



Invasive Exotic Plant Monitoring in Capitol Reef National Park

2015 Field Season and Invasive Plant Infestations, 2003–2015

Natural Resource Report NPS/NCPN/NRR—2016/1260



ON THE COVER

Scenic Drive and Fruita Cliffs. NPS/Nathan Gross.

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Executive Summary

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 11 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 June 5–10, 2015, NCPN staff detected three IEP species (all priority IEPs) on monitoring routes and three IEP species in transects along 41.3 kilometers of Oak Creek, Scenic Drive, and Cathedral Valley Road. Tamarisk (*Tamarix* spp.), Russian olive (*Elaeagnus angustifolia*), and field bindweed (*Convolvulus arvensis*) were detected along monitoring routes in 2015, with 65, 3, and 4 patches, respectively. Tamarisk was widespread along Oak Creek and Cathedral Valley Road. Tamarisk was the only priority species found on transects. Russian thistle (*Salsola tragus*) along Cathedral Valley Road was the most widespread IEP species, present on 58% of transects, and had the highest average percent cover, at 0.13%. Cheatgrass (*Bromus tectorum*) was also detected on transects. When the most recently completed monitoring rotation of 2013–2015 is compared to the earlier time periods of 2003–2005 and 2009–2012, it appears that park control efforts have resulted in decreases of targeted invasive plants, such as tree-of-heaven (*Ailanthus altissima*) and Russian knapweed (*Centaurea repens*) across the park, Russian olive along the Highway 24/Fremont River corridor, and tamarisk along the Scenic Drive. Tamarisk has increased and/or grown larger along Cathedral Valley Road, Highway 24/Fremont River, Oak Creek, and Pleasant Creek, where the park has not performed control efforts. Russian olive has also expanded along Oak and Pleasant creeks.

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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 (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 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 escapees, livestock grazing and trailing, and seeds transported on apparel 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
1. To determine status and trends of selected invasive plant populations of management significance.

This report summarizes the 2015 field season along Oak Creek, Scenic Drive, and Cathedral Valley Road at Capitol Reef National Park (NP). This work completed the second full rotation of NCPN IEP monitoring at the park. This report also summarizes and compares data collected by Utah State University and by the NCPN from 2003 to 2015.

2 Methods

We followed the invasive exotic plant monitoring protocol developed by the NCPN (Perkins et al. 2013). 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 2015, 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. In addition to the priority species, cheatgrass (*Bromus tectorum*), Russian thistle (*Salsola tragus*), and crested wheatgrass (*Agropyron cristatum*) were all searched for consistently in transects but not mapped along monitoring routes.

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,

Table 2-1. Priority invasive exotic plant list, Capitol Reef NP, 2009–2015.

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 houndstongue
<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>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> ²	plumeless thistle
<i>Malcolmia africana</i> ³	African mustard
<i>Medicago sativa</i> ³	alfalfa

¹Added in 2012

²2009–2011 only

³2012–2013 only

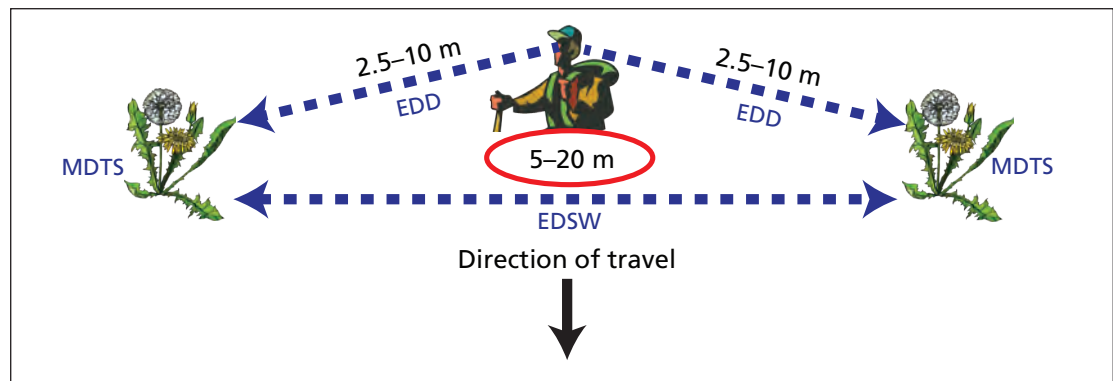


Figure 2-1. The maximum Effective Detection Distance (EDD) at Capitol Reef National Park was between 2.5 and 10 meters, making the Effective Detection Swath Width (EDSW) between 5 and 20 meters.

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 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 2015 ranged between 2.5 and 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 ranged between 5 and 20 m at Capitol Reef NP in 2015.

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. 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. 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 patch during planning and implementation of weed-control operations. If a patch 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 patch.

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, the Pleasant Creek cattle trail, Oak Creek cattle trail, Scenic Drive, and Cathedral Valley Road monitoring routes (Figure 2-2, Table 2-2). In 2015, the network visited Oak Creek, Scenic Drive, and Cathedral Valley Road for the second time.

Along Highway 24, Cathedral Valley Road, and Scenic Drive, the observer walks out on one side of the road and walks back on the other. For all other routes, the observer

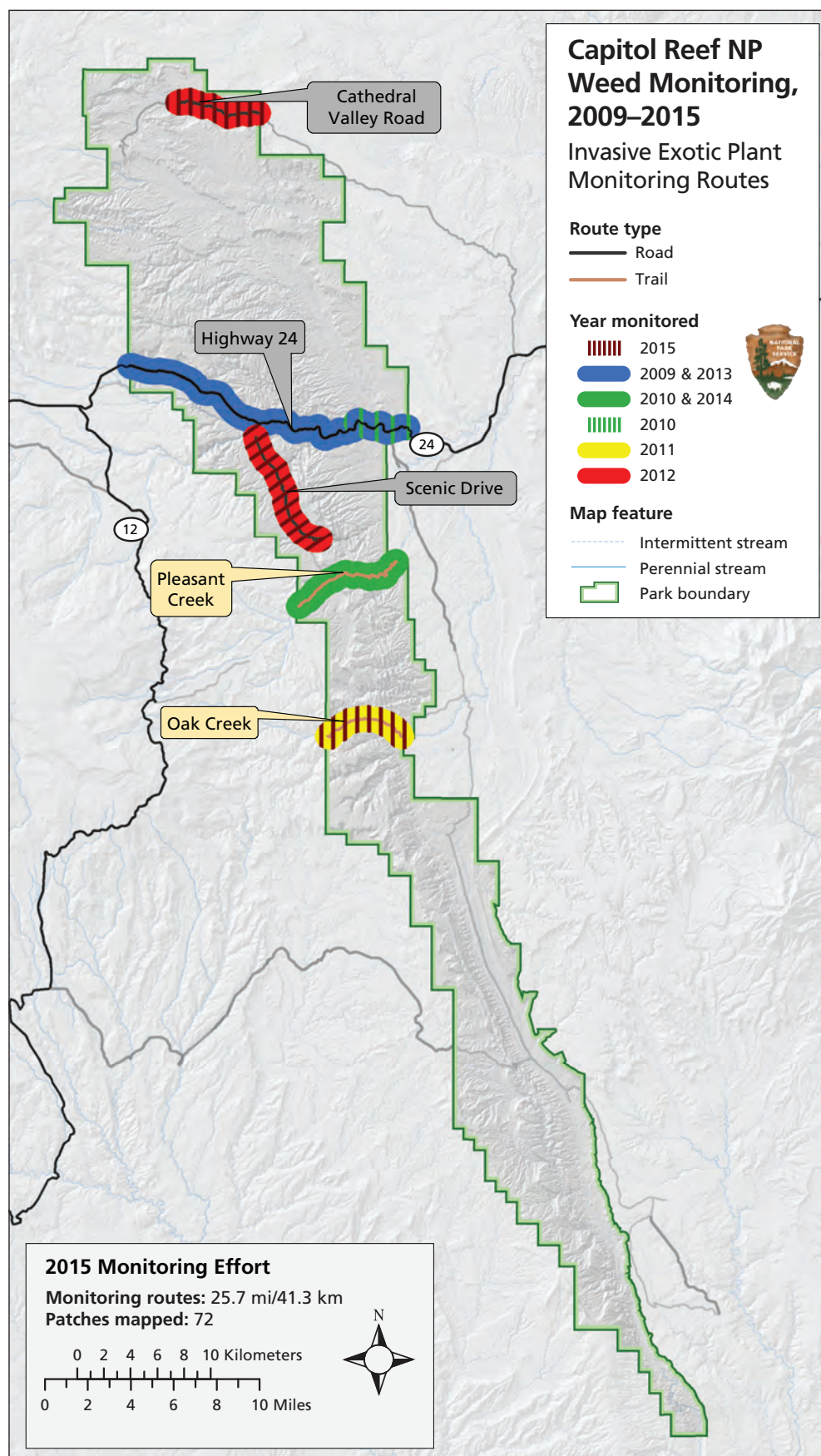


Figure 2-2. Overview of invasive exotic plant monitoring routes and extra areas surveyed at Capitol Reef National Park, 2009–2015.

