



Invasive Exotic Plant Monitoring at Dinosaur National Monument, 2009

Natural Resource Technical Report NPS/NCPN/NRTR—2010/353



ON THE COVER

Russian olive (*Elaeagnus angustifolia*). Photo courtesy USDA-NRCS PLANTS Database / Herman, D.E., et al. 1996. North Dakota tree handbook. USDA NRCS ND State Soil Conservation Committee; NDSU Extension and Western Area Power Administration, Bismarck.

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July 2010

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

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Please cite this publication as:

Perkins, D. W. 2010. Invasive exotic plant monitoring at Dinosaur National Monument, 2009. Natural Resource Technical Report NPS/NCPN/NRTR—2010/353. National Park Service, Fort Collins, Colorado.

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Abstract

Invasive exotic plant (IEP) species are a significant threat to natural ecosystem integrity and biodiversity, and controlling them is a high priority for the National Park Service. The Northern Colorado Plateau Network (NCPN) selected the early detection of IEPs as one of 10 monitoring protocols to be implemented as part of its long-term monitoring program. This report represents work completed on June 18, 2009, at Dinosaur National Monument (DINO), by the Desert Ecology class from Mesa State College. This class tested the “Monitoring Lite” procedures, which collect data on IEPs in a manner similar to that of the routine monitoring, but are designed for individuals who recognize only a few IEP species. Invasive plants on the search list included Canada thistle (*Cirsium arvense*), perennial pepperweed (*Lepidium latifolium*), tamarisk (*Tamarix* spp.), Russian olive (*Elaeagnus angustifolia*), Russian knapweed (*Centaurea repens*), leafy spurge (*Euphorbia esula*), and teasel (*Dipsacus fullonum*). All species except teasel and leafy spurge were detected in 326 infestations along 20.8 km of the Green River. Comparisons between these surveys and surveys done in 2002 and 2003 clearly show reduced tamarisk and Russian olive infestations in areas where these species were targeted for management. The NCPN will return to DINO in 2010 with network crews to begin implementing IEP monitoring.

Acronyms

BFP	Between Feature Position
DINO	Dinosaur National Monument
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

Acknowledgements

S. Dewey assisted with questions on methods. K. Duran's Desert Ecology class conducted the field work. A. Wight was extremely helpful in generating routes, plots, and other GIS information. T. Naumann assisted with reviewing the park target invasive plant list, arranging site logistics, and providing history of the site. D. Witwicki improved this report with her thoughtful review. Data management was provided by H. Thomas. D. Perry assisted with administrative details.

1 Introduction

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

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

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

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

Specific objectives of NCPN invasive exotic plant monitoring are:

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

This report summarizes the testing of the network’s “monitoring lite” methods at Dinosaur National Monument (DINO) on June 18, 2009.

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).

This survey utilized and tested the NCPN's "monitoring lite," a method by which park staff or volunteers with less knowledge of invasive species than network staff may collect data for use in NCPN databases and reporting. Under monitoring lite, field crews follow the same procedures for surveying monitoring routes as are implemented under the network's full IEP monitoring protocol, but search for only a limited number of target species. Also, no plots are monitored under monitoring lite.

2.1 Study area and target list

For both management reasons and ease of access by a college class, park staff suggested that the 2009 survey be conducted along the Green River, from the Split Mountain boat takeout to the park's western boundary. Park and NCPN staff compiled a list of seven IEP species of management importance that the Mesa State students could quickly learn to recognize. Five of those species, Canada thistle (*Cirsium arvense*), perennial pepperweed (*Lepidium latifolium*), Russian knapweed (*Centaurea repens*), Russian olive (*Elaeagnus angustifolia*), and tamarisk (*Tamarix* spp.), had previously been detected at DINO. Two additional species were also on the list for early detection: teasel (*Dipsacus fullonum*) has not been located within the park, and leafy spurge (*Euphorbia esula*) has not been detected along this section of river within DINO.

2.2 Survey components

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 and tamarisk, is possible due to their large size, single plants of other species, such as perennial pepperweed, 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 DINO was between 5 and 50 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 10 to 100 m at DINO.

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 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

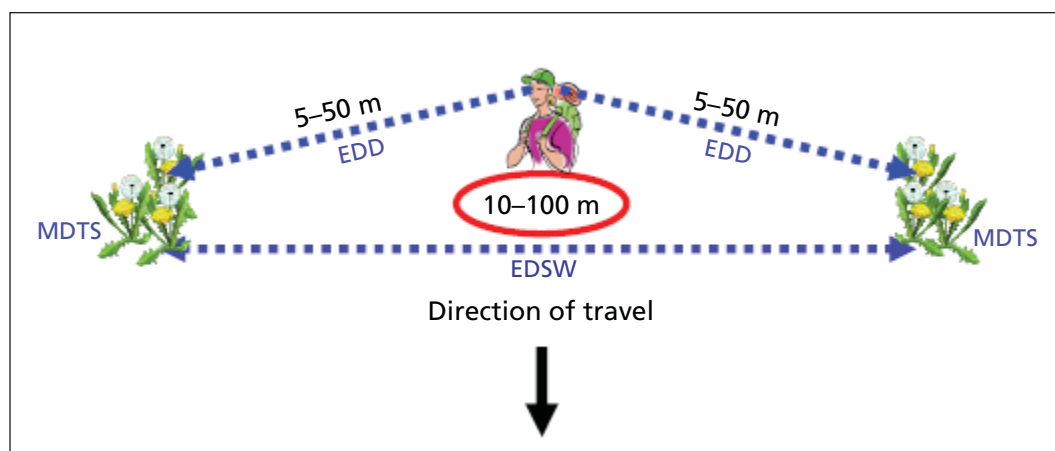


Figure 2-1. The maximum Effective Detection Distance (EDD) at Dinosaur NM ranged from 5 to 50 meters, making the Effective Detection Swath Width (EDSW) 10–100 meters.

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.

