



Invasive Exotic Plant Monitoring at Dinosaur National Monument

2010 Field Season

Natural Resource Technical Report NPS/NCPN/NRDS—2011/177



ON THE COVER

Canada thistle (*Cirsium arvense*). Photo courtesy Steve Dewey, Utah State University, 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

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 5–12 and July 18–25, 2010, NCPN staff detected 13 Priority 1 IEP species and 5 additional IEP species on monitoring routes and quadrats along 234 kilometers (383 hectares) of the Green and Yampa rivers (includes both sides). Almost the entire riparian corridor along the Yampa and upper Green rivers, and limited portions the lower Green River, was monitored in 2010. Tamarisk (*Tamarix chinensis*), broadleaf pepperwort (*Lepidium latifolium*), and yellow sweetclover (*Melilotus officinalis*) were widespread along all three monitored sections (upper Green, lower Green, and Yampa) of the river corridor. Canada thistle (*Cirsium arvense*) was widespread on the upper Green River, while Russian olive (*Elaeagnus angustifolia*) was widespread along the westernmost portion of the lower Green River. NCPN crews will return in 2011 to complete monitoring of the entire river corridor at Dinosaur National Monument.

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
NM	national monument
NPS	National Park Service
PSR	patch separation resolution

Acknowledgements

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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 Dinosaur National Monument (DINO). Following the 2011 field season, data collected in 2010 and 2011 will be analyzed and presented in a Natural Resources Technical Report that addresses the entire river corridor.

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 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).

We establish a series of co-located monitoring routes for the park. The quadrats, which are sampled in a quantitative manner, are used to make inference to the percent cover of IEPs located along the park's invasive pathways (i.e., the monitoring routes) and allow us to estimate trends in IEP percent cover over time. The monitoring routes, which are not quantitatively sampled, are used to increase the spatial coverage of mapping performed, with the goal of maximizing our opportunities for detecting IEPs in the park.

2.1 Developing a park target invasive exotic plant list

Prior to beginning monitoring in 2010, NCPN and DINO staff reviewed and updated the list of target invasive plants for the park (see Appendix A). The 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. The list of Priority 1 species will be reviewed before every field season.

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 chinensis*), 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. Using fake plants of a targeted size, crew members were trained by walking away and determining the maximum distance from which they could consistently see and recognize the patch with complete confidence. The size of the EDD was then estimated in the field by crew members. The distance was measured either by pacing or using a laser range-finder. The EDD for DINO was between 5 and 35 m, depending on vegetation.

2.2.3 Effective detection swath width

Effective detection swath width (EDSW) was the maximum width of a linear search swath (band transect) in which an observer was confident of visually detecting 90% of all target species of the MDTS. The effective detection swath width (EDSW) is normally 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. However, because these routes were often completed by raft, and the river was on one side of the route, the EDSW was the same as the EDD, ranging from 5 to 35 meters (Figure 2-1).

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

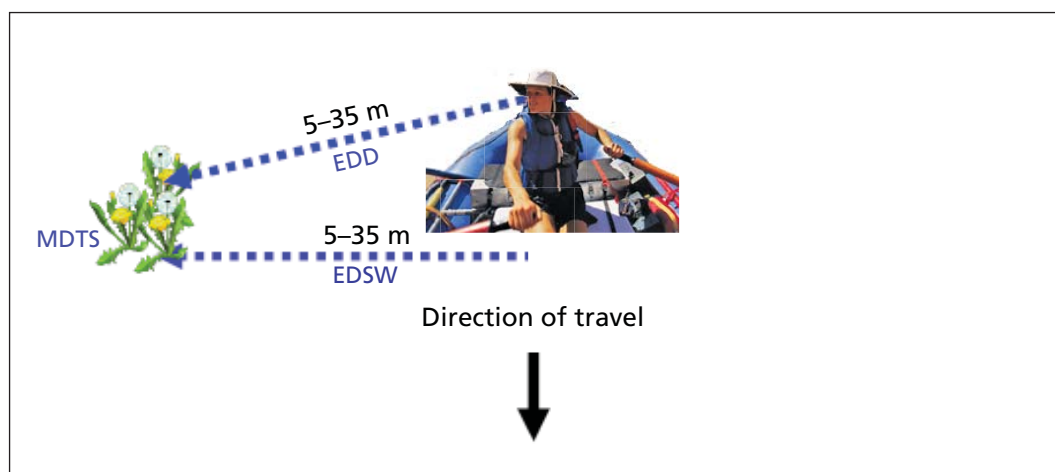


Figure 2-1. At Dinosaur NM, the maximum effective detection distance (EDD) and effective detection swath width (EDSW) were both 5–35 meters.

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 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 (BFPs) allow electronic tracking of a user's route. A 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

While walking along the shore or floating on a raft, 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 5–35 m

(the length of one EDSW) and visually scanned the area.* As monitoring routes were traversed (Figure 2-2), 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. Because the purpose of the monitoring is to detect invasives, rather than to control them, plants are generally not pulled unless they comprise an isolated population. However, at the request of the park, all leafy spurge (*Euphorbia esula*) infestations on the Yampa River, and some on the Green River, were pulled when detected.

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, then 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.

*In places where the monitoring route was inaccessible on foot, observers did their best to detect infestations while rafting. In these cases, periodic stops were not possible.