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

Year	Monitoring routes
2009	Highway 24/Fremont Corridor
2010	Pleasant Creek
2011	Oak Creek
2012	Cathedral Valley Road/Scenic Drive
2013	Highway 24/Fremont Corridor
2014	Pleasant Creek
2015	Oak Creek/Cathedral Valley Road
2016	Highway 24/Fremont Corridor/Scenic Drive
2017	Rest
2018	Pleasant Creek
2019	Oak Creek
2020	Cathedral Valley Road

walks down the center of the trail/route. 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 global positioning system (GPS) units with at least five-meter accuracy.

Only IEPs that were designated as priority were consistently recorded on 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) monitoring route, (2) sequential number of the invasion per monitoring route, (3) patch 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. Patch 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 patch: 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

2.3.1 Quadrat establishment

We established one transect with three vegetation quadrats every 500 m along monitoring routes (see Figures 2-3, 2-4, 2-5, and 2-6). 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, crested wheatgrass, and Russian thistle. 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, bio-

logical soil crust, road, rock, standing water/flooded, stream, or trash/junk).

2.4 Analyses

We calculated the mean number of patches per kilometer 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.

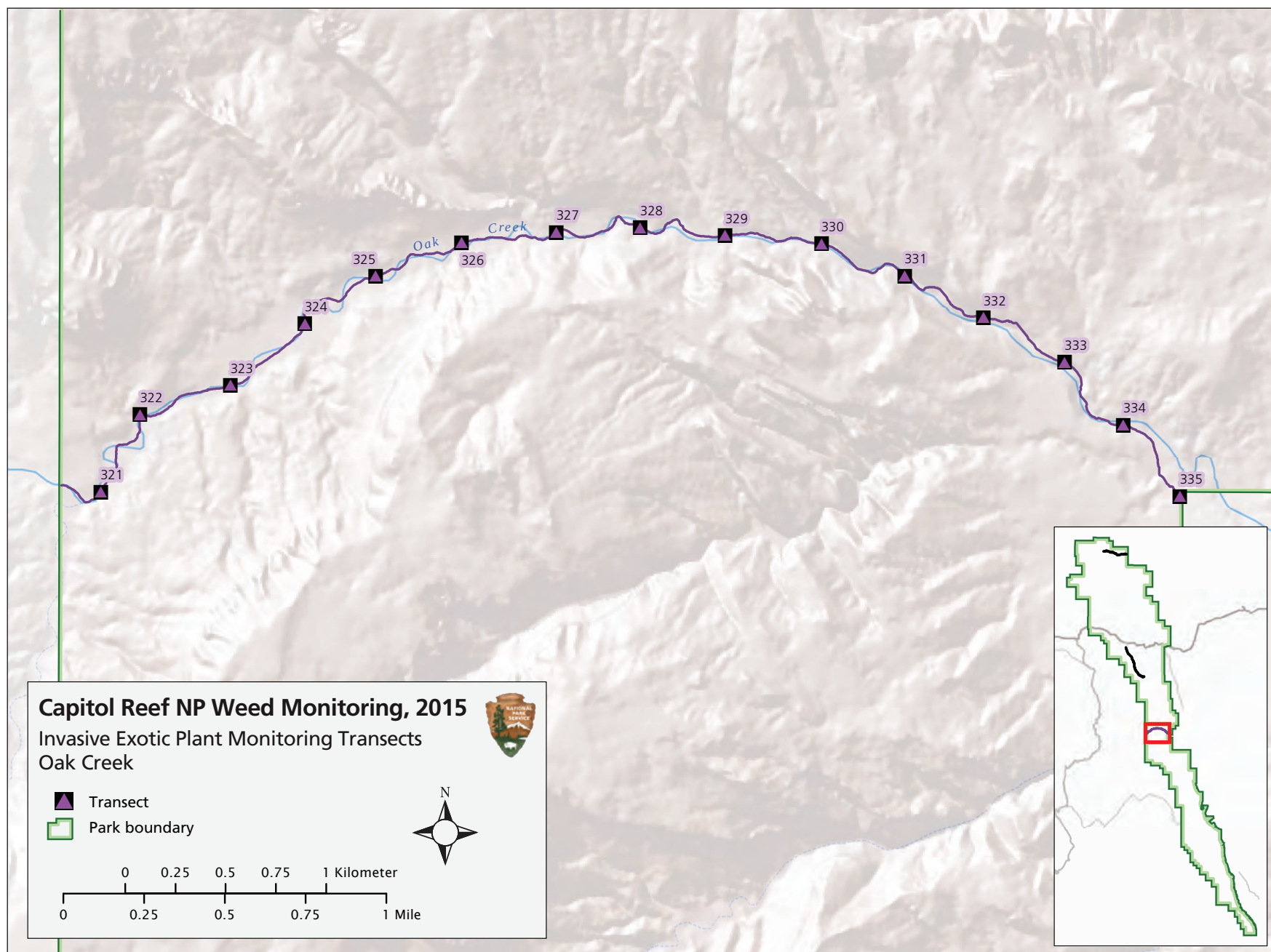


Figure 2-3. Monitoring transects surveyed along Oak Creek, Capitol Reef National Park, 2015.

