



Invasive Exotic Plant Monitoring at Capitol Reef National Park

2024 Field Season



Cathedral Valley at Capitol Reef National Park, where open desert shrublands are surveyed for invasive exotic plant species.

NPS / AMY WASHUTA

Invasive Exotic Plant Monitoring at Capitol Reef National Park: 2024 Field Season

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Abstract

Invasive exotic plant (IEP) species are among the biggest threats to natural ecosystem integrity and biodiversity, and their control is a high priority for the National Park Service. The Northern Colorado Plateau Network (NCPN) selected early detection of IEPs as one of the 11 long-term monitoring protocols. This report summarizes work completed during the 2024 field season at Capitol Reef National Park. On May 24, 2024, we detected 102 patches of four priority IEP species along 13.5 km of Cathedral Valley Road. We observed more patches of tamarisk IEPs than in previous years. This increase may reflect how observers categorized infestations into the 400–1,000 m² class and fewer in the >1000 m² class in 2024 than in 2019. Tamarisk (*Tamarix* sp., 86 patches) was the most prevalent priority IEP species. IEP species were found on 96.4% (27 of 28) of monitored transects. All but one of these detections was Russian thistle (*Salsola* sp.). Russian thistle increased in frequency along the Cathedral Valley Road monitoring route in all four rotations from 2012 to 2024.

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1 Introduction

Invasive exotic species fragment native ecosystems, displace native plants and animals, and alter ecosystem function. Invasive species are among the top threats to biodiversity (Maxwell et al. 2016) and represent one of the most serious threats to natural ecosystem integrity (NRC 2002). However, 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, the 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, 1999). With the aim of facilitating strategic control approaches, NCPN IEP monitoring detects early invasions, identifies existing invasions, and tracks, to the extent possible, changes in the abundance and distribution of priority IEPs in parks along key invasive pathways.

Invasive exotic plants can spread into national parks via multiple types of pathways. Predictable IEP pathways include roads, trails, and riparian corridors. Long-distance dispersal through cargo containers and air freight is an example of sudden pathways. Anthropogenic pathways include horticultural escapes and seeds transported on shoes and in restoration seed mixes. For the National Park Service, the consequences of these plant invasions present a significant challenge to the bureau’s ability to maintain natural resources “unimpaired for the enjoyment of future generations” (NPS 1916).

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 focuses on the most likely areas where a broad range of invasive exotic plants may occur: riparian corridors, reservoir shorelines, 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 or animals.

Specific objectives of NCPN invasive exotic plant monitoring are:

1. To detect incipient populations and new introductions of IEPs before they become established in areas of management significance and invasion pathways, and
2. To determine status and trends of selected IEP populations of management significance.

This report summarizes IEP monitoring results from the 2024 field season at Capitol Reef National Park (NP).

2 Methods

We followed the invasive plant monitoring protocol developed by the NCPN (Perkins et al. 2016). The protocol emphasizes the rapid collection of IEP location and abundance data to maximize the 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 capture the greatest amount of information (i.e., benefit) with the least amount of time and effort (i.e., cost).

After park and NCPN staff reviewed the list of priority invasive plants (see Section 2.1), we established a series of co-located monitoring routes and quadrats along roads and major drainages in the park. The quadrats, which are sampled quantitatively, are used to make inferences about the percent cover of IEPs located along the park's invasive pathways (i.e., the monitoring routes) and allow us to estimate trends in IEP percent cover over time. The monitoring routes, which are not quantitatively sampled, are used to increase the spatial coverage of mapping performed, maximizing our opportunities for detecting IEPs in the park.

2.1 Developing a Park Priority Invasive Exotic Plant List

Prior to beginning monitoring in 2024, staff from the NCPN and Capitol Reef NP reviewed the park's list of priority IEPs (Table 1). The original list of target IEPs was developed by reviewing past park literature and state and county weed lists, as well as consulting with park staff and county weed managers. The priority IEP list includes existing IEPs and potential IEPs of high management concern. Because these methods were designed to be rapid, field crews were trained to develop a focused search image for the priority IEPs, rather than looking for every possible invasive plant species. Eradicating these priority species, or containing them within a park, is still thought to be possible. We added stork's bill (*Erodium cicutarium*) to the priority IEP list in 2024.

Table 1. Priority invasive plant list, Capitol Reef NP, 2009–2024.

