



Invasive Exotic Plant Monitoring along Highway 24 in Capitol Reef National Park

Field Season 2013

Natural Resource Technical Report NPS/NCPN/NRTR—2014/889



ON THE COVER

Russian olive and tamarisk along the Fremont River, Capitol Reef National Park. NPS photo.

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Prepared by

Dustin W. Perkins
Northern Colorado Plateau Network
National Park Service
P.O. Box 848
Moab, UT 84532

Gary Lenhart
Capitol Reef National Park
HC 70 Box 15
Torrey, UT 84775

Editing and Design

Alice Wondrak Biel
Northern Colorado Plateau Network
National Park Service
P.O. Box 848
Moab, UT 84532

July 2014

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

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Please cite this publication as:

Perkins, D., and G. Lenhart. 2014. Invasive exotic plant monitoring along Highway 24 in Capitol Reef National Park: field season 2013. Natural Resource Technical Report NPS/NCPN/NRTR—2014/889. National Park Service, Fort Collins, Colorado.

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Abstract

Invasive exotic plant (IEP) species are a significant threat to natural ecosystem integrity and biodiversity, and controlling IEPs 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. In conjunction with park staff, NCPN created a target list of priority IEPs for early detection. During surveys conducted on August 12–28, 2013, Capitol Reef National Park staff detected four priority IEP species on monitoring routes and three priority IEP species in transects along 50 kilometers of Highway 24. An additional five non-priority IEP species were recorded consistently in transects. Tamarisk (*Tamarix* spp.) and Russian olive (*Elaeagnus angustifolia*) were the most common (245 and 24 infestations, respectively) IEPs detected along monitoring routes, and these two species represented 97% of all infestations detected. Russian thistle (*Salsola tragus*) is not a priority IEP species but was consistently recorded in transects and was widespread—present in 35% of the 102 transects sampled. Tamarisk had the highest percent cover, based on transects, at 2.4%. The number of tamarisk infestations mapped along monitoring routes and percent cover of tamarisk in monitoring transects in 2013 declined from 2009–2010. However, that decline in number may not represent a decrease in area, as the number of infestations larger than 400 m² increased substantially. This increase could indicate that smaller infestations joined together into large infestations. Tree-of-heaven (*Ailanthus altissima*), field bindweed (*Convolvulus arvensis*), and asparagus (*Asparagus officinalis*) infestations decreased considerably between both the 2003–2005 surveys and the more recent time periods of 2009–2010 and 2013. After 71 tree-of-heaven infestations were found in 2003–2005 and 2 in 2009–2010, no infestations were found in 2013.

Acknowledgements

A. Wight was extremely helpful in generating routes, transects, and other GIS information. D. Worthington and S. Borthwick assisted with reviewing the park's target invasive plant list, arranging site logistics, and providing land-use history of the site. R. Weissinger, T. Fisk, and S. Borthwick improved this report with their thoughtful review. Data management was provided by H. Thomas. D. Perry assisted with administrative and logistical details.

1 Introduction

Invasive exotic species fragment native ecosystems, displace native plants and animals, and alter ecosystem function. Invasive species are second only to habitat loss as threats to global biodiversity (Scott and Wilcove 1998) and represent one of the most serious threats to natural ecosystem integrity (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 (Loope 1992). 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 2013 field season at Capitol Reef National Park (NP).

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

We 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).

2.1 Developing a park target invasive exotic plant list

Prior to beginning monitoring in 2013, NCPN and Capitol Reef NP staff reviewed the park’s list of high-priority target IEPs (Table 2-1), initially created in 2009. 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 are designed to be rapid, field crews are trained to develop a focused search image on the target plants, instead of looking for every possible invasive plant species. The likelihood of eradicating these target species, or containing them within a park, is generally high. The list of priority species is reviewed before each field season with a few minor changes from year to year.

2.2 Monitoring routes

2.2.1 Minimum detection target size

The minimum detection target size (MDTS) represents the patch size that is large enough to be detected with a high level of confidence (typically at least 90% of the total number of patches of that size and larger in the monitoring area) under actual field conditions, but small enough 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 are not expected to find every single plant of every targeted IEP species during route surveys. Searching for single mature plants of some species, such as Russian olive (*Elaeagnus angustifolia*) and tamarisk (*Tamarix* spp.), 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) is 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 (Figure 2-1). Using fake plants of a targeted

Table 2-1. Priority invasive plant list, Capitol Reef National Park, 2009–2013.

Scientific name	Common name
<i>Ailanthus altissima</i>	tree-of-heaven
<i>Arctium minus</i>	burdock
<i>Asparagus officinalis</i>	asparagus
<i>Cardaria draba</i>	hoary cress
<i>Carduus nutans</i>	musk thistle
<i>Centaurea diffusa</i>	diffuse knapweed
<i>Centaurea maculosa</i>	spotted knapweed
<i>Centaurea repens</i>	Russian knapweed
<i>Cirsium arvense</i>	Canada thistle
<i>Cirsium vulgare</i>	bull thistle
<i>Convolvulus arvensis</i>	field bindweed
<i>Cynoglossum officinale</i> ¹	common hounds-tongue
<i>Elaeagnus angustifolia</i>	Russian olive
<i>Elymus repens</i>	quackgrass
<i>Euphorbia esula</i>	leafy spurge
<i>Hyoscyamus niger</i> ¹	black henbane
<i>Isatis tinctoria</i>	Dyer’s woad
<i>Lythrum salicaria</i>	purple loosestrife
<i>Malcolmia africana</i> ²	African mustard
<i>Marrubium vulgare</i>	horehound
<i>Onopordum acanthium</i>	Scotch thistle
<i>Tamarix</i> spp.	tamarisk
<i>Ulmus pumila</i>	Siberian elm
<i>Verbascum thapsus</i>	woolly mullein
<i>Carduus acanthoides</i> ³	plumeless thistle
<i>Medicago sativa</i> ³	alfalfa

¹ Added in 2012; ²2012–2013 only; ³2009–2011 only

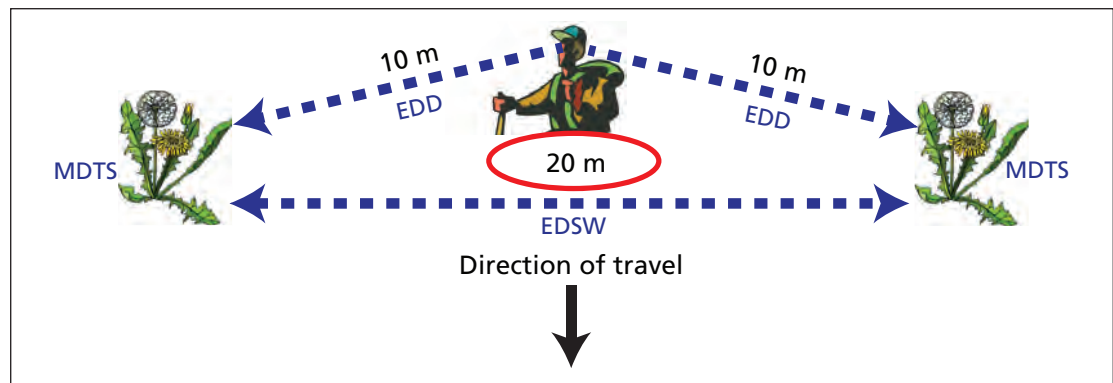


Figure 2-1. The maximum effective detection distance (EDD) at Capitol Reef National Park was 10 meters, making the effective detection swath width (EDSW) 20 meters.

size, crew members are trained by walking away and determining the maximum distance from which they can consistently see and recognize the patch with complete confidence. The size of the EDD is then estimated in the field by crew members. The distance is measured either by pacing or using a laser rangefinder. The EDD for Capitol Reef NP in 2013 was 10 m.

2.2.3 Effective detection swath width

Effective detection swath width (EDSW) is defined as the maximum width of a linear search swath (band transect) in which a walking observer is confident of visually detecting 90% of all target species of the MDTs (Figure 2-1). The 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 was 20 m at Capitol Reef NP in 2013.