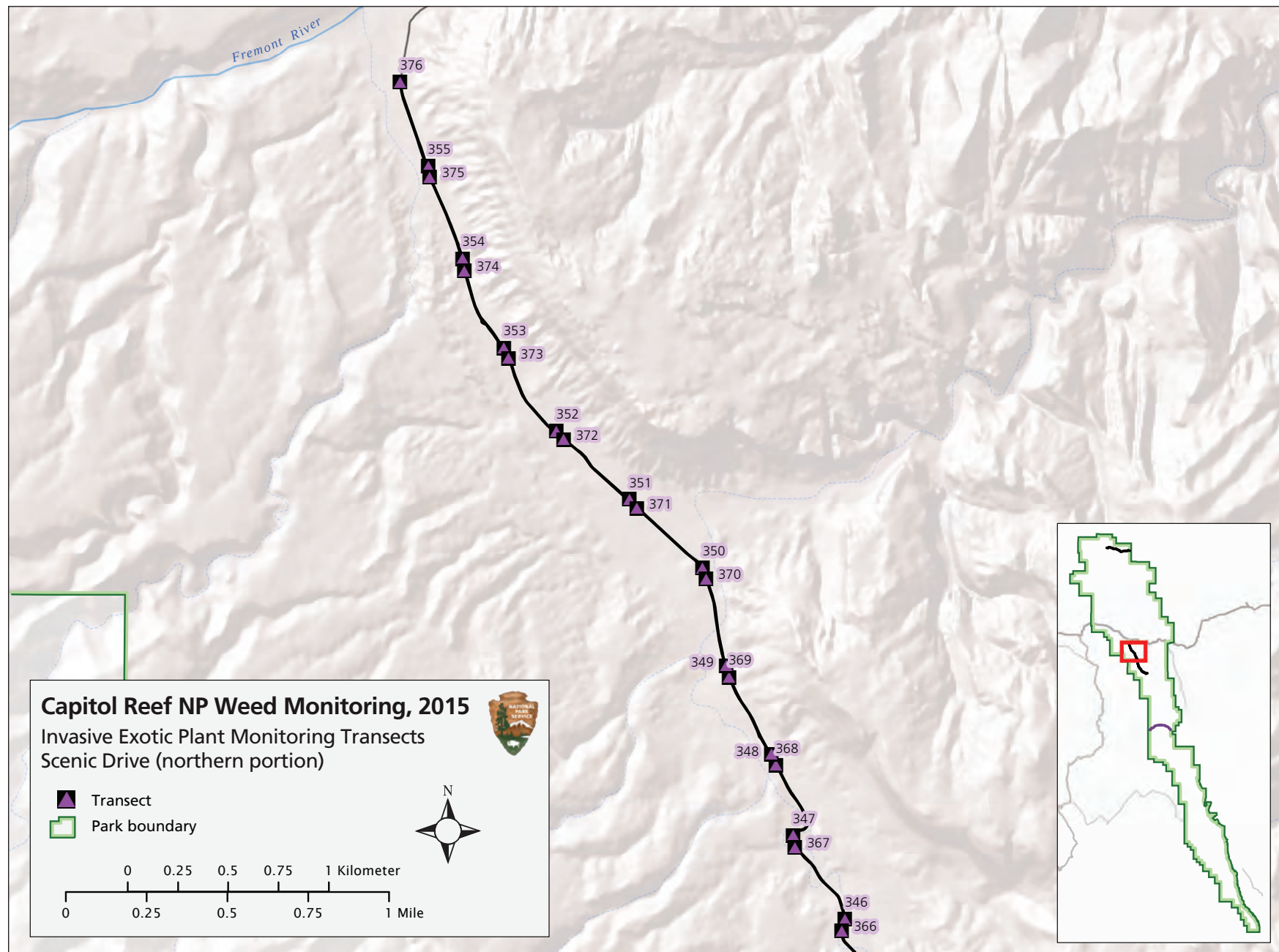
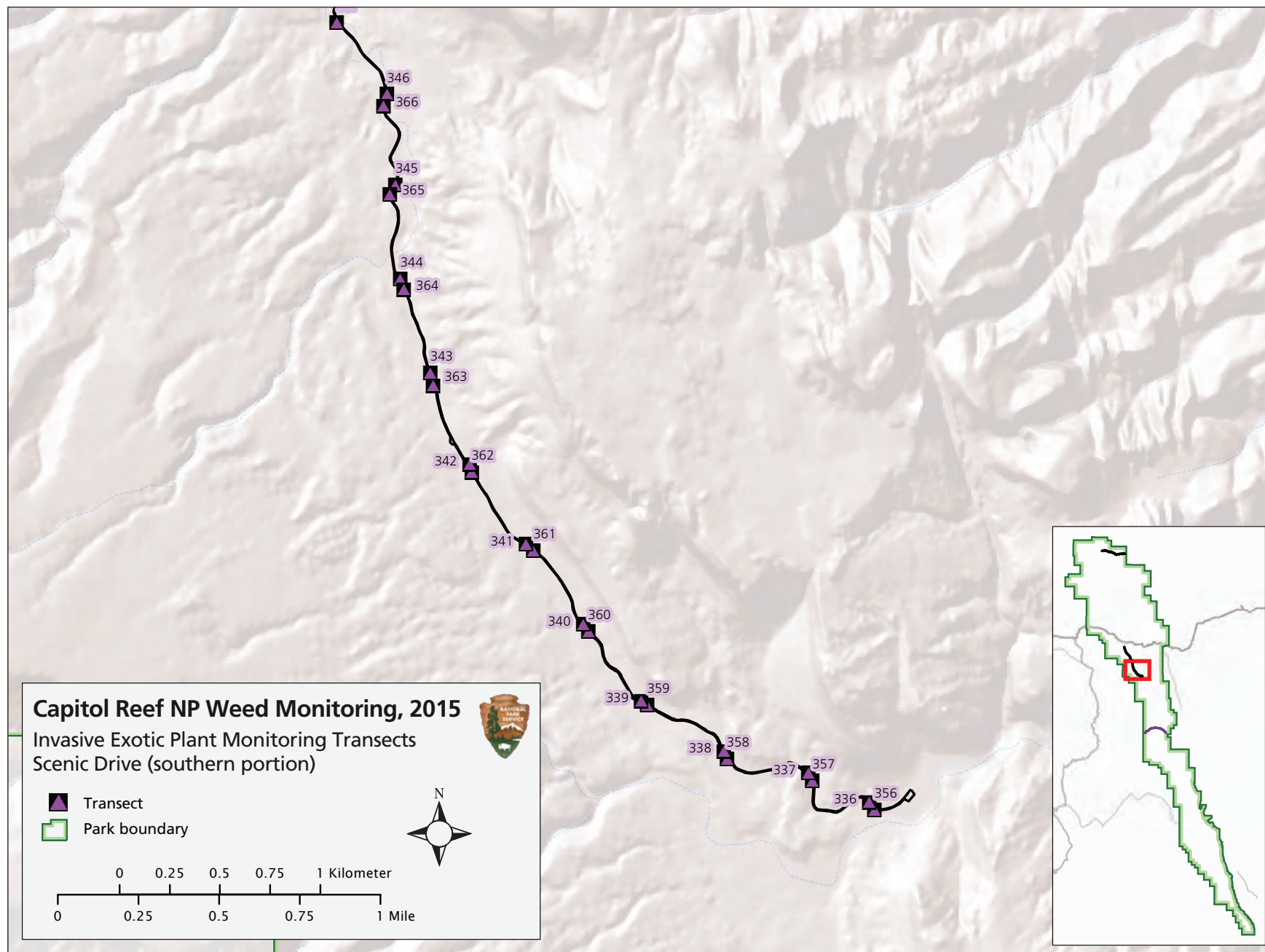


Figure 2-4. Monitoring transects surveyed along the northern portion of Scenic Drive, Capitol Reef National Park, 2015.