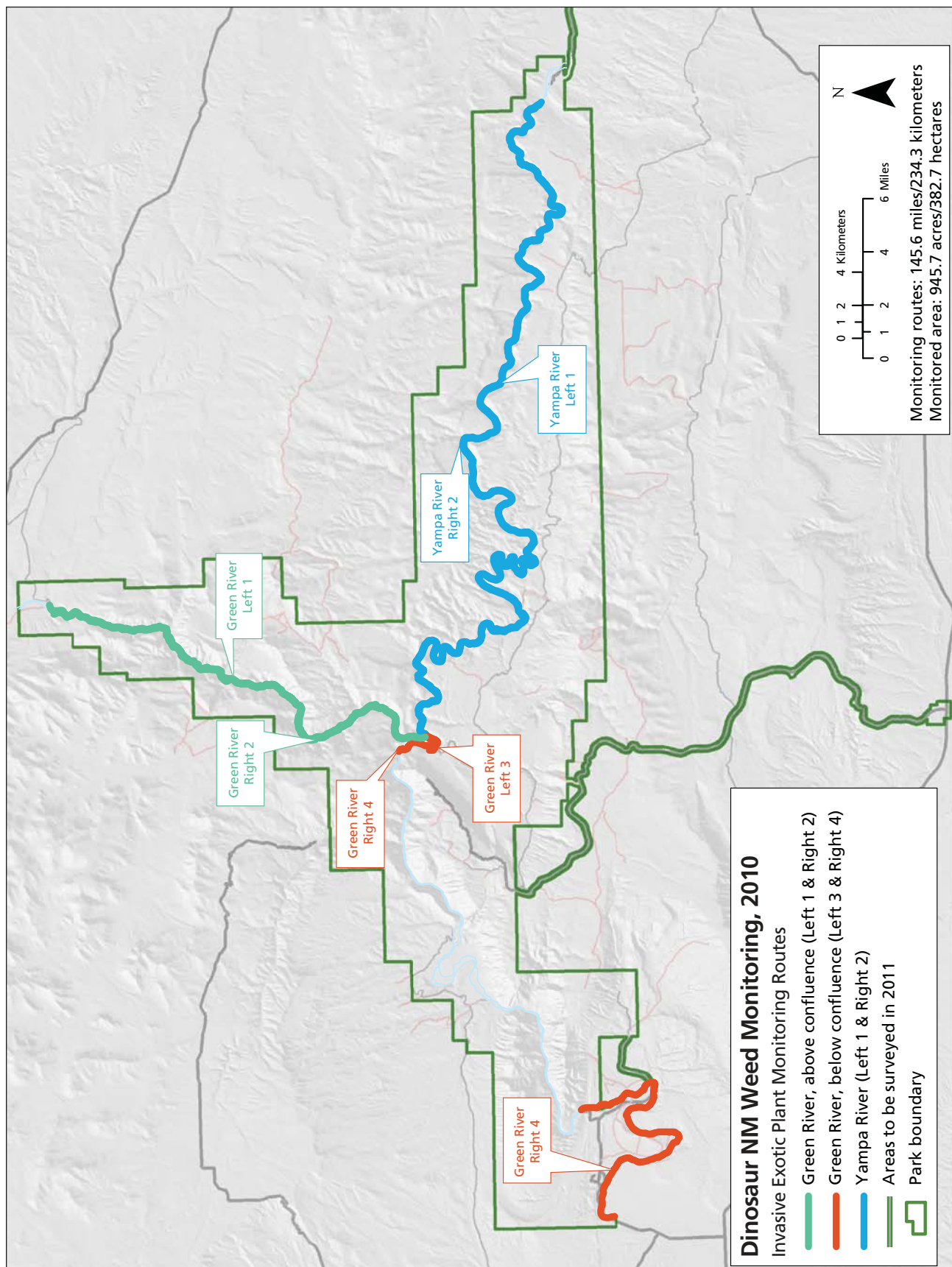


Figure 2-2. Overview of invasive plant monitoring routes surveyed, Dinosaur NM, July 5–24, 2010.

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%).

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, 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.* 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 went back to establishing transects every 500 m (Figures 2-3, 2-4, 2-5, 2-6, 2-7, 2-8, 2-9, 2-10).

2.3.1 Quadrat establishment

We centered vegetation quadrats at 0.5, 5, and 10 m away from the edge of the water’s edge on the same side as the route that was being walked or rafted. A 1-m² sampling frame, placed on the right side of the transect line as the technician walked/rafted the monitoring route, was used to sample vegetation cover and soil surface features. In some cases, we leveled the sampling frame by propping up quadrat corners.

2.3.2 Data collection methods

In the monitoring quadrats, all Priority 1 IEP species observed were recorded, as well as cheatgrass (*Bromus tectorum*). 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).

*Due to swift currents, canyon walls, and river safety in some portions of the river, some transects were missed.