2.2.4 Patch separation resolution

We define patch separation resolution (PSR) as the minimum distance between plants that must be considered members of separate patches or infestations. Individuals or clusters of a target species separated by the PSR distance or more are recorded as separate patches. We consider plants separated by less than the PSR to be a single patch or infestation. The PSR is set at 50 m, based on the assumption that most plants or groups of plants separated by less than 50 m are typically considered to be one infestation during planning and implementation of weed-control operations. If an infestation is continuous for more than 50 m, then cover estimates

are made every 50 m to aid in developing an effective management strategy for the entire infestation.

2.2.5 Between feature position

Between feature positions allow electronic tracking of a user's route. A GPS unit is set to automatically generate these positions at a distance equal to the EDSW. Each time a surveyor walks the equivalent of one EDSW, the GPS unit creates a point.

2.2.6 Data collection methods

We have established a four-year rotation of monitoring routes at Capitol Reef NP that covers Highway 24, Pleasant Creek cattle trails, Oak Creek cattle trails, and the Cathedral monitoring route (Table 2-2, Figure 2-2). In 2013, the first round of re-visits began.

Table 2-2. Planned monitoring revisit design for invasive plant monitoring at Capitol Reef National Park.

Year	Monitoring route
2009	Highway 24/Fremont Corridor
2010	Pleasant Creek
2011	Oak Creek
2012	Cathedral
2013	Highway 24/Fremont Corridor
2014	Pleasant Creek
2015	Oak Creek
2016	Cathedral
2017	Highway 24/Fremont Corridor
2018	Pleasant Creek
2019	Oak Creek
2020	Cathedral

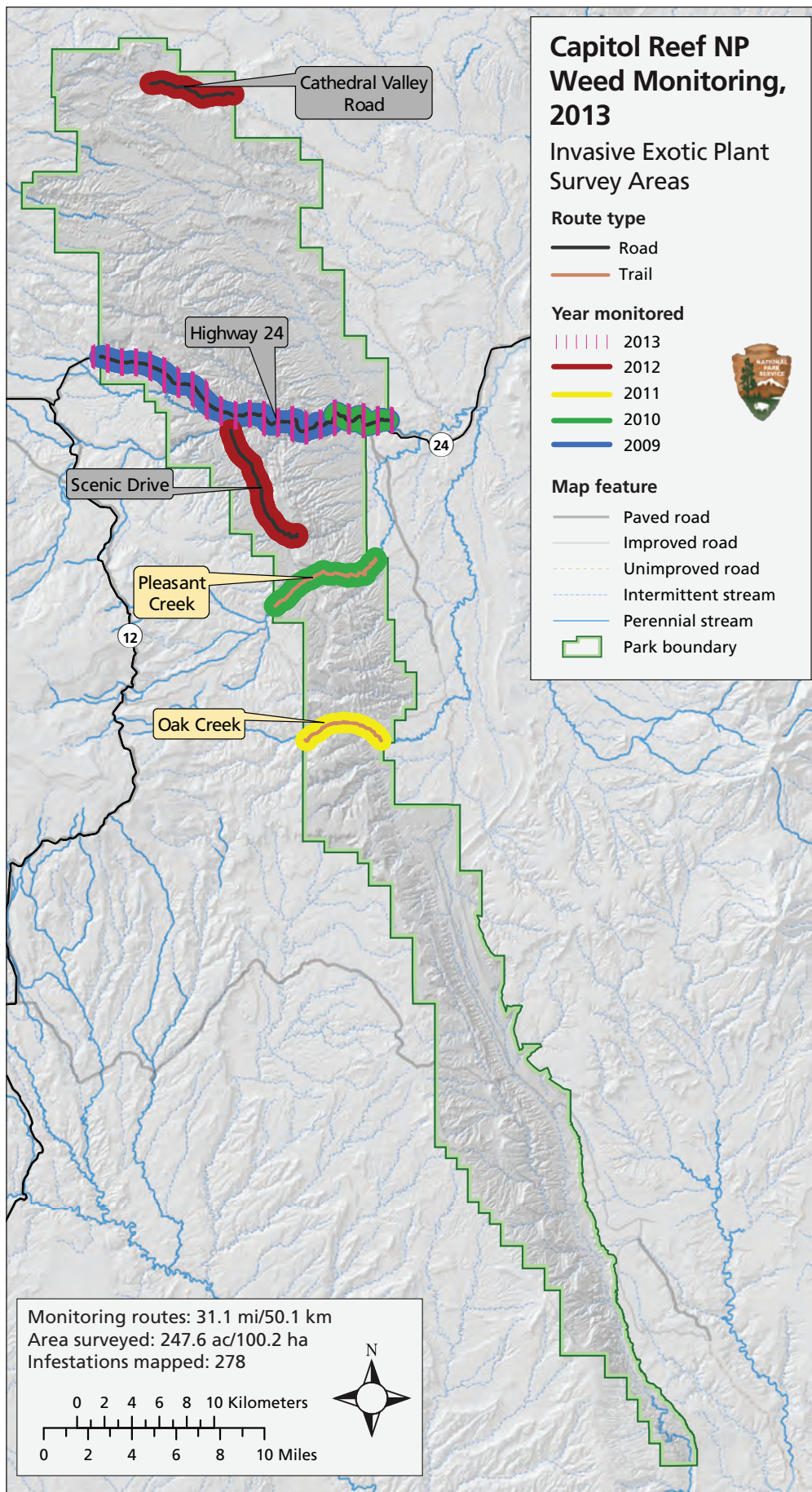


Figure 2-2. Overview of invasive exotic plant monitoring routes and extra areas surveyed at Capitol Reef National Park, 2009–2013.

Along Highway 24, the observer walks out on one side of the road and walks back on the other. For all other routes, the observer walks down the center of the trail/route.

While walking, we searched for IEPs by visually scanning (side-to-side) all of the land within the borders of the swath. However, if the terrain was uneven or steep, and the observer had to glance frequently at the ground to ensure safe foot placement, then searchers stopped approximately every 40 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 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 IEPs were present with similar distributions at a single point, then we recorded a point for each individual species and assigned it its own sequential identification number. Invasions more than 50 m (55 yards) apart were considered separate invasions and recorded with separate points. Infestation size class was estimated as follows:

1. 1–a few plants (used for isolated single plants or very small patches ($\leq 2 \times 2$ m),
2. few plants–40 m² (48 yd²),
3. 40–400 m² (48–478 yd²),
4. 400–1,000 m² (0.1–0.25 acre), and
5. 1,000–2,000 m² (0.25–0.5 acre).

We recorded canopy cover class by estimating the amount, or “percentage,” of ground covered by the vertical projection of plant matter as visualized from a bird’s-eye view of the vegetation (Elzinga et al. 1998). This estimate included both the living and dead standing material of the vegetation of a single plant species. 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 (e.g., 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 (see Figures 2-3, 2-4, 2-5). Our methods for sampling the monitoring quadrats were based on Stohlgren and others (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 being walked and on alternating sides for riparian areas, small roads, or trails. A 1-m² sampling frame, used to sample vegetation cover and soil surface features, was placed on the right side of the transect line as the technician walked the monitoring route. In some cases, we leveled the sampling frame by propping up quadrat corners. (In 2009, quadrats were placed at 1, 6, and 11 m away from the monitoring route.)

2.3.2 Data collection methods

In the monitoring quadrats, all IEP species known to the observer were recorded. At minimum, this included all priority species, as well as cheatgrass (*Bromus tectorum*), crested wheatgrass (*Agropyron cristatum*), and Russian thistle (*Salsola tragus*). 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%. We also recorded percent cover, to the nearest 10%, of dominant soil surface features (i.e., dead wood, dung, fungus, lichen, litter/duff, live root/bole, mineral soil/sediment, moss, biological soil crust, road, rock, standing water/flooded, stream, or trash/junk).

2.4 Analyses

We calculated the mean number of infestations per 100 m for monitoring routes. Percent cover estimates were generated from the monitoring quadrat data. We calculated the

mean and standard error of percent cover by species for monitoring quadrats. Due to differences in observers' knowledge, only priority species should be used when comparing results from year to year.

