



Invasive Exotic Plant Monitoring at Capitol Reef National Park, 2009

Natural Resource Technical Report NPS/NCPN/NRTR—2010/349



ON THE COVER

Tamarisk (*Tamarix ramosissima*). Photo ©Patrick J. Alexander.

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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. Capitol Reef National Park (CARE) staff detected 14 IEP species on monitoring routes and plots along 41 kilometers of Utah State Highway 24 (includes walking on both sides) during surveys conducted from July 28 to October 8, 2009. Seven were Priority 1 species for the park that were consistently recorded in each year. In 2010, field work will continue at CARE, along Highway 24, Oak Creek, Pleasant Creek, and Notom Road.

Acronyms

BFP	Between Feature Position
CARE	Capitol Reef National Park
EDD	effective detection distance
EDSW	effective detection swath width
IEP	invasive exotic plant
MDTS	minimum detection target size
NCPN	Northern Colorado Plateau Network
NPS	National Park Service
PSR	patch separation resolution

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1 Introduction

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

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

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

Because regular, comprehensive monitoring of the distribution and abundance of all exotic plant species within NCPN units is beyond the fiscal capabilities of the network and parks, the NCPN is focusing on the most likely areas where a broad range of invasive exotic plants may occur: riparian corridors, roads, trails, areas of high visitor impact (e.g., campgrounds), and park boundaries. This approach is cost-effective for finding many new invasions in areas where they are most likely to occur, but it may miss exotic plants dispersed to the interior areas of large parks by wind and/or animals. This report summarizes the 2009 field season at Capitol Reef National Park (CARE).

Specific objectives of NCPN invasive exotic plant monitoring are:

1. To detect incipient populations and new introductions of invasive plant species before they become established in areas of management significance and invasion pathways; and
2. To determine status and trends of selected invasive plant populations of management significance.

2 Methods

Field work followed the invasive exotic plant monitoring protocol developed by the NCPN (in prep.), adapted from Andersen and Dewey (2007). The protocol emphasizes the quick collection of IEP location and abundance data in order to maximize the amount of area searched, thus increasing our chances of finding a higher percentage of both new invasions and established IEPs. By focusing on roads, trails, and waterways, which are major vectors for invasive plants, we will capture the greatest amount of information (i.e., benefit) with the least amount of time and effort (i.e., cost).

The first step was to have CARE and NCPN staff review and update the list of target invasive plants for the park (see below). Next, we established a series of co-located monitoring routes and plots along all roads, major drainages, and trails in the park. The plots, which are sampled in a quantitative manner, are used to make inference to the percent cover of target IEPs located along the park's invasive pathways (i.e., the monitoring routes) and allow us to estimate trends in selected IEP percent cover over time. The monitoring routes, which are not quantitatively sampled, are used to increase the spatial coverage of mapping performed, with the goal of maximizing our opportunities for detecting IEPs in the park.

2.1 Developing a park target invasive exotic plant list

NCPN and CARE staff reviewed the list of high-priority target IEPs for CARE (see Appendix A). The original list was developed by reviewing past park literature and state and county weed lists and consulting with park staff and county weed managers. Our high-priority target IEP list includes existing IEPs and potential IEPs of high management concern. Because these methods were designed to be rapid, field crews were trained to develop a focused search image on the 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.

2.2 Monitoring routes

2.2.1 Minimum Detection Target Size

The minimum detection target size (MDTS) represented the patch size that was large enough to be

detected with a high level of confidence (typically at least 90% of the total number of patches of that size and larger in the monitoring area) under actual field conditions, but small enough so that any missed patches smaller than the MDTS could still feasibly be eradicated if not found until the next scheduled monitoring visit. We established an MDTS of 40 m² (0.01 acres or approximately 20 × 20 ft) for all IEPs. Use of the MDTS was necessary because field technicians were not expected to find every single plant of every targeted weed species during route surveys. Although searching for single mature plants of some species, such as Russian olive (*Elaeagnus angustifolia*) and tamarisk (*Tamarix ramosissima*), is possible due to their large size, single plants of other species, such as field bindweed (*Convolvulus arvensis*), are nearly impossible to detect in most field conditions.

2.2.2 Effective Detection Distance

The effective detection distance (EDD) was the maximum distance from which a searcher could consistently detect (i.e., see and recognize) the MDTS of the least-visible targeted species with at least 90% detection efficiency. Crew members calibrated themselves by walking away from a targeted patch size of the least-visible species and determining the maximum distance from which they could consistently see and recognize the patch with complete confidence. The distance was measured either by pacing or using a laser rangefinder. The EDD for CARE was between 10 and 15 m, depending on vegetation.

2.2.3 Effective Detection Swath Width

Effective detection swath width (EDSW) was defined as the maximum width of a linear search swath (band transect) in which a walking observer is confident of visually detecting 90% of all 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 CARE.

2.2.4 Patch Separation Resolution

We defined patch separation resolution (PSR) as the minimum distance between plants that must be considered members of separate patches or infestations. Individuals or clusters of a target species separated by the PSR distance or more

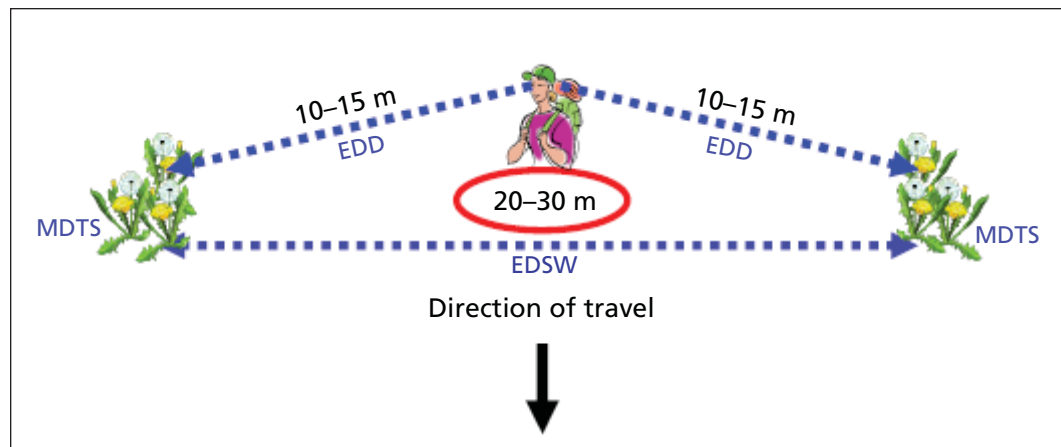


Figure 2-1. The maximum Effective Detection Distance (EDD) at Capitol Reef NP ranged from 10 to 15 meters, making the Effective Detection Swath Width (EDSW) 20–30 meters.