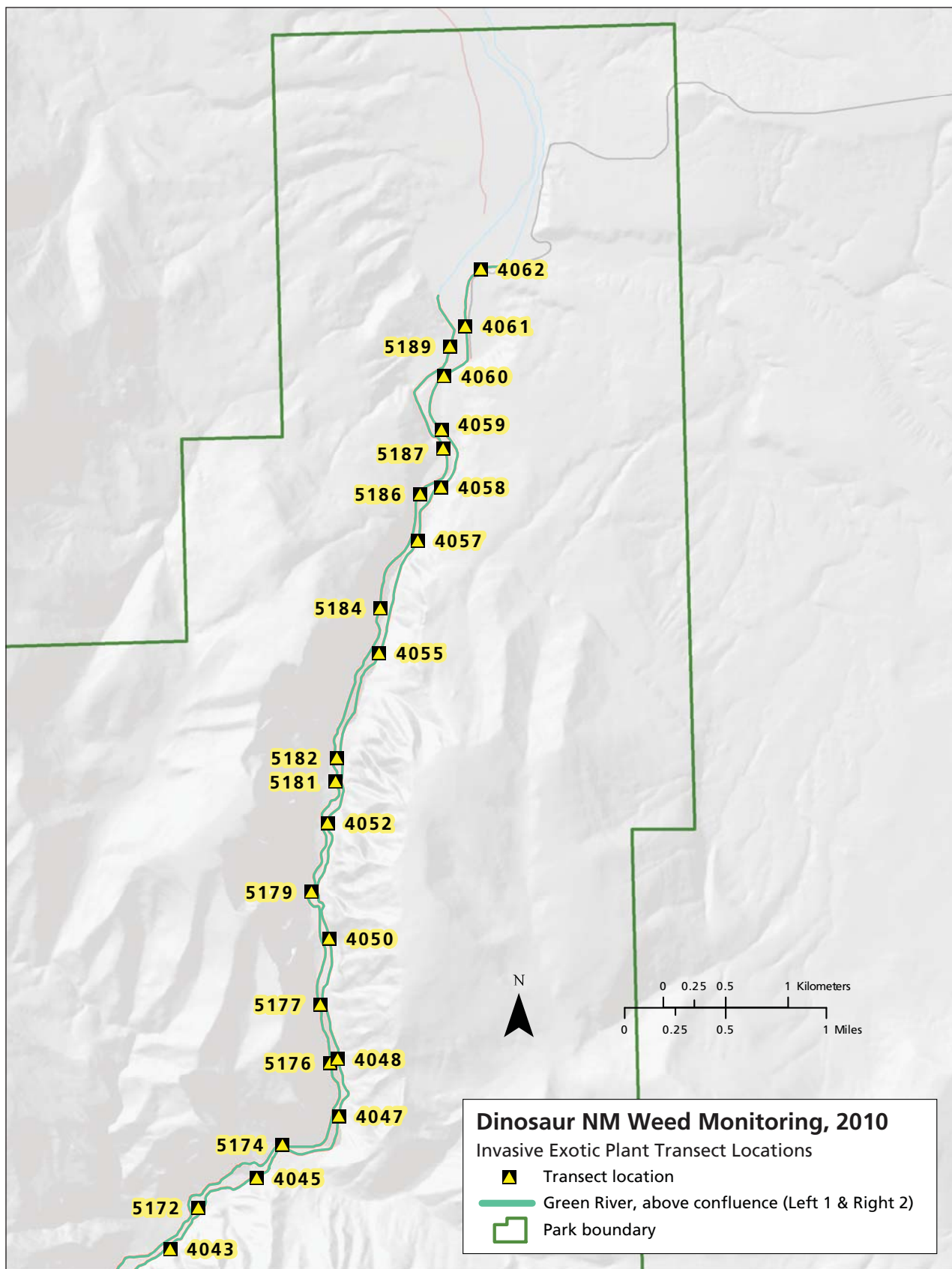


Figure 2-3. Monitoring quadrats established along the northern section of the Upper Green River, Dinosaur NM, July 5–24, 2010.

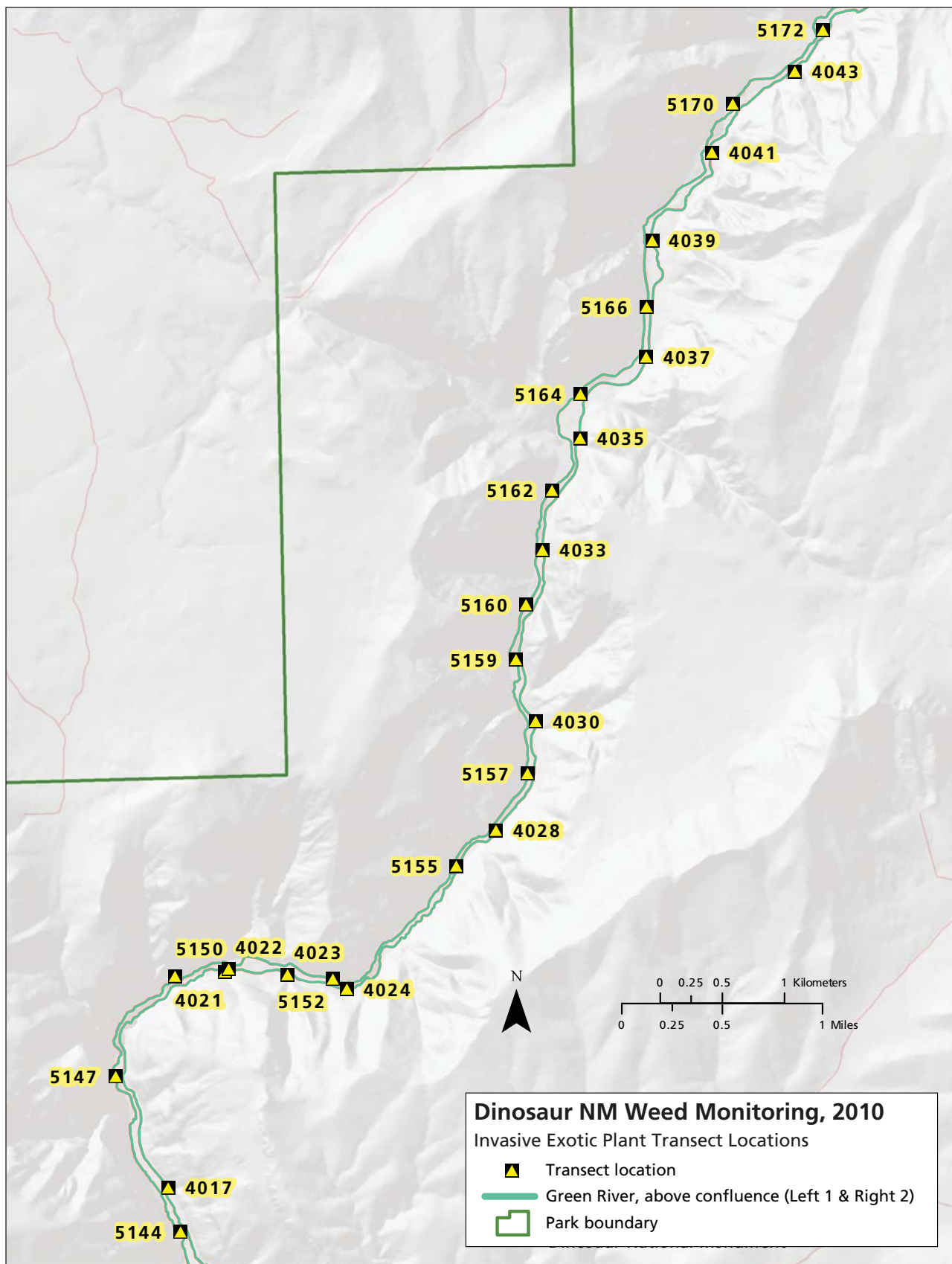


Figure 2-4. Monitoring quadrats established along the central section of the upper Green River, Dinosaur NM, July 5–24, 2010.