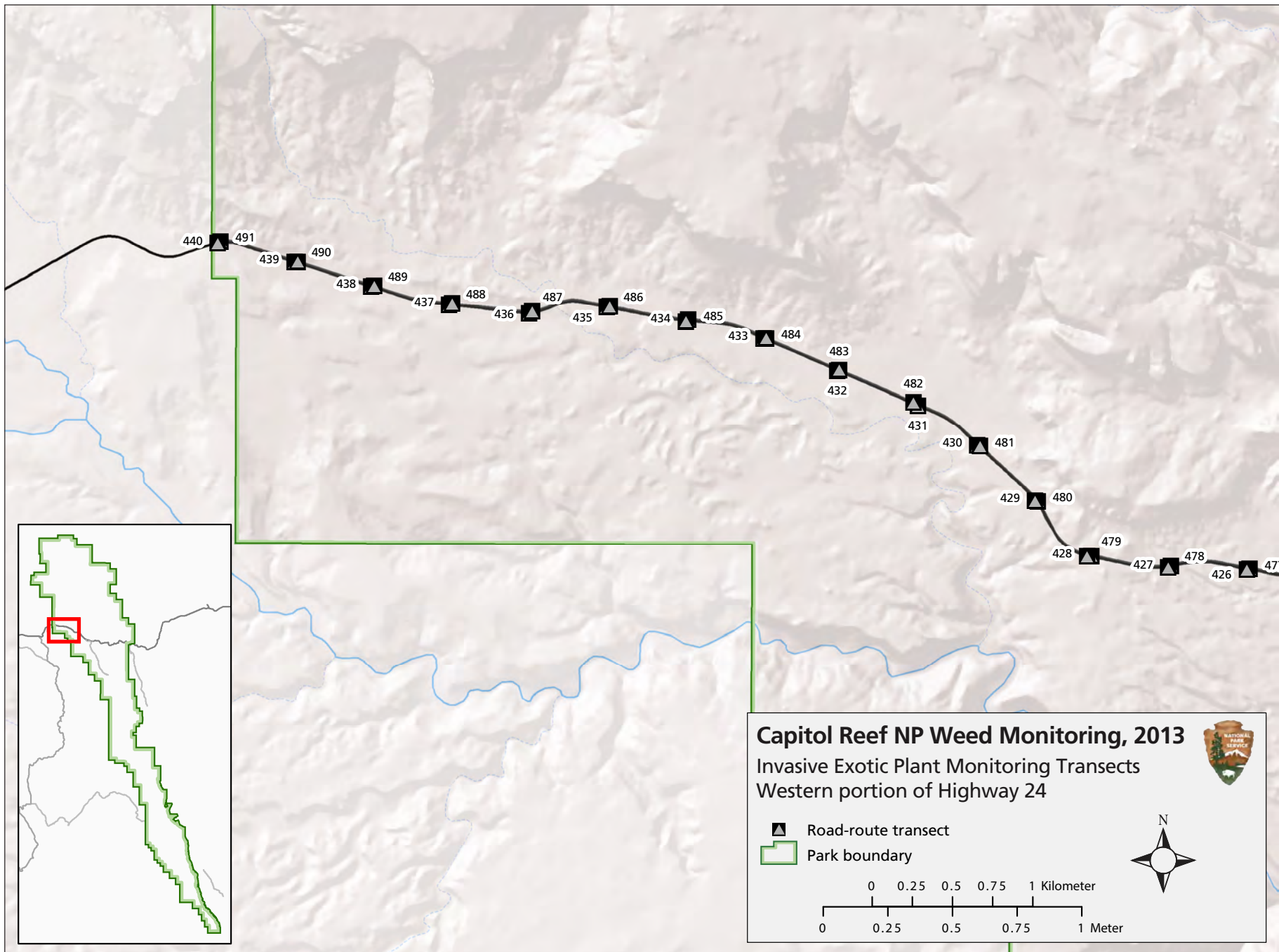


Figure 2-3. Monitoring routes and transects along the western portion of Highway 24, Capitol Reef NP, August 12–28, 2013.

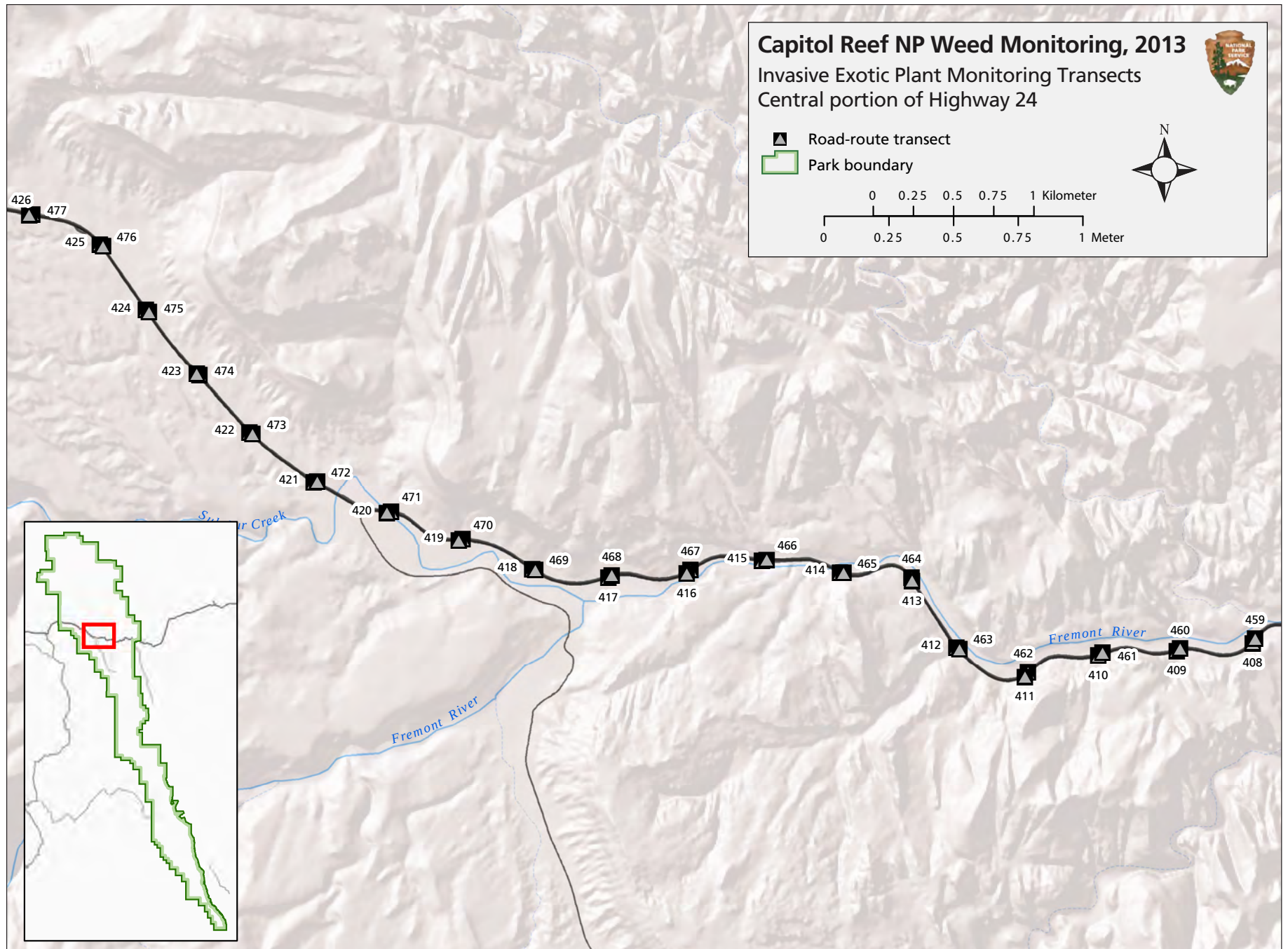


Figure 2-4. Monitoring routes and transects along the central portion of Highway 24, Capitol Reef NP, August 12–28, 2013.

