



Invasive Exotic Plant Monitoring at Capitol Reef National Park

2010 Field Season

Natural Resource Technical Report NPS/NCPN/NRTR—2011/467



ON THE COVER

Tree-of-heaven (*Ailanthus altissima*). Capitol Reef NP staff estimate that they are close to eradicating this exotic invasive from the park. Photo courtesy Jan Samanek, State Phytosanitary Administration, Bugwood.org.

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Prepared by

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

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

Editing and Design

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

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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. During surveys conducted from July 12 to September 24, 2010, Capitol Reef National Park staff detected eight IEP species on monitoring routes and transects along 19.4 kilometers of Utah State Highway 24 and Pleasant Creek. Of the invasive species considered Priority 1 for the park, tamarisk (*Tamarix chinensis*) and Russian olive (*Elaeagnus angustifolia*) were the most common along Highway 24, while tamarisk and alfalfa (*Medicago sativa*) were the most common along Pleasant Creek. Tamarisk, tree-of-heaven (*Ailanthus altissima*), and Russian knapweed (*Centaurea repens*) all have declined along Highway 24 and Pleasant Creek since the last surveys were completed from 2003 to 2005 and control efforts were undertaken by the park.

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 2010 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

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

2.1 Developing a park target invasive exotic plant list

Prior to beginning monitoring in 2010, NCPN and CARE staff reviewed the list of high-priority target IEPs for CARE (see Appendix A) that was initially developed 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 1 species is reviewed before each field season. There were no changes to the Priority 1 List between the 2009 and 2010 field seasons.

2.2 Monitoring routes

2.2.1 Minimum detection target size

The minimum detection target size (MDTS) represents the patch size that is large enough to be detected with a high level of confidence (typically at least 90% of the total number of patches of that size and larger in the monitoring area) under actual field conditions, but small enough so that any missed patches smaller than the MDTS could still feasibly be eradicated if not found until the next scheduled monitoring visit. 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 weed species during route surveys. 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) 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. 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 CARE in 2010 was 10 m.

2.2.3 Effective detection swath width

Effective detection swath width (EDSW) is defined as the maximum width of a linear search swath (band transect) in which a walking observer is confident of visually detecting 90% of all target species of the MDTS (Figure 2-1). The effective detection swath width (EDSW) is equal to two times the EDD, because the surveyor is able to effectively detect weeds for one EDD on either side of his/her search route. The EDSW was 20 m at CARE in 2010.

2.2.4 Patch separation resolution

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

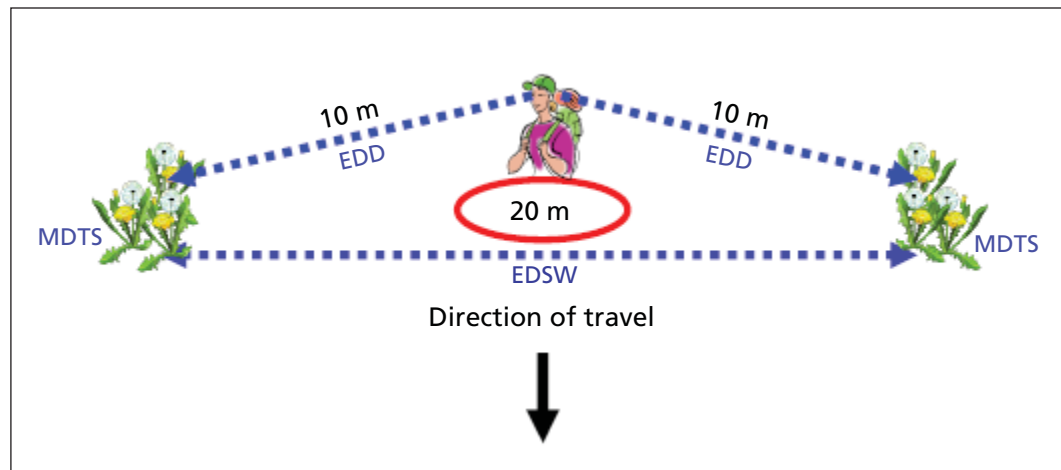


Figure 2-1. The maximum effective detection distance (EDD) at Capitol Reef NP was 10 meters, making the effective detection swath width (EDSW) 20 meters.

2.2.5 Between feature position

Between Feature Positions (BFPs) 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

For Highway 24, we walked one EDD out from one side of the road and then returned to the starting point by walking back one EDD from the road on the other side. For the Pleasant Creek Trail, we walked down the center of the route (Figure 2-2).

While walking, we searched for IEPs by visually scanning (side-to-side) all of the land within the borders of the swath. However, if the terrain was uneven or steep, and the observer had to glance frequently at the ground to ensure safe foot placement, then searchers stopped approximately every 20 m (the length of one EDSW) and visually scanned the area in all directions. As monitoring routes were traversed, locations of all target species were documented using global positioning system (GPS) units with at least five-meter accuracy. Only species designated as Priority 1 were consistently recorded during monitoring routes. Survey crew members were permitted 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 recorded with separate points.

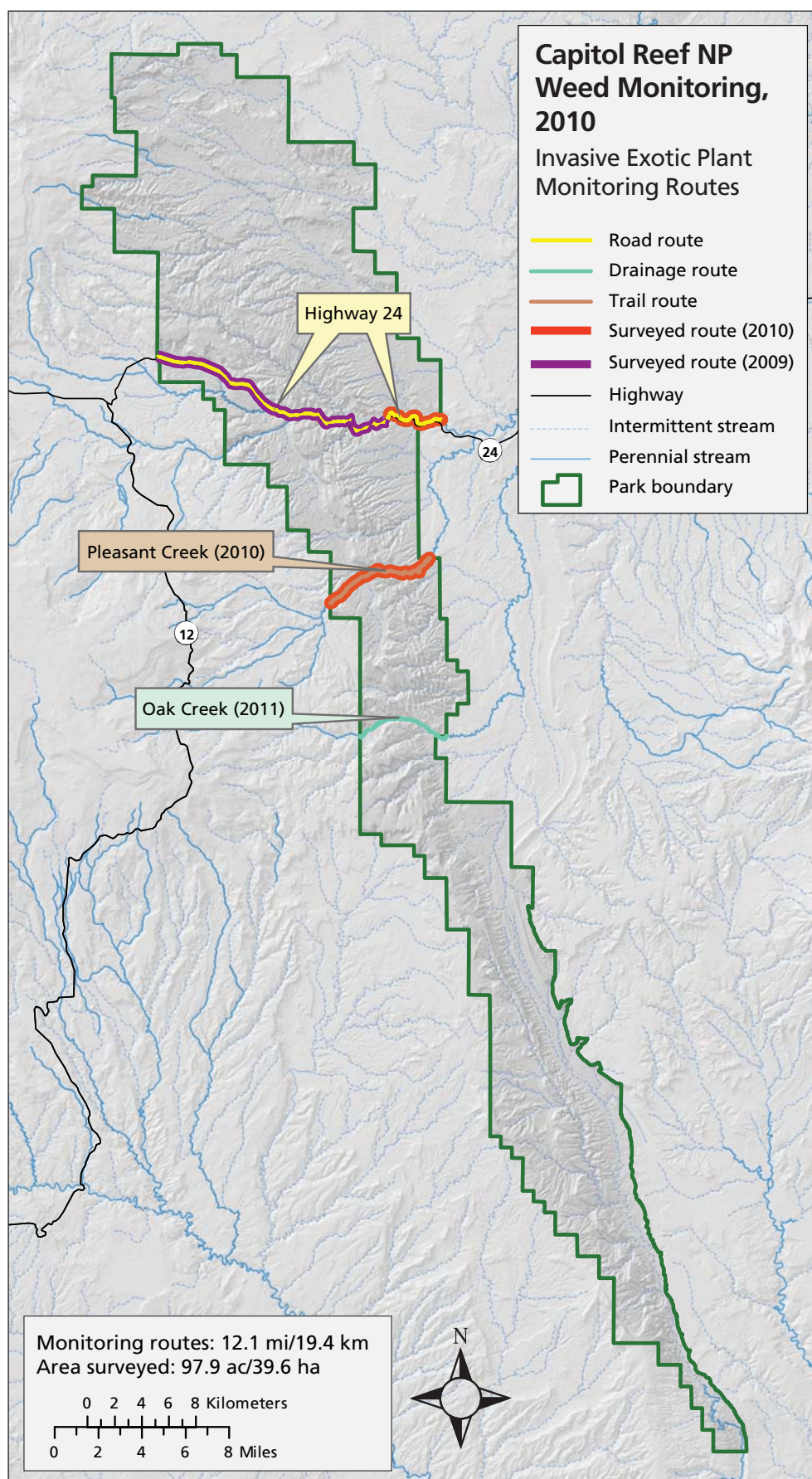
Infestation size class was estimated as follows:

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

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

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

Figure 2-2. Overview of invasive plant monitoring routes surveyed at Capitol Reef NP, July 28–October 8, 2009 and July 12–September 24, 2010, plus route scheduled for 2011.