Scientific Name	Common Name	Notes
<i>Aegilops cylindrica</i>	jointed goatgrass	Added in 2019
<i>Ailanthus altissima</i>	tree-of-heaven	–
<i>Arctium minus</i>	burdock	–
<i>Asparagus officinalis</i>	asparagus	–
<i>Cardaria</i> sp.	whitetop	Added in 2019
<i>Cardaria draba</i>	hoary cress	2009–2016 only
<i>Carduus acanthoides</i>	spiny plumeless thistle	2009–2011 only
<i>Carduus nutans</i>	musk thistle	Added in 2019
<i>Centaurea diffusa</i>	diffuse knapweed	–
<i>Centaurea maculosa</i>	spotted knapweed	–
<i>Centaurea repens</i>	Russian knapweed	–
<i>Chorispora tenella</i>	blue mustard	Added in 2020

Table 1 (continued). Priority invasive plant list, Capitol Reef NP, 2009–2024.

Scientific Name	Common Name	Notes
<i>Cirsium arvense</i>	Canada thistle	–
<i>Cirsium vulgare</i>	bull thistle	–
<i>Convolvulus arvensis</i>	field bindweed	–
<i>Cynoglossum officinale</i>	common hound's-tongue	Added in 2012
<i>Elaeagnus angustifolia</i>	Russian olive	–
<i>Elymus repens</i>	quackgrass	–
<i>Erodium cicutarium</i>	stork's-bill	Added in 2024
<i>Euphorbia esula</i>	leafy spurge	–
<i>Halogeton glomeratus</i>	halogeton	Added in 2024
<i>Hyoscyamus niger</i>	black henbane	Added in 2012
<i>Isatis tinctoria</i>	Dyer's woad	–
<i>Lythrum salicaria</i>	purple loosestrife	–
<i>Malcolmia africana</i>	African mustard	2012–2013, 2016, 2019–2020
<i>Marrubium vulgare</i>	horehound	–
<i>Medicago sativa</i>	alfalfa	2009–2010 only
<i>Onopordum acanthium</i>	Scotch thistle	–
<i>Rubia tinctoria</i>	madder	Added in 2019
<i>Sisymbrium altissimum</i>	tumble mustard	Added in 2021
<i>Tamarix</i> spp.	tamarisk	–
<i>Tribulus terrestris</i>	puncture vine	–
<i>Ulmus pumila</i>	Siberian elm	–
<i>Verbascum thapsus</i>	woolly mullein	–

2.2 Monitoring Routes

While observers strive to observe and map all priority IEP patches along monitoring routes, some priority IEP species, especially those with low numbers and small size, will inevitably be overlooked. To account for these non-detections, the NCPN has developed a minimum detection target size (MDTS), effective detection distance (EDD), and effective detection swath width (EDSW) that are based on the observability of the least-visible priority IEP species. Therefore, these areas and distances should be considered conservative estimates of an observer's ability to detect IEP patches, as most (and potentially all) IEP patches mapped during monitoring are made up of more easily visible species. As a result, many mapped patches of priority IEP species are observed partially or completely beyond these values.

2.2.1 Minimum Detection Target Size

The minimum detection target size (MDTS) represents the patch size large enough to detect 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. The NCPN has established an MDTs of 40 m² (0.01 acres, or approximately 20 × 20 ft) for all priority IEPs. Use of the MDTs is necessary because field technicians are not expected to find every single plant of every priority IEP species during route surveys. Although searching for single mature plants of some priority IEP species, such as tamarisk (*Tamarix* sp.), is possible due to their large size, single plants of other priority IEP species, such as field bindweed (*Convolvulus arvensis*), are nearly impossible to detect in most field conditions unless the observer is very near the patch.

2.2.2 Effective Detection Distance

The effective detection distance (EDD) is the maximum distance from which a searcher can consistently detect (i.e., see and recognize) the MDTs of the least-visible priority IEP species with at least 90% detection efficiency (Figure 1). Crew members are trained to quantify EDD by walking away from the least-visible priority IEP species (or, if this species is not present, plants of similar stature) from a MDTs (i.e., 40 m²) and determining the maximum distance from which they could consistently see and recognize this patch with complete confidence.

