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Invasive Exotic Plant Monitoring in Capitol Reef National Park

Field Seasons 2009–2012

Natural Resource Technical Report NPS/NCPN/NRTR—2013/747



ON THE COVER

Surveying a transect for invasive exotic plants, Capitol Reef National Park. NPS photo.

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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 documents invasive plant infestations detected at Capitol Reef National Park during 2012. It also covers all work completed from 2009 to 2012, which represents the first full rotation of desired monitoring routes and presents a rotational panel for future monitoring. During surveys conducted from 2009 to 2012, Capitol Reef National Park staff detected 14 IEP species on monitoring routes and transects comprising 94 kilometers along Cathedral Valley Road, Highway 24, Pleasant Creek, Oak Creek, and the Scenic Drive. Tamarisk (*Tamarix* spp.), Russian olive (*Elaeangus angustifolia*), and alfalfa (*Medicago sativa*) were the most prevalent IEP species, together representing 98% of all infestations found along monitoring routes. While infestations were widespread, actual IEP percent cover was low on Cathedral Valley Road, the Scenic Drive, and Oak Creek. Control efforts appear to be working for tamarisk, tree-of-heaven (*Ailanthus altissima*), bull thistle (*Cirsium arvense*), and Russian knapweed (*Centaurea repens*), as all were found in lower levels in 2009–2012 than during earlier surveys conducted by Utah State University from 2003 to 2005.

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1 Introduction

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

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

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

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

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.

This report summarizes the 2012 field season in detail and covers all work from 2009 to 2012 which represents the first full rotation of desired monitoring routes at Capitol Reef National Park (NP).

2 Methods

We followed the invasive exotic plant monitoring protocol developed by the NCPN (Perkins et al. in review), 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 the start of monitoring, NCPN and Capitol Reef NP staff reviewed the park's list of high-priority target IEPs (see Appendix A), 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. The 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.

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 so that any missed patches smaller than the MDTS could still feasibly be eradicated if not found until the next scheduled monitoring visit (4 years). 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 are not expected to find every single plant of every targeted weed 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

Table 2-1. Priority invasive plant list, Capitol Reef National Park, 2009–2012.

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

[1]2009–2011 only
[2]2012 only
[3]2009–2010 only

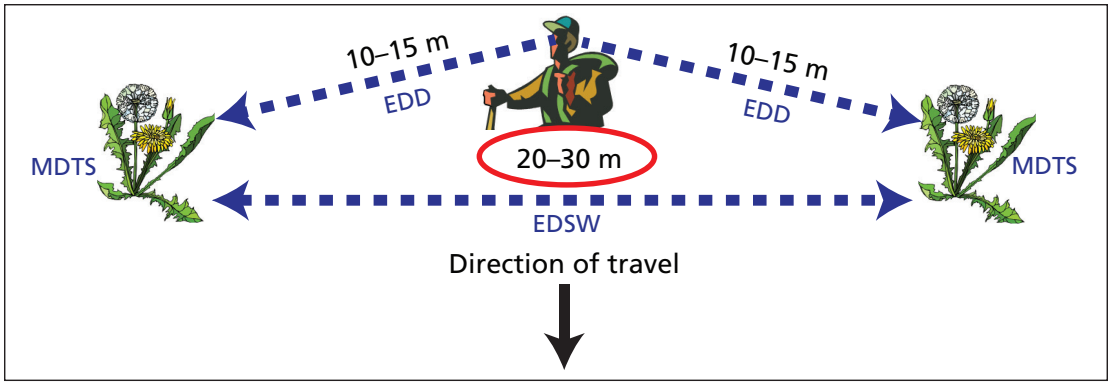


Figure 2-1. The maximum effective detection distance (EDD) for 2009–2012 at Capitol Reef National Park ranged from 10 to 15 meters, making the effective detection swath width (EDSW) 20–30 meters.

targeted species with at least 90% detection efficiency (Figure 2-1). Using fake plants of a targeted 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 from 2009 to 2012 ranged from 10 to 15 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 weeds for one EDD on either side of his/her search route. The EDSW ranged from 20 to 30 m at Capitol Reef NP from 2009 to 2012.

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 (BFPs) allow electronic tracking of a user's route. A global positioning system (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, the Scenic Drive, and the Cathedral Valley Road monitoring route (Figure 2-2). In 2013, we will initiate the second round of monitoring panel by re-visiting the Highway 24 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 20 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 GPS units with at least five-meter accuracy. For roads, the observer walks out on one side of the road and walks back on the other. For all other routes, the

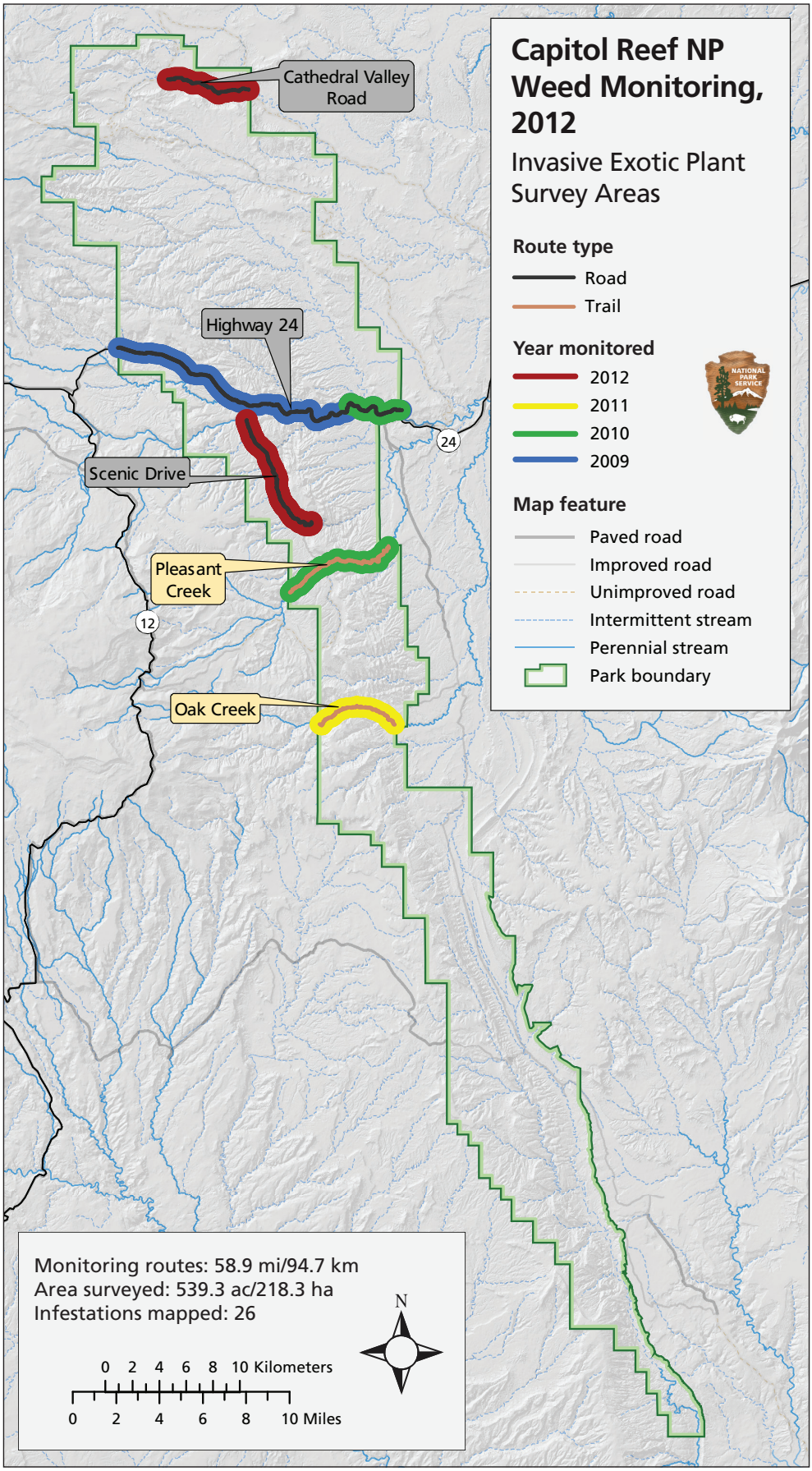


Figure 2-2. Overview of invasive plant monitoring routes and extra areas surveyed at Capitol Reef National Park, 2009–2012.

observer walks down the center of the trail/route. Only priority species were consistently recorded during monitoring routes. Survey crew members were permitted 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. 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 (≤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), and
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, distance to road, wetland, stream), 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). Our methods for sampling the monitoring quadrats were based on Stohlgren and others (2005). 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 to establishing transects every 500 m.