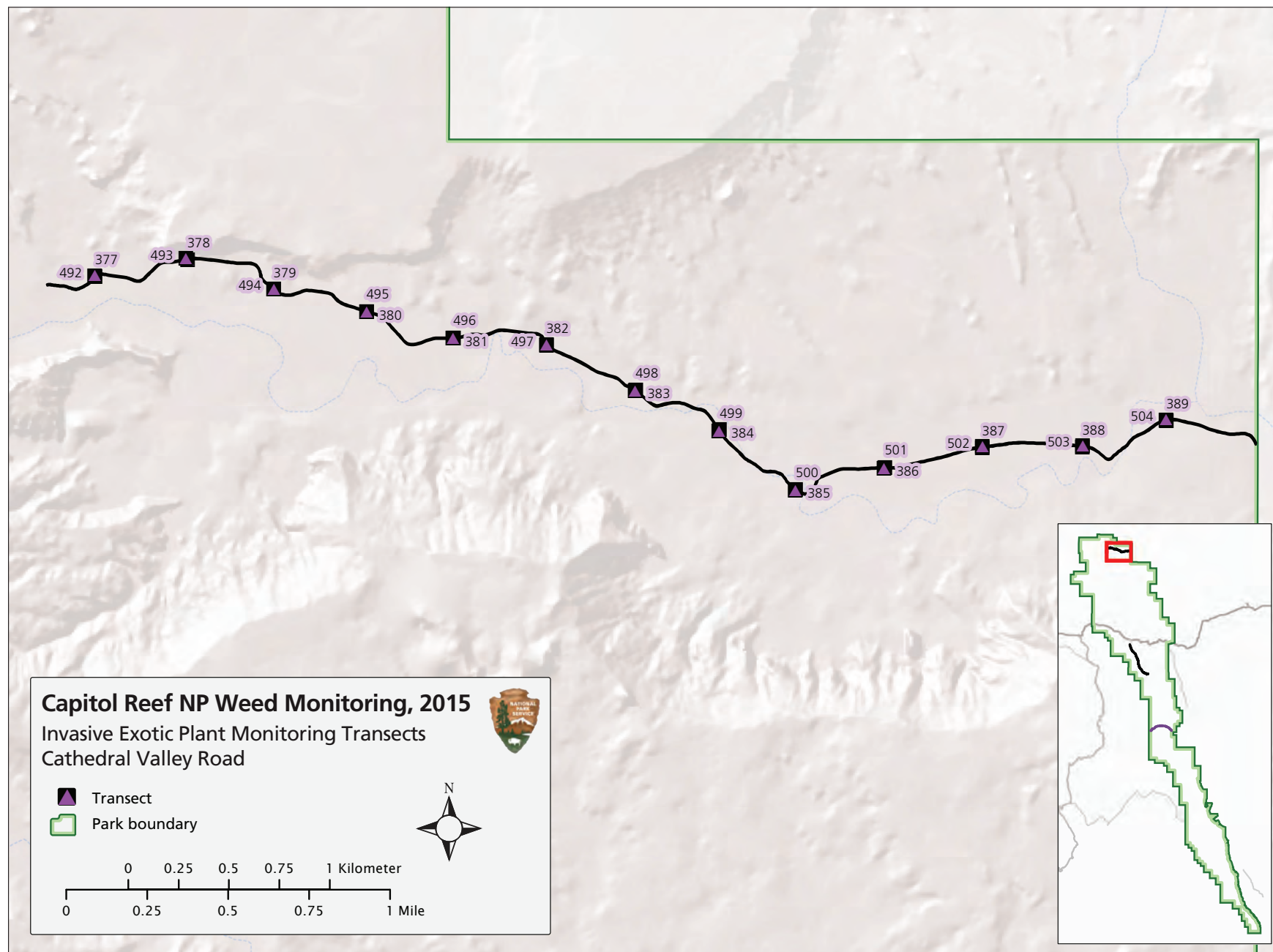


Figure 2-6. Monitoring transects surveyed along Cathedral Valley Road, Capitol Reef National Park, 2015.

3 Results

3.1 Target invasive exotic plant list

In 2015, field crews searched on monitoring routes for 23 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 five IEP species on monitoring routes and transects in 2015 (Table 3-1). Tamarisk, field bindweed, and Russian olive, all priority species, were recorded on monitoring routes. Tamarisk, cheatgrass, and Russian thistle were recorded on monitoring transects. We covered 41.3 km (25.7 miles) of monitoring routes in 2015.

Drive, and Cathedral Valley Road monitoring routes in 2015. A total of 72 patches of three different species were detected along the monitoring routes (Table 3-2; Figures 3-1, 3-2, 3-3; Appendix A).^{*} We recorded patches of tamarisk (65), field bindweed (4), and Russian olive (3). Tamarisk had high infestation rates along Oak Creek, followed by Cathedral Valley Road (Table 3-2). Scenic Drive had very few invasive patches, with only four small patches of field bindweed detected along 20.5 km. There were no exotic plants detected on the northern portion of the Scenic Drive monitoring route. Of the 67 tree patches where growth stage was noted, 7 were in the seedling stage, 40 were in the sapling stage, and 20 were mature trees (see Appendix A). Patches along Cathedral Valley Road were clustered along the central and eastern portions of the route (Figure 3-4).

^{*} Tables begin on page 16, figures on page 18.

3.2 Monitoring routes

We surveyed all of the Oak Creek, Scenic

Table 3-1. Invasive exotic plants detected along monitoring routes at Capitol Reef National Park, 2003–2015.

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>Centaurea repens</i>	Russian knapweed	X		Yes
<i>Cirsium vulgare</i>	bull thistle	X		Yes
<i>Convolvulus arvensis</i>	field bindweed	X ²⁰¹⁵		Yes
<i>Elaeagnus angustifolia</i>	Russian olive	X ²⁰¹⁵		Yes
<i>Medicago sativa</i> [*]	alfalfa		X	Yes
<i>Tamarix</i> spp.	tamarisk	X ²⁰¹⁵	X ²⁰¹⁵	Yes
<i>Verbascum thapsus</i>	woolly mullein	X		Yes
<i>Agropyron cristatum</i>	crested wheatgrass		X	No
<i>Bromus tectorum</i>	cheatgrass		X ²⁰¹⁵	No
<i>Halogeton glomeratus</i>	halogeton		X	No
<i>Melilotus officinalis</i>	yellow sweetclover		X	No
<i>Portulaca oleracea</i>	common purslane		X	No
<i>Salsola tragus</i>	Russian thistle		X ²⁰¹⁵	No
<i>Tribulis terrestris</i>	puncturevine		X	No

^{*}*M. sativa* was the only priority IEP not monitored consistently in all years.

²⁰¹⁵ Detected in 2015 monitoring efforts.

3.3 Monitoring transects

A total of 82 transects were sampled in 2015 (Table 3-3; Appendix B). Russian thistle, cheatgrass, and tamarisk were detected. IEPs were found on 37% of transects, with an average of 0.39 IEP species detected per plot. Percent cover of these invasives was very low, with the highest being Russian thistle, at 0.13% along Cathedral Valley Road. All other percent covers were <0.08% (Table 3-3). Russian thistle was the most widespread IEP species, present on 58% of transects along Cathedral Valley Road.

3.4 Results comparison: 2003–2005, 2009–2012, and 2013–2015

From 2003 to 2005, Dewey and Anderson (2005a, b) surveyed the same general sections that the NCPN monitored from 2009 to 2012 and 2013–2015. NCPN monitoring methods were based on the methods used by Dewey and Anderson (2005), but it should be noted that mapping is subjective. For example, one observer may call two small patches, 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. 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 priority species were detected in at least one of the three sample periods.

In 2003, Dewey and Anderson (2005) surveyed the same sections of Pleasant Creek, Oak Creek, and Scenic Drive that the NCPN surveyed in 2010 and 2014. Although the area covered along Pleasant Creek, Oak Creek, and Scenic Drive in 2003–2005 was significantly larger than the area covered from 2010 to 2015, and survey methods differed in some respects, general comparisons between the two survey periods are useful (if somewhat problematic). However, since NCPN began monitoring in 2009, the methods and routes have been comparable.

The following is a comparison of results from the three sample periods, given the caveats

described above.

3.4.1 Oak Creek

While the number of tamarisk patches declined from 89 in 2003–2005 to 68 in 2011, and 48 in 2015, the distribution remained the same. The percentage of patches of more than 40 m² increased from 41% in 2011 to 71% in 2015. In addition, the percentage of patches in the largest size class (>1,000 m²) increased from 10% (7 patches) to 31% (15 patches) between 2011 and 2015 (Table 3-2). Percent cover of invasive plants has remained low (Table 3-3). Russian olive increased from one to three patches in the western portion of Oak Creek from 2011 to 2015 (Figure 3-2). In 2011, the single patch was in the smallest size class (1–a few plants). In 2015, one patch was still in that class, but an additional patch was in size class 2 (few plants–40 m²) and the third patch was in size class 4 (400–1,000 m²).

3.4.2 Scenic Drive

Tamarisk patches declined dramatically, from 18 patches in 2003–2005 to 3 in 2012, and 0 in 2015. There were two field bindweed patches in 2015 that had not previously been recorded on Scenic Drive. Percent cover of invasives was low for all species, but Russian thistle presence in monitoring transects increased from 0% in 2012 to 20% percent frequency in 2015.

3.4.3 Cathedral Valley Road

Tamarisk patches increased from 12 in 2003–2005 to 23 and 20 in 2012 and 2015, respectively. In 2011, there were seven patches in the smallest size class (1–a few plants), and the remainder (70%) were larger than 40 m². In 2015, all 20 patches were larger than 40 m² and the number of patches in the largest size class (>1,000 m²) had increased from 0 patches to 16 (Table 3-2). Russian thistle was present in 46% and 58% of the transects in 2012 and 2015, respectively. No other species were encountered in the monitoring transects (Table 3-3).

3.4.4 Highway 24/Fremont River

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 patches 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 patches of tamarisk and Russian olive cannot be compared across the three time periods.