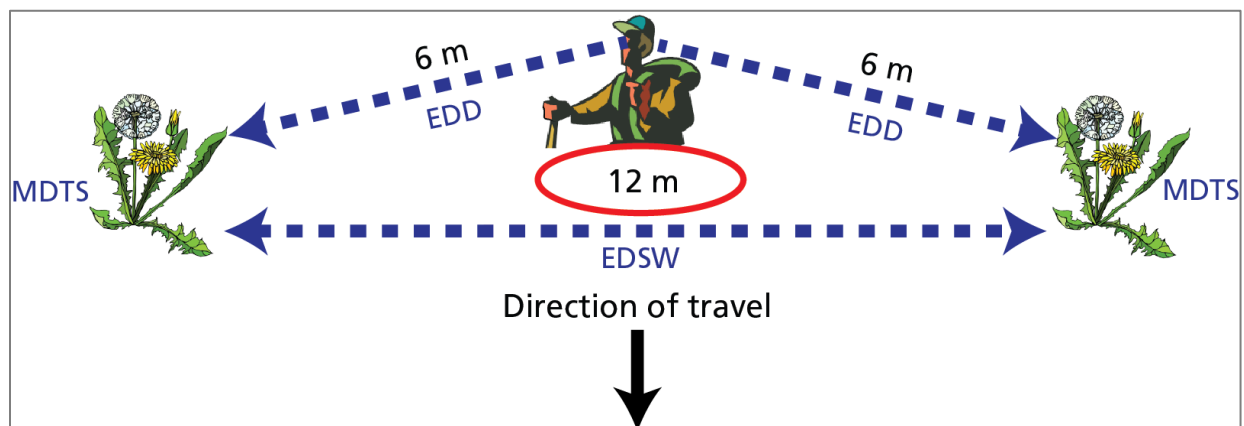


Figure 1. The maximum Effective Detection Distance (EDD) at Capitol Reef NP was 6 m in 2024, making the Effective Detection Swath Width (EDSW) 12 m.

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The size of the EDD is quantified in the field by crew members at the start of each monitoring route and adjusted as necessary, depending on surrounding vegetation and terrain. In 2024, the EDD for Capitol Reef NP was 6 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 priority IEP species meeting the MDTs (Figure 1). The effective detection swath width (EDSW) is equal to two times the EDD, because the surveyor can effectively detect priority IEPs for one EDD on either side of the search route. The EDSW was 12 m at Capitol Reef NP in 2024.

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 infestations or patches. Individuals or clusters of a priority IEP 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 one patch during planning and implementation of weed control operations. If a patch is continuous for more than 50 m, cover estimates are made every 50 m to aid in developing an effective management strategy for the entire patch.

2.2.5 Data Collection Methods

Along the Cathedral Valley Road, observers walked out on one side of the road and walked back on the other. If the terrain was uneven or steep and the observers had to glance frequently at the ground to ensure safe foot placement, searchers stopped approximately every 6 m (the length of one EDSW) and visually scanned the area in all directions. As monitoring routes were traversed, locations of all priority IEP species were documented using GPS units with at least 5 m of accuracy. Only species designated as priority IEP species were consistently recorded on monitoring routes. Survey crew members were allowed to record additional IEP species not listed on the park's list of priority IEPs 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, and (5) cover class (see below). If several species 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 apart were considered separate patches and recorded with a separate point.

Patch size class was estimated as follows:

1. 1–3 plants (used for isolated single plants or very small patches of $\leq 2 \times 2$ m),
2. Four 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 m² (>0.25 acre).

We recorded cover class by estimating the amount, or percentage, of ground covered by the vertical projection of plant matter in the patch 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 from a single plant species. Percent 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, distance to road, wetland, stream); the growth stage of exotic trees (i.e., seedling, sapling, mature tree); evidence of prior treatment; and evidence of disturbances (e.g., recent fire, flood, small mammal disturbance).

2.3 Monitoring Transects and Quadrats

The ability to map priority IEPs along routes is inherently subjective because of differences in observer experience and attention to detail. Furthermore, the broad cover classes used in mapping are insufficient to accurately represent the percent cover of an IEP along monitoring routes. To improve consistency in detecting and quantifying IEPs among observers, we supplemented IEP mapping with additional observations along transects.