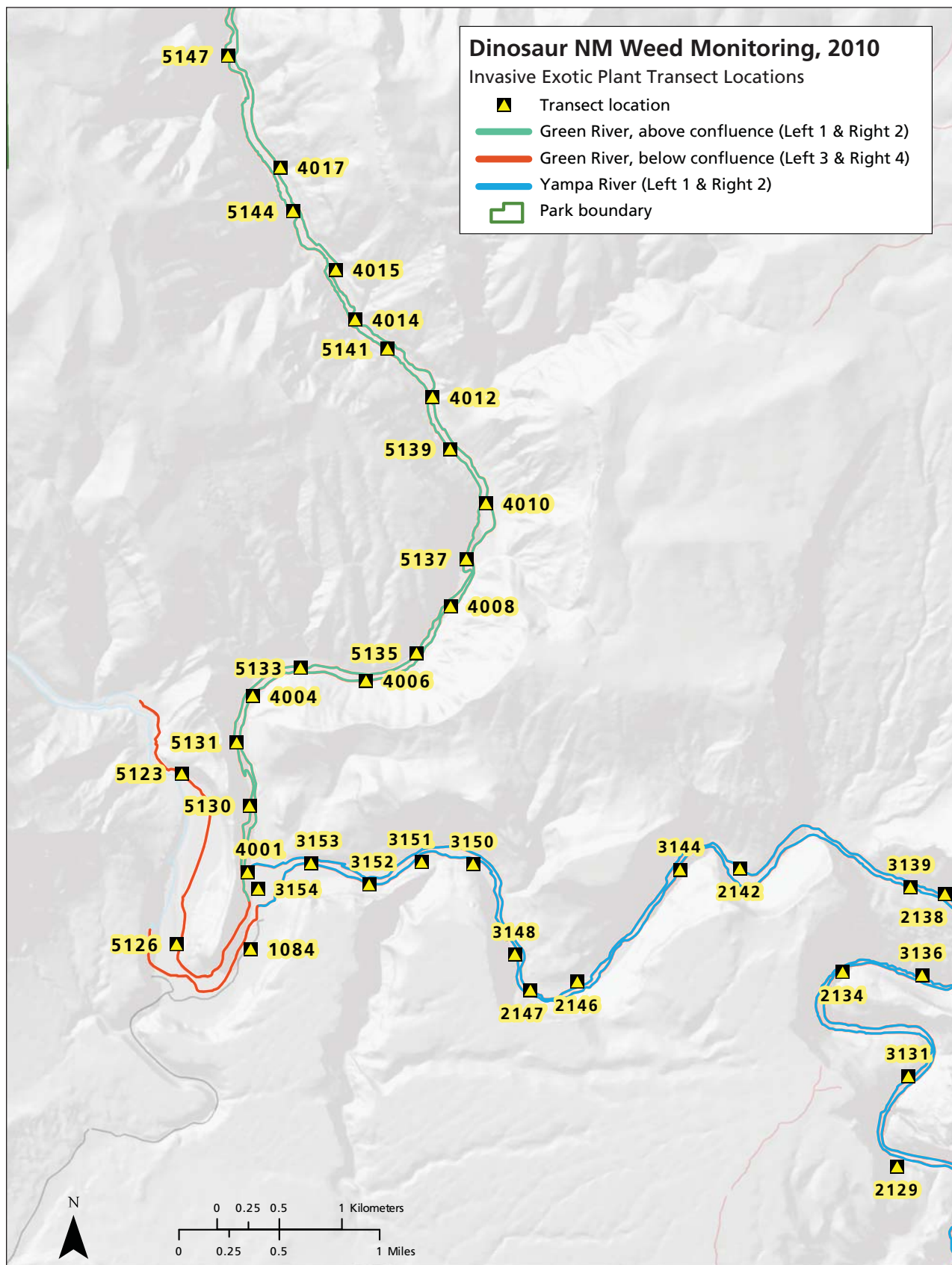


Figure 2-5. Monitoring quadrats established near the confluence of the upper Green and Yampa rivers, Dinosaur NM, July 5–24, 2010.