There were 71 tree-of-heaven (*Ailanthus altissima*) patches in 2003–2005 (Dewey and Anderson 2005 a, b). These declined to just two in 2009 and none in 2013. When comparing 2009–2010 to 2013 (when the methods were the same), Russian olive and tamarisk both had fewer patches in 2013 than in 2009–2010. Total patches declined from 7.62 patches per km in 2009–2010 (Perkins and Lenhart 2011) to 5.54 per km in 2013. Perkins (2014) reported that 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 patches, 49% were larger than 40 m² (Table 3-3) in 2013, compared to 50% in 2009–2010. However, the number of patches larger than 400 m² increased from 21 (5% of patches) in 2009–2010 to 78 in 2013 (28% of patches).

3.4.5 Pleasant Creek

Tamarisk, Russian olive, and tree-of-heaven were all detected in at least one of the three

time periods. One tree-of-heaven patch was detected in 2003, but this species was not detected in 2010 or 2014. Russian olive has been detected in a few patches in each year: four in 2003, three in 2010, and eight in 2014. The number of tamarisk patches has declined over time, from 100 patches detected in 2003, to 60 in 2010, and 49 in 2014.

Monitoring methods were the same between 2010 and 2014, so these numbers are directly comparable (Table 3-2). While there were fewer patches of tamarisk in 2014 than 2010, the number of tamarisk patches larger than 40 m² increased from 5 to 24, while patches smaller than a few plants decreased from 41 to 11. There were minimal changes in percent cover of the three species detected and in total cover of invasive species from 2010 to 2014 (Perkins 2015).

3.4.6 Across all monitoring routes

Three species were detected in small numbers in the 2009–2012 sample period but not in the 2013–2015 timeframe: asparagus (*Asparagus officinalis*), tree-of-heaven, and woolly mullein (*Verbascum thapsus*). Bull thistle (*Cirsium vulgare*) was only detected in the latter time period (Table 3-2). The two most frequently detected species, tamarisk and Russian olive, had fewer patches in the latter time period, but the number of large patches (>40 m²) has increased for Russian olive and the number of patches of >400 m² has increased for tamarisk.

Table 3-2. Total patches observed, nNumber of patches/kilometer, and size of patches detected along monitoring routes, Capitol Reef NP, 2009–2015.

Scientific name	Common name	Year	Total patches	Km	Patches/ km	Patch size class*				
						1	2	3	4	5
Oak Creek										
<i>Elaeagnus angustifolia</i>	Russian olive	2011	1	7.3	0.14	1	0	0	0	0
		2015	3	7.27	0.41	1	1	0	1	0
<i>Tamarix</i> spp.	tamarisk	2011	68	7.3	9.36	24	16	12	9	7
		2015	45	7.27	6.19	5	8	10	7	15
Total		2011	69	7.3	9.49	25	16	12	9	7
		2015	48	7.27	6.61	6	9	10	8	15
Cathedral Valley Road										
<i>Tamarix</i> spp.	tamarisk	2012	23	13.5	1.70	7	0	7	9	0
		2015	20	13.5	1.48	0	0	3	1	16
Scenic Drive										
<i>Tamarix</i> spp.	tamarisk	2012	3	20.3	0.15	2	0	1	0	0
<i>Convolvulus arvensis</i>	field bindweed	2015	4	20.5	0.20	2	2	0	0	0
Pleasant Creek										
<i>Elaeagnus angustifolia</i>	Russian olive	2010	3	9.9	0.30	2	1	0	0	0
		2014	8	10.2	0.78	6	2	0	0	0
<i>Tamarix</i> spp.	tamarisk	2010	60	9.9	6.07	41	14	5	0	0
		2014	49	10.2	4.82	11	13	24	1	0
Total		2010	63	9.9	6.37	43	15	5	0	0
		2014	57	10.2	5.61	17	15	24	1	0
Fremont/Highway 24										
<i>Ailanthus altissima</i>	tree-of-heaven	2009–2010	2	50.6	0.04	2	0	0	0	0
		2013	0	50.1	0.00	0	0	0	0	0
<i>Asparagus officinalis</i>	asparagus	2009–2010	5	50.6	0.10	4	1	0	0	0
		2013	0	50.1	0.00	0	0	0	0	0
<i>Cirsium vulgare</i>	bull thistle	2009–2010	-	50.6	-	-	-	-	-	-
		2013	1	50.1	0.02	0	0	1	0	0
<i>Convolvulus arvensis</i>	field bindweed	2009–2010	2	50.6	0.04	2	0	0	0	0
		2013	8	50.1	0.16	3	5	0	0	0
<i>Elaeagnus angustifolia</i>	Russian olive	2009–2010	34	50.6	0.67	23	11	0	0	0
		2013	24	50.1	0.48	14	7	3	0	0
<i>Tamarix</i> spp.	tamarisk	2009–2010	341	50.6	6.74	60	87	173	21	0
		2013	245	50.1	4.89	48	65	54	78	0
<i>Verbascum thapsus</i>	woolly mullein	2009–2010	1	50.6	0.02	1	0	0	0	0
		2013	0	50.1	0.00	0	0	0	0	0
Total		2009–2010	385	50.6	7.62	92	99	173	21	0
		2013	278	50.1	5.54	65	77	58	78	0

Table 3-2. Number of patches/kilometer, total patches observed, and size of patches detected along monitoring routes, Capitol Reef NP, 2009–2015.

Scientific name	Common name	Year	Total patches	Km	Patches/ km	Patch size class*				
						1	2	3	4	5
Capitol Reef National Park										
<i>Ailanthus altissima</i>	tree-of-heaven	2009–2012	2	101.5	0.02	2	0	0	0	0
		2013–2015	0	101.6	0.00	0	0	0	0	0
<i>Asparagus officinalis</i>	asparagus	2009–2012	5	101.5	0.05	4	1	0	0	0
		2013–2015	0	101.6	0.00	0	0	0	0	0
<i>Cirsium vulgare</i>	bull thistle	2009–2012	0	101.5	0.00	0	0	0	0	0
		2013–2015	1	101.6	0.01	0	0	1	0	0
<i>Convolvulus arvensis</i>	field bindweed	2009–2012	2	101.5	0.02	2	0	0	0	0
		2013–2015	8	101.6	0.08	3	5	0	0	0
<i>Elaeagnus angustifolia</i>	Russian olive	2009–2012	38	101.5	0.37	26	12	0	0	0
		2013–2015	35	101.6	0.34	21	10	3	1	0
<i>Tamarix</i> spp.	tamarisk	2009–2012	495	101.5	4.87	134	117	198	39	7
		2013–2015	363	101.6	3.58	66	88	91	87	31
<i>Verbascum thapsus</i>	woolly mullein	2009–2012	1	101.5	0.01	1	0	0	0	0
		2013–2015	0	101.6	0.00	0	0	0	0	0
	Total	2009–2012	543	101.5	5.35	169	130	198	39	7
		2013–2015	407	101.6	4.01	90	103	95	88	31

*Patch size classes: 1=1–a few plants ($\leq 2 \times 2$ 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), 5=1,000–2,000 m² (0.25–0.5 acre).

Table 3-3. Number of monitoring transects where invasive exotic plant species were detected/total number of transects monitored, mean percent cover, and standard error by sampling area along Oak Creek, Scenic Drive, and Cathedral Valley Road, Capitol Reef NP, 2011–2012 and 2015.