We established transects with three vegetation quadrats every 500 m along monitoring routes. Quadrats were centered at 0.5, 5, and 10 m away from the edge of the road on the same side as the route being walked. We placed a 1 m² sampling frame to sample vegetation cover and soil-surface features on the right side of the transect line as the technician walked from the monitoring route. In some cases, we leveled the sampling frame by propping up quadrat corners. In other cases, quadrats could not be placed at 5 and 10 m due to safety concerns.

All priority IEP species, in addition to crested wheatgrass (*Agropyron cristatum*), cheatgrass (*Bromus tectorum*), and Russian thistle (*Salsola* sp.), were recorded in transects. Plants recorded as present in quadrats include both plants rooted within quadrats and plants rooted outside of, but leaning over, the quadrat frame. 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, 100%. We also recorded percent cover 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) using the same cover classes.

2.4 Analyses

We calculated the mean number of patches per kilometer for monitoring routes. Percent cover estimates for individual or grouped monitoring routes were generated from monitoring transect data. We calculated the mean and standard error of percent cover by species for monitoring quadrats. Because of differences in observers' knowledge and potential inconsistencies in identifying species not listed on the priority IEP list, only priority species were used when comparing results from year to year, as shown in Table 1.

3 Results

3.1 Priority Invasive Exotic Plant List

In 2024, field crews searched monitoring routes for 31 species identified as high priority at Capitol Reef NP (see Table 1). Observers were trained to recognize priority IEP species but given the freedom to map additional species. Therefore, presence and absence data for priority IEP species are reliable for the areas searched, but presence and absence data for other species may be less reliable. We detected four priority IEP along the 13.5 km (8.4 miles) Cathedral Valley Road monitoring route (Figure 2, Table 2). Russian thistle (*Salsola* sp.) and tamarisk (*Tamarix* sp.) were detected in transects in 2024.



Figure 2. Invasive plants detected on the Cathedral Valley monitoring route, Capitol Reef NP, May 24, 2024.

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Table 2. Invasive exotic plants detected at Capitol Reef National Park, May 24, 2024.

Scientific Name	Common Name	Method Detected	Species Designation
<i>Elaeagnus angustifolia</i>	Russian olive	Routes	Priority
<i>Halogeton glomeratus</i>	halogeton	Routes	Priority
<i>Malcolmia africana</i>	African mustard	Routes	Priority
<i>Tamarix</i> sp.	Tamarisk	Routes, Transects	Priority
<i>Salsola</i> sp.	Russian thistle	Transects	Transect

3.2 Monitoring Routes

We surveyed the Cathedral Valley Road monitoring route for the fourth time. A total of 102 patches of four priority IEP species were detected (Table 2, Figure 2, NCPN 2025a). The most common patch size was 400–1,000 m², accounting for 57.8% of patches. Tamarisk was the most prevalent priority species on the Cathedral Valley Road monitoring route. With a total of 86 patches recorded, tamarisk represented 84.3% of all priority patches (Table 3). Two tree species were found along the monitoring routes: tamarisk and Russian olive (*Elaeagnus angustifolia*). Of the 86 tamarisk patches recorded, 67 (77.9%) were mature trees, and 19 (22.1%) were saplings. The lone Russian olive patch consisted of mature trees (see NCPN 2025a).

Table 3. Species observed and infestation size class detected along Cathedral Valley Road, Capitol Reef National Park, May 24, 2024.

Species	Total Infestations	No Size Class Recorded	1 to 3 Plants	Three Plants– 40 m²	40–400 m²	400–1000 m²	>1000 m²
<i>Elaeagnus angustifolia</i>	1	1	0	0	0	0	0
<i>Halogeton glomeratus</i>	7	1	0	1	1	4	0
<i>Malcolmia africana</i>	8	1	0	1	2	4	0
<i>Tamarix</i> sp.	86	2	0	1	0	51	32
Priority Species	102	5	0	3	3	59	32

3.3 Monitoring Transects

IEP priority species were found on 27 of 28 transects (96.4%) (see NCPN 2025b). Two IEP species were detected: Russian thistle and tamarisk. Russian thistle, detected in 92.9% of transects sampled, was by far the most widespread IEP species. Russian thistle had 0.87% (standard error [SE] = 0.25) cover across the Cathedral Valley Road monitoring route. Tamarisk was only found in one transect at 1% cover in that transect.