2.3 Data collection methods

We walked one EDD out from the park side of the Green River. 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 20–40 m 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 5-meter accuracy.

When an 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), and (4) 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).

3 Results

3.1 IEPs detected

The survey crew walked a total of 20.8 km (12.9 miles) along the Green River, representing a total of 142 hectares (352 acres) surveyed. A total of 326 infestations were detected along the monitoring route (Tables 3-1, 3-2, Figures 3-1, 3-2, 3-3, 3-4, Appendix A). Tamarisk, perennial pepperweed, and Russian olive were the most commonly detected IEPs, representing 98% of infestations detected. Of the 326 infestations, 55% were classified as infestations in class sizes 1 (1–a few plants) or 2 (few plants–40 m²) (Table 3-2). There were no detections of leafy spurge or teasel.

Two invasive tree species were present, Russian olive and tamarisk. Of the 186 tree infestations for which growth stage was noted, 19 were seedlings, 98 were in the sapling stage, 67 were mature trees, and 2 were noted as old growth.

Control efforts of Russian olive took place along approximately 13 of the 20.8-km surveyed section from 2006 to 2009. All species except Canada thistle (only four infestations) had lower infestation rates in areas where Russian olive had been removed than in areas where control efforts had not taken place. Overall, there were approximately 2.5 times as many target IEPs in areas where removal had not occurred. Although control efforts removed most Russian olive, there were still 19 Russian olive infestations, or 0.15 per 100 m, in the “removed” areas (Table 3-2).

3.2 Results comparison, 2009 and 2002–2003

The area of the Green River surveyed in 2009 was last surveyed for IEPs in 2002 and 2003 (Dewey et al 2003). Except for teasel, every species in this study was also on the target list for 2002 and 2003. While methods were not exactly the same, and route endpoints might have deviated slightly, it is still useful to compare results from the two surveys. Dewey et al. (2003) recorded infestations of tamarisk and Russian olive as lines and point features, while the 2009 effort recorded all infestations as point features. Therefore, comparing the number of infestations is not appropriate, but comparisons can be made by looking at the infestations by area (Figures 3-2, 3-3, 3-4). The effects of the Russian olive and tamarisk removal are clearly shown with reduced infestations in 2009, whereas (Figures 3-2, 3-3) in areas where no Russian olive removal took place, infestation patterns look very similar between 2002–2003 and 2009 (Figures 3-3, 3-4).

Table 3-1. Monitoring routes surveyed, length (km), number of IEP infestations, and number of infestations/100 m in areas where Russian olive was removed and not removed, Dinosaur NM, June 18, 2009.

Scientific name	Common name	Number of infestations			Infestations/100 m		
		Russian olive removal area (13 km)	Russian olive non-removal area (7.8 km)	Total (20.8 km)	Russian olive removal area (13 km)	Russian olive non-removal area (7.8 km)	Total (20.8 km)
<i>Centaurea repens</i>	Russian knapweed	2	2	4	0.02	0.03	0.02
<i>Cirsium arvensis</i>	Canada thistle	4	0	4	0.03	0.00	0.02
<i>Elaeagnus angustifolia</i>	Russian olive	19	54	73	0.15	0.69	0.36
<i>Lepidium latifolium</i>	perennial pepperweed	32	47	79	0.24	0.60	0.38
<i>Tamarix</i> spp.	saltcedar	68	98	166	0.52	1.26	0.80
All species (no Russian olive)		106	147		0.82	1.88	
All species		125	201	326	0.96	2.58	1.57

Table 3.2. Species observed and size of infestation detected along the Green River, Dinosaur NM, June 18, 2009.

Scientific name	Common name	Total infestations	Infestation size class Number of infestations			
			1	2	3	4
<i>Centaurea repens</i>	Russian knapweed	4	1	2	1	0
<i>Cirsium arvensis</i>	Canada thistle	4	0	4	0	0
<i>Elaeagnus angustifolia</i>	Russian olive	73	34	23	16	0
<i>Lepidium latifolium</i>	perennial pepperweed	79	21	33	23	2
<i>Tamarix</i> spp.	saltcedar	166	15	47	98	6
All species		326	71	109	138	8

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)