Sampling area	Year(s)	<i>Bromus tectorum</i>		<i>Tamarix</i> spp.		<i>Salsola tragus</i>	
		Detected/Total	Percent cover (SE)	Detected/Total	Percent cover (SE)	Detected/Total	Percent cover (SE)
Oak Creek	2011–2012	0/15	0.00 (0.00)	1/15	0.02 (0.02)	3/15	0.06 (0.03)
	2015	3/15	0.08 (0.04)	1/15	0.01 (0.01)	1/15	0.01 (0.01)
Scenic Drive	2011–2012	0/38	0.00 (0.00)	0/38	0.00 (0.00)	0/38	0.00 (0.00)
	2015	4/41	0.02 (0.01)	0/41	0.00 (0.00)	8/41	0.05 (0.02)
Cathedral Valley Road	2011–2012	0/13	0.00 (0.00)	0/13	0.00 (0.00)	6/13	1.31 (0.87)
	2015	0/26	0.00 (0.00)	0/26	0.00 (0.00)	15/26	0.13 (0.03)

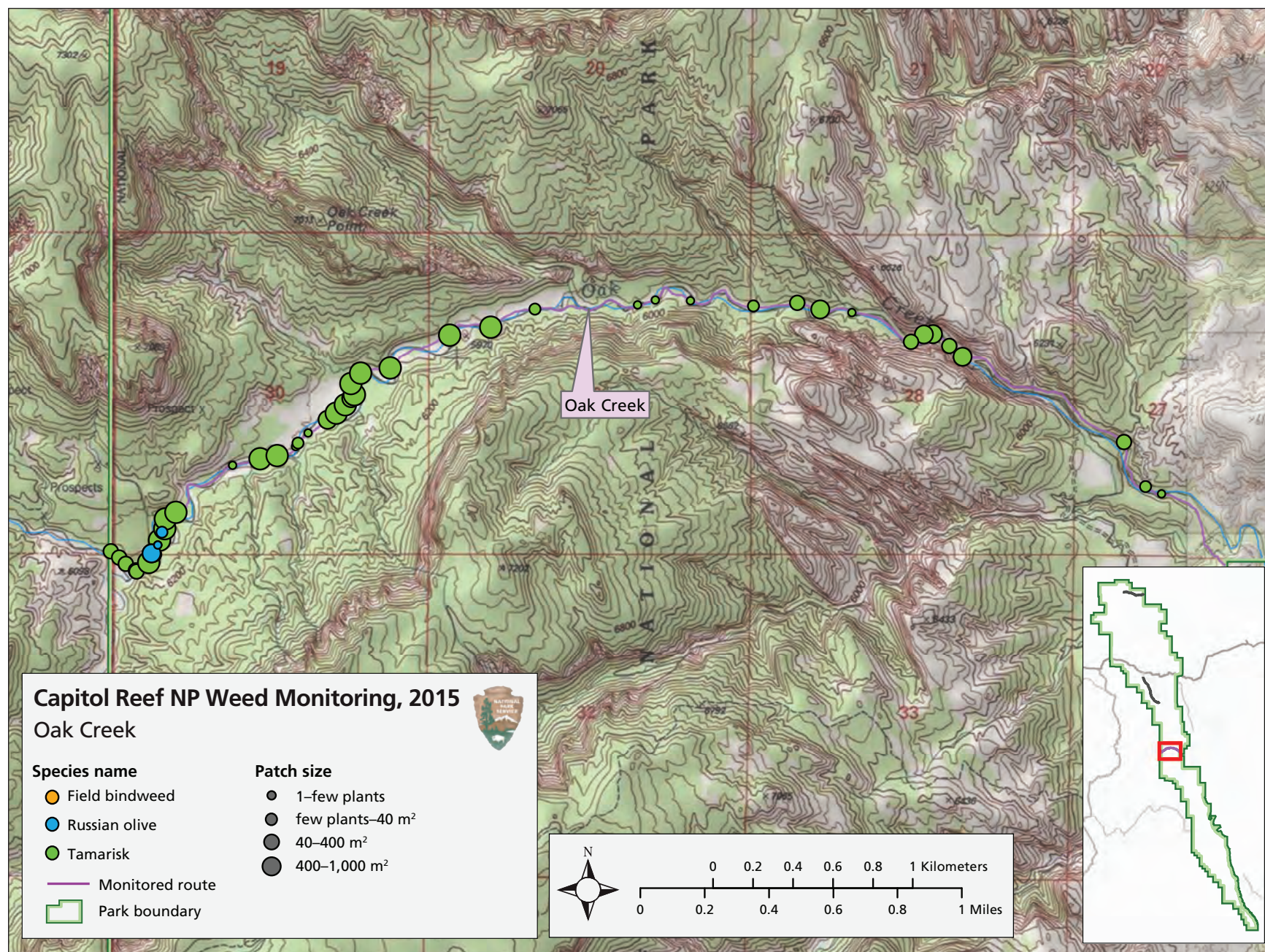


Figure 3-1. Priority invasive exotic plants detected on the Oak Creek monitoring route, Capitol Reef National Park, June 5-10, 2015.

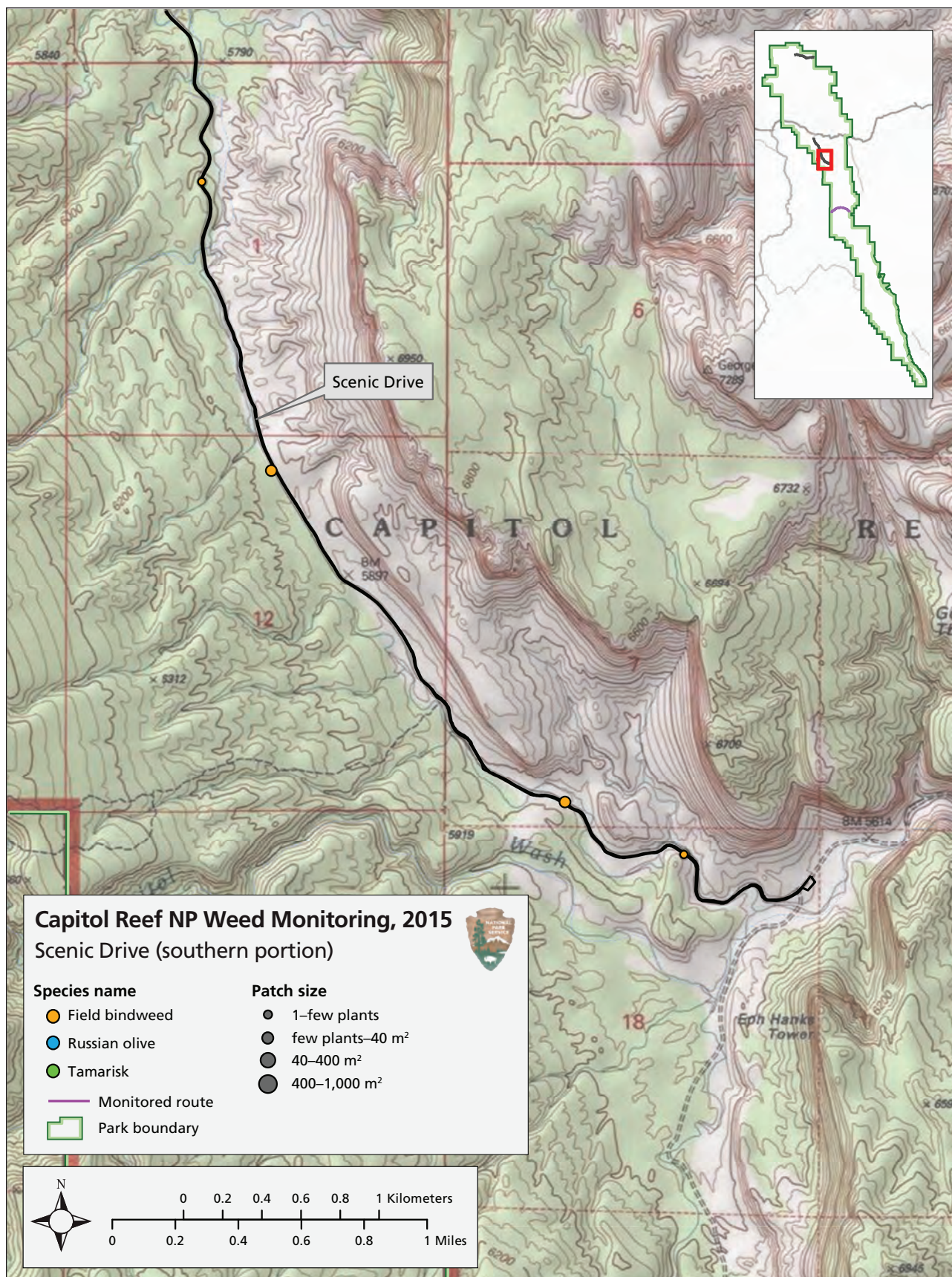


Figure 3-2. Priority invasive exotic plants detected on the southern portion of the Scenic Drive monitoring route, Capitol Reef National Park, June 5–10, 2015.