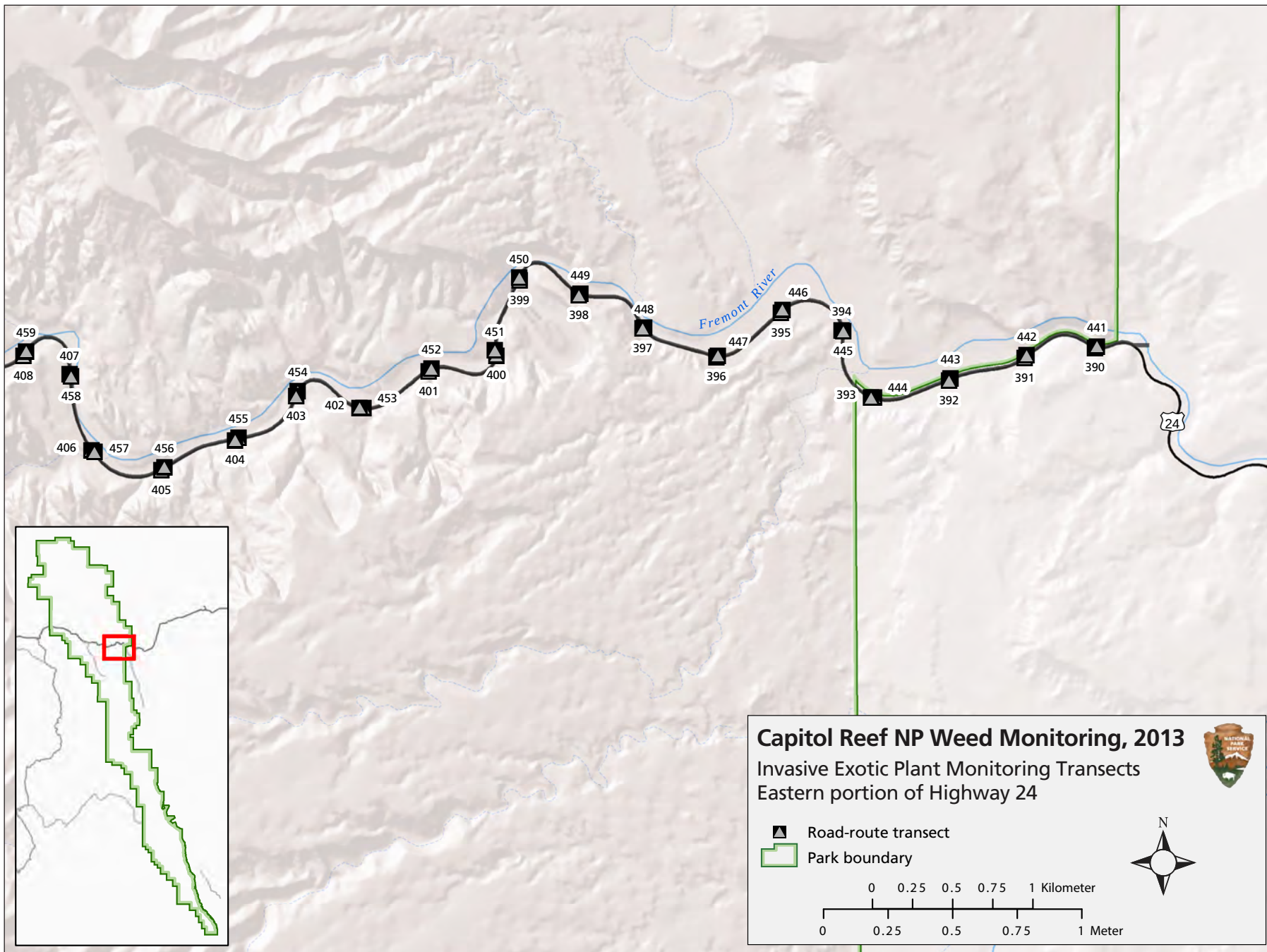


Figure 2-5. Monitoring routes and transects along the eastern portion of Highway 24, Capitol Reef NP, August 12–28, 2013.

3 Results

3.1 Target invasive exotic plant list

In 2013, field crews searched on monitoring routes for 24 species identified as high-priority at Capitol Reef NP (see Table 2-1). Observers were trained to recognize priority species but given the freedom to map additional species; therefore, presence and absence data for priority species are reliable for the areas searched, but absence data for other species are suspect.

We recorded a total of 10 IEP species on monitoring routes and transects in 2013. Four IEP species (all priority) were recorded on monitoring routes and eight species (three priority) were recorded on monitoring transects (Table 3-1). We covered 100.2 hectares (247.6 acres) along 50.1 km (31.1 miles) of monitoring routes in 2013.

3.2 Monitoring routes

We surveyed the entire Highway 24 corridor within the park in 2013. A total of 278 infestations of four different priority species were detected along the monitoring routes (Table 3-2; Figures 3-1 to 3-6; Electronic Appen-

dix A). We recorded infestations of tamarisk (245), Russian olive (24), field bindweed (8), and bull thistle (1). Bull thistle was not recorded along Highway 24 during the last monitoring cycle in 2009–2010. This resulted in 0.55 priority infestations per 100 m along Highway 24. Of the 269 tree infestations, 2 were in the seedling stage, 81 were in the sapling stage, 181 were mature trees, and growth stage was not noted for 5 infestations (see Electronic Appendix A). The eastern portion of Highway 24, where the Fremont River is adjacent to the highway, had more infestations than the western portion (see Figures 3-2 to 3-6).

3.3 Monitoring transects

A total of 102 transects were sampled in 2013 (Table 3-3; Electronic Appendix B). Two priority IEP species and eight additional IEP species were detected on transects. IEPs were found on 72% of transects, with an average of 1.09 IEP species detected per plot. Percent cover of these invasives along Highway 24 was 5.66%. Russian thistle was the most widespread species, present on 35% of transects, while tamarisk had the highest average percent cover, of 2.37%.

Table 3-1. Invasive exotic plants detected at Capitol Reef National Park, 2009–2013.

Scientific name	Common name	Method detected		Priority?
		Route	Transect	
<i>Ailanthus altissima</i>	tree-of-heaven	X		Yes
<i>Asparagus officinalis</i>	asparagus	X		Yes
<i>Cirsium vulgare</i>	bull thistle	X		Yes
<i>Convolvulus arvensis</i>	field bindweed	X		Yes
<i>Elaeagnus angustifolia</i>	Russian olive	X	X	Yes
<i>Medicago sativa</i>	alfalfa		X	Yes
<i>Tamarix</i> spp.	tamarisk	X	X	Yes
<i>Verbascum thapsus</i>	woolly mullein	X		Yes
<i>Agropyron cristatum</i>	crested wheatgrass		X	No
<i>Bromus tectorum</i>	cheatgrass		X	No
<i>Halogeton glomeratus</i>	halogeton		X	No
<i>Melilotus officinalis</i>	yellow sweet clover		X	No
<i>Portulaca oleracea</i>	common purslane		X	No
<i>Salsola tragus</i>	Russian thistle		X	No
<i>Tribulis terrestris</i>	puncturevine		X	No

Bold type indicates those species found in the 2013 monitoring efforts.

3.4 Results comparison: 2003–2005, 2009–2010, and 2013

From 2003 to 2005, Dewey and Anderson (2005a, b) surveyed the same sections of Highway 24 that the NCPN surveyed in 2009–2010 and 2013. However, in the 2003–2005 surveys, crews mapped infestations of tamarisk and Russian olive with a combination of points, lines, and polygons, whereas in 2009–2010 and 2013, the crew used points exclusively. Due to these differences in mapping methods, the number of infestations of tamarisk and Russian olive cannot be compared between the three time periods.

Tree-of-heaven (*Ailanthus altissima*), field bindweed (*Convolvulus arvensis*), and asparagus (*Asparagus officinalis*) infestations all decreased considerably between the

2003–2005 surveys and the more recent two time periods (Table 3-4). When comparing 2009–2010 to 2013 (when the methods were the same), Russian olive and tamarisk both had fewer infestations in 2013 than in 2009–2010. Total infestations declined from 0.76 infestations per 100 m in 2009–2010 (Perkins and Lenhart 2011) to 0.55 per 100 m in 2013. Percent cover also declined, from 8.42% in 2009–2010 to 5.66% in 2013, while the number of species per transect stayed the same (1.10 in 2009–2010, 1.09 in 2013). Of the 278 infestations, 49% were larger than 40 m² (Table 3-2) in 2013, compared to 50% in 2009–2010. However, the number of infestations larger than 400 m² increased from 21 (5% of infestations) in 2009–2010 to 78 in 2013 (28% of infestations).