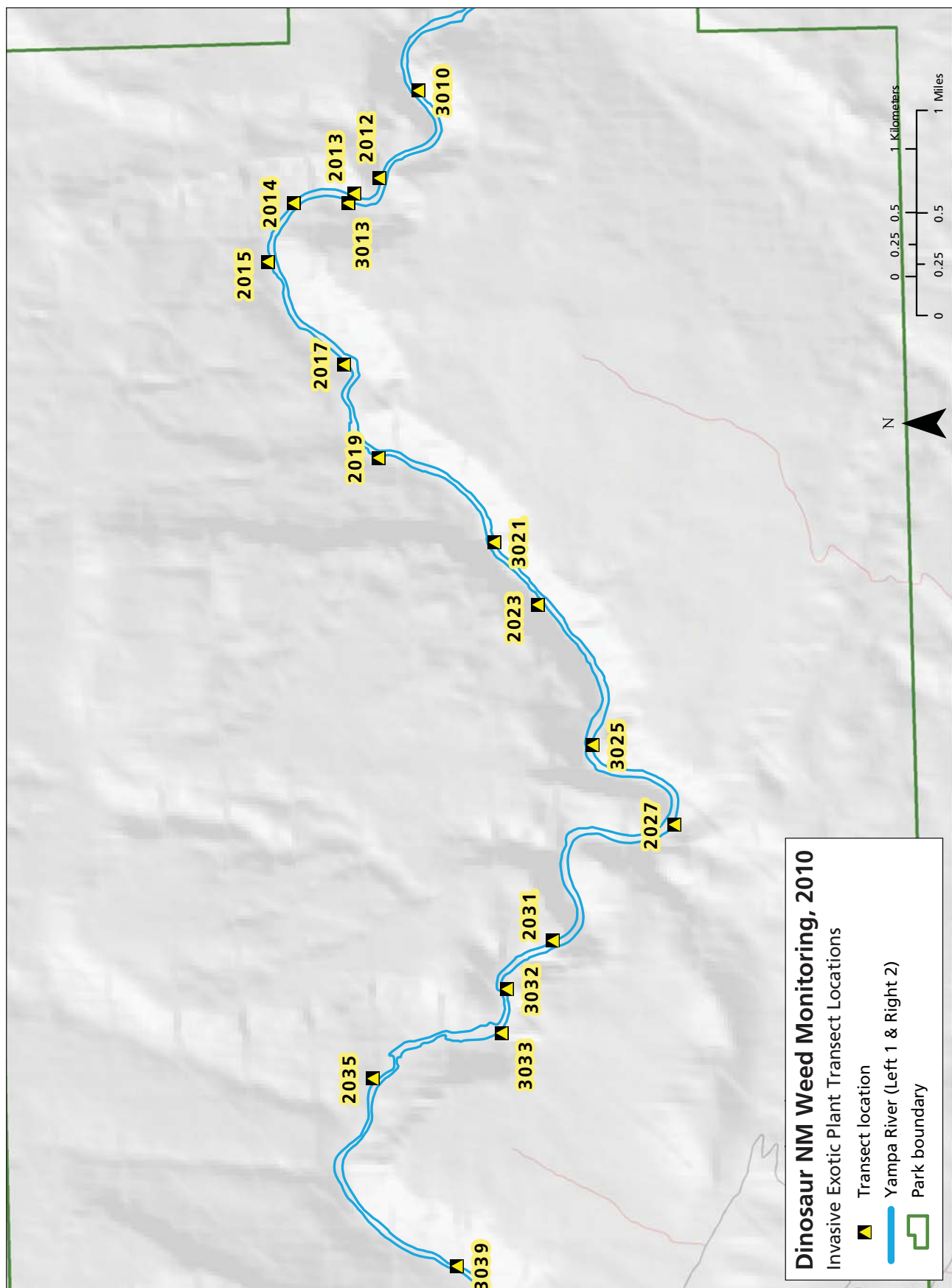


Figure 2-6. Monitoring quadrats established on the eastern section of the Yampa River, Dinosaur NM, July 5-24, 2010.

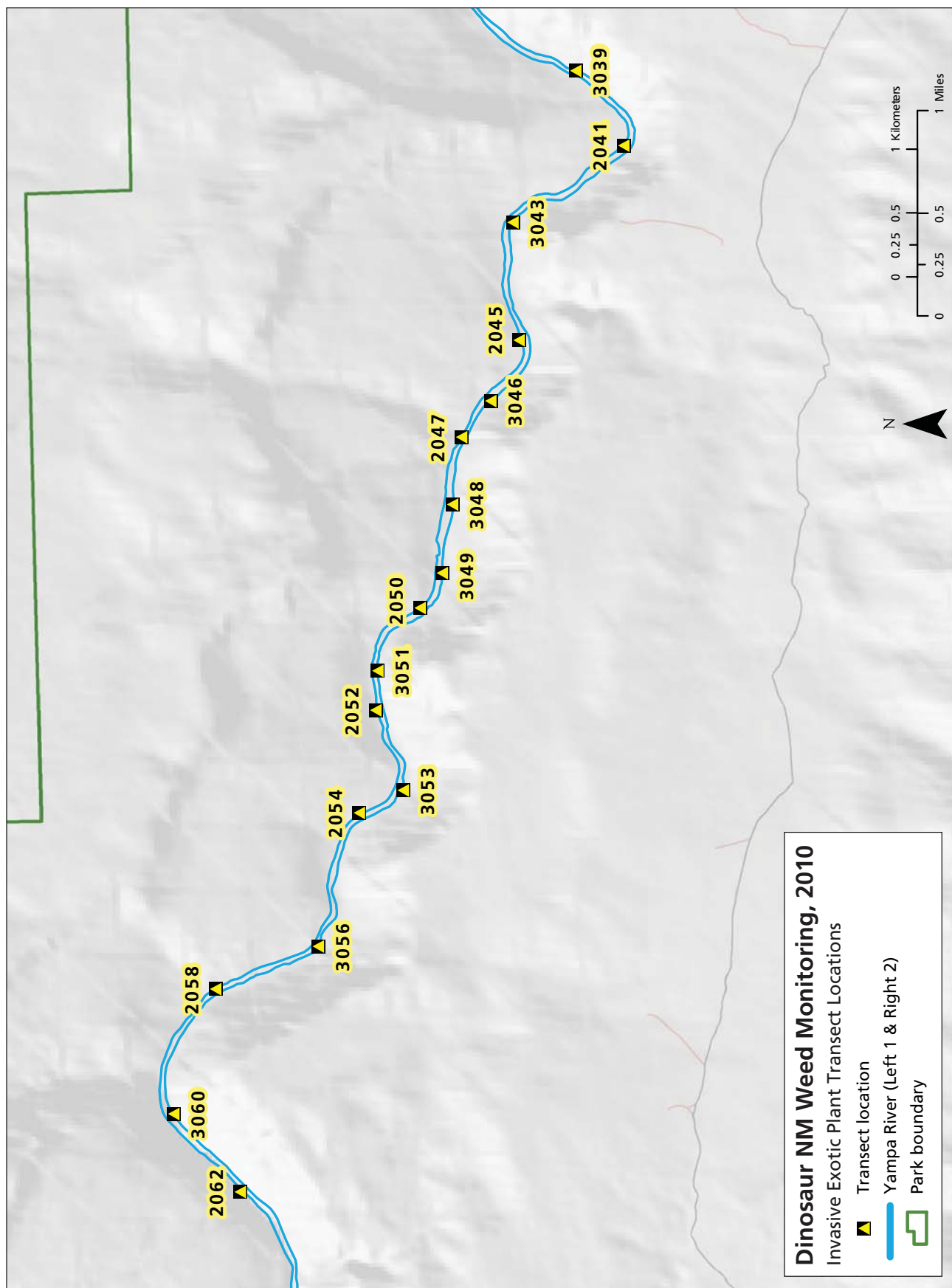


Figure 2-7. Monitoring quadrats established on the central section of the Yampa River, Dinosaur NM, July 5–24, 2010.