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-m^2 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 priority IEP species observed were recorded, as well as cheatgrass (*Bromus tectorum*) 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.

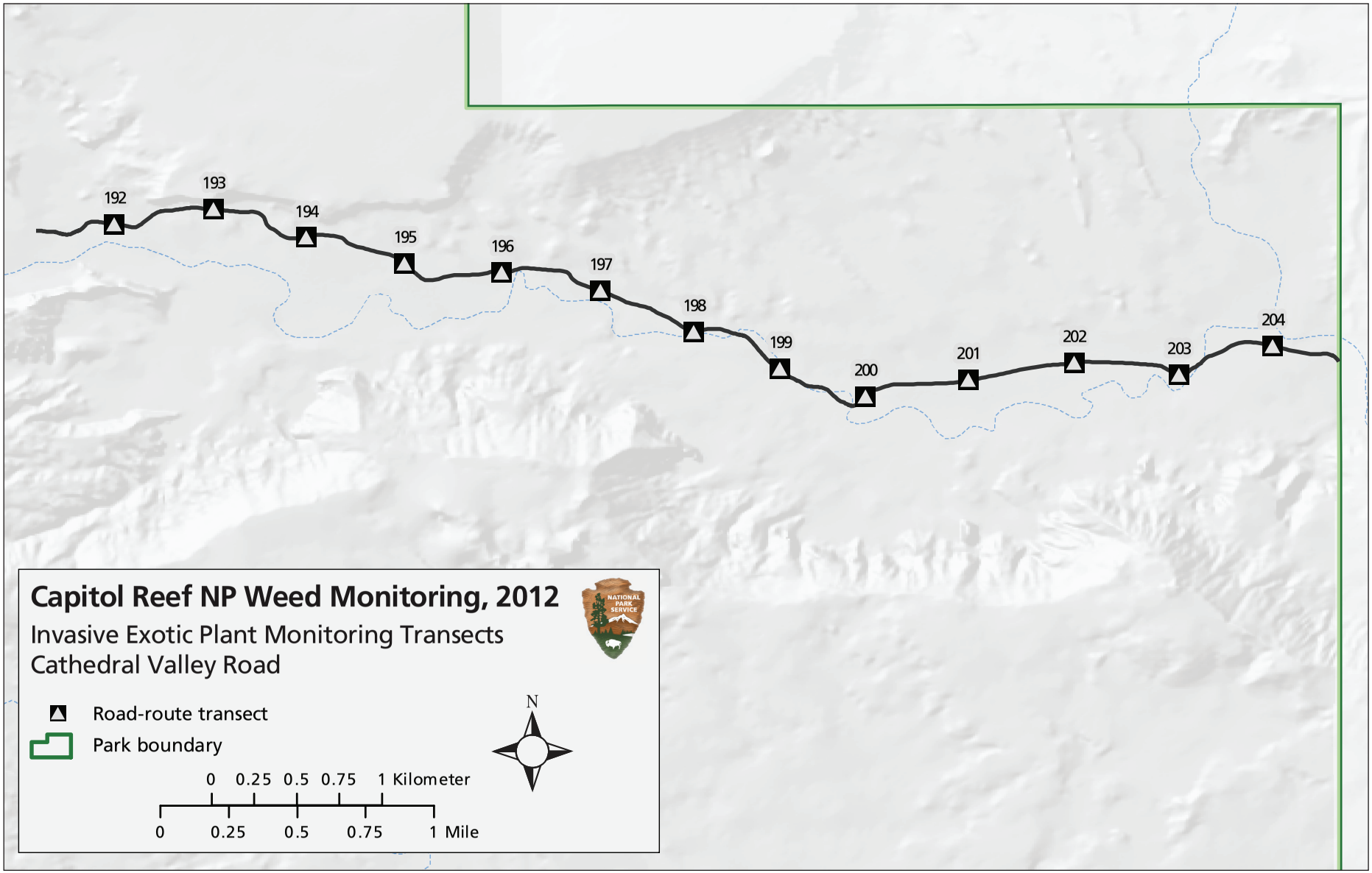


Figure 2-3. Monitoring quadrats established in along Cathedral Valley Road at Capitol Reef National Park, September 20–October 10, 2012.

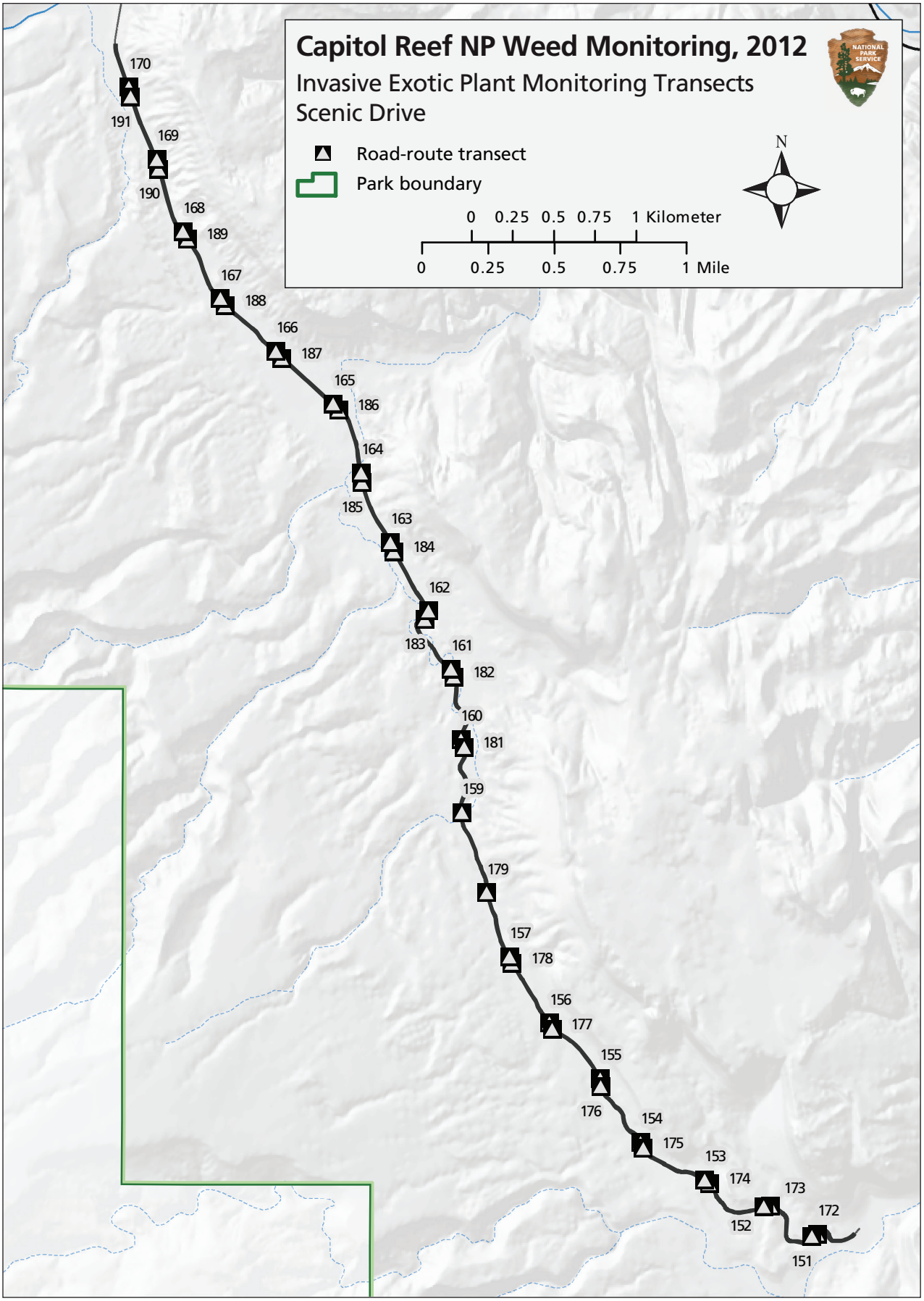


Figure 2-4. Monitoring quadrats established along the Scenic Drive at Capitol Reef National Park, September 20–October 10, 2012.

3 Results

3.1 Priority invasive exotic plant list

Twenty-six species were identified as high-priority at Capitol Reef NP between 2009 and 2012 (24 in 2012) (see Table 2-1). Twenty-one of the same species were on the list in each of those years. Observers also recorded all IEPs in monitoring quadrats, but did not map these infestations due to their widespread prevalence. Observers are trained to recognize priority species, but given the freedom to map additional species; therefore, presence and absence data for priority species and presence data for all species are reliable for the areas searched, but absence data for other species are suspect.