Table 3-2. Number of infestations by species and infestation size class detected along the Highway 24 monitoring route, Capitol Reef NP, 2013 and 2009–2010.

Scientific name	Common name	Total infestations	Infestation size class				
			1	2	3	4	5
2013							
<i>Ailanthus altissima</i>	tree-of-heaven	0	0	0	0	0	0
<i>Asparagus officinalis</i>	asparagus	0	0	0	0	0	0
<i>Cirsium vulgare</i>	field bindweed	1	0	0	1	0	0
<i>Convolvulus arvensis</i>	Russian olive	8	3	5	0	0	0
<i>Elaeagnus angustifolia</i>	tamarisk	24	14	7	3	0	0
<i>Tamarix</i> spp.	woolly mullein	245	48	65	54	78	0
<i>Verbascum thapsus</i>	tree-of-heaven	0	0	0	0	0	0
Total 2013		278	65	77	58	78	0
2009–2010							
<i>Ailanthus altissima</i>	tree-of-heaven	2	2	0	0	0	0
<i>Asparagus officinalis</i>	asparagus	5	4	1	0	0	0
<i>Convolvulus arvensis</i>	field bindweed	2	2	0	0	0	0
<i>Elaeagnus angustifolia</i>	Russian olive	34	23	11	0	0	0
<i>Tamarix</i> spp.	tamarisk	341	60	87	173	21	0
<i>Verbascum thapsus</i>	woolly mullein	1	1	0	0	0	0
Total 2009–2010		385	92	99	173	21	0

Table 3-3. Number of monitoring transects where exotic plant species were detected, mean percent cover, and standard error by sampling area along the Highway 24 monitoring route, Capitol Reef NP, 2013 and 2009–2010.

Scientific name	Common name	2013		2009–2010	
		Detected (of 102)	Percent cover (SE)	Detected (of 50)	Percent cover (SE)
Priority species					
<i>Elaeagnus angustifolia</i>	Russian olive	1	0.33 (0.33)	0	0.00 (0.00)
<i>Medicago sativa</i> *	alfalfa	13	0.08 (0.03)	2	0.01 (0.01)
<i>Tamarisk</i> spp.	tamarisk	10	2.37 (0.92)	3	2.27 (1.49)
Non-priority species					
<i>Agropyron cristatum</i> *	crested wheatgrass	2	<0.01 (<0.01)	2	0.09 (0.07)
<i>Bromus tectorum</i> ^	cheatgrass	24	0.61 (0.22)	8	0.21 (0.14)
<i>Halogeton glomeratus</i> *	halogeton	6	0.03 (0.01)	5	0.14 (0.08)
<i>Melilotus officinalis</i> *	yellow sweetclover	19	0.13 (0.03)	5	0.70 (0.56)
<i>Portulaca oleracea</i> *	Little hogweed	0	0.00 (0.00)	1	0.02 (0.02)
<i>Salsola tragus</i> ^	Russian thistle	36	2.12 (0.63)	27	4.72 (1.42)
<i>Tribulus terrestris</i> *	puncturevine	0	0.00 (0.00)	2	0.26 (0.25)
All invasive species		73	5.66 (1.66)	36	8.42 (2.04)

*These species were consistently mapped in transects in 2011, 2012, and 2013, but may not have been in earlier years.

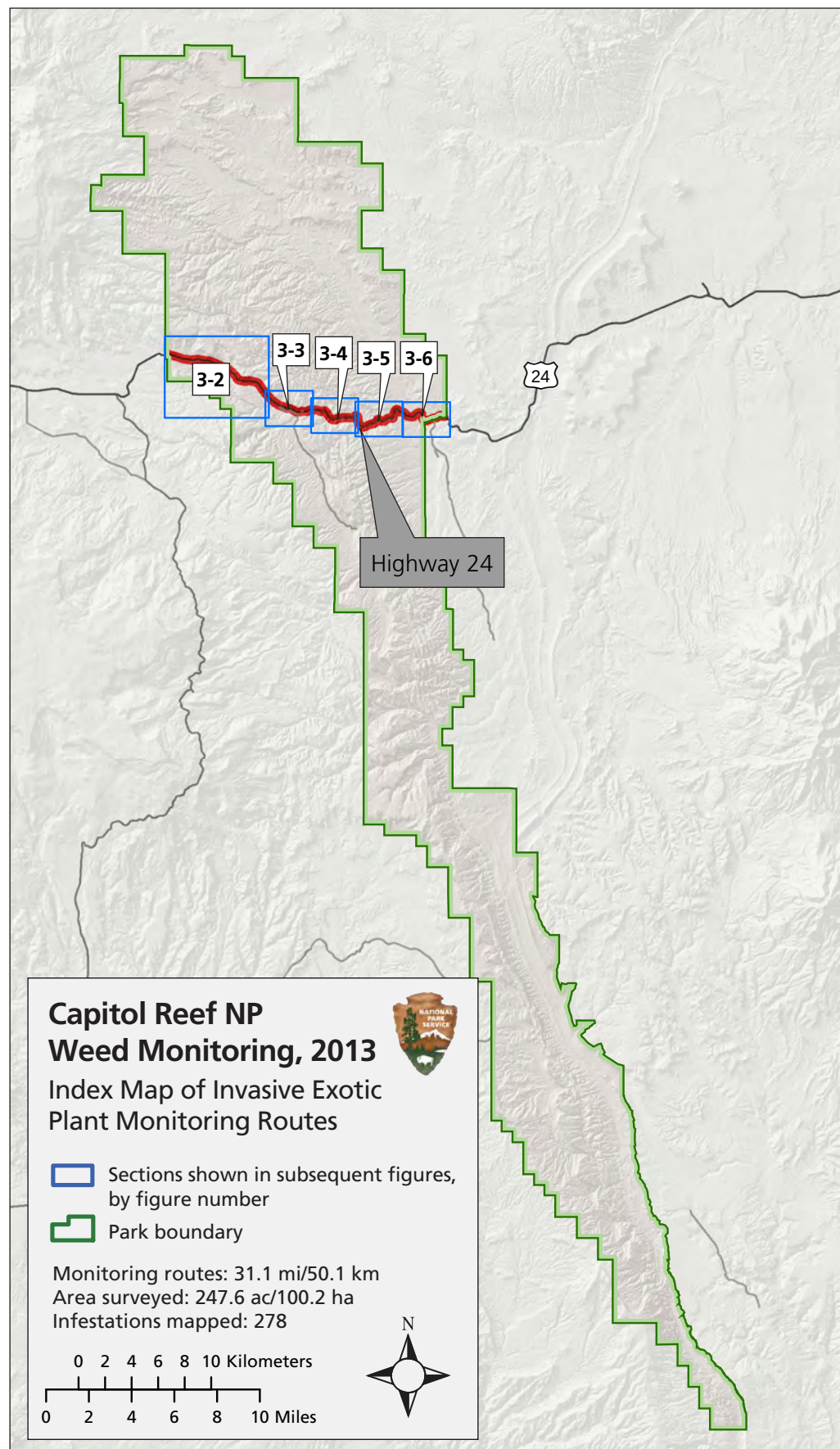
^Not on priority list, but species is consistently recorded in all transects.