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

2.3 Monitoring transects

Our methods for sampling the monitoring quadrats were based on Stohlgren and others (2005). We established transects with three vegetation quadrats every 500 m along monitoring routes (Figure 2-3). If no invasives were detected for four consecutive transects (12 quadrats), then transects were established every 1,000 m. If invasive plants were found in categories greater than 1 for canopy cover class or infestation size class, then we reverted back to establishing transects every 500 m.

2.3.1 Quadrat establishment

In 2010, 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 was used to sample vegetation cover and soil surface features, and was placed on the right side of the transect line as the technician walked the monitoring route. In some cases, we leveled the sampling frame by propping up quadrat corners. In 2009, quadrats were placed at 1, 6, and 11 m away from the monitoring route.

2.3.2 Data collection methods

In the monitoring quadrats, all Priority 1 IEP species observed were recorded, as well as cheatgrass (*Bromus tectorum*) and Russian thistle (*Salsola tragus*). For each quadrat, we recorded percent cover of each IEP using the following classes: <1, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11–25, 26–50, or >50%. We also recorded percent cover, to the nearest 10%, of dominant soil surface features (i.e., dead wood, dung, fungus, lichen, litter/duff, live root/bole, mineral soil/sediment, moss, biological soil crust, road, rock, standing water/flooded, stream, or trash/junk).

2.4 Analyses

We calculated the mean number of infestations per 100 m for monitoring routes. Percent cover estimates were generated from the monitoring quadrat data. We calculated the mean and standard error of percent cover by species for monitoring quadrats. For classes represented by a range of percent-cover values (11–25, 26–50, 51–75, and >75% cover), midpoints were used (18, 38, 63, and 88%) when calculating the mean and standard error. Due to differences in observers' knowledge, only Priority 1 species should be used when comparing results from year to year.

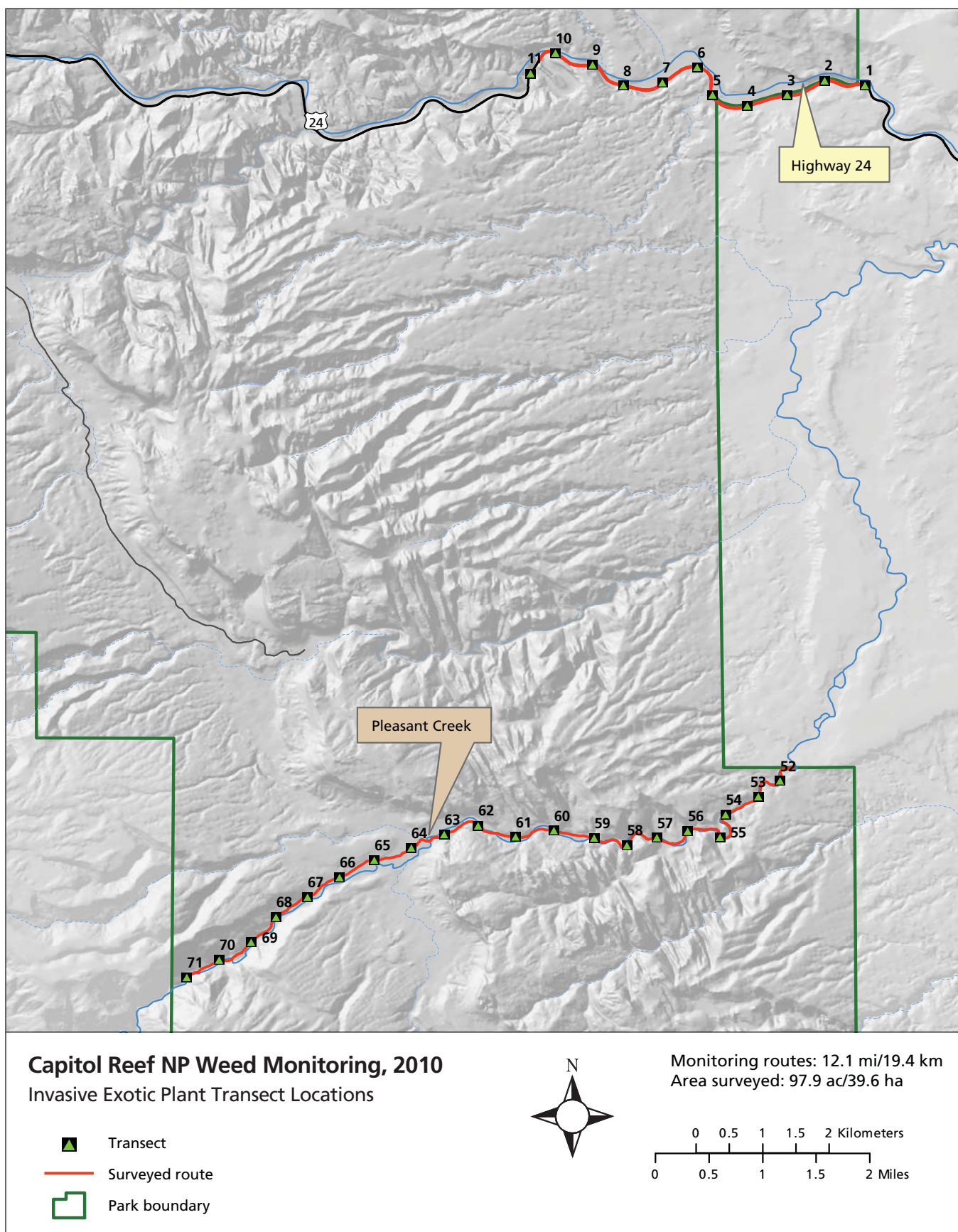


Figure 2-3. Monitoring transects established at Capitol Reef NP, July 28–October 8, 2010.

3 Results

3.1 Target invasive exotic plant list

There are 23 IEP species identified as Priority 1 on the CARE target IEP list (Appendix A). We also recorded cheatgrass in monitoring transects. 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 for the areas searched, but absence data for other species are suspect.

We recorded a total of eight IEP species on monitoring routes and quadrats in 2010. Five IEP species were recorded on monitoring routes and four in monitoring quadrats. Of the eight IEP species detected, five were Priority 1 (Table 3-1). We covered 58.8 hectares (145.3 acres) along 19.4 km of monitoring routes in 2010. In 2009, we covered an additional 82.2 hectares (203.0 acres) along the Highway 24 corridor, for a total of 141.0 hectares (348.3 acres) over the past two years.

3.2 Monitoring routes

The survey crew covered the entire Pleasant Creek corridor in 2010, and the entire Highway 24 corridor over 2009 (Perkins 2010) and 2010. A total of 479 infestations of six different species (all Priority 1) were detected along the monitoring routes (Table 3-2, Figures 3-1, 3-2, 3-3, 3-4, 3-5, Appendix B) in 2009 and 2010. This resulted in 3.80 and 2.37 Priority 1 infestations per 100 meters along Highway 24 and Pleasant Creek, respectively.

Only the easternmost section of Highway 24 was monitored in 2010, with findings similar to those of 2009. The eastern section of Highway 24, which follows the Fremont River, had higher levels of IEP infestation than the western section, which passes through upland vegetation. Tamarisk (*Tamarix chinensis*; 83% of infestations detected), alfalfa (*Medicago sativa*; 10%) and Russian olive (*Elaeagnus angustifolia*; 7%) were the most commonly detected IEPs in 2010. Of the 263 tamarisk infestations, 49% (50% in 2009) were larger than 40 m², demonstrating the widespread prevalence and significant length time since establishment of this invasive (Table 3-3).

Table 3-1. Invasive exotic plants detected at Capitol Reef NP, July 12–September 24, 2010.

Scientific name	Common name	Method detected		Park priority
		Routes	Quadrats	
<i>Ailanthus altissima</i>	tree-of-heaven	X		1
<i>Asparagus officinalis</i>	asparagus	X		1
<i>Elaeagnus angustifolia</i>	Russian olive	X		1
<i>Medicago sativa</i>	alfalfa	X		1
<i>Tamarix chinensis</i>	five-stamen tamarisk	X	X	1
<i>Bromus tectorum</i>	cheatgrass		X	Not on list
<i>Melilotus officinalis</i>	yellow sweetclover		X	Not on list
<i>Salsola tragus</i>	Russian thistle		X	Not on list

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

Table 3-2. Priority 1 IEP infestations per route surveyed, Capitol Reef NP, July 28–October 8, 2009 and July 12–September 24, 2010.

