Scientific name	Common name	Total	# with IEPs	Percent cover	SE
Roads						
East Glade Park Road	<i>Bassia sieversiana</i>	summer cypress	16	7	1.86	0.99
	<i>Bromus inermis</i>	smooth brome	16	4	1.83	0.97
	<i>Anisantha tectorum</i>	cheatgrass	16	7	0.94	0.58
	<i>Agropyron cristatum</i>	crested wheatgrass	16	1	0.42	0.42
	<i>Salsola australis</i>	Russian thistle	16	1	0.04	0.04
	<i>Melilotus officinale</i>	yellow sweetclover	16	2	0.03	0.03
	<i>Convolvulus arvensis</i>	field bindweed	16	1	0.02	0.02
Rim Rock South	<i>Anisantha tectorum</i>	cheatgrass	24	19	2.76	0.75
	<i>Alyssum desertorum</i>	desert madwort	24	2	0.10	0.09
	<i>Halogeton glomeratus</i>	halogeton	24	1	0.08	0.08
	<i>Melilotus officinale</i>	yellow sweetclover	24	2	0.06	0.04
	<i>Cylindropyrum cylindricum</i>	jointed goatgrass	24	1	0.04	0.04
Rim Rock Ute	<i>Anisantha tectorum</i>	cheatgrass	18	7	0.17	0.07
Trails						
No Thoroughfare Trail	<i>Anisantha tectorum</i>	cheatgrass	2	2	5.00	4.33
Kodel's Canyon Trail	<i>Anisantha tectorum</i>	cheatgrass	2	2	0.50	0.01

Table 3-5. Total number of monitoring transects per route number of transects where priority exotic plant species were detected, mean percent cover, and standard error by sampling type of monitoring route at Colorado NM from June 22–August 21, 2011.

Transect type	Trail			Road			Riparian			All		
	Total	# with IEPs	Percent cover (SE)	Total	# with IEPs	Percent cover (SE)	Total	# with IEPs	Percent cover (SE)	Total	# with IEPs	Percent cover (SE)
Cheatgrass	4	4	2.75 (2.53)	58	33	1.45 (0.38)	93	69	1.30 (0.41)	155	106	1.39 (0.29)
Field bindweed	4	0	0.00 (0.00)	58	1	0.01 (0.01)	93	0	0.00 (0.00)	155	1	<0.01
Jointed goatgrass	4	0	0.00 (0.00)	58	1	0.02 (0.02)	93	0	0.00 (0.00)	155	1	<0.01
Yellow sweetclover	4	0	0.00 (0.00)	58	4	0.03 (0.02)	93	24	0.13 (0.04)	155	28	0.09 (0.02)
Woolly mullein	4	0	0.00 (0.00)	58	0	0.00 (0.00)	93	1	0.002 (0.002)	155	1	<0.01
Total priority species	4	4	2.75 (2.53)	58	37	1.51 (0.38)	93	83	1.42 (0.41)	155	124	1.49 (0.29)

Table 3-6. Number of infestations of field bindweed, Russian olive, tamarisk, woolly mullein, and other invasive exotics detected in areas that were surveyed in 2003, 2009, and 2011.

Route	Field bindweed			Russian olive			Tamarisk			Woolly mullein			Others ¹			Total		
	2003	2009	2011	2003	2009	2011	2003	2009	2011	2003	2009	2011	2003	2009	2011	2003	2009	2011
Routes surveyed in all three years																		
Gold Star Canyon	0	0	1	0	2	0	6	4	1	0	0	0	-	1	0	6	7	2
Monument Canyon	1	2	4	1	9	21	33	11	9	0	0	0	-	4	3	35	26	37
No Thoroughfare Cyn ²	1	1	1	2	14	19	17	8	8	0	11	4	-	5	8	20	39	40
Ute Canyon	3	0	0	6	4	4	37	8	0	5	4	1	-	10	4	51	26	9
<i>subtotal</i>	<i>5</i>	<i>3</i>	<i>6</i>	<i>9</i>	<i>29</i>	<i>44</i>	<i>93</i>	<i>31</i>	<i>18</i>	<i>5</i>	<i>15</i>	<i>5</i>	<i>-</i>	<i>20</i>	<i>15</i>	<i>112</i>	<i>98</i>	<i>88</i>
Routes surveyed only in 2009 and 2011																		
Columbus Canyon	-	0	0	-	0	0	-	0	2	-	0	0	-	0	0	-	0	2
Kodel's Canyon	-	0	0	-	1	0	-	0	1	-	0	0	-	4	0	-	5	1
Red Canyon	-	3	0	-	0	1	-	0	4	-	4	1	-	4	3	-	11	9
Wedding Canyon ²	-	0	0	-	0	0	-	7	0	-	0	0	-	0	0	-	7	0
East Glade Park Rd	-	2	15	-	0	0	-	0	0	-	0	0	-	1	1	-	3	16
Rim Rock South	-	14	28	-	0	3	-	0	0	-	0	0	-	8	2	-	22	33
<i>subtotal</i>	<i>-</i>	<i>19</i>	<i>43</i>	<i>-</i>	<i>1</i>	<i>4</i>	<i>-</i>	<i>7</i>	<i>7</i>	<i>-</i>	<i>4</i>	<i>1</i>	<i>-</i>	<i>17</i>	<i>6</i>	<i>-</i>	<i>48</i>	<i>61</i>
Totals, 2009–2011	-	22	49	-	30	48	-	38	25	-	19	6	-	37	21	-	146	149