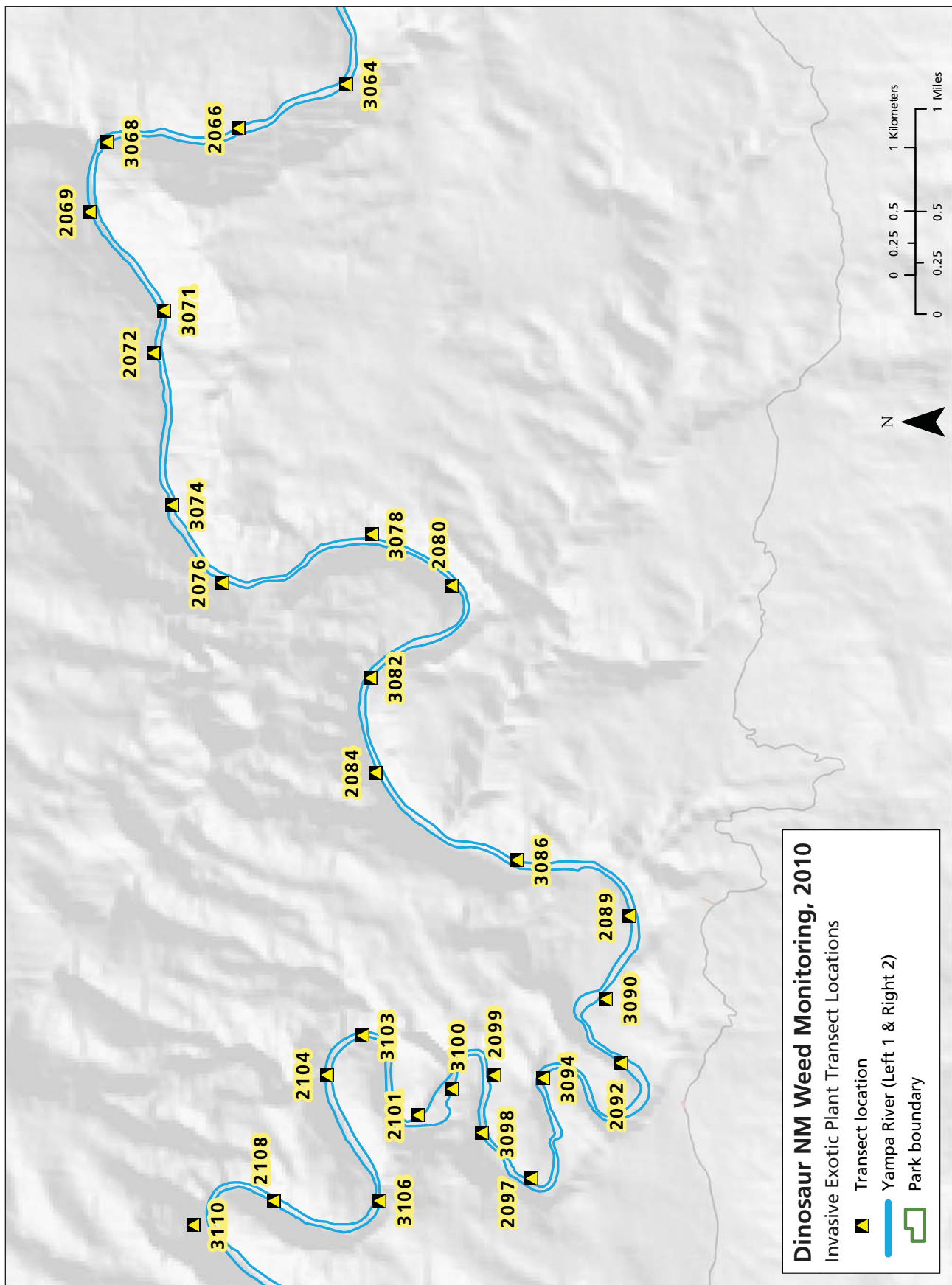


Figure 2-8. Monitoring quadrats established on the western section of the Yampa River, Dinosaur NM, July 5–24, 2010.

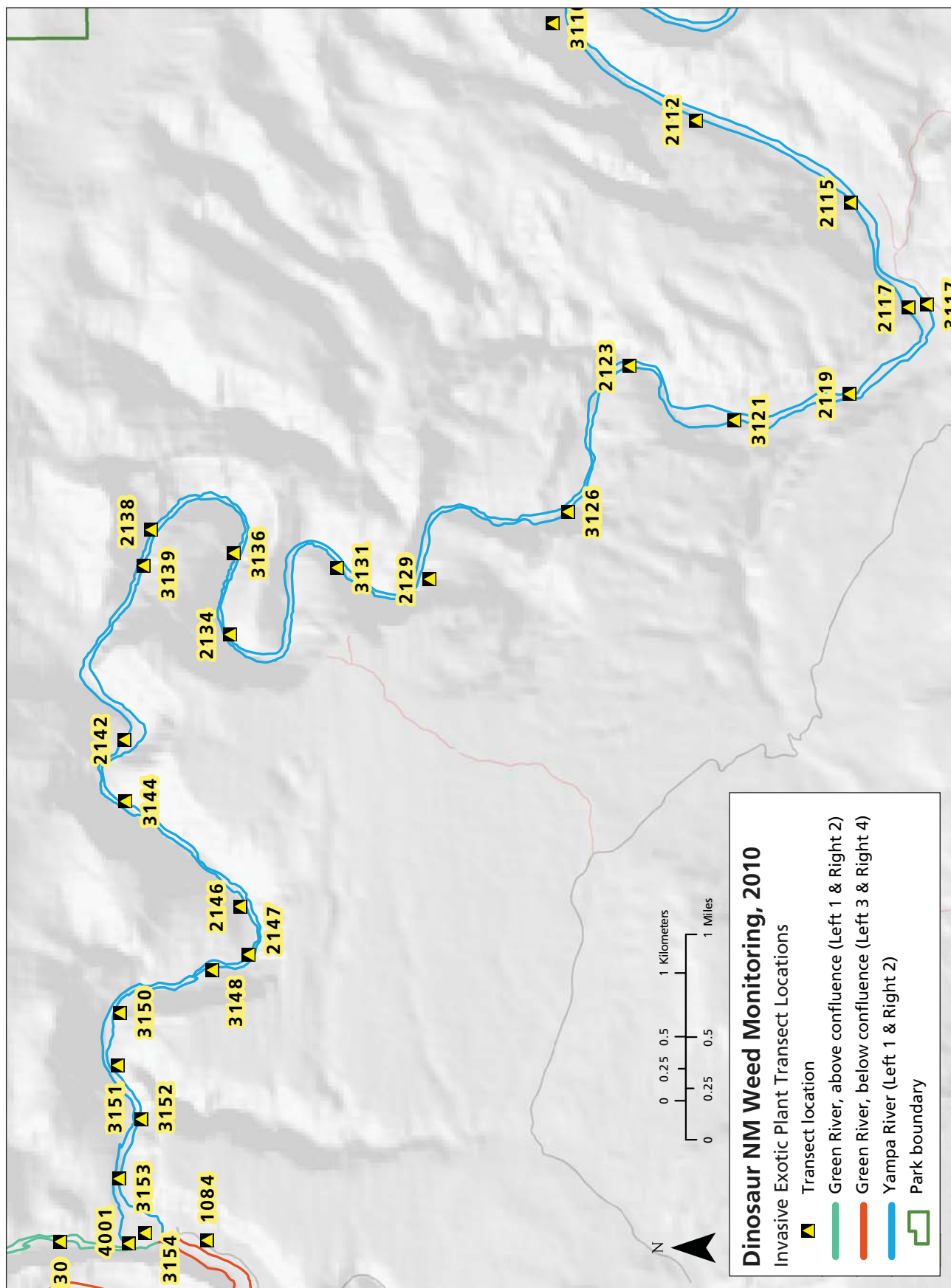


Figure 2-9. Monitoring quadrats established near the confluence of the Green and Yampa rivers, Dinosaur NM, July 5-24, 2010.