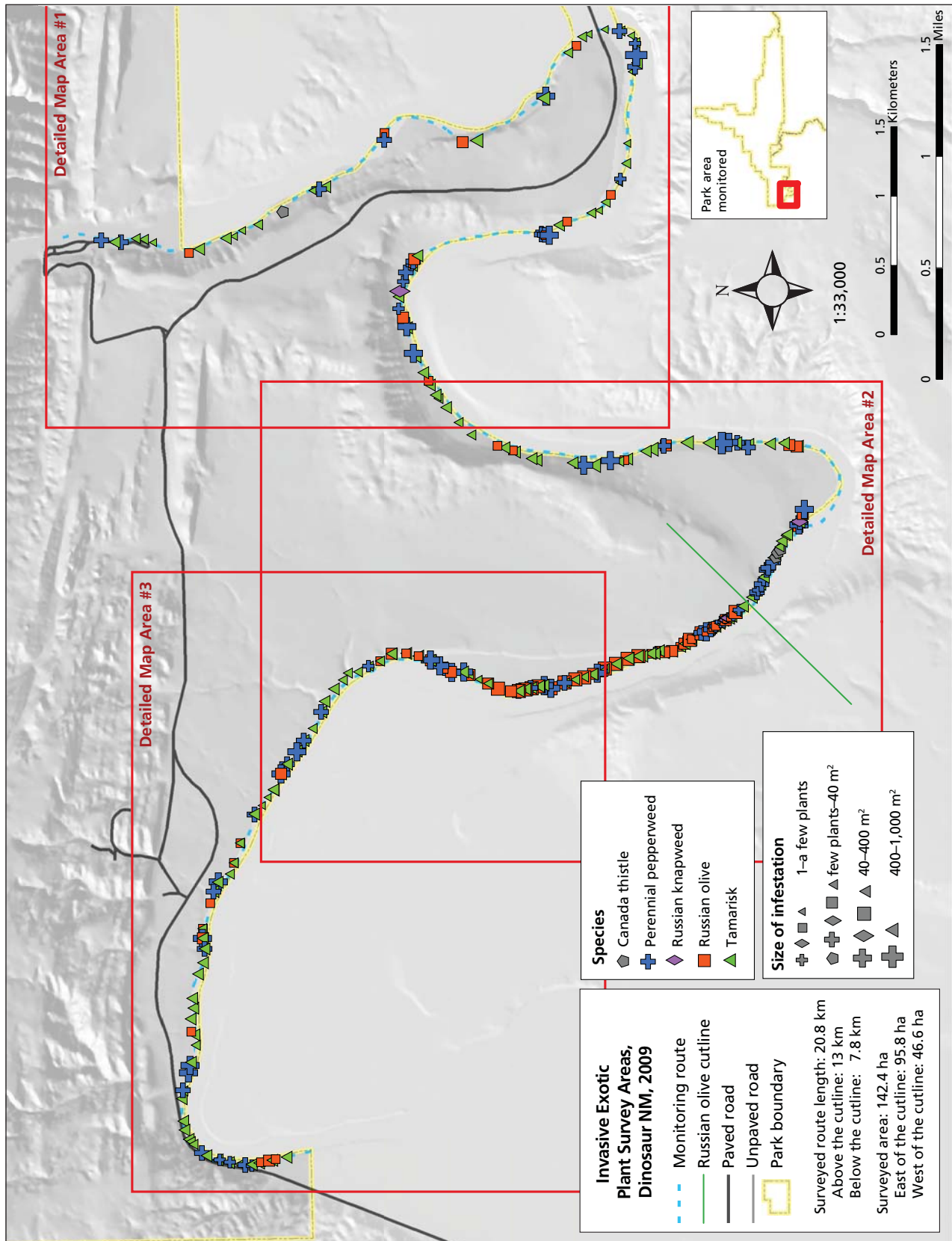


Figure 3-1. Invasive plants detected on monitoring routes along the Green River, Dinosaur National Monument, June 18, 2009. Russian olive was removed upstream (east) of the green line.

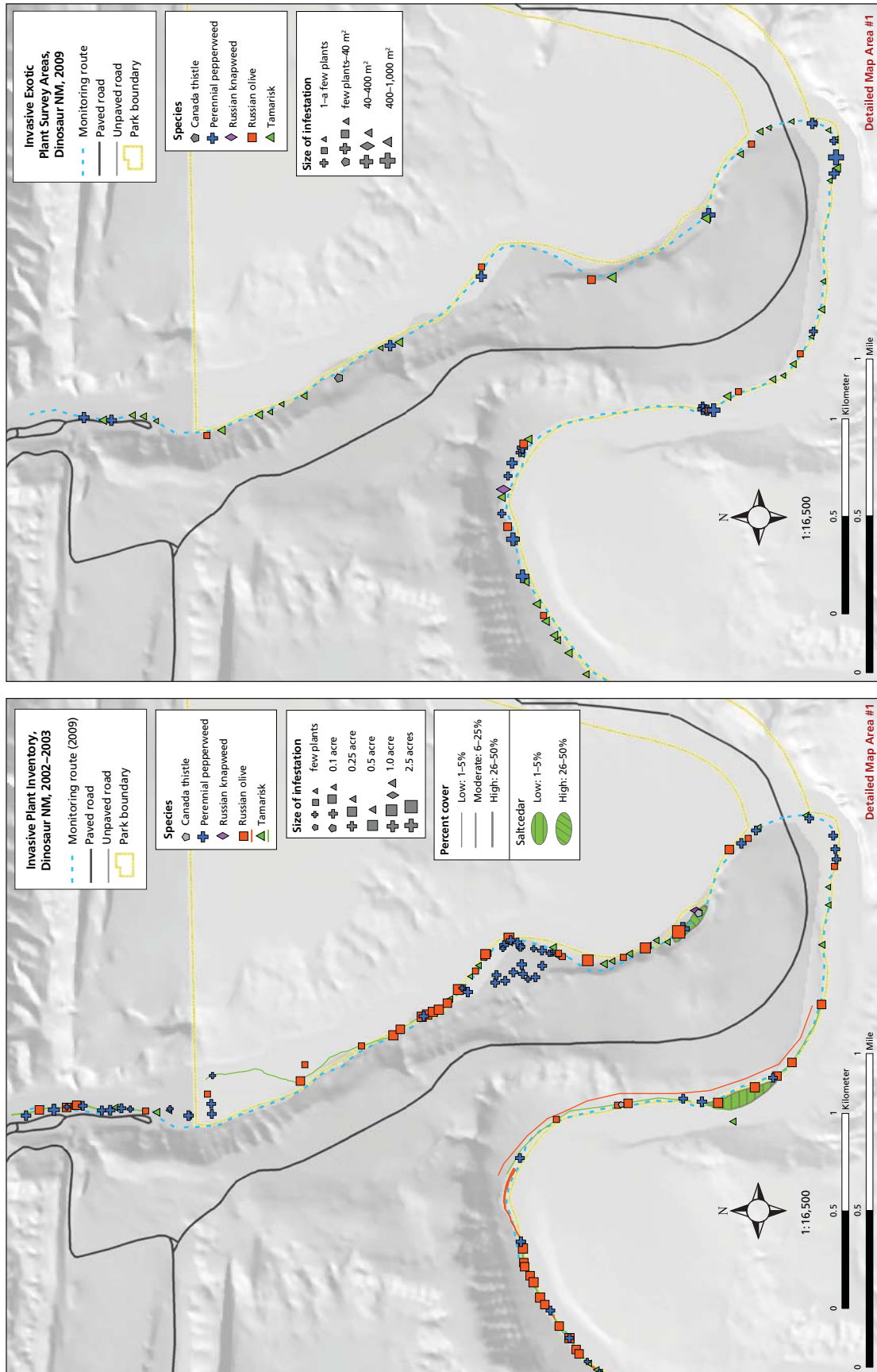


Figure 3-2. Results of inventories conducted in 2002 and 2003 (Dewey et al. 2003; left) and on June 18, 2009 (right). All of this area was subject to Russian olive removal efforts. Only species monitored in both years are shown.