3.2 Monitoring routes

3.2.1 2012 results

A total of 26 infestations of tamarisk, a priority species, were detected along monitoring routes in 2012 (see Tables 3-2 and 3-3, Figures 3-1, 3-2, 3-3, 3-4, 3-5, Electronic Appendix A) (figures begin on page 14). We detected more infestations in the central and eastern portions of Cathedral Valley Road, while the Scenic Drive had very few detections. A total of 94.7 kilometers (58.9 mi) were monitored in 2012.

3.2.2 2009–2012 results

We recorded a total of 14 IEP species on monitoring routes and transects from 2009 to 2012 (Table 3-1). Six IEP species were recorded on monitoring routes and nine on monitoring transects. Of the 14 IEP species detected, seven were priority species. We covered 67.5 hectares (166.8 acres) along 27.0 km (16.8 miles) of monitoring routes in 2012. A total of 218.3 hectares (539.4 acres) and 94.2 km (58.5 miles) were monitored from 2009 to 2012. Results from 2009 to 2011 are displayed in the table for reference but their location data are not presented, as they have been reported in previous years (Perkins 2010; Perkins and Lenhart 2011, 2012).

We surveyed along the Cathedral Valley Road and the Scenic Drive in 2012, Oak Creek corridor in 2011, Pleasant Creek in 2010, and the Highway 24 corridor over 2009 and 2010 (Perkins 2010; Perkins and Lenhart 2011, 2012). We detected a total of 574 infestations of seven different priority species along monitoring routes from 2009 to 2012 (Table 3-2; Appendix A). Four hundred ninety-five (86%) of these infestations were tamarisk. Infestation rates were highest along Pleasant Creek and Highway 24, particularly in the eastern portion, where the highway is adjacent to the Fremont River. Infestation rates were lowest along the Scenic Drive

Table 3-1. Invasive exotic plants detected at Capitol Reef National Park, 2009–2012.

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

*Species found during 2012 monitoring efforts.

(Table 3-2). Of the 574 infestations, 44% were larger than 40 m^2 (Table 3-3). We detected three invasive tree species, including 495 tamarisk, 38 Russian olive, and 2 trees-of-heaven (*Ailanthus altissima*). Of the 514 tree infestations where growth stage was noted, three were in the seedling stage, 86 were in the sapling stage, and 425 were mature trees (see Appendix A).

3.3 Monitoring transects

3.3.1 2012 results

Infestations were detected on 11 of the 51 transects sampled in 2012 (see Table 3-4, Figures 2-3 and 2-4, Electronic Appendix B). Russian thistle (*Salsola* sp.) had the highest percent cover, with 11.3% along the Cathedral Valley Road. Halogeton (*Halogeton glomeratus*) and yellow sweetclover (*Melilotus officinalis*) were also detected in transects but had less than 1.5% cover.

3.3.2 2009–2012 results

A total of 136 transects were sampled from 2009 to 2012 (Table 3-4). Nine IEP species were detected on transects; only one was a priority species. One additional species, alfalfa (*Medicago sativa*), was a priority species in two of the four years. IEP percent cover was highest along Highway 24 and Pleasant Creek, with 8.42 and 6.35 total IEP percent cover, respectively (Table 3-4). There were IEPs present in 72% and 50% of the plots along Highway 24 and Pleasant Creek, respectively. IEP cover was lower than 1.5% along Oak Creek, Cathedral Valley Road, and the Scenic Drive. Russian thistle had the highest percent cover of any species along any route, with cover estimated at 5.13 and 4.72 along Pleasant Creek and Highway 24, respectively.

3.4 Results comparison: 2003–2005 and 2009–2012

From 2003 to 2005, Dewey and Anderson (2005a, b) surveyed the same general sections that the NCPN monitored from 2009 to 2012. NCPN monitoring methods were based on the methods used by Dewey and Anderson (2005), but it should be noted that mapping is subjective.[1] Therefore, although general comparisons and major differences noted between the two survey periods are useful (if somewhat problematic) and likely represent biological differences, smaller changes may not reflect actual conditions.

Eight species were detected in both the early and later sampling periods. However, in the earlier surveys, crews mapped infestations of tamarisk and Russian olive with a combination of points, lines, and polygons along Highway 24, whereas from 2009 to 2012, the crew used points exclusively. Due to these differences in mapping methods, the number of infestations of tamarisk and Russian olive along Highway 24 cannot be compared between the two time periods. In addition, a much wider section along Highway 24, in the vicinity of the Fruita developed area, was sampled in the earlier period than in the more recent period, and this is where the majority of field bindweed (*Convolvulus arvensis*) infestations occurred. Finally, the area covered along Pleasant Creek, Oak Creek, and the Scenic Drive in 2003–2005 was significantly larger than the area covered in 2009–2012, and survey methods differed in some respects.

Tree-of-heaven along Highway 24, and tamarisk along the Scenic Drive and Pleasant Creek, showed large declines, while tamarisk along the Cathedral Valley Road showed a large increase from the earlier time period (Table 3-5). Most other species had similar numbers of infestations. Future NCPN rotations will follow the same monitoring routes, making comparisons between years easier. Figure 3-1. Index map of invasive plant monitoring routes, Capitol Reef National Park, September 20–October 10, 2012.

[1]For example, one observer may call two small infestations separated by 45 m (the patch separation rule is 50 m, but exact measurements are not made in the field) as two infestations, while another observer may call them one large infestation.

Table 3-2. Number of priority IEP infestations per route surveyed, Capitol Reef National Park, 2009–2012.

Route	Route type	Length (m)	Area (ha)	Infestations	Infestations/ha
Oak Creek	Riparian/Trail	7,267	28.98	69	2.38
Highway 24	Riparian/Road	50,055	101.43	385	3.80
Pleasant Creek	Trail	9,888	20.34	94	4.62
Cathedral Valley*	Road	6,727	26.95	23	0.85
Scenic Drive*	Road	20,280	40.55	3	0.07
Total		**94,217**	**218.25**	**574**	**2.63**

*Routes monitored in 2012.

Table 3-3. Number of infestations by species and infestation size class detected along monitoring routes at Capitol Reef National Park, 2009–2012.

Scientific name	Common name	Total infestations	Infestation size class				
			1	2	3	4	5
Cathedral Valley Road (2012)							
Tamarix spp.	tamarisk	23	7	0	7	9	0
Scenic Drive (2012)							
Tamarix spp.	tamarisk	3	2	0	1	0	0
Oak Creek (2011)							
Elaeagnus angustifolia	Russian olive	1	1	0	0	0	0
Tamarix spp.	tamarisk	68	24	16	12	9	7
	Oak Creek total	*69*	*25*	*16*	*12*	*9*	*7*
Pleasant Creek (2010)							
Medicago sativa	alfalfa	31	2	13	16	0	0
Elaeagnus angustifolia	Russian olive	3	2	1	0	0	0
Tamarix spp.	tamarisk	60	41	14	5	0	0
	Pleasant Creek total	*94*	*45*	*28*	*21*	*0*	*0*
Highway 24 (2009–2010)							
Ailanthus altissima	tree-of-heaven	2	2	0	0	0	0
Asparagus officinalis	asparagus	5	4	1	0	0	0
Convolvulus arvensis	field bindweed	2	2	0	0	0	0
Elaeagnus angustifolia	Russian olive	34	23	11	0	0	0
Tamarix spp.	tamarisk	341	60	87	173	21	0
Verbascum thapsus	woolly mullein	1	1	0	0	0	0
	Highway 24 total	*385*	*92*	*99*	*173*	*21*	*0*
All areas							
Ailanthus altissima	tree-of-heaven	2	2	0	0	0	0
Asparagus officinalis	asparagus	5	4	1	0	0	0
Convolvulus arvensis	field bindweed	2	2	0	0	0	0
Elaeagnus angustifolia	Russian olive	38	26	12	0	0	0
Medicago sativa	alfalfa	31	2	13	16	0	0
Tamarix spp.	tamarisk	495	134	117	198	39	7
Verbascum thapsus	woolly mullein	1	1	0	0	0	0
Total		**574**	**171**	**143**	**214**	**39**	**7**

*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).

Table 3-4. Number of monitoring transects where exotic plant species were detected, mean percent cover, and standard error by sampling area, Capitol Reef National Park, 2009–2012.