Route	Type of route	Length (m)	Area (ha)	Infestations	
				Number	Infestations/ha
Highway 24 (2010)	Riparian	9,536	19.20	221	11.51
Highway 24 (2009/2010)	Riparian	50,055	101.36	385	3.80
Pleasant Creek	Trail	9,888	39.60	94	2.37
Total		60,443	140.96	479	3.40

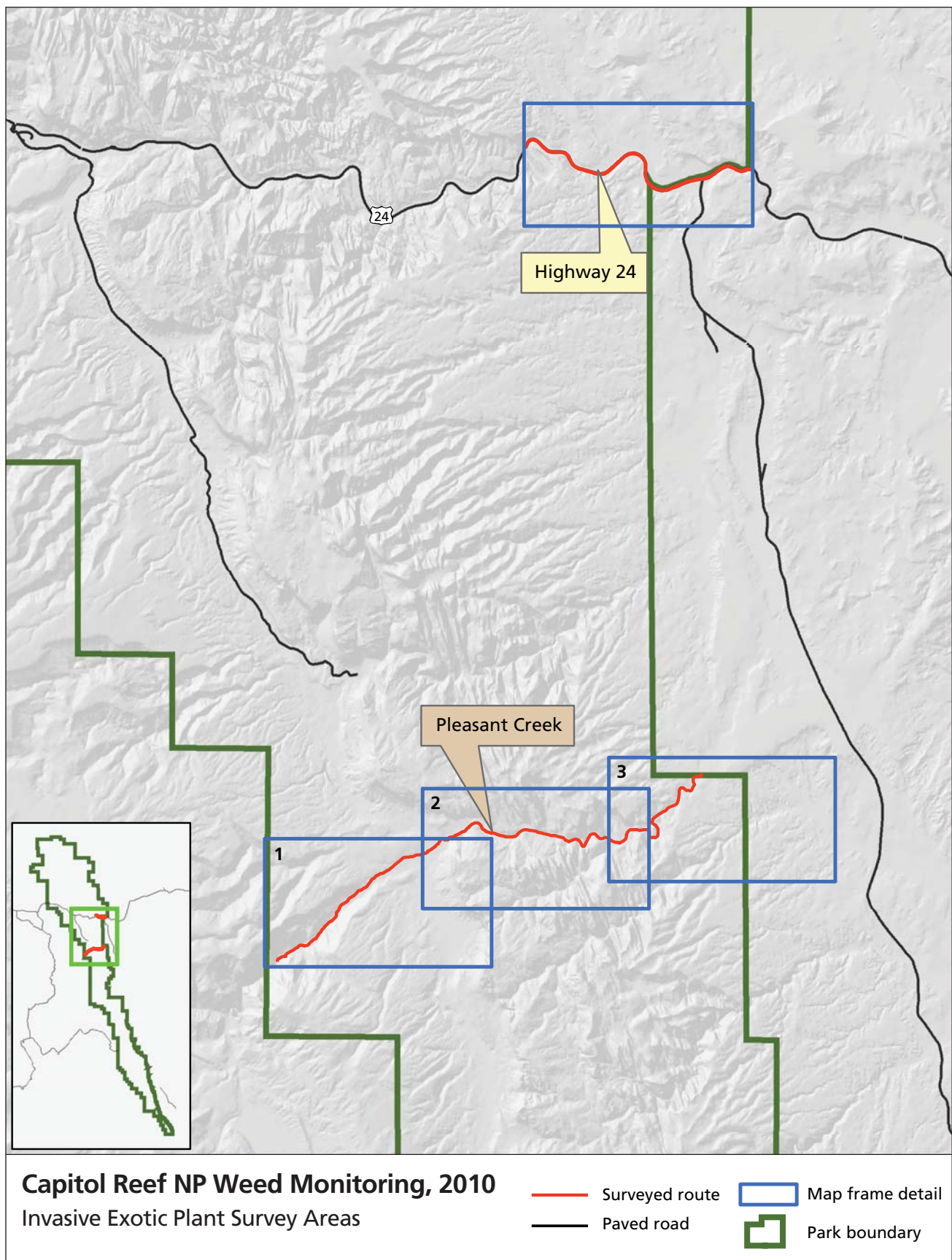


Figure 3-1. Routes surveyed for invasive exotic plants, Capitol Reef NP, July 28–October 8, 2010.

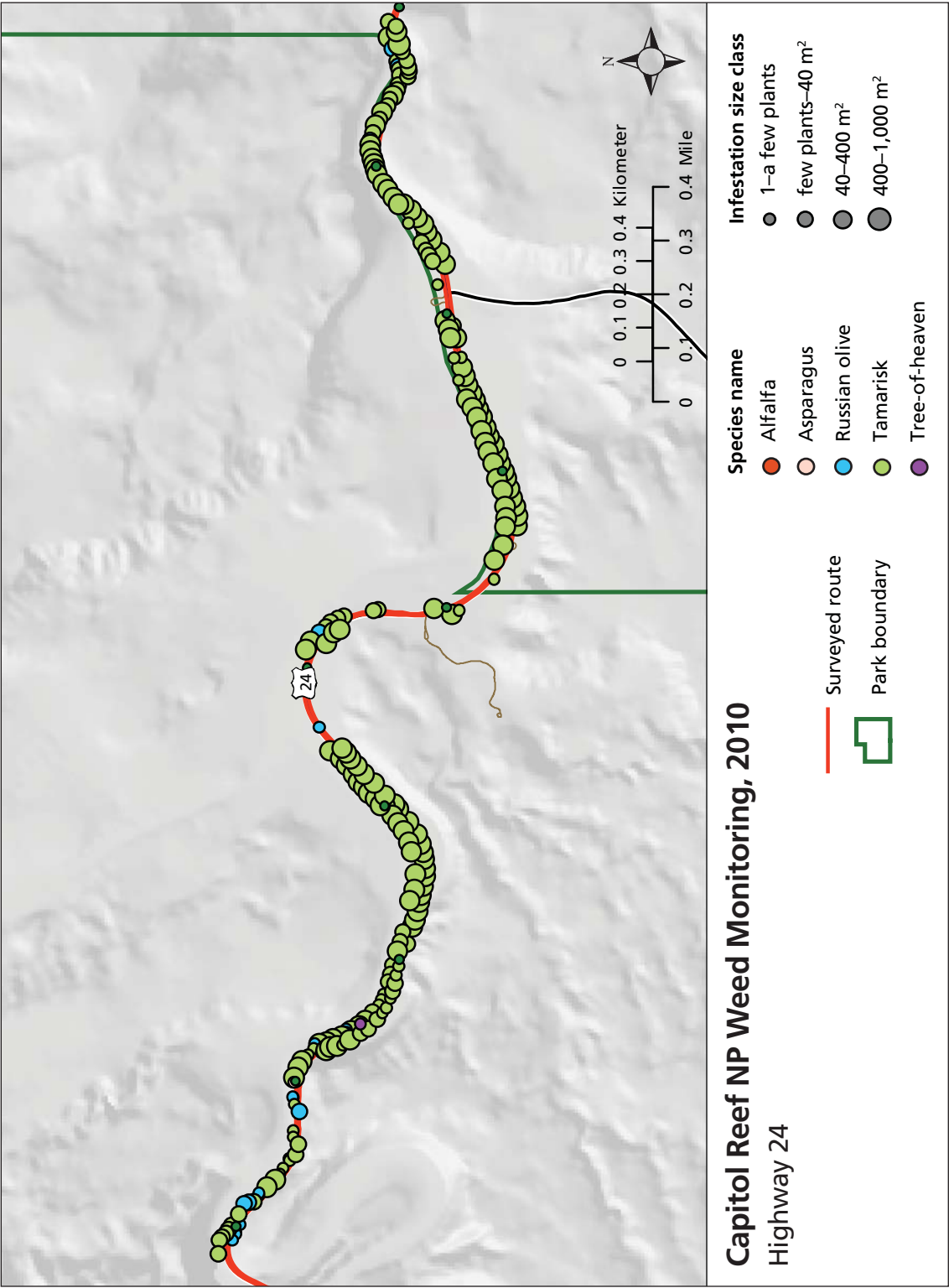


Figure 3-2. Invasive plants detected on monitoring routes along Highway 24, Capitol Reef NP, July 28–October 8, 2010.