3.4 Results Comparison: 2005–2024

In 2005, Dewey and Anderson (2005a, b) surveyed the same general area along Cathedral Valley that NCPN has monitored from 2012 to 2024. Network staff previously sampled the Cathedral Valley Road route in 2012, 2015, and 2019. Although Dewey and Anderson covered a significantly larger area than the NCPN surveyed from 2012 to 2024 (Perkins and Lenhart 2013, Perkins 2016, Fahey and Perkins 2021), and survey methods differed in some respects, general comparisons across all survey periods are useful, if somewhat problematic.

NCPN sampling methods have been consistent and were based on the methods used by Dewey and Anderson (2005a, 2005b), but mapping is subjective. For example, one observer may record two small patches, separated by 45 m, as two infestations, while another observer records one large infestation. Dewey and Anderson were also searching for a smaller list of priority species, so comparisons can only be made among priority species common to all monitoring years in which they were listed as priority IEPs. Therefore, although general comparisons and major differences noted across all survey periods are useful and likely represent biological differences, smaller changes may not reflect actual conditions. The following is a comparison of results from the four sampling periods conducted by NCPN, given the caveats described above. Four different priority species were detected in at least one of the four sampling periods (Table 4), but the vast majority of these patches were tamarisk. Russian olive (one infestation) and African mustard (*Malcolmia africana*) (eight infestations) were the only other species detected in 2024 and other sampling periods.

Table 4. Number of priority patches by species, and patch size class detected along Cathedral Valley Road in Capitol Reef NP, 2012, 2015, 2019, and 2024.

Species	Common Name	Year	Total	No Size Class Recorded	1 to Few Plants	Few Plants–40 m ²	40–400 m ²	400–1000 m ²	>1000 m ²
<i>Elaeagnus angustifolia</i>	Russian olive	2012	0	0	0	0	0	0	0
	Russian olive	2015	0	0	0	0	0	0	0
	Russian olive	2019	3	0	3	0	0	0	0
	Russian olive	2024	1	1	0	0	0	0	0
<i>Halogeton glomeratus</i> ^A	Halogeton	2024	7	1	0	1	1	4	0
<i>Malcolmia africana</i> ^B	African mustard	2012	0	0	0	0	0	0	0
	African mustard	2019	12	0	4	7	1	0	0
	African mustard	2024	8	1	0	1	2	4	0
<i>Tamarix</i> sp.	Tamarisk	2012	23	0	7	0	8	8	0
	Tamarisk	2015	20	0	0	0	3	1	16
	Tamarisk	2019	62	0	3	2	1	2	54
	Tamarisk	2024	86	2	0	1	0	51	32
Total Priority Species ^C	–	2012	23	0	7	0	8	8	0
	–	2015	20	0	0	0	3	1	16
	–	2019	65	0	6	2	1	2	54
	–	2024	87	3	0	1	0	51	32

^A Added to priority list in 2024.

^B On priority list in 2012–2013, 2016, 2019–2020.

^C Only priority species that were on the priority list (tamarisk and Russian olive) in all years are included in the totals.

The number of tamarisk patches along Cathedral Valley Road increased substantially over our sampling period. Tamarisk patches increased from 12 in 2005 to 23 in 2012, 62 in 2019, and 86 in 2024 (see Table 4). The 2005 survey covered a larger area than surveys conducted from 2012–2024. In 2019 and 2024, most patches were in the two largest size classes. However, the number of patches in the 400–1,000 m² class went from two in 2019 to 51 in 2024, while the number of patches in the >1,000 m² class declined from 54 in 2019 to 32 in 2024. Therefore, some of the increase in infestations between 2019 and 2024 may be due to how observers classified infestation size. However, the extent of tamarisk infestations has substantially increased since the first NCPN sample in 2012 (Figures 3, 4). Russian thistle was present in 46% of transects on Cathedral Valley Road in 2012, increasing to 58% in 2015, 81% in 2019, and 93% in 2024.

Halogeton (*Halogeton glomeratus*) was a new species detected in 2024. However, it was not included on the priority species list in prior years, so it may have been present but unrecorded.