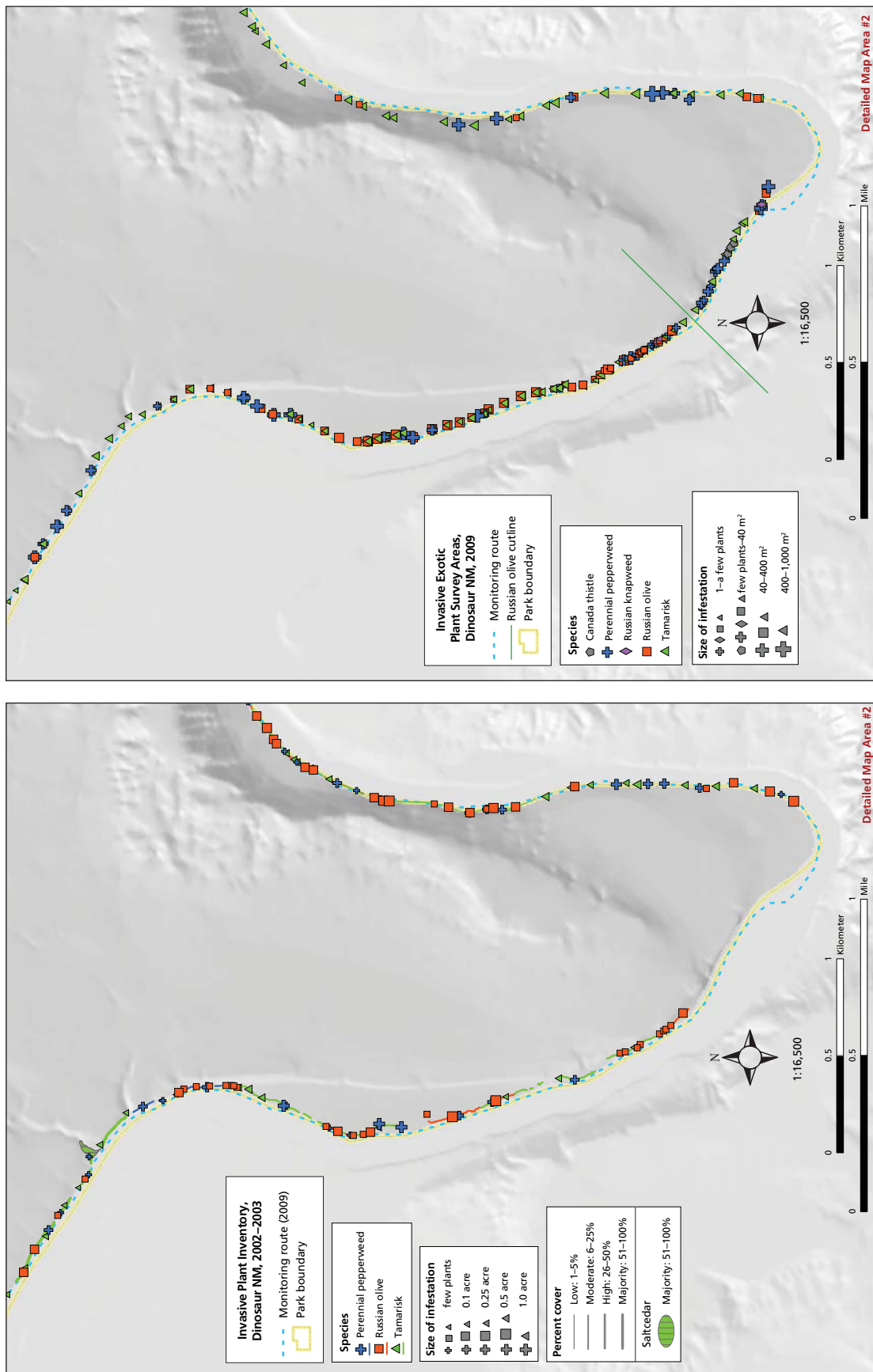


Figure 3-3. Results of inventories conducted in 2002 and 2003 (Dewey et al. 2003; left) and on June 18, 2009 (right). Russian olive was removed upstream (east) of the green line. Only species monitored in both years are shown.