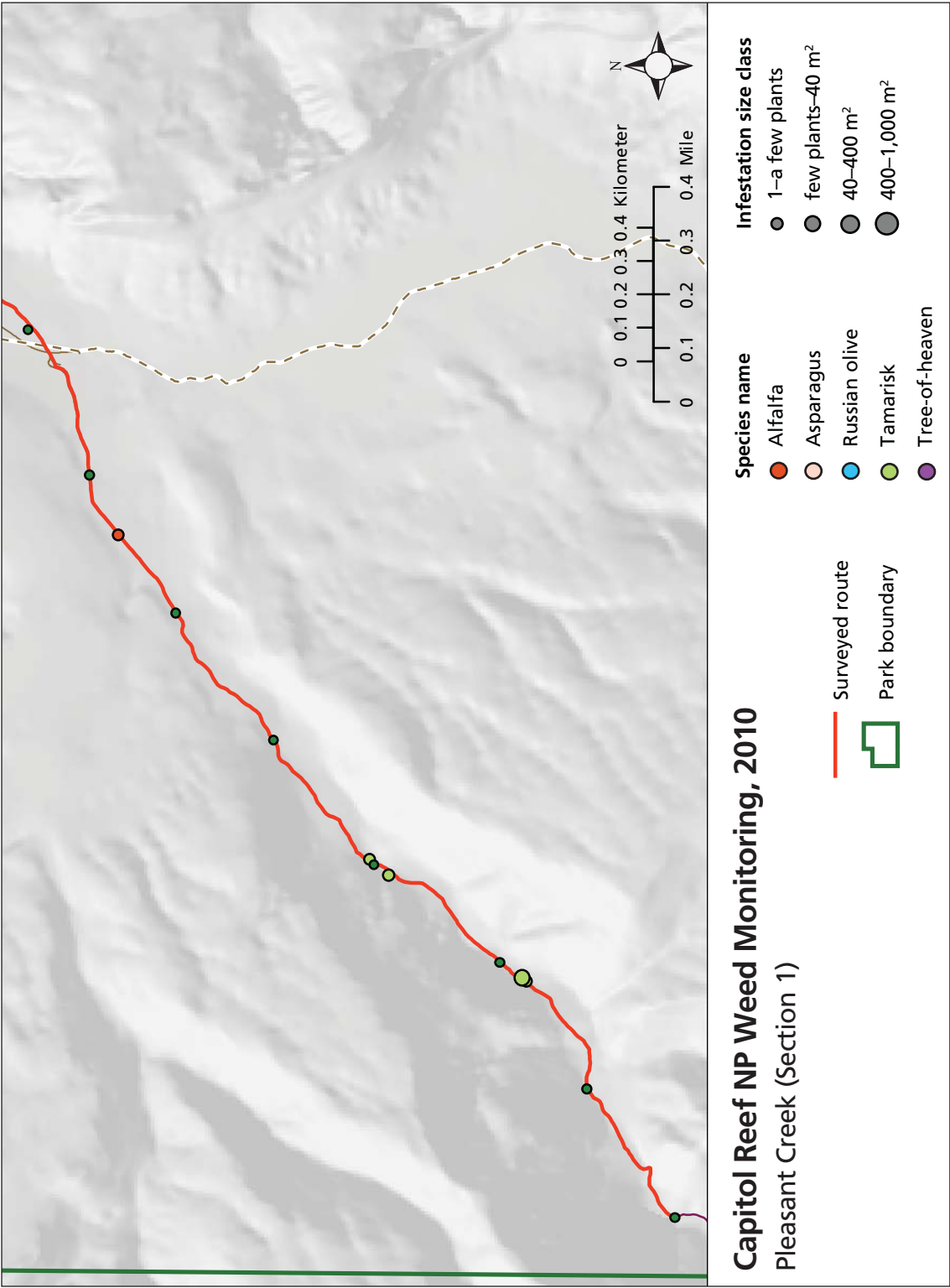


Figure 3-3. Invasive plants detected on monitoring routes along the western section of Pleasant Creek, Capitol Reef NP, July 28–October 8, 2010.

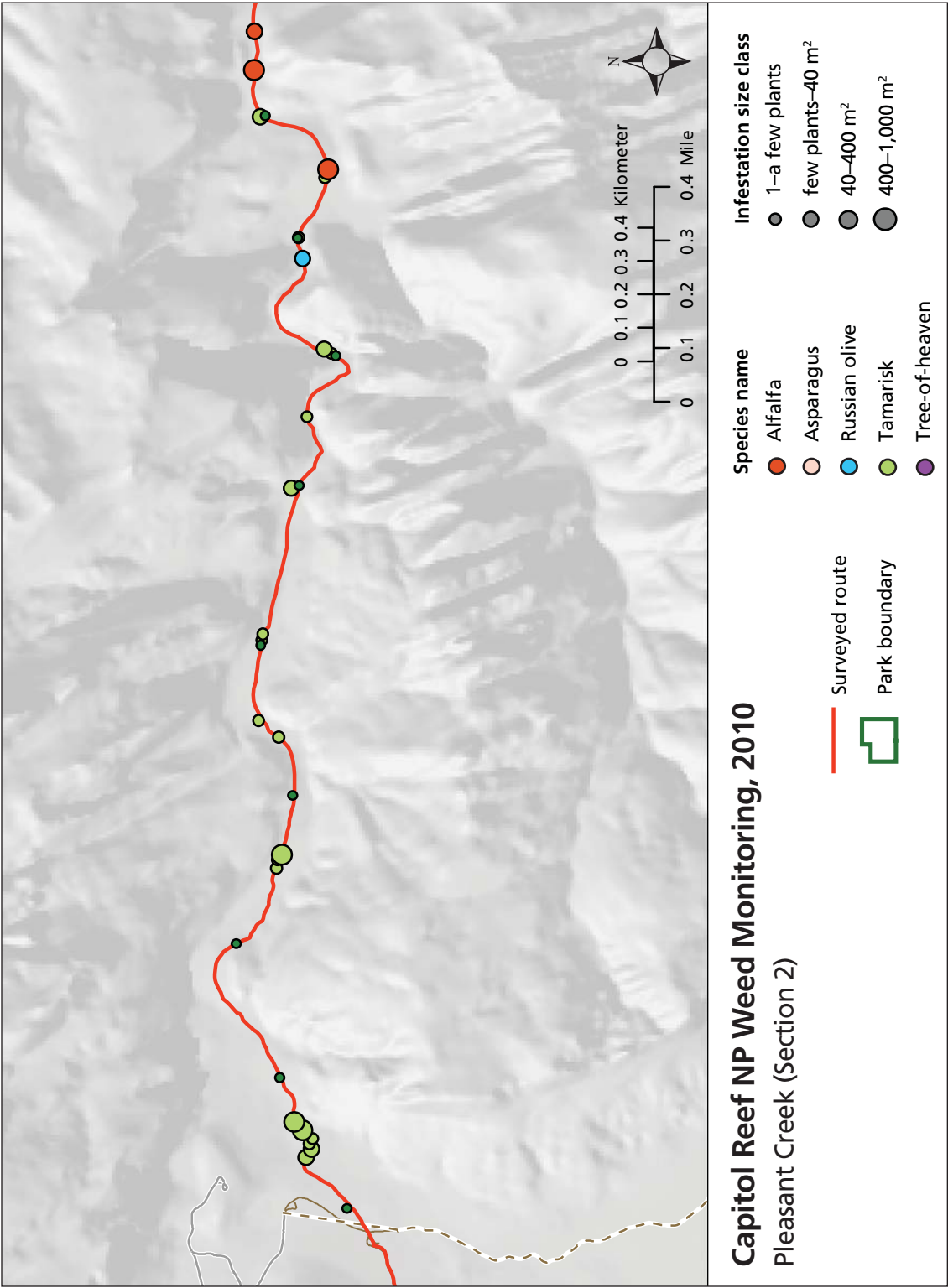


Figure 3-4. Invasive plants detected on monitoring routes along the central section of Pleasant Creek, Capitol Reef NP, July 28–October 8, 2010.