were recorded as separate patches. We considered plants separated by less than the PSR to be a single patch or infestation. The PSR was set at 50 m, based on the assumption that most plants or groups of plants separated by less than 50 m are typically considered to be one infestation during planning and implementation of weed-control operations. If an infestation was continuous for more than 50 m, cover estimates were made every 50 m to aid in developing an effective management strategy for the entire infestation.

2.2.5 Between Feature Position

Between Feature Positions allow electronic tracking of the user's route. The GPS unit was set to automatically generate these positions at a distance equal to the EDSW. Each time a surveyor walked the equivalent of one EDSW, the GPS unit created a point.

2.2.6 Data collection methods

Along Highway 24, we walked 5–10 m out from one side of the road and then returned to the starting point by walking back 5–10 m out from the other side (Figure 2-2). While walking, we searched for selected IEPs by visually scanning (side-to-side) all of the land within the borders of the swath. However, if the terrain was uneven or steep, and the observer had to glance frequently at the ground to ensure safe foot placement, then searchers stopped approximately every 20–30 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 species that were designated as Priority 1 were consistently recorded during monitoring routes. Survey crew members were given the latitude to record additional species if they were noteworthy.

When a Priority 1 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 were recorded with a separate point.

Infestation size class was estimated as follows:

- 1) 1—a few plants (used for isolated single plants or very small patches ($\leq 2 \times 2$ 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).

We recorded canopy cover class by estimating the amount, or “percentage,” of ground covered by the vertical projection of plant matter as visualized from a bird's-eye view of the vegetation (Elzinga et al. 1998). This estimate included both the living and dead standing material of the vegetation of a single plant species. Canopy cover of a patch was recorded using the following classes:

- 1) Trace (<1%)
- 2) Low (1–5%)
- 3) Moderate (6–25%)
- 4) High (26–50%)
- 5) Majority (51–100%).

We recorded the following ancillary information with every infestation: descriptive notes (e.g., hillside, distance to road, wetland, stream), the growth stage of exotic trees (i.e., sapling, pole, mature), evidence of prior treatment, whether it was pulled, and evidence of disturbances (e.g., recent fire, flood, small mammal disturbance).

2.3 Monitoring plots

Our methods for sampling the monitoring plots were based on Stohlgren and others (2005). We established plots with three 1-m² vegetation quadrats every 500 m along all routes along the south side of Highway 24 (Figure 2-3).

2.3.1 Plot establishment

We centered vegetation quadrats at 1, 6, and 11 m away from the edge of the road on the south side of Highway 24. A 1-m² sampling frame was used to sample cover of vegetation and soil surface features by placing it on the right side of the transect line as the technician walked from the monitoring route. In some cases, the crew leveled the sampling frame by propping up quadrat corners.