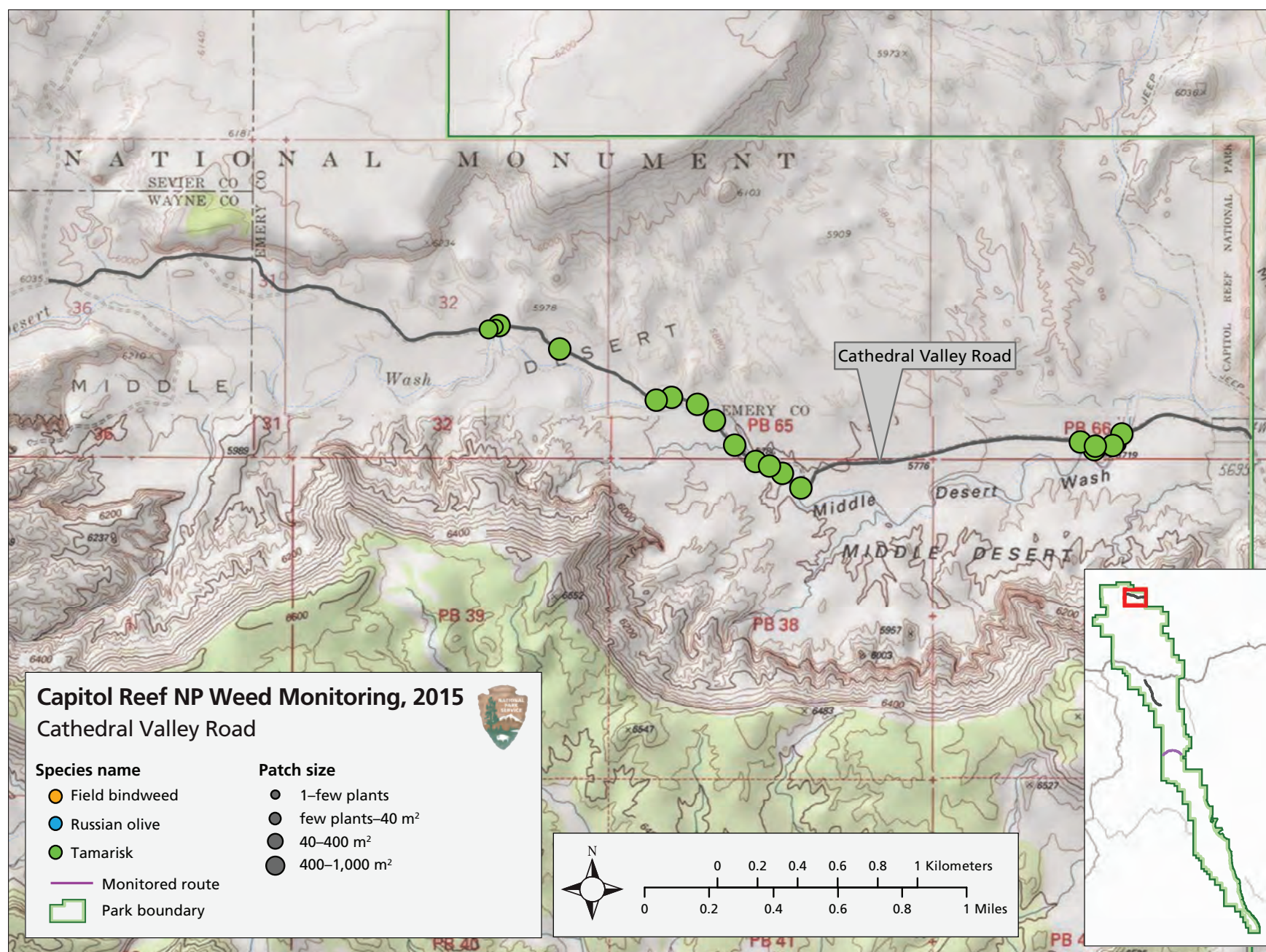


Figure 3-3. Priority invasive exotic plants detected on the Cathedral Valley Road monitoring route, Capitol Reef National Park, June 5–10, 2015.

4 Discussion

4.1 Priority invasive exotic plant 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. No changes to the list are currently recommended.

4.2 Possibilities for management control

The park has targeted tree-of-heaven and Russian knapweed (*Centaurea repens*) for control efforts since the inventories in 2003–2005. Both species remain absent from all monitoring routes. Tamarisk has also been controlled along Scenic Drive, where patch numbers have declined from 18 patches detected in 2003–2005 to three in 2012 and none in 2015. Asparagus also went from five infestations to none along the Highway 24/Fremont River corridor. Russian olive along Highway 24 continues to be a target of the Exotic Plant Management Team (EPMT) each year, which is likely the main reason why its patch numbers have declined by 29% since 2009–2010. In the fall of 2015, after monitoring was conducted, the EPMT removed eight Russian olive infestations in the lower section of Pleasant Creek. These had been previously identified through NPCN's IEP monitoring efforts.

Tamarisk invasion along four of the five monitoring routes is increasing. The number and size of patches has increased along Cathedral Valley Road. The overall number of patches has declined along Highway 24/Fremont River, Pleasant Creek, and Oak Creek—but the number of larger patches has increased, indicating that smaller patches are combining into larger patches. 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.

Park staff is hoping that defoliation by the tamarisk beetle (*Diorhabda carinulata*) will make future control efforts easier. The tamarisk beetle's presence was confirmed for the first time along the Fremont River in 2010 (G. Lenhart, pers. comm.). However, the beetle had not been detected in Pleasant or Oak creeks, Scenic Drive, or Cathedral Valley Road as of the end of the 2015 field season (S. Borthwick, pers. comm.). Continued monitoring will show the effects of both future control efforts and the tamarisk beetle as a biological control agent. Mortality of tamarisk from the beetle has required several years of defoliation 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.

Although there are still only three patches, Russian olive appears to be expanding in the western portion of Oak Creek and has also increased from three patches to eight along Pleasant Creek. However, these patches were treated in the fall of 2015. NCPN monitoring detected bull thistle for the first time along the Fremont/Highway 24 route in 2013, but this plant had been detected in the 2003–2005 sample period. Anecdotal evidence suggests that bull thistle infestations are increasing in the park, especially in the Fruita area and the Highway 24/Fremont River corridor. Control of these Russian olive and bull thistle infestations should take place before they become too widespread.

There was no control work on Oak Creek, Pleasant Creek, or Cathedral Valley Road between the early and later sampling periods, which is reflected in the increases of tamarisk and Russian olive.

It should be noted that estimates of percent cover in this report (see Table 3-3) are limited to the routes surveyed. Actual percent cover of IEPs across the entire park cannot be inferred with these methods. Because we have chosen to monitor along areas most likely to be invaded by a broad suite of IEPs, it is plausible that the percent cover for most IEP spe-

cies 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 of year each time monitoring occurs. 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 2016, the NCPN will start the third round of monitoring by revisiting the Highway 24/Fremont River 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.

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Appendix A. Exotic Plant Patches Detected on Monitoring Routes, Capitol Reef NP, 2015.