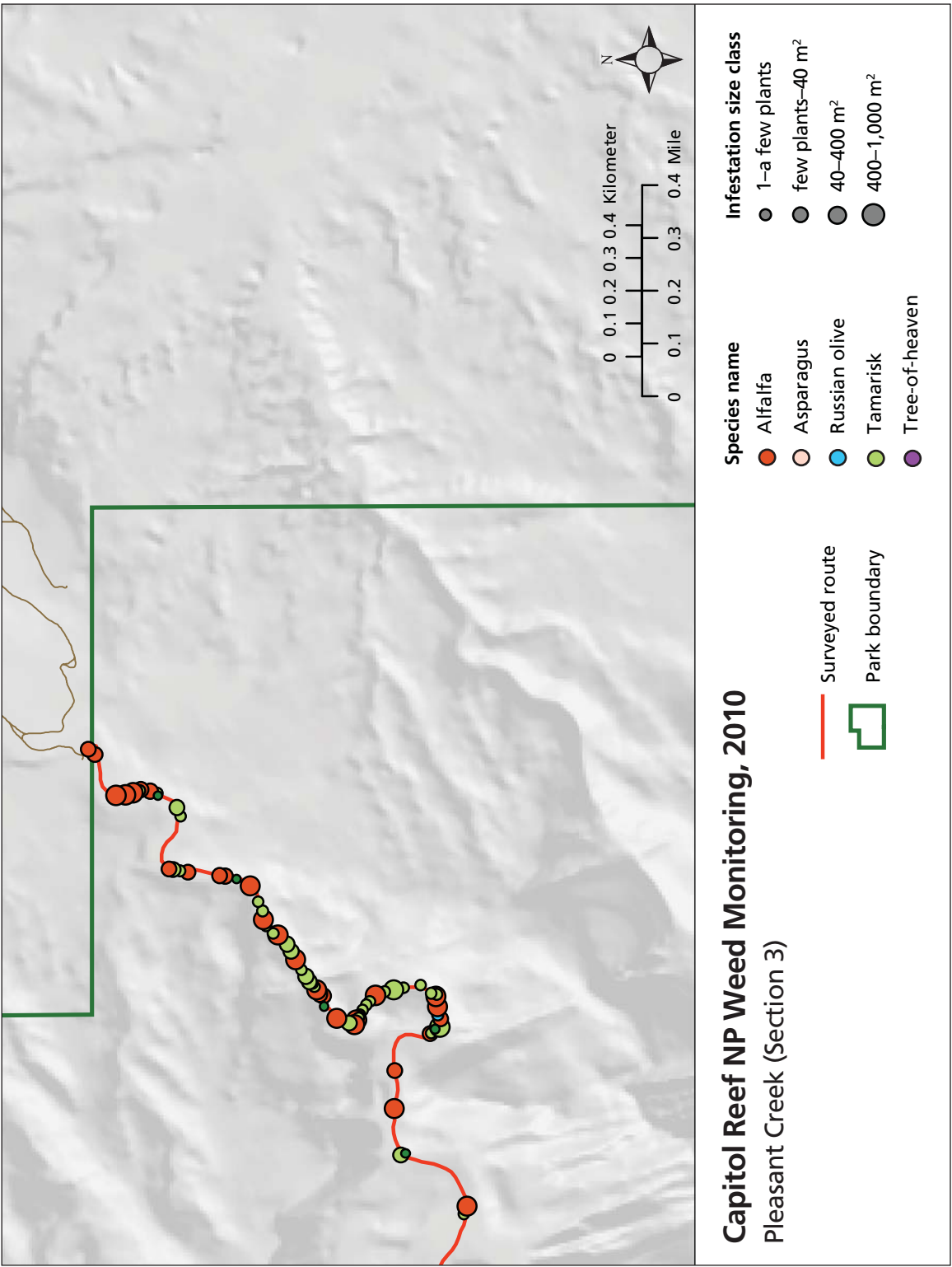


Figure 3-5. Invasive plants detected on monitoring routes along the eastern section of Pleasant Creek, Capitol Reef NP, July 28–October 8, 2010.

Pleasant Creek also had more infestations in eastern areas than western areas. Tamarisk had the highest number of infestations (64% of infestations detected), followed by alfalfa (33%). Infestations were generally smaller at Pleasant Creek, where 78% of infestations were smaller than 40 m², than on Highway 24, (Table 3-3).

Three invasive tree species were present: Russian olive, tree-of-heaven (*Ailanthus altissima*), and tamarisk. Growth stage of all trees was not noted for all infestations. Of the 282 tree infestations that noted the growth stage, 1 was a seedling, 14 were in the sapling stage, and 267 were mature trees (see Appendix B).

3.3 Monitoring transects

A total of 31 transects were sampled in 2010 (Table 3-4, see Figure 2-3, Appendix C). Five IEP species were detected in transects. IEPs were present in 61% of transects (set of three quadrats), with an average of 0.94 IEP species detected per plot. We combined the 2009 and 2010 data along Highway 24 to provide a complete survey of this corridor within the park. Russian thistle was the most widespread species, present in 54% of the transects, with a total cover of 4.87% along Highway 24. Tamarisk was only present in 6% of the transects but had the second-highest percent cover along Highway 24, at 2.6%. Russian thistle and yellow sweetclover (*Melilotus officinalis*) were the most widespread species along Pleasant Creek, where both were present in 30% of the plots with 5.13 and 0.55 percent cover, respectively. We likely did not observe tamarisk or Russian olive infestations in plots in 2009 because

transects 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. In 2010, transects were established on both sides of Highway 24. Also, the section of Highway 24 sampled in 2010 bordered the Fremont River for its entirety, while in 2009, the sampled section ran along the river as well as upland areas.

3.4 Results comparison: 2009–2010 and 2003–2005

In 2003, 2004, and 2005, Dewey and Anderson (2005a, b) surveyed the same sections of Highway 24 and Pleasant Creek that the NCPN surveyed in 2009 and 2010. Although the area covered along Pleasant Creek in 2003–2005 was significantly larger than the area covered in 2010, and survey methods differed in some respects, general comparisons between the two survey periods are useful (if somewhat problematic). Eight species that were target species in 2003–2005, and Priority 1 species in 2009, were detected.* There were fewer detections of tree-of-heaven along Highway 24 in 2009 and 2010 than in 2003–2005 (Table 3-5), while tree-of-heaven and tamarisk both decreased along Pleasant Creek (Table 3-6). None of the species that can be compared between sampling periods increased in 2009 and 2010. Field bindweed (*Convolvulus arvensis*) was also detected less in 2009–2010, but it is unclear why, as no treatments have taken place. The explanation may be that previous sampling efforts also focused on the orchards, where bindweed is widespread, and the more recent surveys focused only on the highway corridor.

*It should be noted that 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. In 2003–2005, some areas along Highway 24 were mapped as large polygons of tamarisk or Russian olive. Due to these differences in mapping methods, the number of infestations of tamarisk and Russian olive cannot be accurately compared between the two time periods.

Table 3-3. Species and infestation size classes detected along monitoring routes at Capitol Reef NP, July 12–September 24, 2010.

Scientific name	Common name	Total infestations	Infestation size class Number of infestations				
			1	2	3	4	5
Highway 24							
<i>Ailanthus altissima</i>	tree-of-heaven	1	1	0	0	0	0
<i>Asparagus officinalis</i>	asparagus	1	1	0	0	0	0
<i>Elaeagnus angustifolia</i>	Russian olive	16	9	7	0	0	0
<i>Tamarix chinensis</i>	five-stamen tamarisk	203	29	49	124	1	0
	<i>Highway 24 total</i>	221	40	56	124	1	0
Pleasant Creek							
<i>Medicago sativa</i>	alfalfa	31	2	13	16	0	0
<i>Elaeagnus angustifolia</i>	Russian olive	3	2	1	0	0	0
<i>Tamarix chinensis</i>	five-stamen tamarisk	60	41	14	5	0	0
	<i>Pleasant Creek total</i>	94	45	28	21	0	0
2010 total		315	85	84	145	1	0

Table 3-4. Number of monitoring transects where exotic plant species were detected, mean percent cover, and standard error by sampling area, Capitol Reef NP, July 28–October 8, 2009 and July 12–September 24, 2010.

Scientific name	Common name	Sampling area*	Number of transects	Mean percent cover	SE
<i>Bromus tectorum</i>	cheatgrass	Highway 24 (11)	5	0.23	(0.10)
		Highway 24 (50)	8	0.22	(0.14)
		Pleasant Creek (20)	0	0.00	(0.00)
<i>Medicago sativa</i>	alfalfa	Highway 24 (11)	0	0.00	(0.00)
		Highway 24 (50)	2	0.01	(0.01)
		Pleasant Creek (20)	0	0.00	(0.00)
<i>Melilotus officinalis</i>	yellow sweetclover	Highway 24 (11)	2	2.94	(2.54)
		Highway 24 (50)	5	0.73	(0.57)
		Pleasant Creek (20)	6	0.55	(0.34)
<i>Salsola tragus</i>	Russian thistle	Highway 24 (11)	6	4.27	(1.67)
		Highway 24 (50)	27	4.87	(1.43)
		Pleasant Creek (20)	6	5.13	(3.00)
<i>Tamarix chinensis</i>	five-stamen tamarisk	Highway 24 (11)	3	10.30	(6.44)
		Highway 24 (50)	3	2.64	(1.54)
		Pleasant Creek (20)	1	0.67	(0.67)

* This column includes data collected in both years along Highway 24, the majority of which was sampled in 2009. Total number of transects per route are listed in parentheses.

Table 3-5. Priority 1 species and number of infestations detected along Highway 24, Capitol Reef NP, July 28–October 8, 2009 and July 12–September 24, 2010, compared to data collected along the same route in 2003–2005.

Scientific name	Common name	Number of infestations	
		2003–2005	2009–2010
<i>Ailanthus altissima</i>	tree-of-heaven	71	2
<i>Asparagus officinalis</i>	asparagus	4	5
<i>Centaurea repens</i>	Russian knapweed	5	0
<i>Cirsium vulgare</i>	bull thistle	4	0
<i>Convolvulus arvensis</i>	field bindweed	89	2
<i>Elaeagnus angustifolia</i> *	Russian olive	29	34
<i>Tamarix chinensis</i> *	five-stamen tamarisk	54	341
<i>Verbascum thapsus</i>	woolly mullein	2	1
Priority 1 species		258	385
Priority 1 (No tamarisk or Russian olive)		175	10

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

Table 3-6. Monitoring revisit design for invasive plant monitoring, Capitol Reef NP.

Year	Monitoring/Survey areas (4-year rotation)			
	Route		Route and extra areas	
	Highway 24/ Fremont corridor	Pleasant Creek	Oak Creek	Cathedral
2009	X			
2010	X	X		
2011			X	
2012				X
2013	X			
2014		X		
2015			X	
2016				X
2017	X			
2018		X		
2019			X	
2020				X
2021	X			

4 Discussion

4.1 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 for the area surveyed; however, absence data for non-Priority 1 species are suspect, because not all observers recorded all of these species in all years. Alfalfa was hard to distinguish from yellow sweetclover during some times of the year, so these data may not present a complete picture of alfalfa infestations. CARE has recommended dropping alfalfa from the priority list for 2011.

4.2 Possibilities for management control

The park has targeted tree-of-heaven and spotted knapweed for control efforts since the inventories in 2003–2005. Park staff estimate that they are close to eradicating tree-of-heaven from CARE, and the monitoring along Highway 24 shows the results—from 71 infestations in these two areas during 2003–2005, to just two in 2009–2010 (see Table 3-5). Neither Russian knapweed (*Centaurea repens*) nor bull thistle (*Cirsium vulgare*), both found in 2003–2005, was found during monitoring in 2009 and 2010 (see Table 3-5).