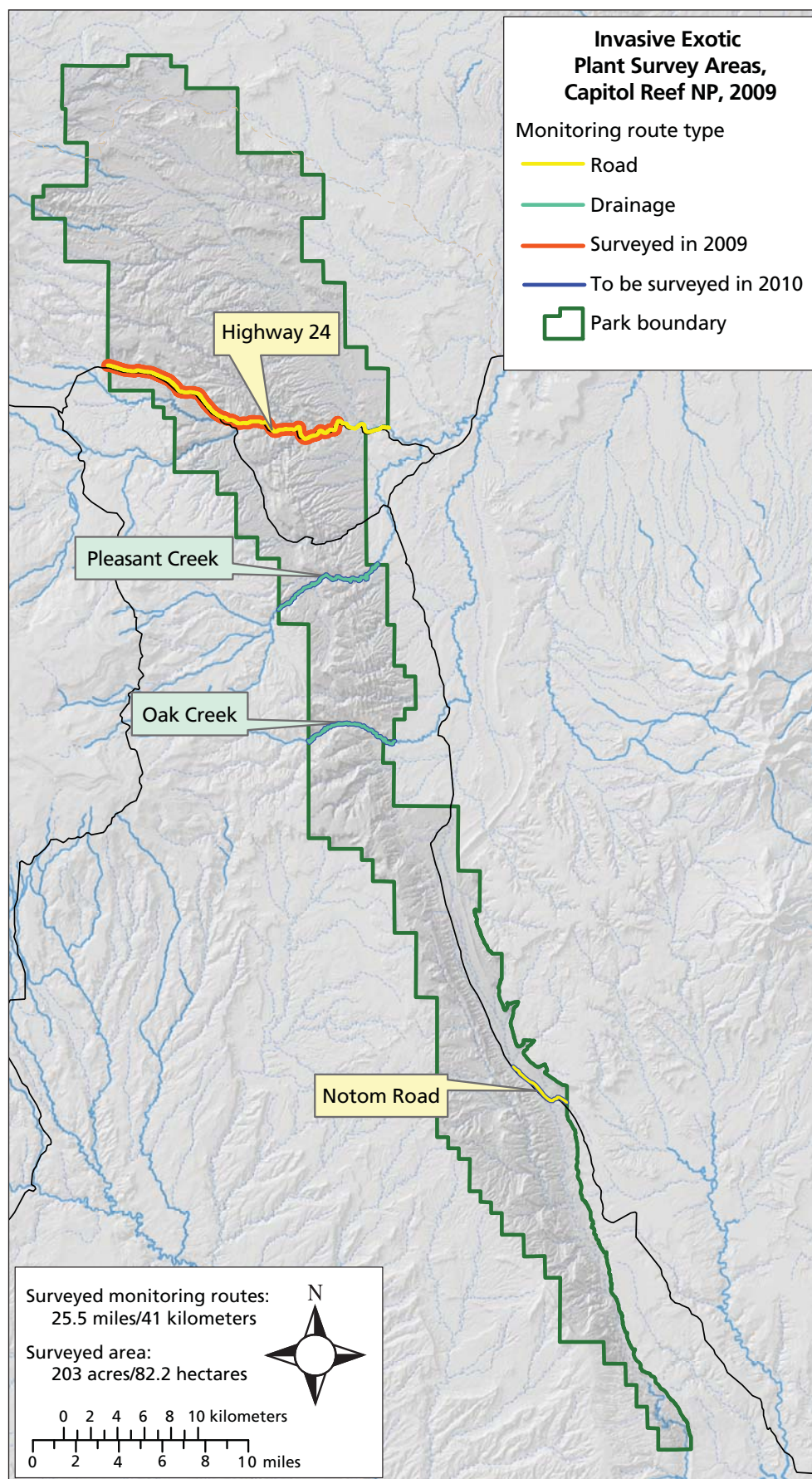
2.3.2 Data collection methods

In the monitoring plots, all Priority 1 IEP species observed were recorded, as well as cheatgrass (*Bromus tectorum*), Russian thistle (*Salsola tragus*), and halogeton (*Halogeton glomeratus*), which were recoded in plots only. 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, 11–25, 26–50, 51–75, or >75%. We also recorded percent cover to the nearest 10% of dominant soil surface features (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 plot data (see below). We calculated the mean and standard error of percent cover by species for monitoring plots. For classes represented by a range of percent cover values (<1, 11–25, 26–50, and >50% cover), midpoints were used (0.5, 18, 38, and 78%) when calculating the mean and standard error.

Figure 2-2. Overview of invasive plant monitoring route surveyed at Capitol Reef National Park, July 28–October 8, 2009, and planned routes for 2010 (when Highway 24 will also be resurveyed).



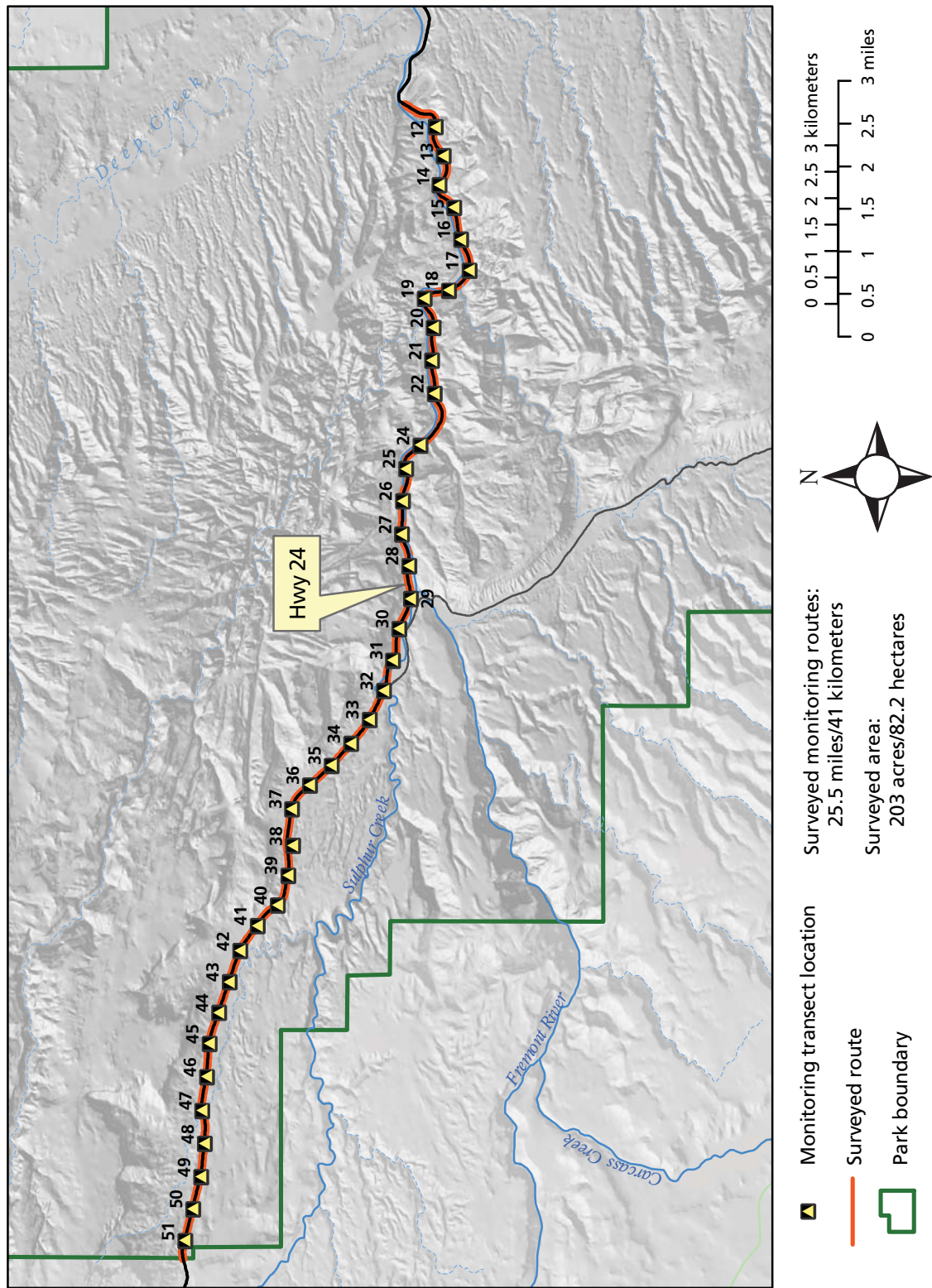


Figure 2-3. Monitoring plots established at Capitol Reef National Park, July 28–October 8, 2009.

3 Results

3.1 Target invasive exotic plant list

Twenty-three IEP species were identified as Priority 1 for the CARE target IEP list (Appendix A). An additional five species were identified as Priority 2. We also recorded cheatgrass in monitoring plots. Observers were trained to recognize Priority 1 species, but given the freedom to map additional species; therefore, presence and absence data for Priority 1 species are reliable, but absence data for other species are suspect.