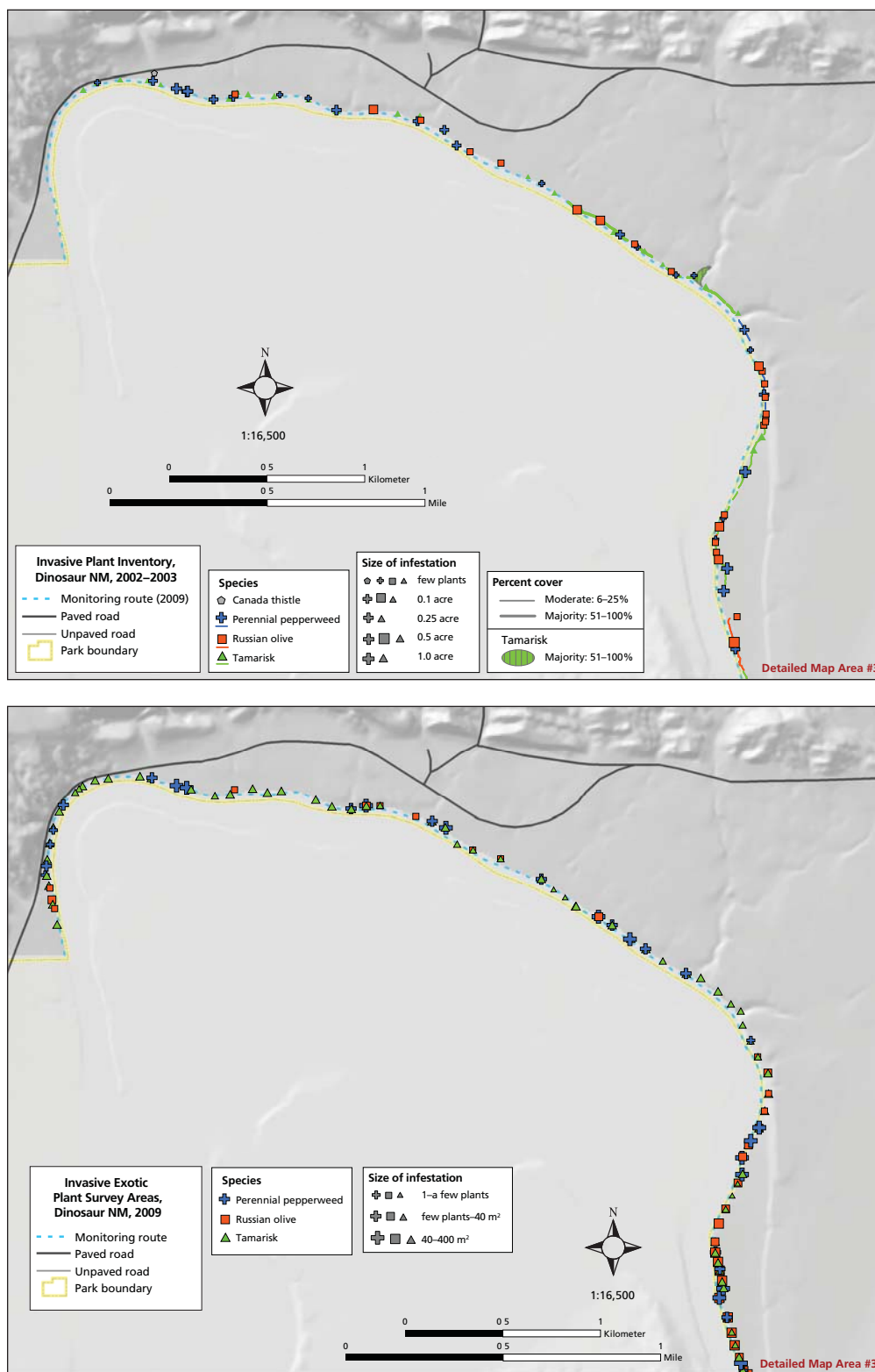


Figure 3-4. Results of inventories conducted in 2002 and 2003 (Dewey et al. 2003; top) and on June 18, 2009 (bottom). Only species monitored in both years are shown. Russian olive was not removed in this river section.

4 Discussion

4.1 Possibilities for management control

Russian olive and tamarisk were the two most widespread species. Even with extensive removal efforts of Russian olive, 19 small ($<40\text{ m}^2$) infestations were still present. Though the 2009 field work only focused on seven species, it is encouraging to note that none of those seven IEPs has shown an increased invasion rate following the removal of Russian olive; that is, none of those seven species appears to be “filling in behind” the targeted removal of another IEP, as can sometimes occur. Future monitoring should be performed to follow up on the plant community after additional IEPs have been removed.

Of perennial pepperweed and tamarisk, respectively, 29% and 63% were present in patches larger than 40 m^2 . Future monitoring will track the response of tamarisk response to the recent arrival of the tamarisk beetle (*Diorhabda elongata*) in the area. However, the substantial number of large infestations of perennial pepperweed is a concern.

4.2 Future monitoring efforts

Invasive exotic plants at DINO 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 larger than the minimum detection target size. In 2010, the NCPN will initiate monitoring with network crews at DINO. Long-term trend reporting will focus on trends in species distributions, trends in percent cover of individual species, and changes in IEP percent cover by monitoring routes of Priority 1 species and other species requested by parks (e.g., cheatgrass). 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.

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Appendix A. Exotic plant invasions detected on monitoring routes at Dinosaur NM, June 18, 2009

Scientific name	Common name	Infestation size class	Canopy cover	Growth stage	Northing	Easting
<i>Cirsium arvensis</i>	Canada thistle	2	1		4476886.041	648442.468
		2	2		4473329.98	645952.413
		2	3		4473314.965	645984.727
		2	2		4473297.134	646007.793
<i>Lepidium latifolium</i>	perennial pepperweed	1	5		4477338.123	641603.213
		1	5		4477266.14	641587.326
		1	5		4477108.526	641562.006
		1	1		4476048.296	647746.467
		1	3		4476016.328	647939.994
		1	2		4475954.052	648059.703
		1	2		4475017.037	648299.432
		1	5		4474447.837	648682.284
		1	2		4474342.621	649659.577
		1	1		4473700.33	645487.894
		1	2		4473593.957	645571.091
		1	2		4473465.533	645686.751
		1	2		4474196.31	645260.504
		1	2		4474579.356	645129.011
		1	2		4476265.754	645167.366
		1	2		4473760.39	645455.345
		1	2		4473720.327	645485.133
		1	2		4473631.923	645536.175
		1	2		4473451.687	645713.241
		1	2		4473414.2	645785.616
		1	2		4473389.788	645871.359
		3	3		4477566.498	642233.771
		3	3		4477555.054	642285.77
		3	4		4475942.185	647425.088
		3	4		4475990.454	647616.118
		3	3		4474986.288	649280.303
		3	3		4474961.051	648277.306
		3	4		4476897.161	644389.603
		3	5		4477350.3	643609.828
		3	4		4477464.476	643202.225
		3	5		4474616.536	645116.804
		3	5		4474950.048	645006.382
		3	5		4475820.279	645211.176

Appendix A. Exotic plant invasions detected on monitoring routes at Dinosaur NM, June 18, 2009, cont.