Plot_ID	Species	Master_Common_Name	Pulled	Growth_Stage	Cover_Class	Size_Class	N_Coord	E_Coord
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Sapling(s)	2	3	4261185.282	477674.167
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Seedling(s)	1	3	4261772.223	474561.101
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Seedling(s)	1	3	4261182.696	477669.112
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Sapling(s)	2	4	4261759.365	474526.447
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Mature Tree(s)	2	5	4261305.341	475655.302
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Mature Tree(s)	2	5	4261040.076	475995.054
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Mature Tree(s)	2	5	4261181.67	475757.078
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Mature Tree(s)	2	5	4261385.261	475569.615
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Mature Tree(s)	2	5	4261406.318	475364.535
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Mature Tree(s)	2	5	4261663.234	474881.417
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Mature Tree(s)	2	5	4260968.159	476087.137
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Mature Tree(s)	2	5	4261237.178	477692.416
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Sapling(s)	2	5	4261779.81	474579.289
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Mature Tree(s)	2	5	4261099.057	475861.052
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Sapling(s)	1	5	4261197.704	477485.158
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Mature Tree(s)	2	5	4261420.449	475441.603
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Sapling(s)	1	5	4261159.247	477554.247
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Mature Tree(s)	2	5	4261076.599	475931.325
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Mature Tree(s)	2	5	4261180.292	477646.084
Cathedral Valley Rd	Tamarix sp.	tamarisk	0	Mature Tree(s)	2	5	4261175.861	477558.898
Oak Creek	Elaeagnus angustifolia	Russian-olive	0	Mature Tree(s)	4	1	4214203.351	483848.922
Oak Creek	Elaeagnus angustifolia	Russian-olive	0	Sapling(s)	4	2	4214138.885	483827.032
Oak Creek	Elaeagnus angustifolia	Russian-olive	0	Sapling(s)	5	4	4214097.184	483795.717
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	5	1	4215336.212	486810.36
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	5	1	4214649.309	484529.61
Oak Creek	Tamarix sp.	tamarisk	0	Seedling(s)	5	1	4214031.705	483766.441
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	3	1	4215319.932	485716.542
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	5	1	4214432.425	488772.401
Oak Creek	Tamarix sp.	tamarisk	0	Mature Tree(s)	1	2	4215340.518	486230.432
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	3	2	4215362.47	486495.443
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	2	2	4214700.346	484580.777
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	2	2	4215365.712	486319.236
Oak Creek	Tamarix sp.	tamarisk	0		2	2	4215303.494	487303.123
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	2	2	4214538.765	484203.083
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	2	2	4214395.191	488852.957
Oak Creek	Tamarix sp.	tamarisk	0	Seedling(s)	2	2	4214632.424	484518.182
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	2	3	4214076.42	483633.896
Oak Creek	Tamarix sp.	tamarisk	0	Mature Tree(s)	3	3	4215136.006	487791.492
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	2	3	4214044.104	483667.036
Oak Creek	Tamarix sp.	tamarisk	0	Seedling(s)	1	3	4214091.135	483807.847
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	2	3	4214012.244	483718.384
Oak Creek	Tamarix sp.	tamarisk	0	Seedling(s)	2	3	4214007.414	483720.991
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	2	3	4214107.758	483593.469
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	3	3	4215351.117	487029.781
Oak Creek	Tamarix sp.	tamarisk	0	Mature Tree(s)	3	3	4215156.19	487599.081
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	2	3	4214654.309	488664.442
Oak Creek	Tamarix sp.	tamarisk	0	Mature Tree(s)	3	4	4215082.264	487856.319

Appendix A. Exotic Plant Patches Detected on Monitoring Routes, Capitol Reef NP, 2015, cont.

Plot_ID	Species	Master_Common_Name	Pulled	Growth_Stage	Cover_Class	Size_Class	N_Coord	E_Coord
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	1	4	4214766.324	484677.364
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	1	4	4214873.763	484795.791
Oak Creek	Tamarix sp.	tamarisk	0	Mature Tree(s)	3	4	4215192.721	487662.821
Oak Creek	Tamarix sp.	tamarisk	0	Seedling(s)	1	4	4214882.253	484808.551
Oak Creek	Tamarix sp.	tamarisk	0	Mature Tree(s)	3	4	4215194.106	487709.001
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	1	4	4215317.915	487144.882
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	1	5	4214269.052	483865.476
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	1	5	4214841.72	484766.383
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	1	5	4214163.989	483837.193
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	1	5	4215189.889	485289.744
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	1	5	4214051.679	483782.993
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	1	5	4214891.819	484812.074
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	1	5	4214221.266	483862.423
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	1	5	4214946.756	484794.569
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	1	5	4215025.056	484991.696
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	1	5	4214571.669	484340.481
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	1	5	4214999.263	484842.68
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	1	5	4215230.249	485494.879
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	1	5	4214799.75	484721.271
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	1	5	4214302.131	483918.14
Oak Creek	Tamarix sp.	tamarisk	0	Sapling(s)	1	5	4214586.57	484424.584
Scenic Drive	Convolvulus arvensis	Field bindweed	0		5	1	4230731.461	480697.159
Scenic Drive	Convolvulus arvensis	Field bindweed	0		5	1	4229318.265	481948.719
Scenic Drive	Convolvulus arvensis	Field bindweed	0		1	2	4231962.817	480400.793
Scenic Drive	Convolvulus arvensis	Field bindweed	0		4	2	4229096.005	482455.02

Appendix B. Exotic Plant Transect Data, Capitol Reef NP, 2015.

Plot_ID	Transect	Species	Master_Common_Name	Cover_Average	E_Coord	N_Coord
Oak Creek	324	Bromus tectorum	Cheatgrass	0.167	484804.75	4214896.101
Oak Creek	328	Bromus tectorum	Cheatgrass	0.667	486476.253	4215375.279
Oak Creek	332	Bromus tectorum	Cheatgrass	0.333	488186.834	4214926.676
Scenic Drive	336	Bromus tectorum	Cheatgrass	0.333	482785.397	4228939.128
Scenic Drive	337	Bromus tectorum	Cheatgrass	0.167	482481.999	4229084.581
Scenic Drive	344	Bromus tectorum	Cheatgrass	0.167	480446.359	4231549.983
Scenic Drive	357	Bromus tectorum	Cheatgrass	0.167	482501.884	4229046.936
Cathedral Valley Rd	379	Salsola sp.	Russian thistle	0.167	473453.463	4261983.453
Cathedral Valley Rd	381	Salsola sp.	Russian thistle	0.167	474344.368	4261741.349
Cathedral Valley Rd	387	Salsola sp.	Russian thistle	0.167	476975.288	4261196.298
Cathedral Valley Rd	388	Salsola sp.	Russian thistle	0.167	477472.829	4261200.604
Cathedral Valley Rd	492	Salsola sp.	Russian thistle	0.167	472563.802	4262050.906
Cathedral Valley Rd	383	Salsola tragus	Russian-thistle	0.167	475249.84	4261478.65
Cathedral Valley Rd	384	Salsola tragus	Russian-thistle	0.167	475666.28	4261279.702
Cathedral Valley Rd	385	Salsola tragus	Russian-thistle	0.167	476046.056	4260983.595
Cathedral Valley Rd	386	Salsola tragus	Russian-thistle	0.5	476486.064	4261094.343
Cathedral Valley Rd	498	Salsola tragus	Russian-thistle	0.167	475252.392	4261482.312
Cathedral Valley Rd	499	Salsola tragus	Russian-thistle	0.167	475669.603	4261284.528
Cathedral Valley Rd	501	Salsola tragus	Russian-thistle	0.667	476491.359	4261098.742
Cathedral Valley Rd	502	Salsola tragus	Russian-thistle	0.167	476976.4	4261201.917
Cathedral Valley Rd	503	Salsola tragus	Russian-thistle	0.167	477474.822	4261207.323
Cathedral Valley Rd	504	Salsola tragus	Russian-thistle	0.333	477888.306	4261335.35
Oak Creek	324	Salsola tragus	Russian-thistle	0.167	484804.75	4214896.101
Scenic Drive	336	Salsola tragus	Russian-thistle	0.333	482785.397	4228939.128
Scenic Drive	340	Salsola tragus	Russian-thistle	0.167	481358.296	4229826.484
Scenic Drive	346	Salsola tragus	Russian-thistle	0.167	480380.283	4232470.852
Scenic Drive	367	Salsola tragus	Russian-thistle	0.333	480129.84	4232828.93
Scenic Drive	368	Salsola tragus	Russian-thistle	0.333	480036.001	4233239.025
Scenic Drive	371	Salsola tragus	Russian-thistle	0.333	479343.65	4234517.725
Scenic Drive	375	Salsola tragus	Russian-thistle	0.167	478312.195	4236167.661
Scenic Drive	376	Salsola tragus	Russian-thistle	0.333	478164.393	4236642.889
Oak Creek	331	Tamarix chinensis	Five-stamen tamarisk	0.167	487793.742	4215134.987

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