A total of 14 IEP species were recorded on monitoring routes and plots in 2009. Six IEP species were recorded on monitoring routes and eight in monitoring plots. Of the 14 IEP species detected, seven were Priority 1, three were Priority 2, and four were not identified as priority species (Table 3-1). We covered 82.2 hectares (203 acres) along 41 km of monitoring routes in 2009.

3.2 Monitoring routes

The survey crew walked a total of 41 km (25.5 miles) along Highway 24 in 2009. With the EDSW, this represents a total of 82.2 hectares (203 acres) surveyed. A total of 164 infestations of six different species (all Priority 1) were detected along the monitoring route (Table 3-2, Figure 3-1, Appendix B). This resulted in 0.4 Priority 1 infestations per 100 meters.

IEPs occurred more frequently along the eastern section of Highway 24, which follows the Fremont River, than the western section, which passes through upland vegetation. Tamarisk (82% of infestations detected) and Russian olive (11%) were the most commonly detected IEPs. Of the 138 tamarisk infestations, 50% were larger than 40 m², demonstrating its widespread prevalence. No species other than tamarisk had infestations of more than 40 m².

There were three invasive tree species present: Russian olive, tree-of-heaven (*Ailanthus altissima*), and tamarisk. Growth stage of all trees was not noted. Of the 137 tree infestations that noted the growth stage, 1 was a seedling, 50 were in the sapling stage, and 86 were mature trees (see Appendix B).

3.3 Monitoring plots

A total of 39 plots were sampled in 2009 (Table 3-3, see Figure 2.3, Appendix C). Eight IEP species were detected in plots. IEPs were present in 69% of plots (set of three quadrats), with an average of one IEP species detected per plot. Total IEP cover was 5.41% for all species combined. Only one Priority 1 species, alfalfa, was detected in the plots, for a total cover of 0.01%. Russian thistle was the most widespread and was present in 54% of the plots, with a total cover of 4.47%. Halogeton was present in 13% of the plots, with a total cover 0.17%. All other IEP species were present in less than 10% of the plots. We likely did not observe tamarisk or Russian olive infestations in plots in 2009 because plots were only established on the south side of the road, which is more of an upland community than the north side, which is more riparian.

3.4 Results comparison, 2009 and 2003–2005

Dewey and Anderson (2005a, b) surveyed this same section of Highway 24 in 2003, 2004, and 2005. Nine species that were target species in 2003–2005 and Priority 1 species in 2009 were detected. However, in the earlier surveys, crews mapped infestations of tamarisk and Russian olive with a combination of points, lines, and polygons, whereas in 2009, the crew used points exclusively. Due to these differences in mapping methods, the number of infestations of tamarisk and Russian olive cannot be compared between the two time periods. Tree-of-heaven, field bindweed, and alfalfa infestations all decreased considerably between the two time periods (Table 3-4). None of the seven species that can be compared between sampling periods increased in 2009.

Table 3-1. Invasive exotic plants detected at Capitol Reef National Park, July 28–October 8, 2009.

Scientific name	Common name	Method detected		Park priority
		Routes	Plots	
<i>Ailanthus altissima</i>	tree-of-heaven	X		1
<i>Asparagus officinalis</i>	asparagus	X		1
<i>Convolvulus arvensis</i>	field bindweed	X		1
<i>Elaeagnus angustifolia</i>	Russian olive	X		1
<i>Medicago sativa</i>	alfalfa		X	1
<i>Tamarix</i> spp.	tamarisk	X		1
<i>Verbascum thapsus</i>	woolly mullein	X		1
<i>Halogeton glomeratus</i>	halogeton		X	2
<i>Melilotus officinalis</i>	yellow sweetclover		X	2
<i>Salsola tragus</i>	Russian thistle		X	2
<i>Agropyron cristatum</i>	crested wheatgrass		X	Not on list
<i>Bromus tectorum</i>	cheatgrass		X	Not on list
<i>Portulaca oleracea</i>	common purslane		X	Not on list
<i>Tribulis terrestris</i>	puncturevine		X	Not on list

Only Priority 1 species were mapped and recorded in plots throughout CARE. Priority 2 and species not on the list were opportunistic observations.

Table 3-2. Species observed, and size of infestation detected, along monitoring routes at Capitol Reef National Park, July 28–August 9, 2009.

Scientific name	Common name	Total infestations	Infestation size class			
			Number of infestations			
			1	2	3	4
<i>Ailanthus altissima</i>	tree-of-heaven	1	1	0	0	0
<i>Asparagus officinalis</i>	asparagus	4	3	1	0	0
<i>Convolvulus arvensis</i>	field bindweed	2	2	0	0	0
<i>Elaeagnus angustifolia</i>	Russian olive	18	14	4	0	0
<i>Tamarix</i> spp.	tamarisk	138	31	38	49	20
<i>Verbascum thapsus</i>	woolly mullein	1	1	0	0	0
All species		164	52	43	49	20

Infestation size classes:

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

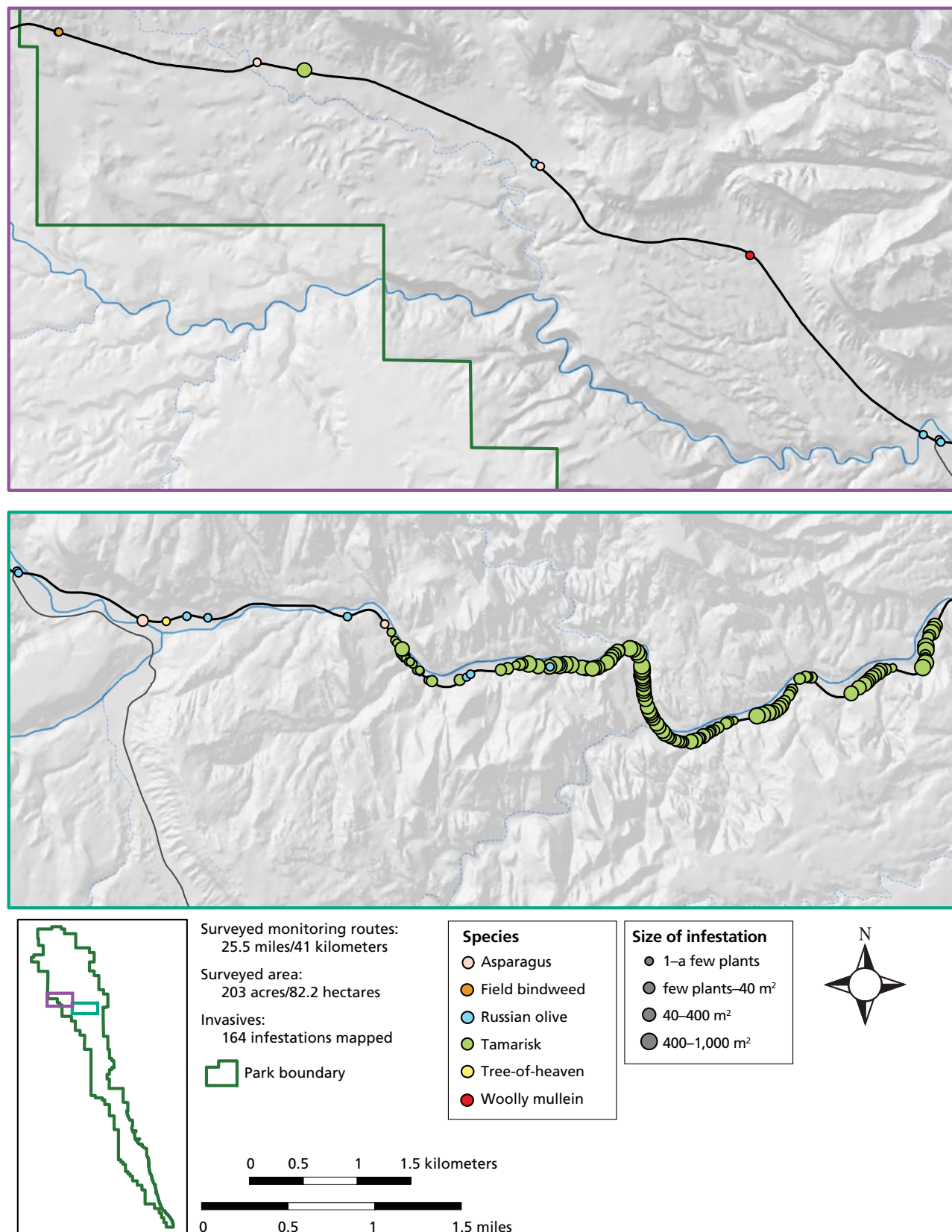


Figure 3-1. Invasive plants detected on monitoring routes at Capitol Reef National Park, July 28–October 8, 2009.

Table 3-3. Number of monitoring plots where exotic plant species were detected along Highway 24, Capitol Reef National Park; mean percent cover; and standard error.

Scientific name	Common name	Plots	Percent cover	SE
<i>Agropyron cristatum</i>	crested wheatgrass	2	0.12	0.57
<i>Bromus tectorum</i>	cheatgrass	3	0.20	1.08
<i>Halogeton glomeratus</i>	halogeton	5	0.18	0.61
<i>Medicago sativa</i>	alfalfa	2	0.01	0.06
<i>Melilotus officinalis</i>	yellow sweetclover	3	0.07	0.29
<i>Portulaca oleracea</i>	common purslane	1	0.03	0.16
<i>Salsola tragus</i>	Russian thistle	21	4.47	10.91
<i>Tribulis terrestris</i>	puncturevine	2	0.33	2.03
All species		39	5.41	11.25

Table 3-4. Number of infestations observed by species along Highway 24 monitoring route, Capitol Reef NP, 2003–2005, and July 28–August 9, 2009.

Scientific name	Common name	2003–2005	2009
<i>Ailanthus altissima</i>	tree-of-heaven	68	1
<i>Asparagus officinalis</i>	asparagus	3	4
<i>Centaurea repens</i>	Russian knapweed	5	0
<i>Cirsium vulgare</i>	horehound	4	0
<i>Convolvulus arvensis</i>	field bindweed	88	2
<i>Elaeagnus angustifolia</i> *	Russian olive	28	18
<i>Medicago sativa</i>	alfalfa	24	0
<i>Tamarix</i> spp.*	tamarisk	49	138
<i>Verbascum thapsus</i>	woolly mullein	2	1
All species		271	164

*Due to differences in mapping methods, the number of infestations of tamarisk and Russian olive cannot be compared between the two time periods.

4 Discussion

4.1 Changes to protocol based on 2008 and 2009 pilot field seasons

Based on work at other NCPN parks, a few changes will be made to the IEP monitoring protocol for 2010. To better capture the roadside verge, where many invasions occur, we will establish the three quadrats at 0.5, 5, and 10 m from the monitoring route, and will establish plots on both sides of the road, instead of just one side, as was done in 2009. We will continue to establish plots with the three quadrats every 500 m along monitoring routes. However, if no Priority 1 IEPs or other park-requested widespread species are detected for four consecutive plots (12 quadrats), then plots will then be established every 1,000 m. If invasive plants are found in categories greater than 1% in subsequent quadrats, the observer will resume establishing plots every 500 m. When the level of invasives is very low (<1% cover), it will be very hard to detect trends based on the monitoring quadrats. However, we will continue monitoring plots to establish a baseline, should invasives ever expand.

4.2 Priority 1 IEP List

The NCPN will continue to work with CARE staff and area weed experts to review and update the list of priority species each year. Presence and absence data for most Priority 1 species, and presence data for other species, should be reliable; however, absence data for non-Priority 1 species are suspect, because not all observers recorded all of these species. Alfalfa was hard to distinguish from yellow sweetclover during some times of the year, so this data may not present a complete picture of alfalfa infestations.

4.3 Possibilities for management control

The park has 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 CARE, and the monitoring along Highway 24 shows the results—from 68 infestations in 2003 and 2004, to just 1 in 2009 (see Table 3-4). It is also encouraging to note that Russian knapweed, a target species for control for CARE, was not found during the 2009 inventories, but has been recorded from the park in the past.