¹others (broad-leaf pepperwort, bull thistle, Canada thistle, musk thistle, puncture vine, Russian knapweed, Siberian elm, and yellow starthistle)²Although tributaries to these canyons were added in 2011, only areas that were surveyed in both 2009 and 2011 were compared in this table. Thus total infestations for Wedding and No Thoroughfare Canyons are not equal to those found in Tables 3-2 and 3-4.

4 Discussion

4.1 Priority 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. At this time, the network has no recommendations for additions or deletions to the current priority list. Presence and absence data for most priority species, and presence data for other species, should be reliable; however, absence data for non-priority species are suspect, because not all observers recorded all of these species.

4.2 Possibilities for management control

Priority invasive exotic plants were most widespread along riparian and road areas. Almost no priority IEPs were recorded along trails. Areas targeted for control should start with East Glade Park Road, No Thoroughfare Canyon, Rim Rock South and Ute Canyon. The increase in Russian olive is a concern and should be addressed before these infestations become more widespread.

There were far 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, COLM 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 through the park.

Excluding yellow sweetclover, it is encouraging that 88% of infestations by priority species detected on monitoring routes were less than 40 m² in size, indicating that rapid control of these infestations may limit their expansion. However, 81% of yellow sweetclover infestations were larger than 40 m². Of areas that were surveyed in both 2009 and 2011, 92% (61 of 66 trees) of the invasive tree infestations for which growth stage was

noted were either in the seedling or sapling stage in 2009. This number had decreased to 75% (60 of 80 trees) in 2011, indicating that some invasive trees have grown beyond the size that can be handled without chainsaws. The still relatively small percentage of mature trees is likely due to extensive previous eradication efforts by COLM staff and volunteers. Continued control efforts should be made before more seedlings and saplings grow into mature trees.

It is likely that the decrease in tamarisk infestations is the result of efforts by volunteers to control this species. A total of 132 volunteer hours were spent on tamarisk control in 2011 alone. These efforts have focused on tamarisk but will expand to Russian olive in the near future. The wet spring of 2011 may have contributed to the increases seen from 2009 to 2011 in cheatgrass (on transects) and field bindweed (along monitoring routes). Whereas cheatgrass was found in just 1 of 169 quadrats in 2009, with percent cover of <1%, it was found on 106 of 155 transects in 2011, with percent cover of more than 1%.

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 Tables 3-4 and 3-5) 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.

4.3 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 2013, 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 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 submitted for peer review in December 2010.

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Appendix A. Priority invasive plant list, Colorado National Monument

Scientific name	Common name
<i>Acosta diffusa</i>	diffuse knapweed
<i>Acosta maculosa</i>	spotted knapweed
<i>Acroptilon repens</i>	Russian knapweed
<i>Arctium minus</i>	burdock
<i>Breea arvensis</i>	Canada thistle
<i>Cardaria draba</i>	hoary cress
<i>Cardaria latifolia</i>	broad-leaf pepperwort
<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>Cylindropyrum cylindricum</i>	jointed goatgrass
<i>Elaeagnus angustifolia</i>	Russian olive
<i>Isatis tintoria</i>	Dyer's woad
<i>Linaria vulgaris</i>	butter-and-eggs
<i>Lythrum salicaria</i>	purple loosestrife
<i>Melilotus officinale</i>	yellow sweetclover
<i>Onopordum acanthium</i>	Scotch thistle
<i>Tamarix ramosissima</i>	five-stamen tamarisk
<i>Tithymalus esula</i>	leafy spurge
<i>Tribulus terrestris</i>	puncturevine
<i>Ulmus pumila</i>	Siberian elm
<i>Verbascum thapsus</i>	woolly mullein

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