Scientific name	Common name	Infestation size class	Canopy cover	Growth stage	Northing	Easting
<i>Lepidium latifolium</i>	perennial pepperweed	3	4		4473827.924	645414.454
		3	3		4473158.628	646186.231
		3	3		4473119.49	646297.923
		3	4		4473664.437	646780.781
		3	4		4474519.294	646648.74
		3	5		4474998.254	645026.845
		3	4		4475580.04	645123.263
		3	4		4475665.784	645122.583
		3	5		4475753.076	645168.112
		3	4		4476782.225	644549.219
		3	4		4474714.335	646616.211
		4	4		4474332.715	649574.362
		4	4		4473716.518	646776.411
		2	5		4477155.662	641568.47
		2	5		4477605.144	642107.329
		2	4		4477466.975	641655.149
		2	3		4475995.327	648006.669
		2	2		4475014.828	648281.501
		2	4		4474342.041	649491.684
		2	2		4474453.164	649748.528
		2	1		4474993.037	648278.139
		2	3		4476152.585	648963.992
		2	4		4476620.185	648608.971
		2	2		4478051.976	648225.654
		2	2		4478193.217	648239.683
		2	4		4475096.943	645009.039
		2	5		4473862.68	645405.609
		2	3		4475942.122	648084.939
		2	4		4473792.693	645431.717
		2	2		4473391.165	645861.935
		2	2		4473379.219	645876.745
		2	3		4473344.776	645915.721
		2	3		4473152.265	646204.456
		2	3		4473525.869	646745.012
		2	3		4473602.985	646778.462
		2	2		4474136.039	646757.319
		2	3		4477088.134	644096.645
		2	3		4477384.236	643539.359
		2	4		4477449.378	643125.315

Appendix A. Exotic plant invasions detected on monitoring routes at Dinosaur NM, June 18, 2009, cont.

Scientific name	Common name	Infestation size class	Canopy cover	Growth stage	Northing	Easting
<i>Lepidium latifolium</i>	perennial pepperweed	2	3		4474850.495	645045.22
		2	3		4475182.518	644987.099
		2	3		4476606.397	644836.51
		2	3		4476732.259	644629.857
		2	3		4476853.505	644458.514
		2	2		4473462.005	645699.533
		2	1		4473428.432	645758.052
<i>Centaurea repens</i>	Russian knapweed	1	2		4473689.431	645498.26
		3	5		4476039.085	647871.24
		2	2		4473667.108	645514.354
		2	4		4473153.057	646207.839
<i>Elaeagnus angustifolia</i>	Russian olive	1	5		4477042.957	641585.85
		1	2		4475834.315	647224.328
		1	1		4475945.387	648075.24
		1	5		4474766	649643.438
		1	5		4476153.286	649012.983
		1	5		4477562.56	648148.243
		1	5	Mature Tree(s)	4476938.373	641609.576
		1	5	Mature Tree(s)	4477545.703	642529.641
		1	3	Mature Tree(s)	4473966.228	645351.392
		1	2	Mature Tree(s)	4475335.282	646755.293
		1	2	Mature Tree(s)	4477192.618	643888.634
		1	3	Mature Tree(s)	4477238.19	643746.994
		1	2	Mature Tree(s)	4477409.729	643456.39
		1	2	Mature Tree(s)	4477463.675	643272.61
		1	2	Mature Tree(s)	4474225.849	645256.441
		1	2	Mature Tree(s)	4474289.983	645239.623
		1	5	Old Growth	4474833.855	648373.336
		1	2	Sapling(s)	4473826.89	645415.415
		1	2	Sapling(s)	4473788.334	645435.834
		1	2	Sapling(s)	4473776.175	645447.804
		1	2	Sapling(s)	4473679.097	645506.177
		1	2	Sapling(s)	4473652.41	645519.814
		1	2	Sapling(s)	4473932.287	645361.681
		1	2	Sapling(s)	4474418.821	646653.212
		1	2	Sapling(s)	4475225.295	646721.745
		1	5	Sapling(s)	4474988.901	648276.903
		1	4	Sapling(s)	4474016.509	645305.814
		1	3	Sapling(s)	4475905.337	645237.69

Appendix A. Exotic plant invasions detected on monitoring routes at Dinosaur NM, June 18, 2009, cont.

Scientific name	Common name	Infestation size class	Canopy cover	Growth stage	Northing	Easting
<i>Elaeagnus angustifolia</i>	Russian olive	1	3	Sapling(s)	4475994.528	645258.677
		1	3	Sapling(s)	4476181.814	645202.987
		1	4	Sapling(s)	4474168.152	645277.454
		1	2	Seedling(s)	4473760.161	645457.396
		1	1	Seedling(s)	4473170.242	646170.289
		1	5	Seedling(s)	4474517.013	648566.787
		3	4	Mature Tree(s)	4473944.814	645355.842
		3	5	Mature Tree(s)	4474315.154	645239.42
		3	5	Mature Tree(s)	4474393.313	645219.017
		3	5	Mature Tree(s)	4474479.021	645184.019
		3	5	Mature Tree(s)	4474559.939	645150.695
		3	5	Mature Tree(s)	4474707.107	645084.48
		3	5	Mature Tree(s)	4474771.114	645069.998
		3	5	Mature Tree(s)	4474849.443	645049.719
		3	4	Mature Tree(s)	4474949.623	645006.7
		3	5	Mature Tree(s)	4475036.853	645021.066
		3	5	Mature Tree(s)	4475088.325	645007.826
		3	5	Mature Tree(s)	4475132.947	644999.464
		3	4	Mature Tree(s)	4475180.934	644986.209
		3	5	Mature Tree(s)	4475329.792	645003.996
		3	2	Sapling(s)	4473861.806	645402.651
		3	3	Sapling(s)	4473613.837	645557.264
		2	5		4476984.154	641596.937
		2	3		4476018.595	647679.806
		2	3		4473987.172	645327.746
		2	2		4475587.754	648946.71
		2	2	Mature Tree(s)	4473131.877	646263.386
		2	3	Mature Tree(s)	4477462.083	643203.041
		2	3	Mature Tree(s)	4474580.221	645132.861
		2	4	Mature Tree(s)	4474647.336	645108.988
		2	4	Mature Tree(s)	4475731.653	645154.866
		2	4	Mature Tree(s)	4475817.218	645209.361
		2	3	Mature Tree(s)	4476098.417	645254.685
		2	2	Mature Tree(s)	4476896.655	644389.93
		2	3	Sapling(s)	4475936.402	648104.092
		2	2	Sapling(s)	4473176.835	646751.659
		2	3	Sapling(s)	4473230.337	646760.981
		2	3	Sapling(s)	4474074.669	645276.109
		2	3	Sapling(s)	4475237.385	644984.875

Appendix A. Exotic plant invasions detected on monitoring routes at Dinosaur NM, June 18, 2009, cont.