While there were relatively few IEP species detected, a few were widespread, including tamarisk, Russian olive, and alfalfa, which together made up 99% of all infestations detected along monitoring routes in 2010. Tamarisk, in particular, was well-established along areas of Highway 24 adjacent to the Fremont River corridor. Tamarisk and alfalfa were widespread along the easternmost section of Pleasant Creek. Russian thistle was not mapped, but is widespread at both Highway 24 and Pleasant Creek.

The entire river bottom consisted of infested polygons on maps from the 2003–2005 surveys. Despite the work that has been completed since then, the majority of tamarisk infestations recorded during the most recent surveys were larger than 40 m², and 95% 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 and the effects of the tamarisk beetle (*Diorhabda elongata*) as a biological control agent. The tamarisk beetle's presence was confirmed for the first time along the Fremont River in 2010 (G. Lenhart, pers. comm.)

The tamarisk infestations along Pleasant Creek tended to be smaller than those along Highway 24, indicating that control efforts may be more feasible in those areas. At Pleasant Creek, infestations were much more frequent in the eastern section. Infestations should be controlled there before they become more widespread. Infestations in the westernmost sections were limited to three of tamarisk and one of alfalfa. The lower prevalence of tamarisk in the western sections could be due to the narrower confines of Pleasant Creek canyon, where more forceful flood currents may have decreased the ability of tamarisk to become well-established. The lower detection rate also could be an artifact of the sampling route, which, in the western portion of Pleasant Creek, follows old roads and trails on upland benches not located in tamarisk habitat. In the eastern portion, the route more closely follows the riparian area, which is more suitable for tamarisk. Alfalfa is also generally found along stream banks, as opposed to non-riparian areas.

It should be noted that estimates of percent cover in this report (see Table 3-4) are limited to the routes surveyed; actual percent cover of IEPs across the entire park cannot be inferred with these methods. Because we have chosen to monitor along areas most likely to be invaded by a broad suite of IEPs, it is plausible that the percent cover for most IEP species is lower in the interior of the park than along the monitoring routes.

4.3 Future monitoring efforts

IEPs at 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 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 2011, the NCPN will expand monitoring efforts to Oak Creek (Figure 2-2). We may also do some extra-area surveys in an area yet to be determined. We plan to sample in the Cathedral Valley in 2012, revisit the Highway 24 corridor in 2013, and Pleasant Creek in 2014 (see Table 3-6). 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 1 species by monitoring route. Extra-area surveys will also be considered for inventories at the park's request. The NCPN invasive plant monitoring protocol was submitted for peer review in December 2010.

5 Literature Cited

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Appendix A. Priority 1 Invasive Exotic Plant List, Capitol Reef National Park

Species name (Utah)	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 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>	common 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

Appendix B. Exotic Plant Invasions Detected on Monitoring Routes, Highway 24 and Pleasant Creek, Capitol Reef National Park, July 28–October 8, 2010

Scientific name	Common name	Infestation size class	Canopy cover class	Growth stage	Pulled?	Northing	Easting
<i>Ailanthus altissima</i>	tree-of-heaven	1	3	Sapling(s)	No	4237538	486567.5
<i>Asparagus officinalis</i>	asparagus	1	2		No	4237739	486393.4
<i>Elaeagnus angustifolia</i>	Russian-olive	1	3	Sapling(s)	No	4237843	486060.7
		1	3	Sapling(s)	No	4237914	485937
		1	3	Sapling(s)	No	4237676	486507.6
		1	3	Sapling(s)	No	4237662	487456.8
		1	3	Sapling(s)	No	4237899	485966.4
		1	3	Sapling(s)	No	4237923	485920.2
		1	3	Sapling(s)	No	4237752	486163.8
		2	3	Mature tree(s)	No	4237510	489213.4
		2	3	Seedling(s)	No	4237722	486304.7
		2	3	Sapling(s)	No	4237874	486033.2
		2	3	Sapling(s)	No	4237889	486029.9
		1	4	Mature tree(s)	No	4237741	486347.4
		1	4	Sapling(s)	No	4226152	487926.6
		1	4	Mature tree(s)	No	4226533	488023.5
		2	4	Mature tree(s)	No	4226137	487076.7
		1	5	Mature tree(s)	No	4237582	486550.2
		2	5	Mature tree(s)	No	4237444	489488.3
		2	5	Mature tree(s)	No	4237426	489435.9
		2	5	Mature tree(s)	No	4237662	487740.1
<i>Medicago sativa</i>	alfalfa	1	2		No	4225736	483617.5
		1	2		No	4226390	487927.9
		2	2		No	4226283	487757.4
		2	2		No	4226511	487989
		2	2		No	4227217	488737.5
		2	2		No	4227058	488613.2
		2	2		No	4226816	488350.9
		2	2		No	4226913	488362.2
		2	2		No	4226501	487984.2
		2	2		No	4227197	488720.6
		2	2		No	4226141	487915.5
		2	2		No	4227029	488608.3
		2	2		No	4226799	488349.2
		2	2		No	4226175	487870
		2	2		No	4226970	488371.5
		3	2		No	4227079	488604.5

Appendix B. Exotic Plant Invasions Detected on Monitoring Routes, Highway 24 and Pleasant Creek, Capitol Reef National Park, July 28–October 8, 2010, cont.

Scientific name	Common name	Infestation size class	Canopy cover class	Growth stage	Pulled?	Northing	Easting
<i>Medicago sativa</i>	alfalfa	3	2		No	4226638	488170.9
		3	2		No	4226152	487951.8
		3	2		No	4226682	488217.3
		3	2		No	4227134	488595.5
		3	2		No	4226520	488004.2
		3	2		No	4226061	487344.5
		3	2		No	4226156	487982.3
		3	2		No	4226458	487917
		3	2		No	4226723	488320.3
		3	2		No	4226341	487985.4
		3	2		No	4227104	488597.5
		3	2		No	4226284	487641.2
		3	2		No	4226585	488094.8
		3	3		No	4226399	487911.8
		3	3		No	4226406	487897.7
<i>Tamarix chinensis</i>	five-stamen tamarisk	3	2	Mature tree(s)	No	4237703	487689
		3	2	Mature tree(s)	No	4237663	486506.6
		3	2	Mature tree(s)	No	4237738	486405.6
		3	2	Mature tree(s)	No	4226162	484491.6
		3	2	Mature tree(s)	No	4226137	484465.6
		1	3	Mature tree(s)	No	4237592	486503.5
		1	3	Mature tree(s)	No	4237843	486054.3
		1	3	Mature tree(s)	No	4237740	486346.6
		1	3	Mature tree(s)	No	4237679	486493.8
		1	3	Mature tree(s)	No	4237433	486713.7
		1	3	Sapling(s)	No	4237912	485942.4
		1	3	Mature tree(s)	No	4237449	486644.2
		1	3	Mature tree(s)	No	4237697	486475.7
		1	3	Mature tree(s)	No	4226256	488009.5
		1	3	Mature tree(s)	No	4226936	488532.9
		1	3	Mature tree(s)	No	4226675	488198
		1	3	Mature tree(s)	No	4226528	488013
		1	3	Mature tree(s)	No	4226402	487900.2
		1	3	Mature tree(s)	No	4226144	487913
		1	3	Mature tree(s)	No	4226171	487992.8
		1	3	Mature tree(s)	No	4226392	487917.6
		1	3	Mature tree(s)	No	4227006	488602.6
		1	3	Mature tree(s)	No	4226052	486794
		1	3	Mature tree(s)	No	4226151	487138.8
		1	3	Mature tree(s)	No	4226259	485933.8
		1	3	Mature tree(s)	No	4226213	485276
		1	3	Mature tree(s)	No	4226216	485251.3

Appendix B. Exotic Plant Invasions Detected on Monitoring Routes, Highway 24 and Pleasant Creek, Capitol Reef National Park, July 28–October 8, 2010, cont.