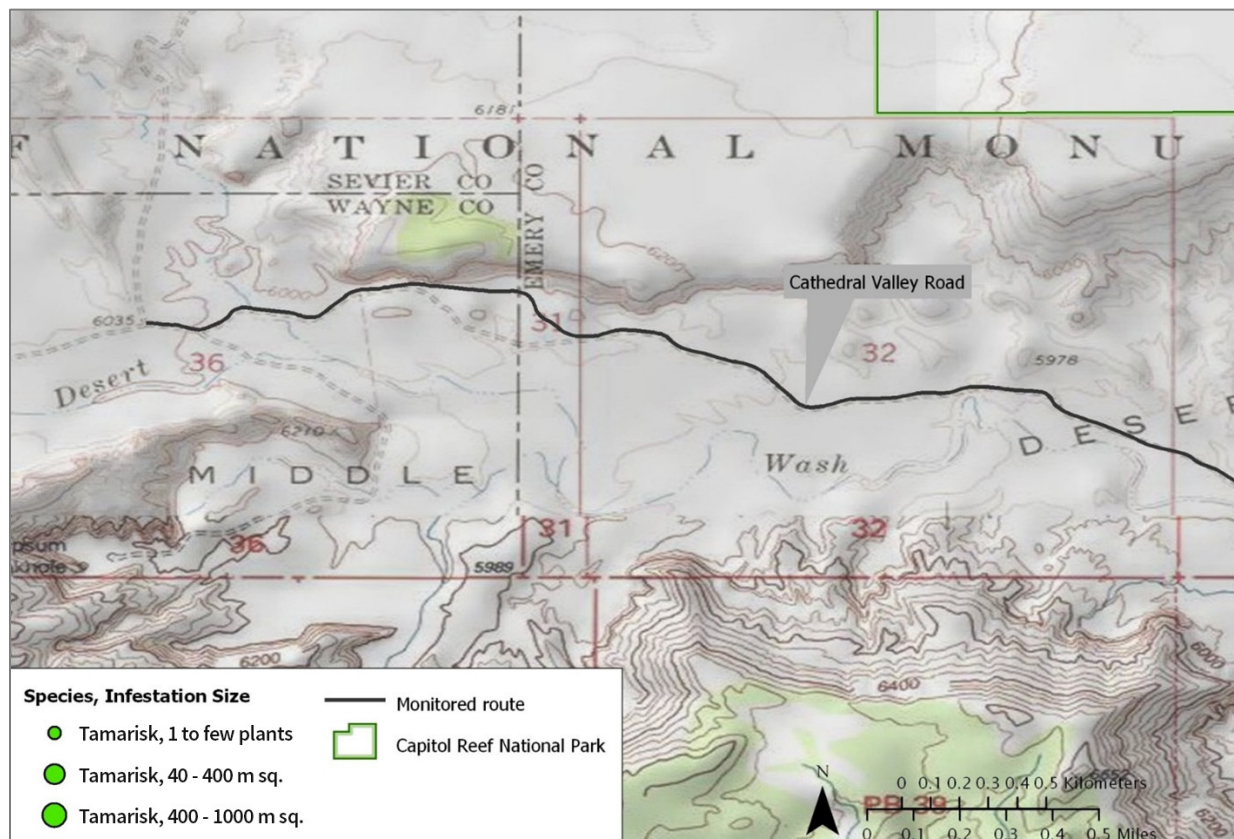


Figure 3. Invasive plants detected on monitoring routes on the west side of Cathedral Valley Road in Capitol Reef NP, September 20 to October 10, 2012.