Scientific name	Common name	Infestation size class	Canopy cover	Growth stage	Northing	Easting
<i>Elaeagnus angustifolia</i>	Russian olive	2	4	Sapling(s)	4475404.095	645039.171
		2	3	Sapling(s)	4475536.807	645101.246
		2	4	Sapling(s)	4475671.149	645125.212
		2	4	Sapling(s)	4474131.806	645265.932
		2	5	Seedling(s)	4473686.64	645498.118
		2	3	Seedling(s)	4474120.379	646759.46
<i>Tamarix</i> spp.	tamarisk	1	2		4474604.611	648455.248
		1	5		4474399.724	648938.971
		1	5		4474678.996	649727.443
		1	2		4476671.15	648596.889
		1	3		4477178.984	648308.803
		1	2		4477237.809	648268.819
		1	5		4477823.592	648222.309
		1	5	Sapling(s)	4474365.636	649456.076
		1	1	Sapling(s)	4474372.79	649713.705
		1	2	Sapling(s)	4474561.205	649759.233
		1	2	Sapling(s)	4476995.807	644218.165
		1	2	Sapling(s)	4477036.806	644160.69
		1	2	Sapling(s)	4475473.61	645071.768
		1	2	Sapling(s)	4475533.908	645100.169
		1	1	Seedling(s)	4474459.758	648655.322
		3	5		4477272.159	641585.044
		3	5		4477188.59	641572.146
		3	4		4477106.211	641569.119
		3	4		4477054.736	641580.214
		3	5		4477602.83	641884.652
		3	5		4477592.387	641817.683
		3	5		4477563.513	641752.159
		3	5		4477435.032	641633.759
		3	5		4477352.458	641603.518
		3	4		4475779.221	647122.378
		3	5		4475822.394	647194.69
		3	4		4475868.633	647283.222
		3	4		4475926.265	647397.507
		3	5		4475987.336	647608.42
		3	4		4476048.65	647831.053
		3	4		4475952.102	648057.17
		3	3		4475912.343	648128.587
		3	5		4473981.62	645328.776

Appendix A. Exotic plant invasions detected on monitoring routes at Dinosaur NM, June 18, 2009, cont.

Scientific name	Common name	Infestation size class	Canopy cover	Growth stage	Northing	Easting
<i>Tamarix</i> spp.	tamarisk	3	5		4473934.69	645359.703
		3	2		4476575.519	648626.357
		3	5		4477295.353	648254.607
		3	4		4477487.054	648174.909
		3	3		4478096.67	648226.647
		3	5	Mature Tree(s)	4477546.516	642307.843
		3	5	Mature Tree(s)	4477529.166	642697.894
		3	5	Mature Tree(s)	4477538.809	642768.844
		3	5	Mature Tree(s)	4477495.387	642944.403
		3	5	Mature Tree(s)	4477460.257	643026.908
		3	5	Mature Tree(s)	4475282.34	646742.053
		3	5	Mature Tree(s)	4474327.889	649520.657
		3	5	Mature Tree(s)	4474890.343	648349.189
		3	4	Mature Tree(s)	4477089.481	644097.529
		3	5	Mature Tree(s)	4477352.124	643607.012
		3	5	Mature Tree(s)	4477384.692	643538.888
		3	4	Mature Tree(s)	4477462.771	643202.675
		3	5	Mature Tree(s)	4477447.134	643126.253
		3	5	Mature Tree(s)	4474318.817	645238.915
		3	5	Mature Tree(s)	4474389.883	645220.987
		3	5	Mature Tree(s)	4474479.131	645183.198
		3	5	Mature Tree(s)	4474648.046	645106.874
		3	5	Mature Tree(s)	4475000.434	645029.315
		3	5	Mature Tree(s)	4475033.678	645020.335
		3	5	Mature Tree(s)	4475091.279	645009.412
		3	5	Mature Tree(s)	4475733.456	645154.644
		3	5	Mature Tree(s)	4475816.608	645209.211
		3	5	Mature Tree(s)	4476583.531	644911.23
		3	5	Mature Tree(s)	4474168.257	645279.21
		3	5	Mature Tree(s)	4476732.519	644630.516
		3	5	Mature Tree(s)	4476896.815	644389.316
		3	4	Sapling(s)	4476959.47	641600.044
		3	3	Sapling(s)	4476856.361	641622.427
		3	3	Sapling(s)	4477613.981	642046.08
		3	4	Sapling(s)	4477520.959	642507.454
		3	5	Sapling(s)	4477549.411	642621.859
		3	4	Sapling(s)	4475706.08	647031.626
		3	3	Sapling(s)	4473806.75	645428.214
		3	2	Sapling(s)	4473663.07	645513.865

Appendix A. Exotic plant invasions detected on monitoring routes at Dinosaur NM, June 18, 2009, cont.