		2012				2011		2009/2010		2010	
		Cathedral Valley Road (13)[a]		Scenic Drive (38)		Oak Creek (15)		Highway 24[b] (50)		Pleasant Creek (20)	
Scientific name	Common name	Detected	Percent cover (SE)	Detected	Percent cover (SE)	Detected	Percent cover (SE)	Detected	Percent cover (SE)	Detected	Percent cover (SE)
Priority species											
Medicago sativa[c]	alfalfa	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	2	0.01 (0.01)	0	0.00 (0.00)
Tamarisk chinensis	tamarisk	0	0.00 (0.00)	0	0.00 (0.00)	1	0.02 (0.02)	3	2.27 (1.49)	1	0.67 (0.67)
Non-priority species[d]											
Agropyron cristatum[c]	crested wheatgrass	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	2	0.09 (0.07)	0	0.00 (0.00)
Bromus tectorum	cheatgrass	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	8	0.21 (0.14)	0	0.00 (0.00)
Halogeton glomeratus[c]	halogeton	3	0.10 (0.08)	0	0.00 (0.00)	0	0.00 (0.00)	5	0.14 (0.08)	0	0.00 (0.00)
Melilotus officinalis[c]	yellow sweetclover	0	0.00 (0.00)	4	0.06 (0.04)	1	0.07 (0.07)	5	0.70 (0.56)	6	0.55 (0.34)
Portulaca oleracea[c]	little hogweed	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	1	0.02 (0.02)	0	0.00 (0.00)
Salsola tragus	Russian thistle	6	1.31 (0.87)	0	0.00 (0.00)	3	0.06 (0.03)	27	4.72 (1.42)	6	5.13 (3.00)
Tribulus terrestris[c]	puncturevine	0	0.00 (0.00)	0	0.00 (0.00)	0	0.00 (0.00)	2	0.26 (0.25)	0	0.00 (0.00)
All invasive species[e]		**7**	**1.41 (0.86)**	**4**	**0.06 (0.04)**	**4**	**0.14 (0.07)**	**36**	**8.42 (2.04)**	**10**	**6.35 (2.98)**

[a]Total number of transects per route is listed in parentheses in the header row.

[b]The majority of Highway 24 was sampled in 2009.

[c]Species was consistently mapped in transects in 2011 and 2012, but may not have been in earlier years.

[d]May not have been recorded by all observers.

[e]Some transects may have contained more than one IEP.

Table 3-5. Priority species observed and size of infestations detected along the same routes in Capitol Reef National Park, 2003–2005 and 2009–2012.

		Number of infestations																	
		Highway 24*			Oak Creek			Cathedral Valley Road			Scenic Drive			Pleasant Creek			All		
Scientific name	Common name	2003–2005	2009–2010	Change	2003–2005	2009–2010	Change	2003–2005	2009–2010	Change	2003–2005	2009–2010	Change	2003–2005	2009–2010	Change	2003–2005	2009–2010	Change
Ailanthus altissima	tree-of-heaven	71	2	-97%	0	0	0%	0	0	0%	0	0	0%	1	0	-100%	72	2	-97%
Asparagus officinalis	asparagus	5	5	0%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	5	5	0%
Centaurea repens	Russian knapweed	5	0	-100%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	5	0	-100%
Cirsium vulgare	bull thistle	4	0	-100%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	4	0	-100%
Convolvulus arvensis	field bindweed	NA	NA	NA	0	0	0%	1	0	-100%	0	0	0%	0	0	0%	1	0	-100%
Elaeagnus angustifolia	Russian olive	NA	NA	NA	3	1	-67%	0	0	0%	1	0	-100%	4	3	-25%	8	4	-50%
Tamarix spp.	tamarisk	NA	NA	NA	89	68	-24%	12	23	+92%	18	3	-83%	100	60	-40%	219	154	-29%
Verbascum thapsus	woolly mullein	2	1	-50%	0	0	0%	0	0	0%	0	0	0%	0	0	0%	2	1	-50%
Priority totals*		**87**	**8**	**-93%**	**92**	**69**	**-25%**	**13**	**23**	**+76%**	**19**	**3**	**-84%**	**105**	**63**	**-40%**	**316**	**166**	**-47%**

*Field bindweed, tamarisk, and Russian olive totals not included at Highway 24 due to differences in methodology.

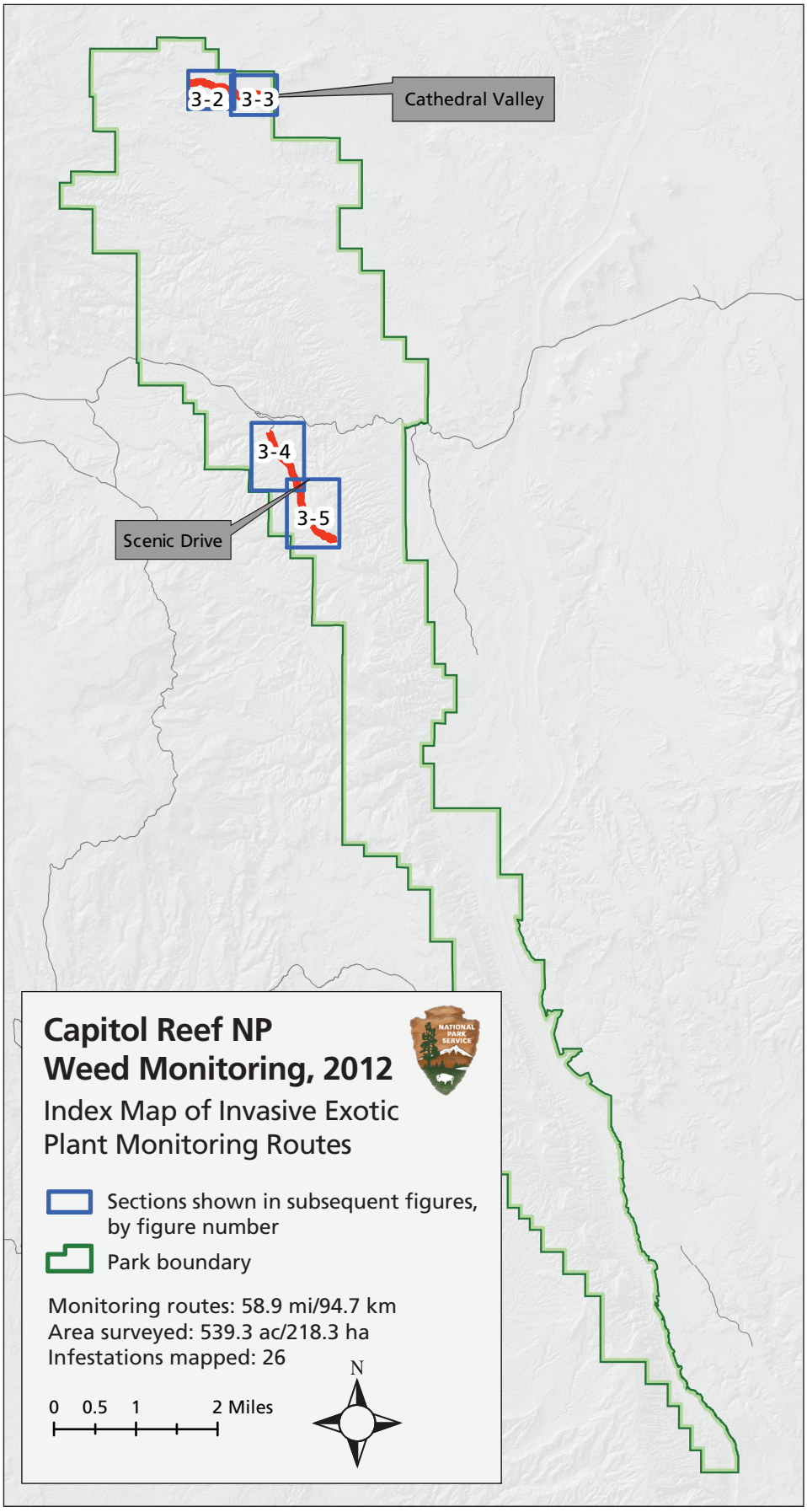


Figure 3-1. Index map of invasive plant monitoring routes, Capitol Reef National Park, September 20–October 10, 2012.