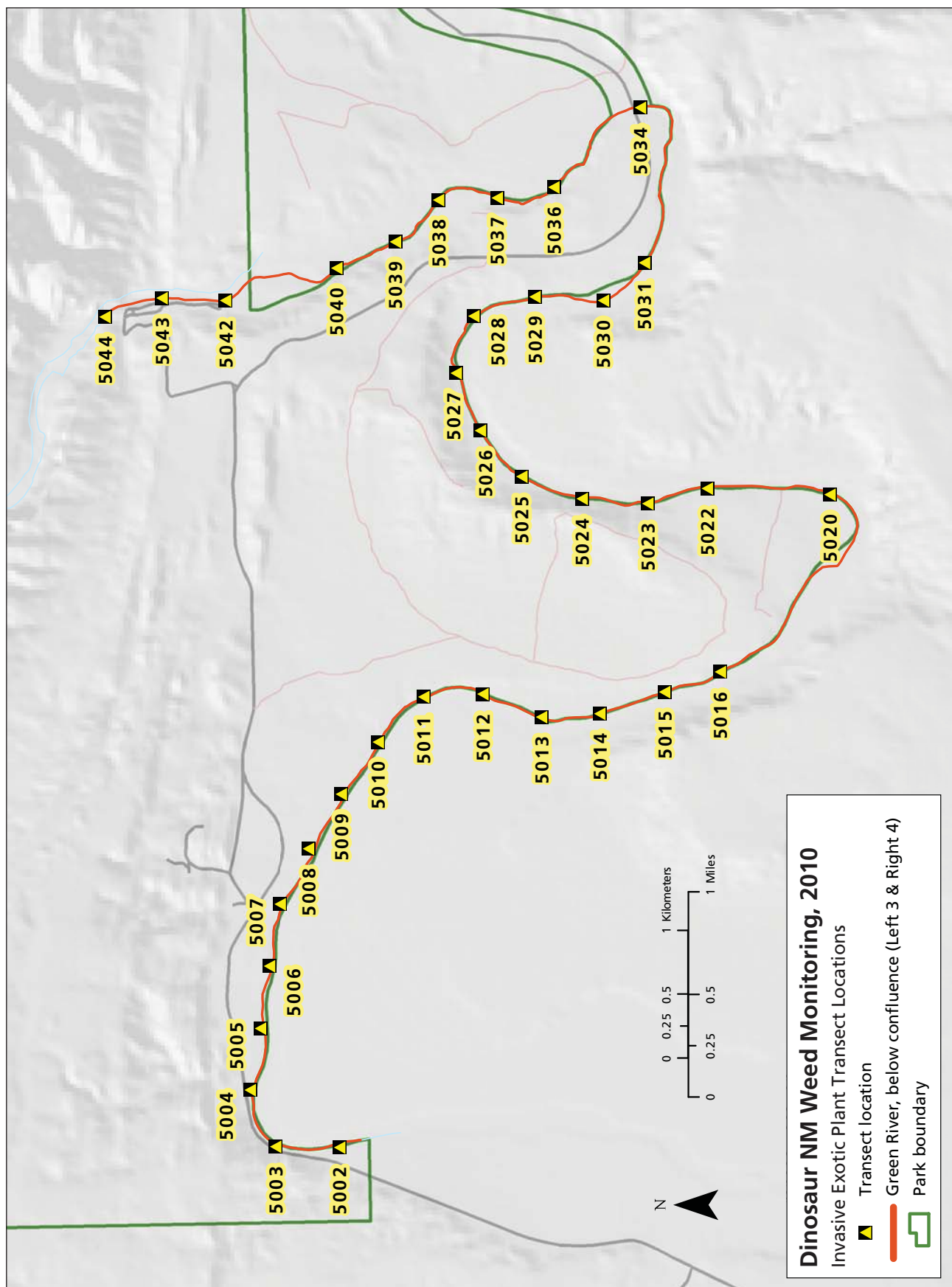


Figure 2-10. Monitoring quadrats established from Split Mountain to the western monument boundary along the Green River, Dinosaur NM, July 5–24, 2010.

3 Results

3.1 Target invasive exotic plant list

There are 26 IEP species identified as Priority 1 on the DINO target IEP list (Appendix A). Because observers were trained to recognize Priority 1 species but given the freedom to map additional species, 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 13 Priority 1 IEP species plus 5 non-priority IEP species on monitoring routes and quadrats in 2010 (Table 3-1). Thirteen Priority IEP species were recorded on monitoring routes and six in monitoring quadrats. We covered 382.7 hectares (946 acres) along 234.1 km (145.6 miles) of river monitoring routes in 2010. Each side of the river counted as a separate “route,” so actual length of river covered was closer to 117 km (72.8 miles).

3.2 Monitoring routes

A total of 2,201 infestations of 13 different Priority 1 species were detected along the monitoring routes (Figures 3-1, 3-2, 3-3, 3-4, 3-5, 3-6, 3-7, 3-8, 3-9, 3-10, 3-11, 3-12, 3-13, 3-14, 3-15, 3-16, 3-17, 3-18, 3-19, 3-20, Appendix B in electronic version). This resulted in 9.12 Priority 1 infestations per hectare. Tamarisk, broadleaf pepperwort (*Lepidium latifolium*), yellow sweetclover (*Melilotus officinalis*), and Canada thistle (*Cirsium arvense*) had the highest number of infestations.