Scientific name	Common name	Infestation size class	Canopy cover	Growth stage	Northing	Easting
<i>Tamarix</i> spp.	tamarisk	3	3	Sapling(s)	4473560.732	645600.056
		3	4	Sapling(s)	4473496.924	645664.247
		3	4	Sapling(s)	4473409.76	645808.573
		3	5	Sapling(s)	4473342.861	645948.074
		3	3	Sapling(s)	4473283.666	646070.053
		3	5	Sapling(s)	4473169.019	646174.549
		3	5	Sapling(s)	4473152.828	646205.433
		3	5	Sapling(s)	4473165.6	646753.981
		3	5	Sapling(s)	4473266.542	646776.751
		3	5	Sapling(s)	4473609.282	646778.563
		3	5	Sapling(s)	4474263.871	646715.647
		3	5	Sapling(s)	4473890.402	645393.645
		3	3	Sapling(s)	4474791.434	646632.088
		3	5	Sapling(s)	4475088.436	646663.288
		3	5	Sapling(s)	4475207.833	646711.716
		3	4	Sapling(s)	4476950.038	644274.681
		3	4	Sapling(s)	4474197.908	645259.625
		3	5	Sapling(s)	4474228.379	645257.314
		3	5	Sapling(s)	4474287.366	645239.991
		3	5	Sapling(s)	4474950.498	645009.456
		3	5	Sapling(s)	4474073.026	645273.956
		3	5	Sapling(s)	4475130.86	645000.168
		3	5	Sapling(s)	4475181.082	644986.407
		3	4	Sapling(s)	4475237.276	644985.502
		3	5	Sapling(s)	4474133.017	645263.556
		3	4	Sapling(s)	4475583.039	645125.61
		3	5	Sapling(s)	4475905.342	645238.22
		3	5	Sapling(s)	4475993.426	645258.387
		3	4	Sapling(s)	4476098.182	645255.117
		3	4	Sapling(s)	4476515.232	645000.273
		3	5	Sapling(s)	4476605.839	644837.35
		3	4	Sapling(s)	4476784.609	644554.044
		3	4	Sapling(s)	4476854.187	644458.451
		3	3	Sapling(s)	4476949.604	644272.299
		3	5	Seedling(s)	4473759.828	645454.875
		3	5	Seedling(s)	4473729.177	645476.907
		3	3	Seedling(s)	4473645.089	645527.458
		3	5	Seedling(s)	4473244.691	646116.027
		3	5	Seedling(s)	4473366.207	646770.255

Appendix A. Exotic plant invasions detected on monitoring routes at Dinosaur NM, June 18, 2009, cont.

Scientific name	Common name	Infestation size class	Canopy cover	Growth stage	Northing	Easting
<i>Tamarix</i> spp.	tamarisk	3	5	Seedling(s)	4474397.422	646660.833
		3	3	Seedling(s)	4475051.234	646653.227
		4	5		4475001.542	649261.443
		4	3		4475483.228	648958.946
		4	5	Sapling(s)	4473803.745	646775.887
		4	5	Seedling(s)	4473964.327	646778.439
		4	3	Seedling(s)	4474219.02	646729.628
		4	5	Seedling(s)	4474634.636	646612.515
		2	5		4477549.178	641734.906
		2	3		4477530.519	641715.332
		2	5		4474658.006	648435.894
		2	3		4474447.85	649749.789
		2	3		4474723.663	649706.868
		2	2		4474824.109	649591.484
		2	3		4477063.374	648350.634
		2	2		4477888.079	648246.471
		2	2		4477945.526	648251.14
		2	3	Mature Tree(s)	4474457.195	646644.028
		2	4	Mature Tree(s)	4475010.572	648280.587
		2	3	Mature Tree(s)	4477193.408	643888.747
		2	3	Mature Tree(s)	4477267.666	643667.089
		2	5	Mature Tree(s)	4474560.478	645148.465
		2	4	Mature Tree(s)	4475329.372	645003.902
		2	3	Mature Tree(s)	4476263.166	645166.353
		2	2	Mature Tree(s)	4476451.781	645064.846
		2	3	Mature Tree(s)	4476670.125	644717.473
		2	3	Old Growth	4476414.889	645115.355
		2	5	Sapling(s)	4477602.096	642101.077
		2	2	Sapling(s)	4477513.804	642429.54
		2	3	Sapling(s)	4475762.231	647097.947
		2	3	Sapling(s)	4473856.506	645406.64
		2	3	Sapling(s)	4473698.249	645488.97
		2	3	Sapling(s)	4473324.458	645972.073
		2	3	Sapling(s)	4473300.215	646027.294
		2	2	Sapling(s)	4473255.938	646108.396
		2	5	Sapling(s)	4473516.781	646773.136
		2	3	Sapling(s)	4475522.595	646833.05
		2	4	Sapling(s)	4475616.57	646922.724
		2	2	Sapling(s)	4474552.898	648514.346

Appendix A. Exotic plant invasions detected on monitoring routes at Dinosaur NM, June 18, 2009, cont.

Scientific name	Common name	Infestation size class	Canopy cover	Growth stage	Northing	Easting
<i>Tamarix</i> spp.	tamarisk	2	2	Sapling(s)	4474405.583	648793.284
		2	3	Sapling(s)	4474337.647	649664.876
		2	3	Sapling(s)	4477238.367	643747.503
		2	3	Sapling(s)	4477465.556	643273.27
		2	4	Sapling(s)	4474008.696	645302.361
		2	4	Sapling(s)	4474582.734	645127.43
		2	4	Sapling(s)	4474710.548	645087.659
		2	4	Sapling(s)	4474775.735	645069.654
		2	4	Sapling(s)	4474848.554	645047.212
		2	4	Sapling(s)	4475403.776	645039.153
		2	4	Sapling(s)	4475668.113	645124.24
		2	3	Sapling(s)	4476182.164	645203.122
		2	3	Sapling(s)	4476343.177	645124.984
		2	2	Seedling(s)	4473785.955	645437.132
		2	3	Seedling(s)	4473607.043	645558.876
		2	3	Seedling(s)	4473431.491	645750.447

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%).

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NPS 122/105046, July 2010

National Park Service
U.S. Department of the Interior



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