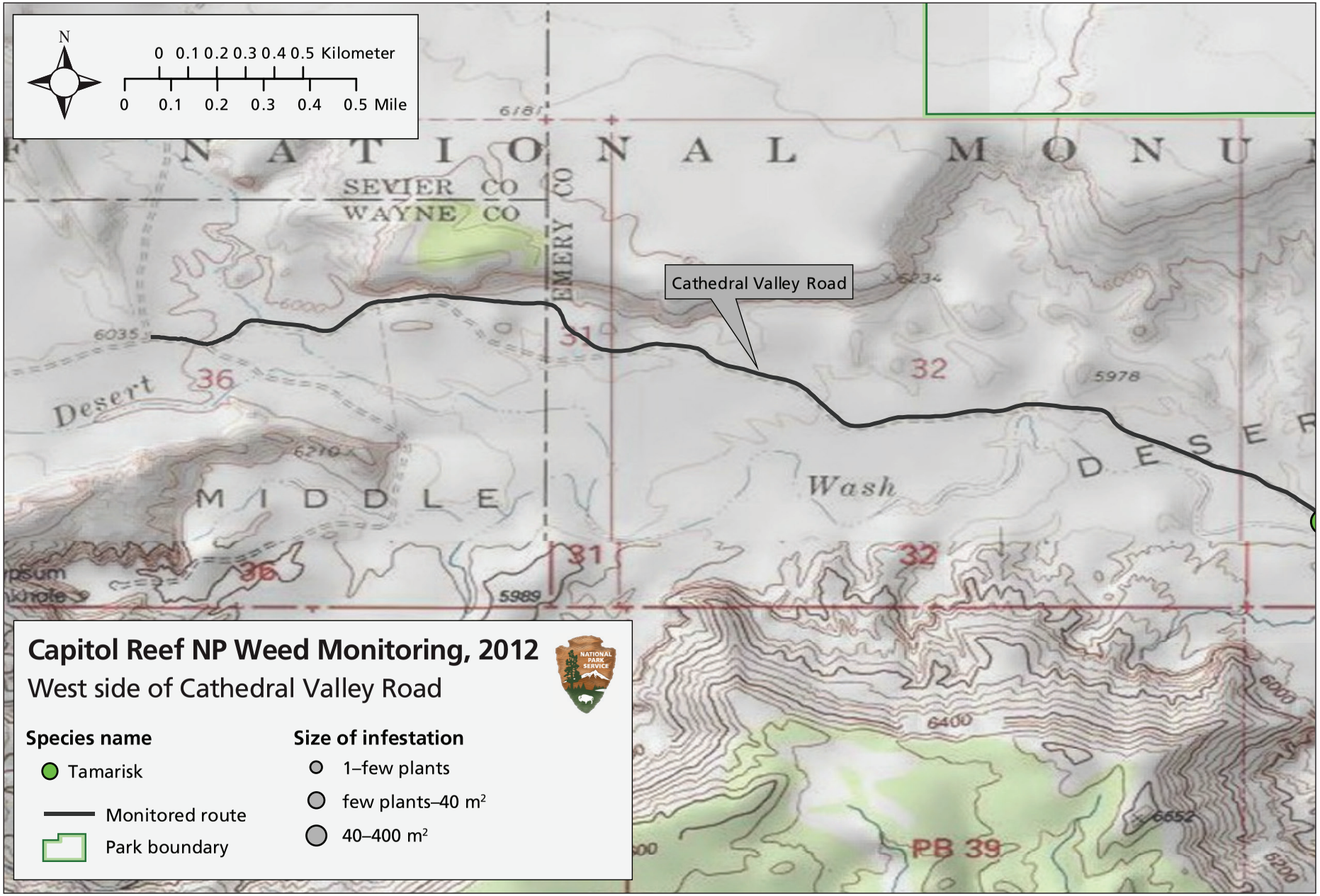


Figure 3-2. Invasive plants detected on monitoring routes and monitoring quadrats on the west side of Cathedral Valley Road in Capitol Reef National Park, September 20–October 10, 2012.

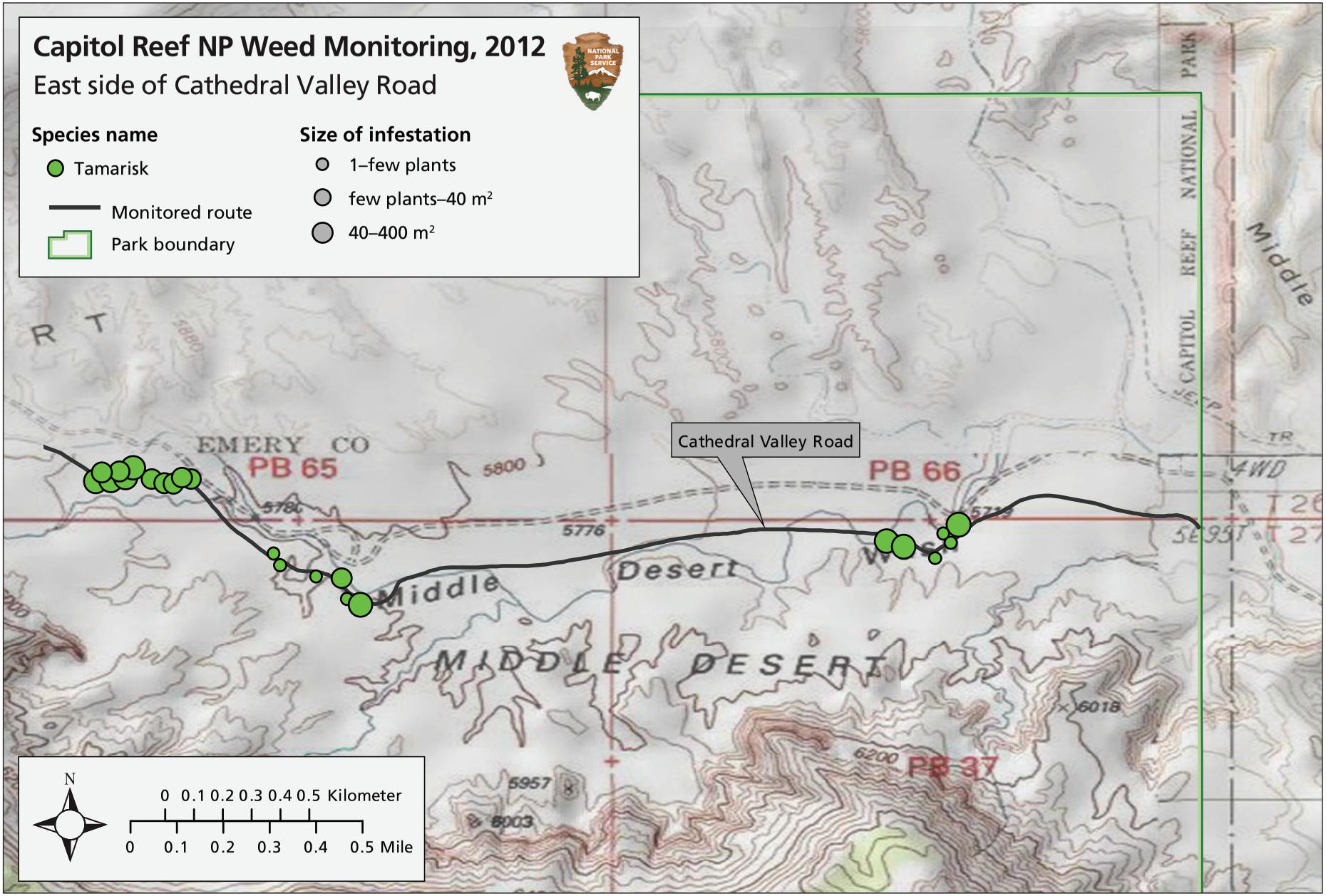


Figure 3-3. Invasive plants detected on monitoring routes and monitoring on the east side of Cathedral Valley Road in Capitol Reef National Park, September 20–October 10, 2012.