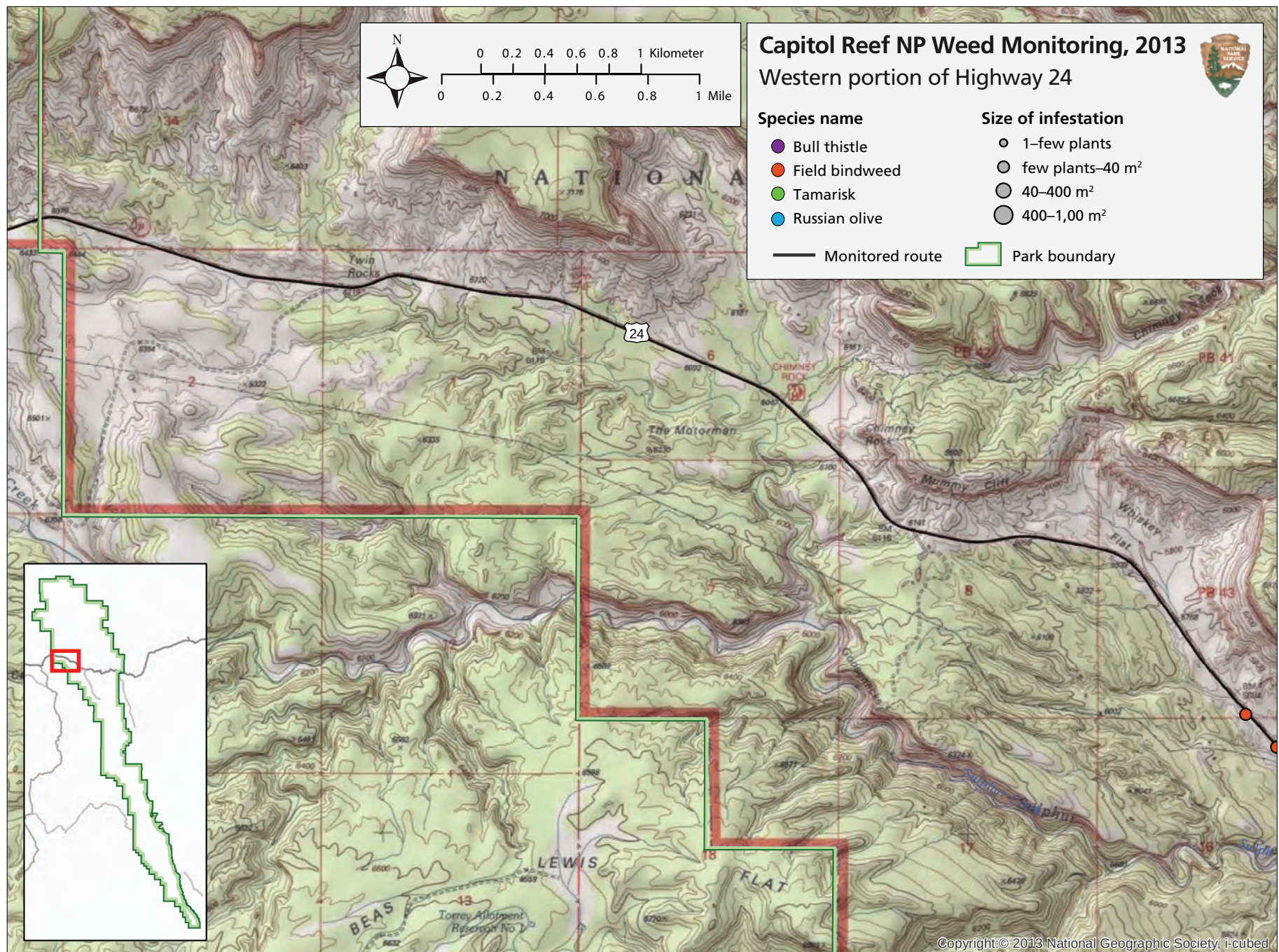
Table 3-4. Priority species observed and number of infestations detected along Highway 24, in Capitol Reef National Park, in 2003–2005, compared to data collected from 2009–2010 and 2013.

Scientific name	Common name	Number of infestations		
		2003–2005	2009–2010	2013
Consistent methodology				
<i>Ailanthus altissima</i>	tree-of-heaven	71	2	0
<i>Asparagus officinalis</i>	asparagus	5	5	0
<i>Centaurea repens</i>	Russian knapweed	5	0	0
<i>Cirsium vulgare</i>	bull thistle	4	0	1
<i>Verbascum thapsus</i>	woolly mullein	2	1	0
subtotal		87	8	1
Differing methodology*				
<i>Convolvulus arvensis</i>	field bindweed	NA	2	8
<i>Elaeagnus angustifolia</i>	Russian olive	NA	34	24
<i>Tamarix</i> spp.	tamarisk	NA	341	245
subtotal		NA	377	277
Totals		NA	385	278

*These species calculated separately due to differences in survey methodology in 2003–2005.

Figure 3-1. Index map of invasive exotic plant monitoring routes by figure number, Capitol Reef National Park, August 12–28, 2013.





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Figure 3-2. Invasive exotic plants detected on monitoring routes on the western portion of Highway 24 in Capitol Reef National Park, August 12–28, 2013.

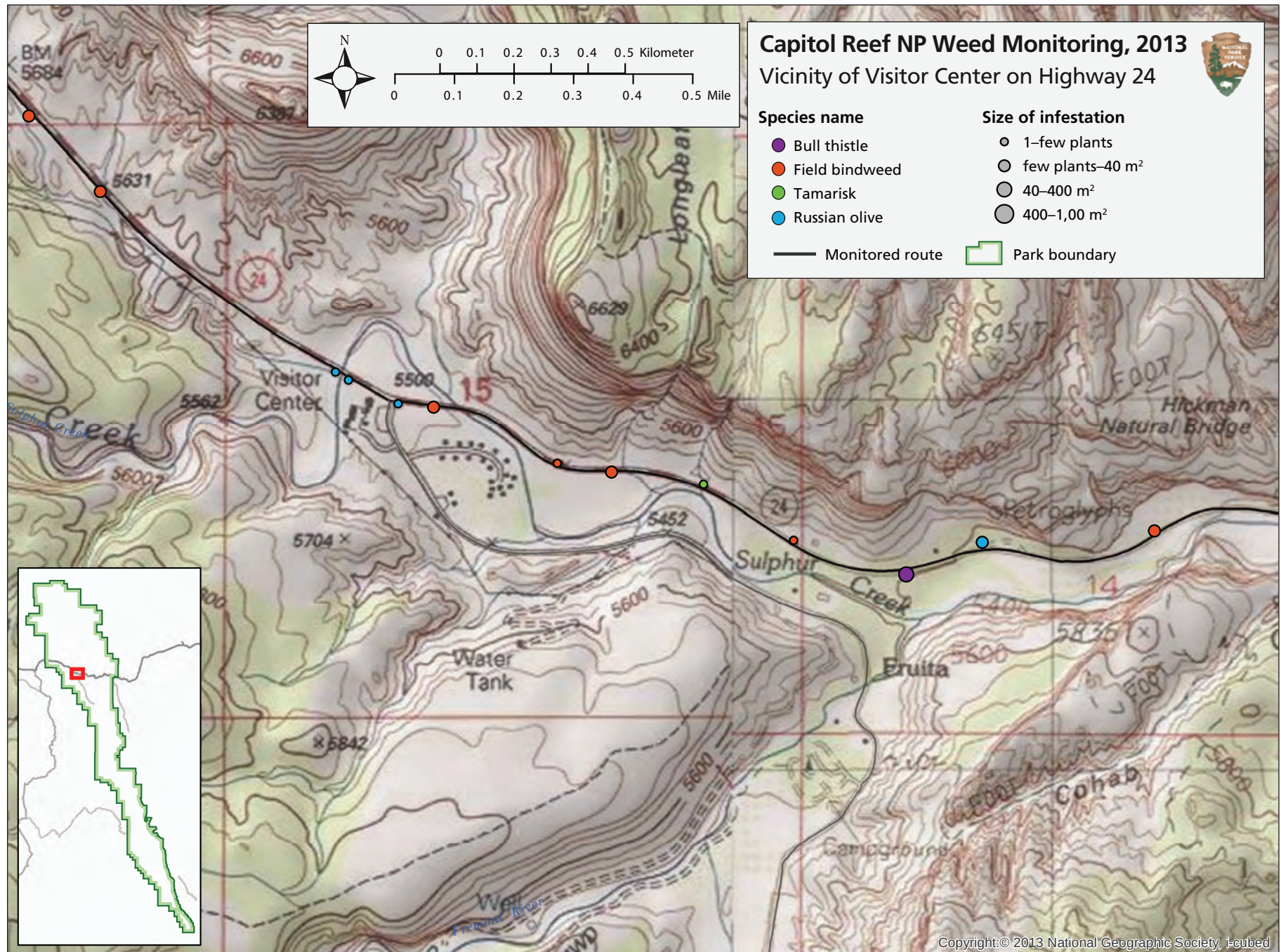


Figure 3-3. Invasive exotic plants detected on monitoring routes along Highway 24 in the vicinity of the visitor center in Capitol Reef National Park, August 12–28, 2013.