Scientific name	Common name	Infestation size class	Canopy cover class	Growth stage	Pulled?	Northing	Easting
<i>Tamarix chinensis</i>	five-stamen tamarisk	1	3	Mature tree(s)	No	4226071	487319.9
		1	3	Mature tree(s)	No	4226257	485952.4
		1	3	Sapling(s)	No	4224983	482645.1
		1	3	Mature tree(s)	No	4226155	487989.9
		1	3	Mature tree(s)	No	4226585	488095
		1	3	Mature tree(s)	No	4226359	487968.7
		1	3	Mature tree(s)	No	4226936	488364.9
		1	3	Mature tree(s)	No	4226683	488216.2
		1	3	Mature tree(s)	No	4226567	488064.7
		1	3	Sapling(s)	No	4224926	482597.3
		1	3	Mature tree(s)	No	4227061	488610.9
		1	3	Mature tree(s)	No	4226653	488176
		1	3	Mature tree(s)	No	4226209	485642.6
		1	3	Mature tree(s)	No	4226699	488271.8
		1	3	Mature tree(s)	No	4226203	488018.1
		1	3	Mature tree(s)	No	4226379	487941.2
		1	3	Mature tree(s)	No	4226686	488243.9
		2	3	Mature tree(s)	No	4237489	486581.1
		2	3	Mature tree(s)	No	4237514	486552.8
		2	3	Mature tree(s)	No	4237860	486034.9
		2	3	Mature tree(s)	No	4237538	486539.9
		2	3	Mature tree(s)	No	4237436	486689.1
		2	3	Mature tree(s)	No	4226554	488044.3
		2	3	Mature tree(s)	No	4226598	488121.1
		2	3	Mature tree(s)	No	4226611	488141.3
		2	3	Mature tree(s)	No	4226959	488369.9
		2	3	Mature tree(s)	No	4226171	486389
		2	3	Mature tree(s)	No	4226111	484408.7
		2	3	Mature tree(s)	No	4226073	486806.2
		2	3	Mature tree(s)	No	4226128	484385.3
		2	3	Mature tree(s)	No	4226264	487500.8
		2	3		No	4226422	487901.7
		2	3	Mature tree(s)	No	4226946	488558.6
		2	3	Mature tree(s)	No	4226335	487987
		3	3	Mature tree(s)	No	4237571	486520.3
		3	3	Mature tree(s)	No	4237356	486953.3
		3	3	Mature tree(s)	No	4237364	486931.6
		3	3	Mature tree(s)	No	4237543	486561.1
		3	3	Mature tree(s)	No	4237370	487135.7
		3	3	Mature tree(s)	No	4237688	487713.8
		3	3	Mature tree(s)	No	4237341	488939.6
		3	3	Mature tree(s)	No	4237386	487083.9

Appendix B. Exotic Plant Invasions Detected on Monitoring Routes, Highway 24 and Pleasant Creek, Capitol Reef National Park, July 28–October 8, 2010, cont.

Scientific name	Common name	Infestation size class	Canopy cover class	Growth stage	Pulled?	Northing	Easting
<i>Tamarix chinensis</i>	five-stamen tamarisk	3	3	Mature tree(s)	No	4237568	486545.9
		3	3	Mature tree(s)	No	4237610	486501.7
		3	3	Mature tree(s)	No	4237303	488879.7
		3	3	Mature tree(s)	No	4237560	487315
		3	3	Mature tree(s)	No	4237390	486937.2
		3	3	Mature tree(s)	No	4237326	488915.3
		3	3	Mature tree(s)	No	4237394	487171.8
		3	3	Mature tree(s)	No	4237369	486904.8
		3	3	Mature tree(s)	No	4237545	487292.8
		3	3	Mature tree(s)	No	4237580	487342.8
		3	3	Mature tree(s)	No	4237105	488118.3
		3	3	Mature tree(s)	No	4237570	487362.5
		3	3	Mature tree(s)	No	4237284	488843.8
		3	3	Mature tree(s)	No	4237581	487379.2
		3	3	Mature tree(s)	No	4237725	486435.9
		3	3	Mature tree(s)	No	4226145	487889.6
		3	3	Mature tree(s)	No	4226200	485290.9
		3	3	Mature tree(s)	No	4226286	488003.7
		1	4	Mature tree(s)	No	4237739	486246.7
		1	4	Mature tree(s)	No	4237470	486655
		1	4	Mature tree(s)	No	4237771	486135.5
		1	4	Mature tree(s)	No	4237737	486327.5
		1	4	Mature tree(s)	No	4237477	486641.2
		1	4	Mature tree(s)	No	4237740	486228.3
		1	4	Mature tree(s)	No	4237485	486623
		1	4	Mature tree(s)	No	4237751	486158.7
		1	4	Mature tree(s)	No	4226146	487949.4
		1	4	Mature tree(s)	No	4226368	487956.6
		1	4	Mature tree(s)	No	4226124	486604.2
		1	4	Mature tree(s)	No	4226312	487997.3
		1	4	Mature tree(s)	No	4226118	484425.5
		1	4	Mature tree(s)	No	4226542	488032.8
		1	4	Mature tree(s)	No	4226108	484441.8
		2	4	Mature tree(s)	No	4237420	486812.6
		2	4	Mature tree(s)	No	4237456	486694
		2	4	Mature tree(s)	No	4237449	486714.2
		2	4	Mature tree(s)	No	4237935	485950.5
		2	4	Mature tree(s)	No	4237324	488851
		2	4	Mature tree(s)	No	4237334	488869.2
		2	4	Mature tree(s)	No	4237412	486843.6
		2	4	Mature tree(s)	No	4237397	489404.8
		2	4	Mature tree(s)	No	4237925	485965.2

Appendix B. Exotic Plant Invasions Detected on Monitoring Routes, Highway 24 and Pleasant Creek, Capitol Reef National Park, July 28–October 8, 2010, cont.

Scientific name	Common name	Infestation size class	Canopy cover class	Growth stage	Pulled?	Northing	Easting
<i>Tamarix chinensis</i>	five-stamen tamarisk	2	4	Mature tree(s)	No	4237961	485919.3
		2	4	Mature tree(s)	No	4237503	486602
		2	4	Mature tree(s)	No	4237399	486807.2
		2	4	Mature tree(s)	No	4237342	488884.9
		2	4	Mature tree(s)	No	4237357	488907.8
		2	4	Mature tree(s)	No	4237262	488658.2
		2	4	Mature tree(s)	No	4237442	486743.4
		2	4	Mature tree(s)	No	4237940	485939.2
		2	4	Mature tree(s)	No	4237954	485928.7
		2	4	Mature tree(s)	No	4237966	485878.7
		2	4	Mature tree(s)	No	4237442	486664.6
		2	4	Mature tree(s)	No	4226543	488027.9
		2	4	Mature tree(s)	No	4224525	482289.3
		3	4	Mature tree(s)	No	4237285	488675.1
		3	4	Mature tree(s)	No	4237155	488280.1
		3	4	Mature tree(s)	No	4237346	487034
		3	4	Mature tree(s)	No	4237425	487211
		3	4	Mature tree(s)	No	4237383	486857.9
		3	4	Mature tree(s)	No	4237138	487957.1
		3	4	Mature tree(s)	No	4237642	487707.1
		3	4	Mature tree(s)	No	4237275	488647
		3	4	Mature tree(s)	No	4237479	487222.3
		3	4	Mature tree(s)	No	4237113	488002.7
		3	4	Mature tree(s)	No	4237176	488343
		3	4	Mature tree(s)	No	4237103	488083.3
		3	4	Mature tree(s)	No	4237130	488200.6
		3	4	Mature tree(s)	No	4237601	487749.6
		3	4	Mature tree(s)	No	4237369	488983.1
		3	4	Mature tree(s)	No	4237346	487010.1
		3	4	Mature tree(s)	No	4237428	486785.8
		3	4	Mature tree(s)	No	4237351	487081.9
		3	4	Mature tree(s)	No	4237488	489113
		3	4	Mature tree(s)	No	4237347	487060.6
		3	4	Mature tree(s)	No	4237426	487168.8
		3	4	Mature tree(s)	No	4237378	486969.1
		3	4	Mature tree(s)	No	4237113	488166.5
		3	4	Mature tree(s)	No	4237466	487219.4
		3	4	Mature tree(s)	No	4237410	487146.4
		3	4	Mature tree(s)	No	4237524	486578.4
		3	4	Mature tree(s)	No	4237376	486878.4
		3	4	Mature tree(s)	No	4237437	487224.6
		3	4	Mature tree(s)	No	4237357	487105.5

Appendix B. Exotic Plant Invasions Detected on Monitoring Routes, Highway 24 and Pleasant Creek, Capitol Reef National Park, July 28–October 8, 2010, cont.

Scientific name	Common name	Infestation size class	Canopy cover class	Growth stage	Pulled?	Northing	Easting
<i>Tamarix chinensis</i>	five-stamen tamarisk	3	4	Mature tree(s)	No	4237715	486455.5
		3	4	Mature tree(s)	No	4237619	487740.2
		3	4	Mature tree(s)	No	4237349	488961.9
		3	4	Mature tree(s)	No	4237105	488056
		3	4	Mature tree(s)	No	4237549	487341.3
		3	4	Mature tree(s)	No	4237494	487242.1
		3	4	Mature tree(s)	No	4237251	488623.4
		3	4	Mature tree(s)	No	4237165	488310.1
		3	4	Mature tree(s)	No	4237319	487812.6
		3	4	Mature tree(s)	No	4237142	488247.5
		3	4	Mature tree(s)	No	4237350	486980.8
		3	4	Mature tree(s)	No	4237527	487315.7
		3	4	Mature tree(s)	No	4237265	487795.2
		3	4	Mature tree(s)	No	4237270	488623.3
		3	4	Mature tree(s)	No	4237374	487015.8
		3	4	Mature tree(s)	No	4237394	487111.2
		3	4	Mature tree(s)	No	4237444	487192.1
		1	5	Mature tree(s)	No	4237781	486117.9
		1	5	Mature tree(s)	No	4237259	488562.5
		1	5	Mature tree(s)	No	4237395	488965.6
		1	5	Mature tree(s)	No	4237580	486543
		1	5	Mature tree(s)	No	4237473	486600.6
		1	5	Mature tree(s)	No	4237425	486741
		1	5	Mature tree(s)	No	4237307	488783.2
		1	5	Mature tree(s)	No	4237461	486615.7
		1	5	Mature tree(s)	No	4237656	486481.1
		1	5	Mature tree(s)	No	4237243	487805.4
		1	5	Mature tree(s)	No	4237244	488496.9
		1	5	Mature tree(s)	No	4237138	487899
		1	5	Mature tree(s)	No	4237236	488562.9
		1	5	Mature tree(s)	No	4226171	487871.8
		1	5	Mature tree(s)	No	4224513	482279
		1	5	Mature tree(s)	No	4226270	485692.2
		2	5	Mature tree(s)	No	4237401	489454.1
		2	5	Mature tree(s)	No	4237394	489422.1
		2	5	Mature tree(s)	No	4237502	489237.7
		2	5	Mature tree(s)	No	4237432	489556.7
		2	5	Mature tree(s)	No	4237459	489316.8
		2	5	Mature tree(s)	No	4237733	486175.6
		2	5	Mature tree(s)	No	4237589	487788.2
		2	5	Mature tree(s)	No	4237430	489364.9
		2	5	Mature tree(s)	No	4237642	487757.7