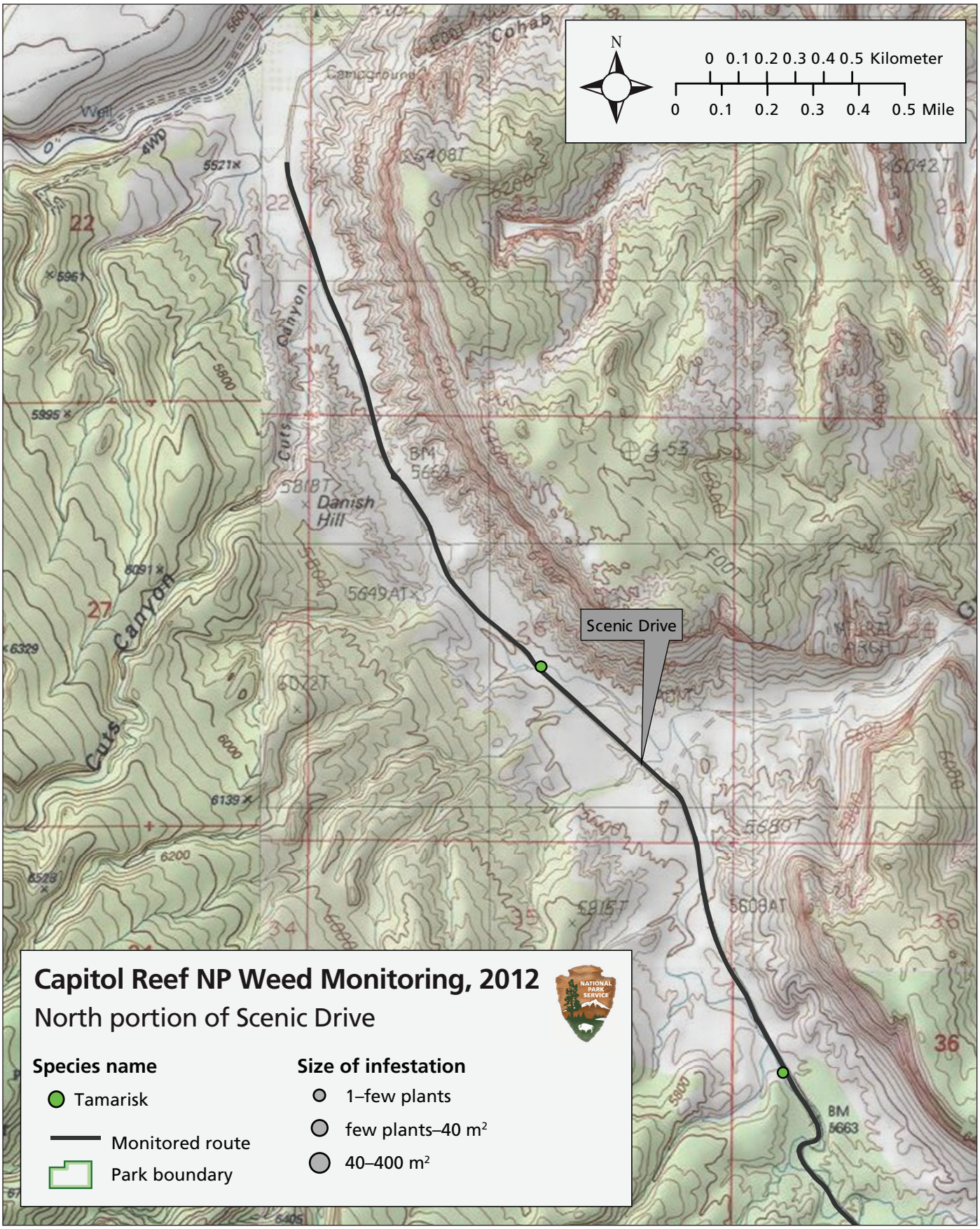


Figure 3-4. Invasive plants detected on monitoring routes and monitoring quadrats on the north portion of the Scenic Drive in Capitol Reef National Park, September 20–October 10, 2012.

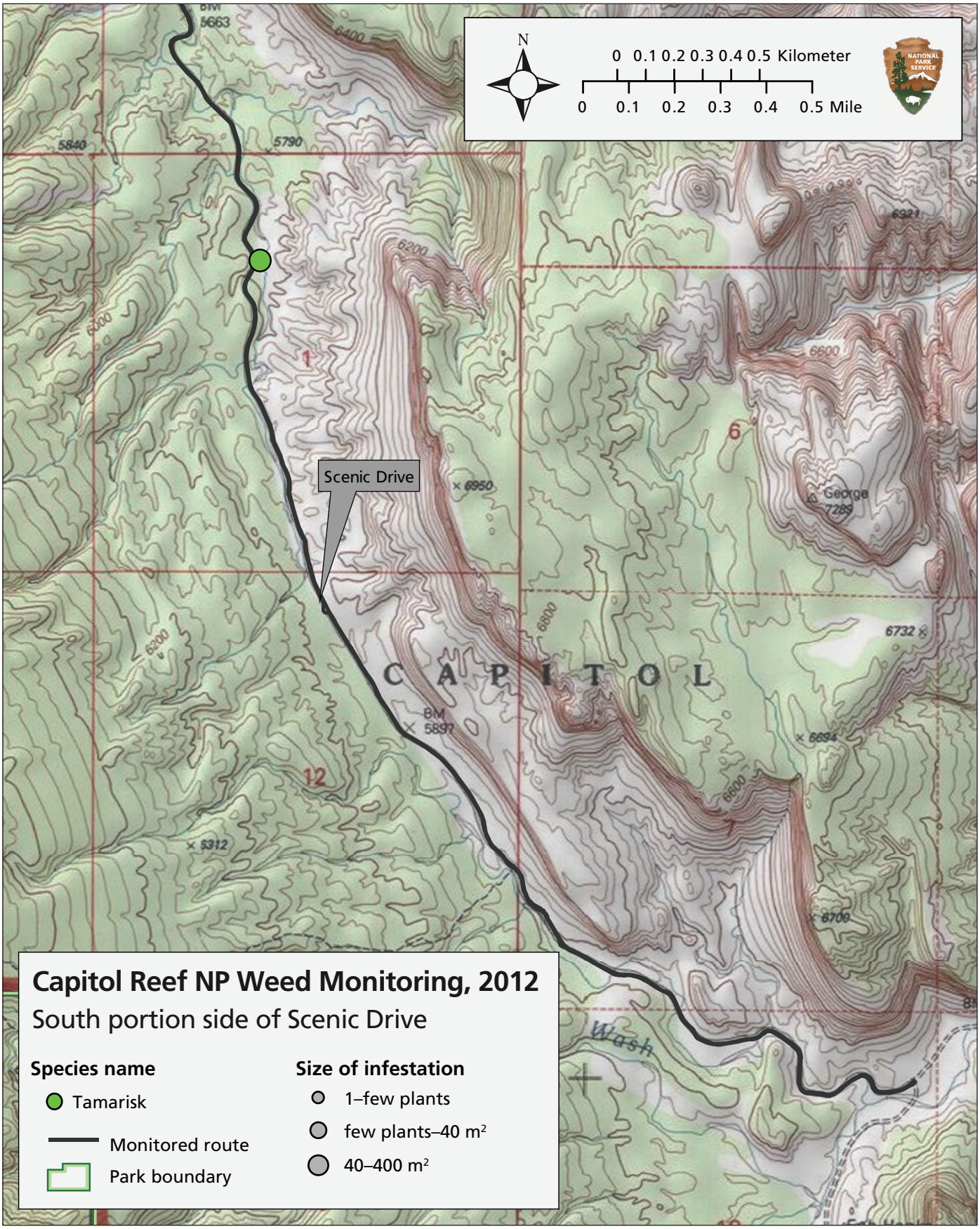


Figure 3-5. Invasive plants detected on monitoring routes and monitoring quadrats on the south portion of the Scenic Drive in Capitol Reef National Park, September 20–October 10, 2012.

4 Discussion

4.1 Priority IEP list

The NCPN will continue to work with park staff and area weed 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 are no recommended changes for 2013.

4.2 Possibilities for management control

While relatively few IEP species were detected, a few were widespread—most notably, tamarisk, which was well-established along Cathedral Valley Road, Highway 24, Oak Creek, and Pleasant Creek; Russian olive along Highway 24; and alfalfa along Pleasant Creek. These three species represented 98% of all infestations found. There were very few priority IEP infestations along the Scenic Drive.

Managers have focused on tamarisk removal along Highway 24 and the Scenic Drive, and positive results are evident along the Scenic Drive, where tamarisk has decreased. Increases in tamarisk along Cathedral Valley Road, where no management control has occurred, demonstrate how this species can spread. However, levels of tamarisk are still far lower along Cathedral Valley Road than along Highway 24, Pleasant Creek, or Oak Creek. Forty-nine percent of tamarisk infestations recorded during the most recent surveys were larger than 40 m^2, and 83% of the infestations were mature trees, demonstrating this weed's widespread prevalence and the length of time it has been present.

Continued monitoring will show the effects of future control efforts and the effects of the tamarisk beetle (*Diorhabda elongata*) 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.) and in areas close to Oak Creek, and it is expected that the beetle will reach Oak Creek in the near future. Major control efforts for tamarisk should likely be postponed until the effects of the beetle can be determined.