While there were relatively few IEP species detected, a few were widespread, including tamarisk and Russian olive, which together made up 95% of all infestations detected along monitoring routes. Tamarisk, in particular, is well-established along Highway 24, where it is adjacent to the Fremont River corridor. Although the entire river bottom consisted of infested polygons on maps from the 2003–2004 surveys, removal work by CARE staff has reduced this infestation to the point where individual infestations are mapped. Despite the work that has been completed, however, 50% of the 138 tamarisk infestations were larger than 40 m², and 70% of the infestations for which growth stage was noted were mature trees, demonstrating tamarisk's widespread prevalence and the length of time the species has been present. Continued monitoring will show the effects of future control efforts.

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 species is lower in the interior of the park than along the monitoring routes.

NCPN staff do not regularly control invasives while monitoring; however, they are instructed to pull IEPs found in areas that require a significant amount of time to access. Crews only pulled two infestations of asparagus (*Asparagus officinalis*), because most other IEPs were more widespread and easily accessible.

4.4 Future monitoring efforts

IEPs at CARE will generally be monitored at the same time of year. Consistency in timing of monitoring should ensure consistency in detection probabilities and cover estimates of most species. For many species, sampling any time from May through September is not expected to drastically alter the chances of detecting invasive species at a level larger than the minimum detection target size. In 2010, the NCPN will continue monitoring along Highway 24 and expand efforts to include Pleasant Creek, Oak Creek, and Notom Road. Because any previous detections could have been eradicated by park staff, the 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 1 species and cheatgrass by monitoring route. Extra-area surveys will also be considered

for inventories at the park's request. It is anticipated that the NCPN invasive plant monitoring protocol will be submitted for peer review in 2010.

5 Literature Cited

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Appendix A. Target invasive exotic plant list, Capitol Reef National Park

Scientific name (Utah)	Common name
Priority 1	
<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 acanthoides</i>	plumeless thistle
<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>Elaeagnus angustifolia</i>	Russian olive
<i>Elymus repens</i>	quackgrass
<i>Euphorbia esula</i>	leafy spurge
<i>Isatis tinctoria</i>	Dyer's woad
<i>Lythrum salicaria</i>	purple loosestrife
<i>Marrubium vulgare</i>	horehound
<i>Medicago sativa</i>	alfalfa
<i>Onopordum acanthium</i>	Scotch thistle
<i>Tamarix</i> spp.	tamarisk
<i>Ulmus pumila</i>	Siberian elm
<i>Verbascum thapsus</i>	woolly mullein
Priority 2	
<i>Halogeton glomeratus</i>	halogeton
<i>Melilotus officinalis</i>	yellow sweetclover
<i>Salsola tragus</i>	Russian thistle
<i>Sisymbrium altissimum</i>	tumblemustard
<i>Tragopogon dubius</i>	yellow salsify

Appendix B. Exotic plant invasions detected on monitoring routes along Highway 24, Capitol Reef National Park, July 28–October 8, 2009

Scientific name	Common name	Infestation size class	Canopy cover	Pulled?	Growth stage	Northing	Easting
<i>Asparagus officinalis</i>	asparagus	1	1	Yes	-	4237710.994	480594.008
		2	2	No	-	4237744.073	478350.729
		1	2	No	-	4241714.806	470843.869
		1	2	Yes	-	4240745.259	473474.569
<i>Verbascum thapsus</i>	woolly mullein	1	2	No	-	4239918.139	475420.988
<i>Convolvulus arvensis</i>	field bindweed	1	2	No	-	4241995.972	468994.201
		1	2	No	-	4241993.866	469002.568
<i>Ailanthus altissima</i>	tree-of-heaven	1	3	No	S	4237734.542	478568.643
<i>Elaeagnus angustifolia</i>	Russian olive	1	2	No	-	4237780.004	480249.449
		1	2	No	S	4238252.972	477033.987
		1	2	No	S	4240772.702	473426.083
		1	2	No	Seedling(s)	4237783.54	478758.609
		1	3	No	-	4237402.562	480788.571
		1	3	No	MT	4237313.236	482130.921
		1	3	No	MT	4237227.725	482989.648
		1	3	No	S	4237215.992	481356.056
		1	3	No	S	4237245.472	481393.782
		1	3	No	S	4237183.201	482971.807
		1	3	No	S	4236676.996	483214.104
		1	3	No	S	4238203.328	477181.559
		1	3	No	S	4238184.095	477193.936
		1	3	No	S	4237768.62	478953.105
		2	4	No	S	4236711.576	483624.718
		2	4	No	S	4236648.475	483517.56
		2	3	No	S	4237328.289	482219.449
		2	3	No	S	4237467.337	482778.447
<i>Tamarix</i> spp.	tamarisk	1	3	No	-	4237557.895	480688.455
		1	3	No	-	4237531.963	480707.42
		1	3	No	-	4237477.97	480743.942
		1	3	No	-	4237394.451	480793.309
		1	3	No	-	4237359.369	480819.195
		1	3	No	-	4237279.464	480892.923
		1	3	No	-	4237184.488	480998.221
		1	3	No	-	4237633.74	480657.358
		1	3	No	MT	4237304.125	485318.544

Appendix B. Exotic plant invasions detected on monitoring routes along Highway 24, Capitol Reef National Park, July 28–October 8, 2009, cont.