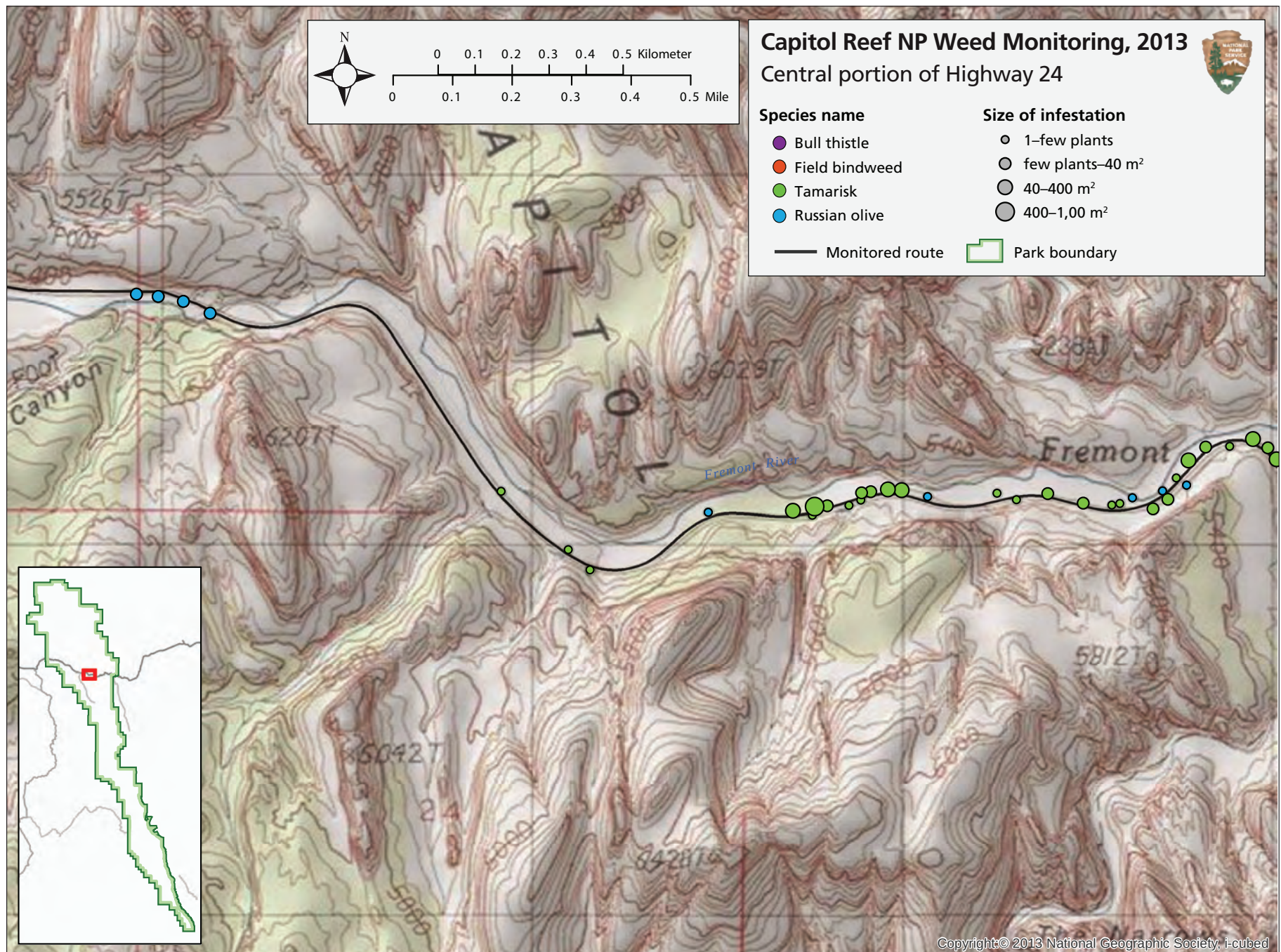


Figure 3-4. Invasive exotic plants detected on monitoring routes on the central portion of Highway 24 in Capitol Reef National Park, August 12–28, 2013.

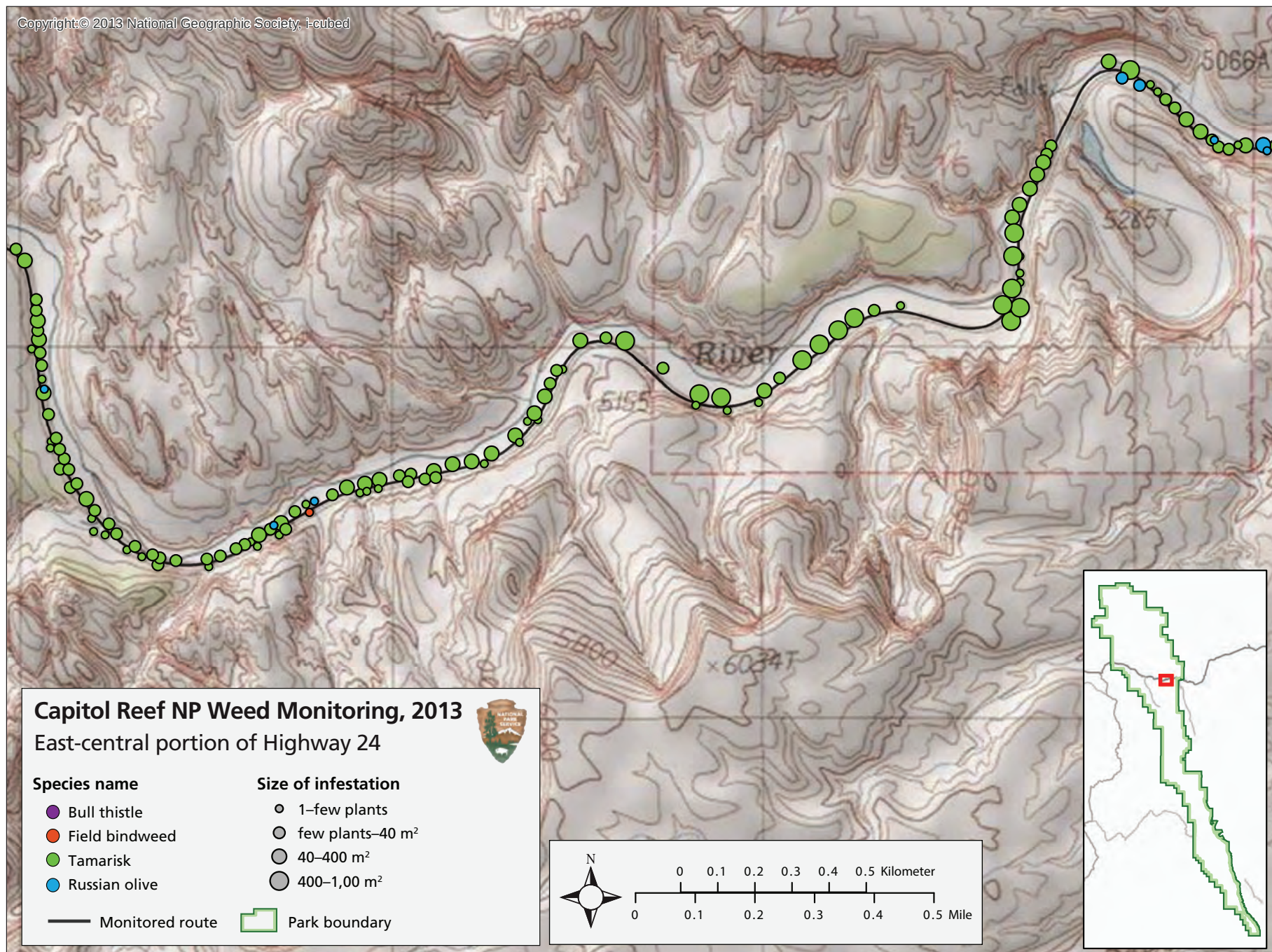


Figure 3-5. Invasive exotic plants detected on monitoring routes on the east-central portion of Highway 24 in Capitol Reef National Park, August 12-28, 2013.