Tamarisk infestations along Oak Creek and Pleasant Creek tended to be smaller than those along Highway 24 (near the Fremont River), indicating that control efforts may be more feasible along the creeks than along the highway. Oak Creek, Cathedral Valley Road, and the Scenic Drive all had low percent cover of IEPs. In these areas, infestations should be controlled before they become more widespread.

The park has also targeted tree-of-heaven for control efforts since the inventories in 2003 and 2004. Park staff estimate they are close to eradicating this species in Capitol Reef NP; only two infestations were found and only along Highway 24 in monitoring during 2009–2010, compared to 72 infestations recorded along Highway 24 and Pleasant Creek in 2003–2005.

Both Russian knapweed (*Centaurea repens*) and bull thistle (*Cirsium vulgare*) were found in 2003–2005, but were absent from 2009 to 2012, due to additional eradication efforts by park staff. In most other areas, the changes in the number of infestations between sampling periods were not large.

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 2013, the NCPN will

initiate the second rotation of monitoring along Highway 24. 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 distribution, trends in percent cover of individual species, and changes in IEP percent cover of priority species by monitoring route. Extra-area surveys will also be considered for inventories at the park's request. Peer review comments on the NCPN invasive plant monitoring protocol were received in September 2012. It is expected that the protocol will be finalized in Fiscal Year 2013.

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Appendix A: Species Detected Along Monitoring Routes, Capitol Reef National Park, 2009–2012, with Emphasis on the Most-Detected Species

Maps begin on next page

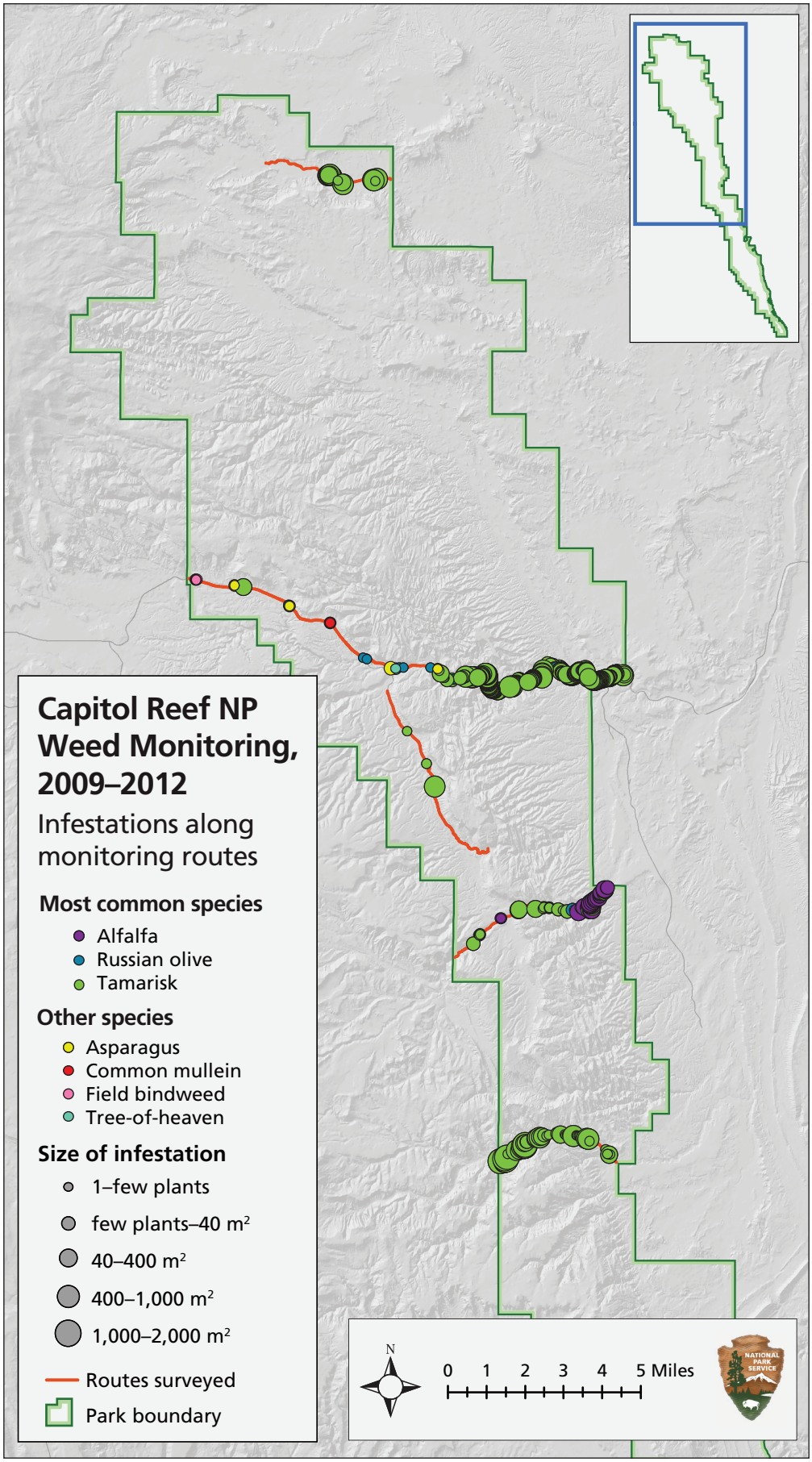


Figure A-1. Infestations along monitoring routes, Capitol Reef National Park, 2009–2012.

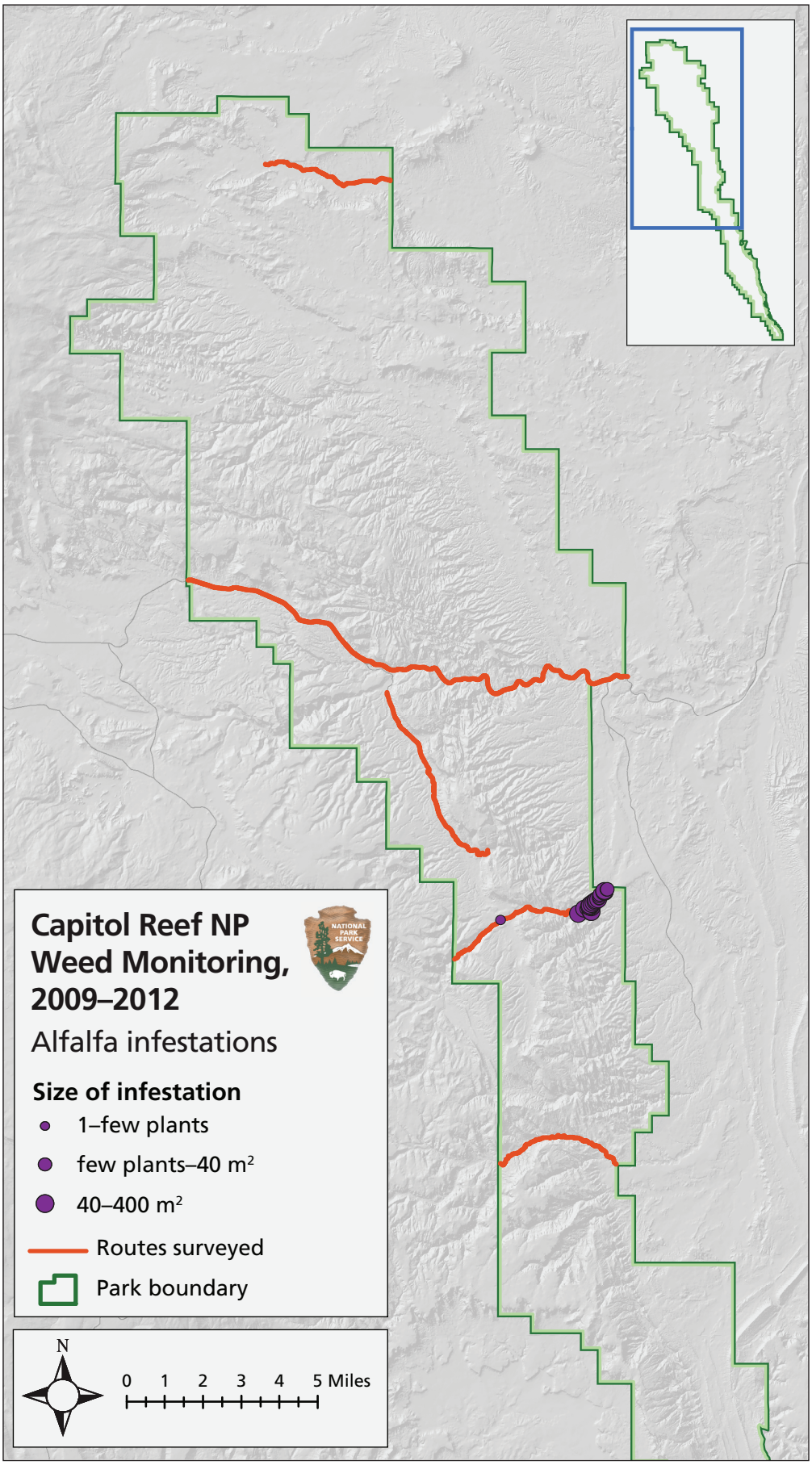


Figure A-2. Alfalfa infestations along monitoring routes, Capitol Reef National Park, 2009–2012.