Scientific name	Common name	Infestation size class	Canopy cover	Pulled?	Growth stage	Northing	Easting
<i>Tamarix</i> spp., cont.	tamarisk	1	3	No	MT	4237326.859	481814.382
		1	3	No	S	4236811.455	483842.109
		1	3	No	S	4237285.478	481748.917
		1	3	No	S	4237321.31	481844.63
		1	3	No	S	4237308.362	482000.263
		1	3	No	S	4237297.995	482038.86
		1	3	No	S	4237283.216	482115.506
		1	3	No	S	4237310.24	482232.331
		1	3	No	S	4237319.184	482247.722
		1	3	No	S	4237304.739	482621.937
		1	3	No	S	4237310.715	482633.404
		1	3	No	S	4237439.953	482927.824
		1	3	No	S	4237257.436	482970.117
		1	3	No	S	4237240.05	482970.426
		1	3	No	S	4236937.236	483026.896
		1	3	No	S	4236860.117	483058.91
		1	3	No	S	4236730.89	483137.323
		1	1	No	-	4237269.498	480924.163
		1	1	No	-	4237280.285	480917.764
		1	1	No	-	4237338.187	480856.486
		1	1	No	-	4237362.316	480836.708
		1	1	No	-	4237447.518	480779.653
		2	4	No	MT	4236795.421	483786.481
		2	4	No	MT	4236786.549	483765.797
		2	4	No	MT	4236744.739	483693.503
		2	4	No	MT	4236719.458	483652.31
		2	4	No	MT	4236699.01	483615.493
		2	4	No	MT	4236684.463	483592.028
		2	4	No	MT	4236615.213	483370.465
		2	4	No	MT	4236616.517	483351.372
		2	4	No	MT	4236620.646	483326.481
		2	4	No	MT	4236630.23	483299.374
		2	4	No	MT	4236652.615	483252.851
		2	4	No	MT	4236663.373	483231.32
		2	4	No	MT	4237211.378	484560.706
		2	4	No	MT	4237216.892	484523.648
		2	4	No	MT	4237218.488	484503.764
		2	4	No	MT	4237202.344	484451.198

Appendix B. Exotic plant invasions detected on monitoring routes along Highway 24, Capitol Reef National Park, July 28–October 8, 2009, cont.

Scientific name	Common name	Infestation size class	Canopy cover	Pulled?	Growth stage	Northing	Easting
<i>Tamarix</i> spp., cont.	tamarisk	2	4	No	MT	4237099.921	484377.512
		2	4	No	MT	4237288.213	485251.706
		2	3	No	-	4237453.226	480754.259
		2	3	No	-	4237439.128	480756.777
		2	3	No	-	4237411.175	480782.282
		2	3	No	-	4237180.19	481036.639
		2	3	No	MT	4236649.662	483530.857
		2	3	No	MT	4237073.689	484365.982
		2	3	No	MT	4237047.12	484351.969
		2	3	No	MT	4236991.956	484310.76
		2	3	No	MT	4237606.139	485658.343
		2	3	No	MT	4237581.72	485644.959
		2	3	No	MT	4237419.243	485620.681
		2	3	No	MT	4237391.796	485620.12
		2	3	No	MT	4237339.905	481878.714
		2	3	No	MT	4237336.542	481850.24
		2	3	No	MT	4237299.832	481739.609
		2	3	No	MT	4237283.404	481676.887
		2	3	No	S	4237191.194	481295.329
		2	3	No	S	4237229.062	482962.624
		2	3	No	S	4237211.786	482972.202
		2	3	No	S	4237191.726	482972.893
		3	4	No	MT	4236628.708	483481.705
		3	4	No	MT	4236618.686	483442.823
		3	4	No	MT	4236954.722	484278.377
		3	4	No	MT	4236930.36	484258.492
		3	4	No	MT	4236906.672	484226.217
		3	4	No	MT	4236889.328	484194.427
		3	4	No	MT	4237276.159	485201.903
		3	4	No	MT	4237255.089	485180.444
		3	4	No	MT	4237233.24	485146.767
		3	4	No	MT	4237210.035	485116.061
		3	4	No	MT	4237184.133	485090.225
		3	4	No	MT	4237165.192	485068.134
		3	4	No	MT	4237150.332	485049.726
		3	4	No	MT	4237116.941	484999.593
		3	4	No	MT	4237312.059	482129.883
		3	4	No	S	4236690.689	483199.945

Appendix B. Exotic plant invasions detected on monitoring routes along Highway 24, Capitol Reef National Park, July 28–October 8, 2009, cont.

Scientific name	Common name	Infestation size class	Canopy cover	Pulled?	Growth stage	Northing	Easting
<i>Tamarix</i> spp., cont.	tamarisk	3	2	No	-	4237479.34	480760.899
		3	5	No	S	4237297.518	482466.935
		3	5	No	S	4237307.686	482428.997
		3	3	No	MT	4236667.744	483556.566
		3	3	No	MT	4237695.63	485705.02
		3	3	No	MT	4237665.936	485690.453
		3	3	No	MT	4237066.837	484931.708
		3	3	No	MT	4237318.718	482024.386
		3	3	No	MT	4237106.467	483000.219
		3	3	No	MT	4237149.376	482997.455
		3	3	No	MT	4237175.275	482996.458
		3	3	No	MT	4237201.019	482993.052
		3	3	No	MT	4237219.849	482991.044
		3	3	No	MT	4237456.838	482761.718
		3	3	No	MT	4237424.773	482724.788
		3	3	No	MT	4237409.663	482708.421
		3	3	No	MT	4237380.289	482687.463
		3	3	No	MT	4237353.79	482664.067
		3	3	No	MT	4237307.467	482570.617
		3	3	No	MT	4237301.168	482545.333
		3	3	No	MT	4237294.872	482523.515
		3	3	No	S	4236713.052	483178.462
		3	3	No	S	4236753.478	483142.359
		3	3	No	S	4236782.146	483120.656
		3	3	No	S	4236831.501	483089.931
		3	3	No	S	4236858.195	483073.518
		3	3	No	S	4236882.278	483062.883
		3	3	No	S	4236902.574	483053.743
		3	3	No	S	4236944.009	483039.434
		3	3	No	S	4237009.752	483018.853
		3	3	No	S	4237058.842	483007.175
		3	3	No	S	4237086.12	483003.127
		3	3	No	S	4241642.198	471281.941
		4	4	No	MT	4236883.353	484157.032
		4	4	No	MT	4236865.814	484105.615
		4	4	No	MT	4236856.199	484053.461
		4	4	No	MT	4237330.812	482180.717
		4	4	No	MT	4237338.922	481931.73

Appendix B. Exotic plant invasions detected on monitoring routes along Highway 24, Capitol Reef National Park, July 28–October 8, 2009, cont.