Appendix B. Exotic Plant Invasions Detected on Monitoring Routes, Highway 24 and Pleasant Creek, Capitol Reef National Park, July 28–October 8, 2010, cont.

Scientific name	Common name	Infestation size class	Canopy cover class	Growth stage	Pulled?	Northing	Easting
<i>Tamarix chinensis</i>	five-stamen tamarisk	2	5	Mature tree(s)	No	4237607	487781.3
		2	5	Mature tree(s)	No	4237904	485996.6
		2	5	Mature tree(s)	No	4237423	489426
		2	5	Mature tree(s)	No	4237455	489569.9
		2	5	Mature tree(s)	No	4237481	489276.5
		2	5	Mature tree(s)	No	4237422	489409.5
		2	5	Mature tree(s)	No	4237395	489432.7
		2	5	Mature tree(s)	No	4237426	489378.8
		2	5	Mature tree(s)	No	4237430	489451.8
		2	5	Mature tree(s)	No	4237630	487772.1
		2	5	Mature tree(s)	No	4237450	489335.4
		2	5	Mature tree(s)	No	4237726	486206
		2	5	Mature tree(s)	No	4237413	489481.6
		2	5	Mature tree(s)	No	4237486	487809.7
		2	5	Mature tree(s)	No	4237501	487806
		3	5	Mature tree(s)	No	4237442	489348.6
		3	5	Mature tree(s)	No	4237493	489126.7
		3	5	Mature tree(s)	No	4237118	488245.4
		3	5	Mature tree(s)	No	4237819	486077.6
		3	5	Mature tree(s)	No	4237195	488434.3
		3	5	Mature tree(s)	No	4237152	488327.3
		3	5	Mature tree(s)	No	4237234	488533.9
		3	5	Mature tree(s)	No	4237410	489022.3
		3	5	Mature tree(s)	No	4237075	488117.6
		3	5	Mature tree(s)	No	4237630	487385.6
		3	5	Mature tree(s)	No	4237127	488273.1
		3	5	Mature tree(s)	No	4237598	487361.6
		3	5	Mature tree(s)	No	4237176	488385.2
		3	5	Mature tree(s)	No	4237068	488089.4
		3	5	Mature tree(s)	No	4237110	488222.1
		3	5	Mature tree(s)	No	4237530	487276.7
		3	5	Mature tree(s)	No	4237593	487393.4
		3	5	Mature tree(s)	No	4237498	487288.9
		3	5	Mature tree(s)	No	4237386	489004.3
		3	5	Mature tree(s)	No	4237102	488201.1
		3	5	Mature tree(s)	No	4237795	486100.8
		3	5	Mature tree(s)	No	4237509	489182.7
		3	5	Mature tree(s)	No	4237595	486532.3
		3	5	Mature tree(s)	No	4237185	488408.7
		3	5	Mature tree(s)	No	4237466	487253
		3	5	Mature tree(s)	No	4237431	489539.6
		3	5	Mature tree(s)	No	4237454	489522.9

Appendix B. Exotic Plant Invasions Detected on Monitoring Routes, Highway 24 and Pleasant Creek, Capitol Reef National Park, July 28–October 8, 2010, cont.

Scientific name	Common name	Infestation size class	Canopy cover class	Growth stage	Pulled?	Northing	Easting
<i>Tamarix chinensis</i>	five-stamen tamarisk	3	5	Mature tree(s)	No	4237499	489143.9
		3	5	Mature tree(s)	No	4237504	489158.9
		3	5	Mature tree(s)	No	4237475	489298.5
		3	5	Mature tree(s)	No	4237510	489202.6
		3	5	Mature tree(s)	No	4237494	489259.1
		3	5	Mature tree(s)	No	4237630	486497.2
		3	5	Mature tree(s)	No	4237515	487259.1
		3	5	Mature tree(s)	No	4237621	486523.1
		3	5	Mature tree(s)	No	4237425	489022.8
		3	5	Mature tree(s)	No	4237070	488059.6
		3	5	Mature tree(s)	No	4237190	488383.4
		3	5	Mature tree(s)	No	4237226	488507.7
		3	5	Mature tree(s)	No	4237441	489043.4
		3	5	Mature tree(s)	No	4237457	489065.3
		3	5	Mature tree(s)	No	4237217	488481.9
		3	5	Mature tree(s)	No	4237084	488142.7
		3	5	Mature tree(s)	No	4237472	489084.9
		3	5	Mature tree(s)	No	4237091	488170.3
		3	5	Mature tree(s)	No	4237163	488353.1
		3	5	Mature tree(s)	No	4237220	488438.6
		3	5	Mature tree(s)	No	4237205	488456.6
		3	5	Mature tree(s)	No	4237140	488303.3
		3	5	Mature tree(s)	No	4237203	488414.3
		3	5	Mature tree(s)	No	4237642	486488.8
		3	5	Mature tree(s)	No	4237640	486514
		4	5	Mature tree(s)	No	4237422	489502.6

Appendix C. Invasive Exotic Plant Percent Cover Detected by Monitoring Transects

Transect #	Scientific name	Common name	Mean cover	Northing	Easting
Highway 24					
1	<i>Melilotus officinalis</i>	yellow sweetclover	28	4237423	489614.2
3	<i>Melilotus officinalis</i>	yellow sweetclover	4.333333	4237279	488695
	<i>Salsola</i> sp.	Russian thistle	13.66667	4237279	488695
4	<i>Salsola</i> sp.	Russian thistle	0.5	4237114	488224.6
	<i>Tamarix chinensis</i>	five-stamen tamarisk	53.33333	4237114	488224.6
5	<i>Salsola</i> sp.	Russian thistle	13.33333	4237281	487815
6	<i>Bromus tectorum</i>	cheatgrass	0.333333	4237698	487633.3
	<i>Salsola</i> sp.	Russian thistle	9.333333	4237698	487633.3
7	<i>Bromus tectorum</i>	cheatgrass	1	4237466	487220.1
	<i>Tamarix chinensis</i>	five-stamen tamarisk	53.33333	4237466	487220.1
8	<i>Bromus tectorum</i>	cheatgrass	0.333333	4237423	486759.6
	<i>Salsola</i> sp.	Russian thistle	3.5	4237423	486759.6
9	<i>Bromus tectorum</i>	cheatgrass	0.166667	4237733	486396.1
	<i>Tamarix chinensis</i>	five-stamen tamarisk	6.666667	4237733	486396.1
11	<i>Bromus tectorum</i>	cheatgrass	0.666667	4237607	485665.9
	<i>Salsola</i> sp.	Russian thistle	6.666667	4237607	485665.9
Pleasant Creek					
54	<i>Tamarix chinensis</i>	five-stamen tamarisk	13.33333	4226497	487951.5
58	<i>Salsola</i> sp.	Russian thistle	0.333333	4226038	486785.6
59	<i>Melilotus officinalis</i>	yellow sweetclover	0.333333	4226149	486398.3
	<i>Salsola</i> sp.	Russian thistle	1	4226149	486398.3
61	<i>Salsola</i> sp.	Russian thistle	2.333333	4226167	485468.7
64	<i>Salsola</i> sp.	Russian thistle	53.33333	4226005	484232
66	<i>Melilotus officinalis</i>	yellow sweetclover	2.333333	4225564	483381.4
	<i>Salsola</i> sp.	Russian thistle	17.33333	4225564	483381.4
67	<i>Melilotus officinalis</i>	yellow sweetclover	1	4225270	483002.6
68	<i>Melilotus officinalis</i>	yellow sweetclover	0.333333	4224970	482629.1
69	<i>Melilotus officinalis</i>	yellow sweetclover	6.666667	4224593	482336.3
	<i>Salsola</i> sp.	Russian thistle	28.33333	4224593	482336.3
71	<i>Melilotus officinalis</i>	yellow sweetclover	0.333333	4224069	481570.9

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1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525

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