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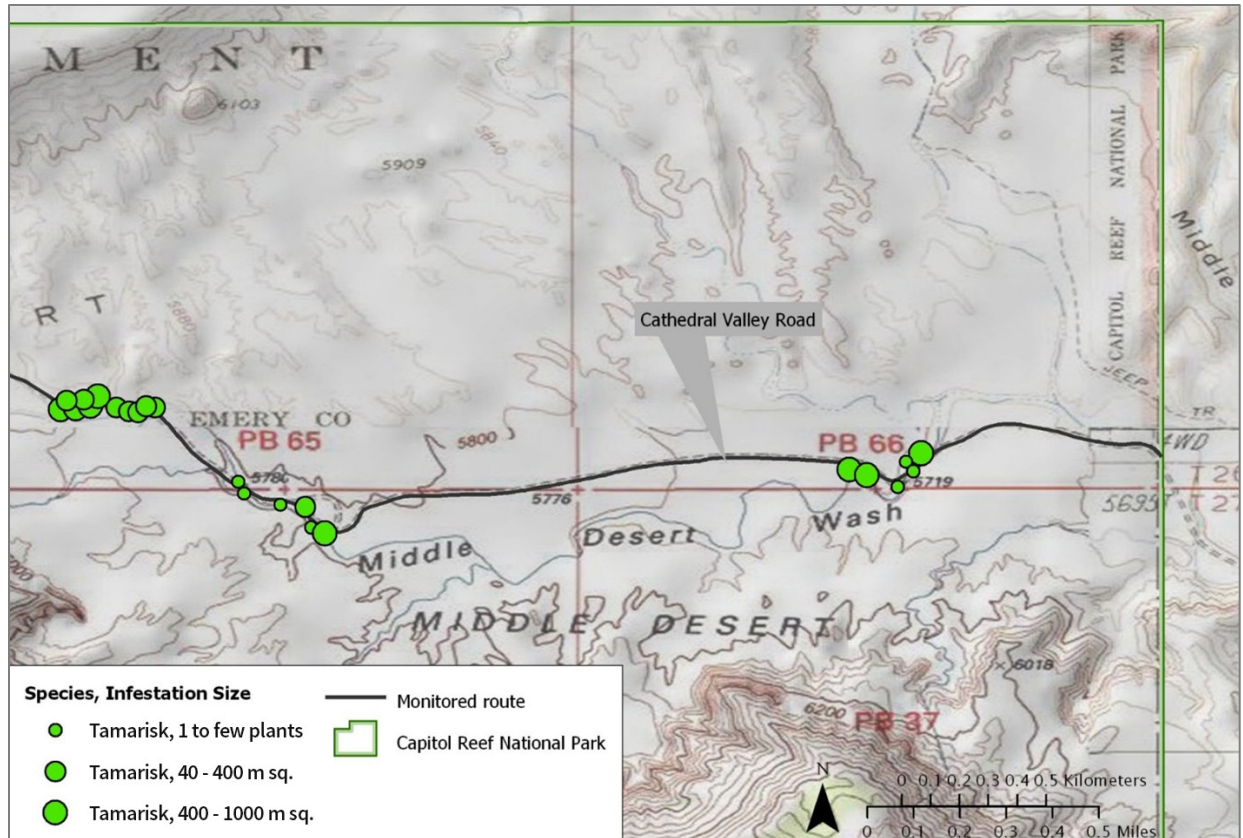


Figure 4. Invasive plants detected on monitoring routes on the east side of Cathedral Valley Road in Capitol Reef NP, September 20 to October 10, 2012.

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4 Discussion

The NCPN will continue to work with Capitol Reef NP staff to review and update the list of priority species each year. Presence and absence data for priority IEP species are considered reliable for the area surveyed. The NCPN does not have any recommendations to add to the priority IEP list for future years.

Tamarisk was the most prevalent priority IEP along the Cathedral Valley Road route. The 86 patches recorded in 2024 (Tables 3, 4) represent a marked increase from previous monitoring years, although some of this may be attributable to observers placing more infestations into the 400–1,000 m² class compared to the >1,000 m² class in 2024 than in 2019. As they are sparsely scattered across a broad landscape, with many individuals in mature growth stages, controlling these populations will be challenging.

The next most common priority species in 2024 were African mustard (*Malcolmia africana*, 8 patches), halogeton (*Halogeton glomeratus*, 7 patches), and Russian olive (*Elaeagnus angustifolia*, 1 patch). We recommend immediate control of these species, as they were found infrequently enough to make control feasible, and they can quickly expand if not treated.

In transects, Russian thistle (*Salsola* sp.) was by far the most widespread species. The proportion of transects that contained Russian thistle increased along Cathedral Valley Road compared to 2019 and has continued to increase since 2012.

Estimates of percent cover in this report (see Tables 3–5) are limited to the routes surveyed; actual percent cover of IEPs across the entire park cannot be inferred with these methods. Because we have chosen to monitor 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.

Priority IEPs at Capitol Reef NP will generally be monitored at the same time each year in future monitoring efforts. Consistency in the timing of monitoring should ensure consistency in detection probabilities and cover estimates of most species. For many species, sampling any time from May through September is not expected to significantly alter the chances of detecting invasive species larger than the MDTS. Extra-area surveys will also be considered for inventories at the park's request.

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