Scientific name	Common name	Infestation size class	Canopy cover	Pulled?	Growth stage	Northing	Easting
<i>Tamarix</i> spp., cont.	tamarisk	4	5	No	MT	4237334.34	482271.507
		4	5	No	MT	4237325.963	482219.146
		4	5	No	S	4237333.596	482326.637
		4	3	No	MT	4237631.216	485674.044
		4	3	No	MT	4237504.797	485624.103
		4	3	No	MT	4237467.959	485624.532
		4	3	No	MT	4237351.287	485617.646
		4	3	No	MT	4237307.221	485592.467
		4	3	No	MT	4237268.783	482985.768
		4	3	No	MT	4237291.222	482986.619
		4	3	No	MT	4237321.138	482984.699
		4	3	No	MT	4237427.286	482953.309
		4	3	No	MT	4237451.047	482935.639
		4	3	No	MT	4237472.653	482900.269
		4	3	No	MT	4237483.004	482875.248

Growth stages:

S = Sapling(s)

MT = Mature trees

Infestation size classes:

- 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)

Canopy cover classes:

- 1) Trace (<1%)
- 2) Low (1–5%)
- 3) Moderate (6–25%)
- 4) High (26–50%)
- 5) Majority (51–100%)

Appendix C. Invasive exotic plant percent cover detected by monitoring transects

Transect #	Scientific name	Common name	Mean cover	Northing	Easting
RA, 12	<i>Salsola tragus</i>	Russian thistle	44.00	4237252.179	485444.535
RA, 13	<i>Salsola tragus</i>	Russian thistle	12.67	4237106.279	485011.748
	<i>Bromus tectorum</i>	cheatgrass	1.00		
RA, 14	<i>Salsola tragus</i>	Russian thistle	7.67	4237180.616	484573.178
RA, 15	<i>Bromus tectorum</i>	cheatgrass	6.67	4236899.915	484239.178
RA, 16	<i>Salsola tragus</i>	Russian thistle	2.00	4236771.447	483763.156
RA, 17	<i>Salsola tragus</i>	Russian thistle	6.00	4236617.394	483298.768
RA, 18	<i>Bromus tectorum</i>	cheatgrass	0.17	4237006.996	483007.56
	<i>Salsola tragus</i>	Russian thistle	0.67		
RA, 19	none	-	0.00	4237468.119	482885.755
RA, 20	<i>Salsola tragus</i>	Russian thistle	16.00	4237291.098	482453.964
RA, 21	<i>Salsola tragus</i>	Russian thistle	14.00	4237322.297	481965.506
	<i>Halogeton glomeratus</i>	halogeton	1.00		
RA, 22	<i>Salsola tragus</i>	Russian thistle	50.67	4237276.621	481473.129
	<i>Halogeton glomeratus</i>	halogeton	3.33		
RA, 24	<i>Agropyron cristatum</i>	crested wheatgrass	3.33	4237547.394	480700.22
RA, 25	<i>Salsola tragus</i>	Russian thistle	6.00	4237817.518	480357.263
RA, 26	<i>Salsola tragus</i>	Russian thistle	0.33	4237879.099	479877.628
	<i>Melilotus officinalis</i>	yellow sweetclover	1.00		
RA, 27	<i>Portulaca oleracea</i>	common purslane	1.00	4237897.567	479382.116
	<i>Salsola tragus</i>	Russian thistle	2.33		
RA, 28	<i>Salsola tragus</i>	Russian thistle	6.00	4237765.834	478913.412
	<i>Tribulis terrestris</i>	puncturevine	0.17		
RA, 29	<i>Tribulis terrestris</i>	puncturevine	12.67	4237731.563	478423.585
	<i>Salsola tragus</i>	Russian thistle	0.17		
RA, 30	<i>Salsola tragus</i>	Russian thistle	0.33	4237957.129	477979.72
	<i>Medicago sativa</i>	alfalfa	0.33		
RA, 31	<i>Salsola tragus</i>	Russian thistle	0.17	4238072.513	477505.059
RA, 32	<i>Melilotus officinalis</i>	yellow sweetclover	1.50	4238246.034	477053.362
	<i>Salsola tragus</i>	Russian thistle	0.50		
	<i>Agropyron cristatum</i>	crested wheatgrass	1.33		
RA, 33	<i>Salsola tragus</i>	Russian thistle	1.00	4238516.895	476626.193
	<i>Halogeton glomeratus</i>	halogeton	0.17		
RA, 34	<i>Medicago sativa</i>	alfalfa	0.17	4238865.529	476271.85
RA, 35	none	-	0.00	4239241.297	475944.705
RA, 36	<i>Melilotus officinalis</i>	yellow sweetclover	0.33	4239651.286	475656.412
RA, 37	none	-	0.00	4239983.264	475304.807
RA, 38	none	-	0.00	4239972.593	474758.71
RA, 39	<i>Halogeton glomeratus</i>	halogeton		4240062.356	474313.61
RA, 40	<i>Salsola tragus</i>	Russian thistle	0.67	4240259.44	473873.175
RA, 41	none	-	0.00	4240645.037	473567.328
RA, 42	<i>Salsola tragus</i>	Russian thistle	0.67	4240974.886	473197.354

Appendix C. Invasive exotic plant percent cover detected by monitoring transects, cont.

Transect #	Scientific name	Common name	Mean cover	Northing	Easting
RA, 43	none	-	0.00	4241174.66	472737.587
RA, 44	none	-	0.00	4241373.306	472278.07
RA, 45	none	-	0.00	4241557.75	471815.175
RA, 46	none	-	0.00	4241606.421	471325.671
RA, 47	none	-	0.00	4241694.249	470823.67
RA, 48	<i>Halogeton glomeratus</i>	halogeton	1.00	4241651.717	470332.779
RA, 49	<i>Salsola tragus</i>	Russian thistle	2.33	4241720.126	469838.355
RA, 50	none	-	0.00	4241873.93	469361.882
RA, 51	none	-	0.00	4242024.244	468887.424

A total of 39 plots were sampled at Capitol Reef National Park, July 28–October 8, 2009.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 158/104294, July 2010

National Park Service
U.S. Department of the Interior



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