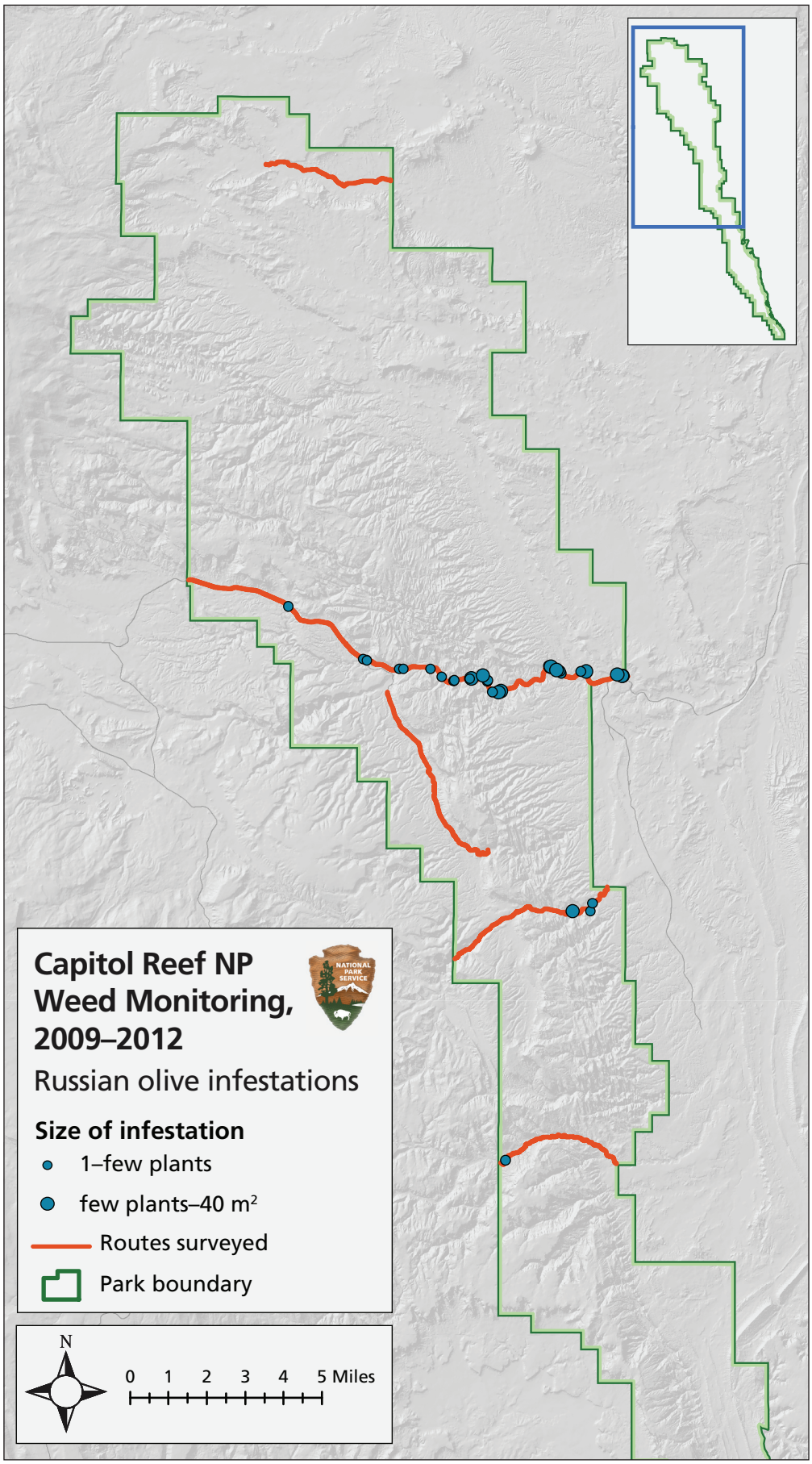


Figure A-3. Russian olive infestations along monitoring routes, Capitol Reef National Park, 2009–2012.

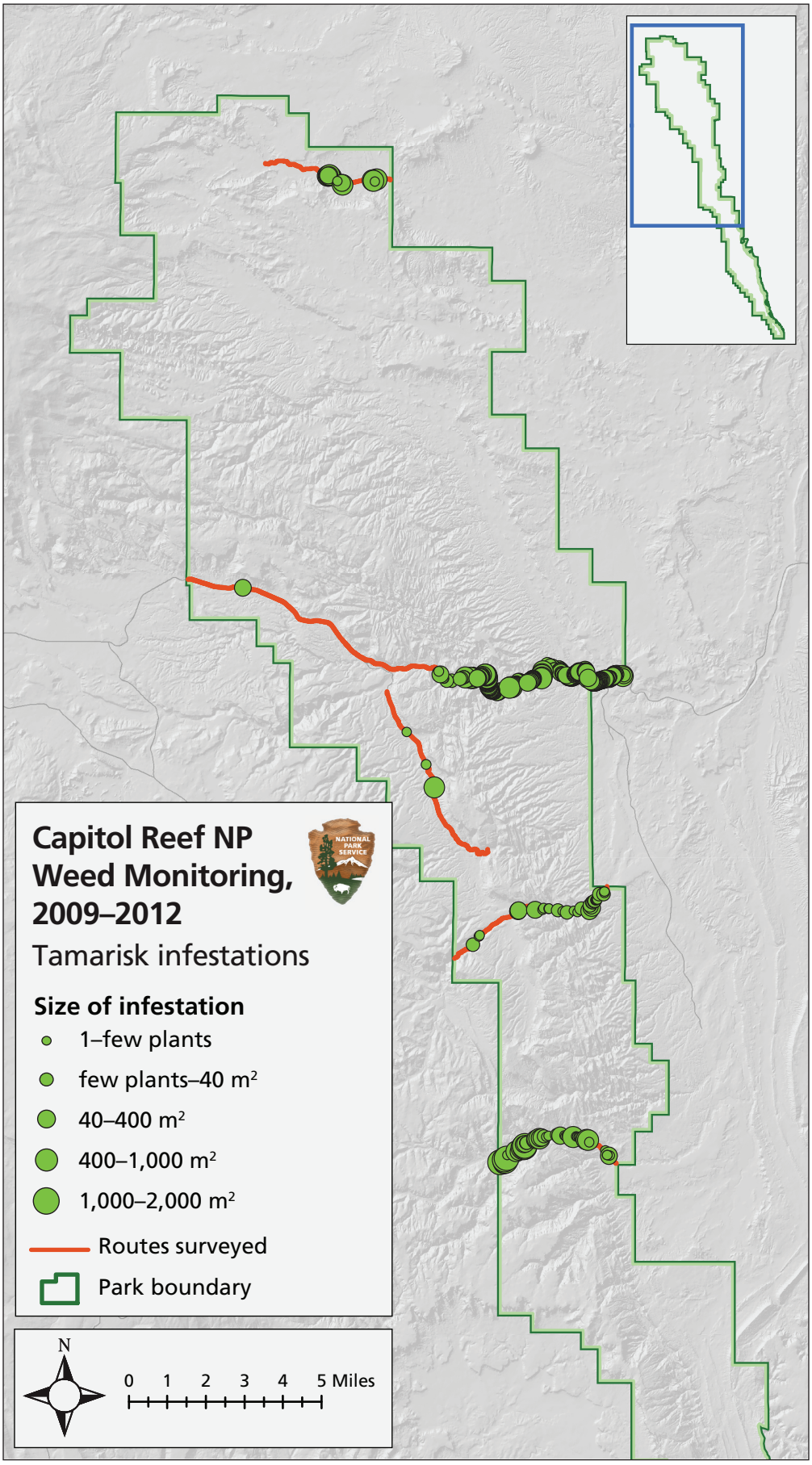


Figure A-4. Tamarisk infestations along monitoring routes, Capitol Reef National Park, 2009–2012.

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