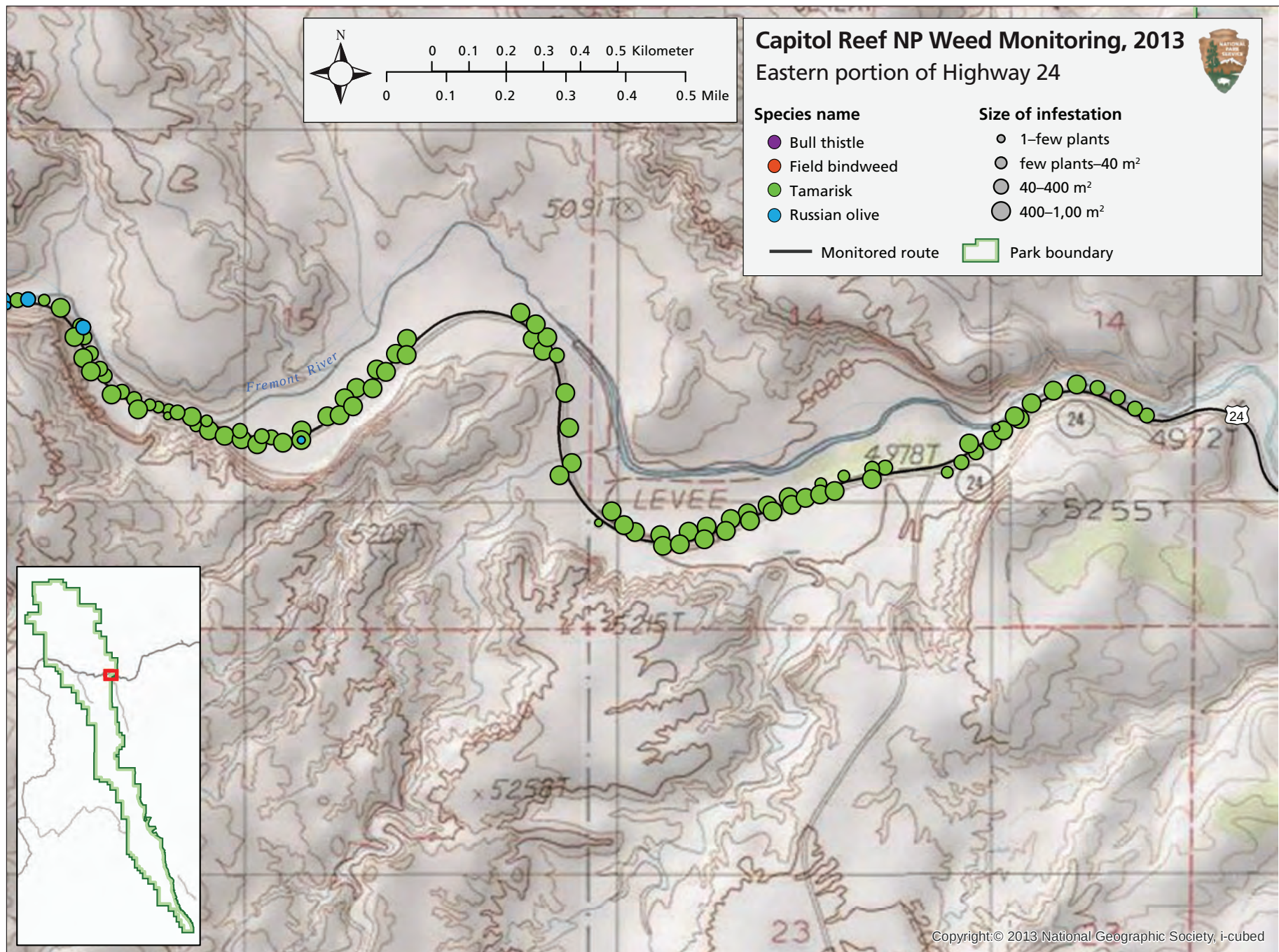


Figure 3-6. Invasive exotic plants detected on monitoring routes on the eastern portion of Highway 24 in Capitol Reef National Park, August 12–28, 2013.

4 Discussion

4.1 Priority IEP list

The NCPN will continue to work with park staff and area IEP experts to review and update the list of priority species each year. Presence and absence data for most priority species, and presence data for other species, should be reliable for the area surveyed; however, absence data for non-priority species are suspect, because not all observers recorded all of these species in all years. After a few small changes to the priority list over the last few years, there were no changes for 2013. Park staff has recommended removing African mustard (*Malcolmia africana*) in 2014, because it is widespread and likely beyond management control.

4.2 Possibilities for management control

The park has targeted tree-of-heaven and spotted knapweed for control efforts since the inventories in 2003–2005. Park staff estimate that they are close to eradicating tree-of-heaven from the park, and the monitoring along Highway 24 shows the results—from 71 infestations along Highway 24 in 2003–2005, to just two in 2009–2010 and zero in 2013 (see Table 3-4). Park staff only had to control one small patch of spotted knapweed and a few scattered tree-of-heaven trees between the two sampling periods. Russian knapweed (*Centaurea repens*) was found in 2003–2005 but was not detected in 2009–2010 or 2013. Bull thistle (*Cirsium vulgare*) was present in 2003–2005, absent in 2009–2010, and reappeared as one infestation in 2013, and should be targeted for control. Anecdotal evidence suggests that bull thistle infestations are increasing in the park, especially in the Fruita area and the Highway 24/Fremont River corridor.

While there were relatively few IEP species detected, a few were widespread, including tamarisk and Russian olive, which together made up 97% of all infestations detected along monitoring routes in 2013. Russian olive along Highway 24 continues to be a target of the Exotic Plant Management Team each year, which is likely the main factor in its infestations' having declined by 29% since 2009–2010. Russian thistle was not mapped, but is widespread along Highway 24, as shown by its presence in 35% of transects.

On maps from the 2003–2005 surveys, the entire river bottom consisted of infested polygons. Despite the work that has been completed since then, the majority of tamarisk infestations recorded during the most recent surveys were larger than 40 m². In addition, the number of infestations larger than 400 m² increased from 21 in 2009–2010 to 78 in 2013. While there were fewer infestations of tamarisk noted in 2013 than in 2009–2010, there may not be fewer hectares of tamarisk, as infestations could have grown into the larger size class by combining with other, smaller infestations. In addition, 73% of the infestations for which growth stage was noted were mature trees. The large size and maturity of the stands demonstrates tamarisk's widespread prevalence and the length of time the species has been present.

There has been little control work on tamarisk, and the overall distribution has not changed between the two time periods. Park staff is hoping that defoliation by the tamarisk beetle (*Diorhabda carinulata*) will make future control efforts easier. Continued monitoring will show the effects of both future control efforts and the tamarisk beetle as a biological control agent. The tamarisk beetle's presence was confirmed for the first time along the Fremont River in 2010 (G. Lenhart, pers. comm.). Mortality of tamarisk from the beetle has taken several years of defoliations at Dinosaur National Monument (NM); however, stem mortality can allow native species to colonize and compete with tamarisk stands (Williams 2013). Stem mortality at Dinosaur NM increased substantially in 2013, seven years after the first releases of tamarisk beetle.

It should be noted that estimates of percent cover in this report (see Table 3-4) 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 Capitol Reef NP will generally be monitored at the same time each year. Consistency in timing of monitoring should ensure consistency in detection probabilities and cover estimates of most species. For many species, sampling at any

time from May through September is not expected to drastically alter the chances of detecting invasive species at a level larger than the minimum detection target size. In 2014, the NCPN will revisit the Pleasant Creek monitoring route. We may also complete some extra-area surveys in locations yet to be determined. Because any previous detections could have been eradicated

by park staff, the locations of monitoring quadrats are re-generated 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 by monitoring route. The NCPN invasive plant monitoring protocol completed the peer review process was approved in September 2013.

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NPS 158/125006, July 2014

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