Growth stage was noted for 94 infestations of Russian olive and 797 infestations of tamarisk. For Russian olive, 1 (1%) was old growth, 12 (13%) were mature trees, 70 (74%) were saplings, and 11 (12%) were seedlings. For tamarisk, 14 (2%) were old growth, 593 (74%) were mature trees, 176 (22%) were saplings, and 14 (2%) were seedlings (see Appendix B).

3.3 Monitoring quadrats

A total of 176 quadrats were sampled in 2010 (see Figures 2-3, 2-4, 2-5, 2-6, 2-7, 2-8, 2-9, 2-10, Appendix C in electronic version), providing both the upper Green and Yampa rivers with near complete coverage of the river corridor. Seven IEP species were detected in quadrats. Canada thistle, broadleaf pepperwort, and Russian knapweed were detected on 12, 8, and 2 transects, respectively, on the upper Green River. None of these species was detected in transects on the Yampa River. One and two infestations of cheatgrass and yellow sweetclover, respectively, were found on transects on the Yampa River; these plants were not found on the upper Green River.

Table 3-1. Invasive exotic plants detected at Dinosaur NM, July 5–24, 2010.

Scientific name	Common name	Method detected		Park priority
		Quadrats	Routes	
<i>Carduus nutans</i>	musk thistle		X	1
<i>Centaurea maculosa</i>	spotted knapweed		X	1
<i>Centaurea repens</i>	Russian knapweed	X	X	1
<i>Cirsium arvense</i>	Canada thistle	X	X	1
<i>Cirsium vulgare</i>	bull thistle		X	1
<i>Dipsacus vulgare</i>	teasel		X	1
<i>Elaeagnus angustifolia</i>	Russian olive	X	X	1
<i>Euphorbia esula</i>	leafy spurge		X	1
<i>Lepidium latifolium</i>	broadleaf pepperwort	X	X	1
<i>Linaria vulgaris</i>	butter-and-eggs		X	1
<i>Melilotus officinalis</i>	yellow sweetclover	X	X	1
<i>Onopordum acanthium</i>	Scotch thistle		X	1
<i>Tamarix chinensis</i>	five-stamen tamarisk	X	X	1
<i>Bromus tectorum</i>	cheatgrass	X		Not on list
<i>Convolvulus arvensis</i>	field bindweed		X	Not on list
<i>Elymus repens</i>	quackgrass		X	Not on list
<i>Nepeta cataria</i>	catnip		X	Not on list
<i>Verbascum thapsus</i>	woolly mullein		X	Not on list

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

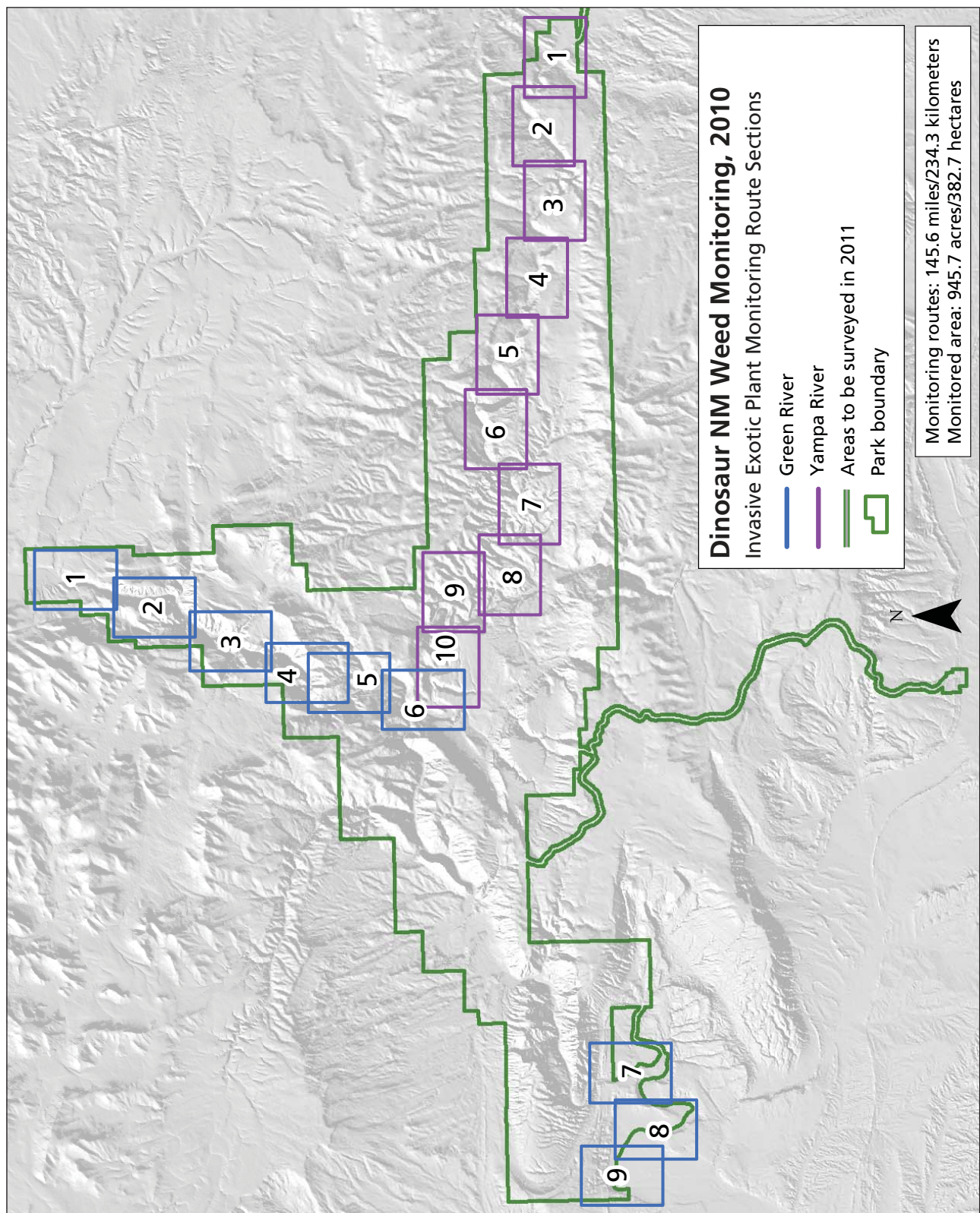
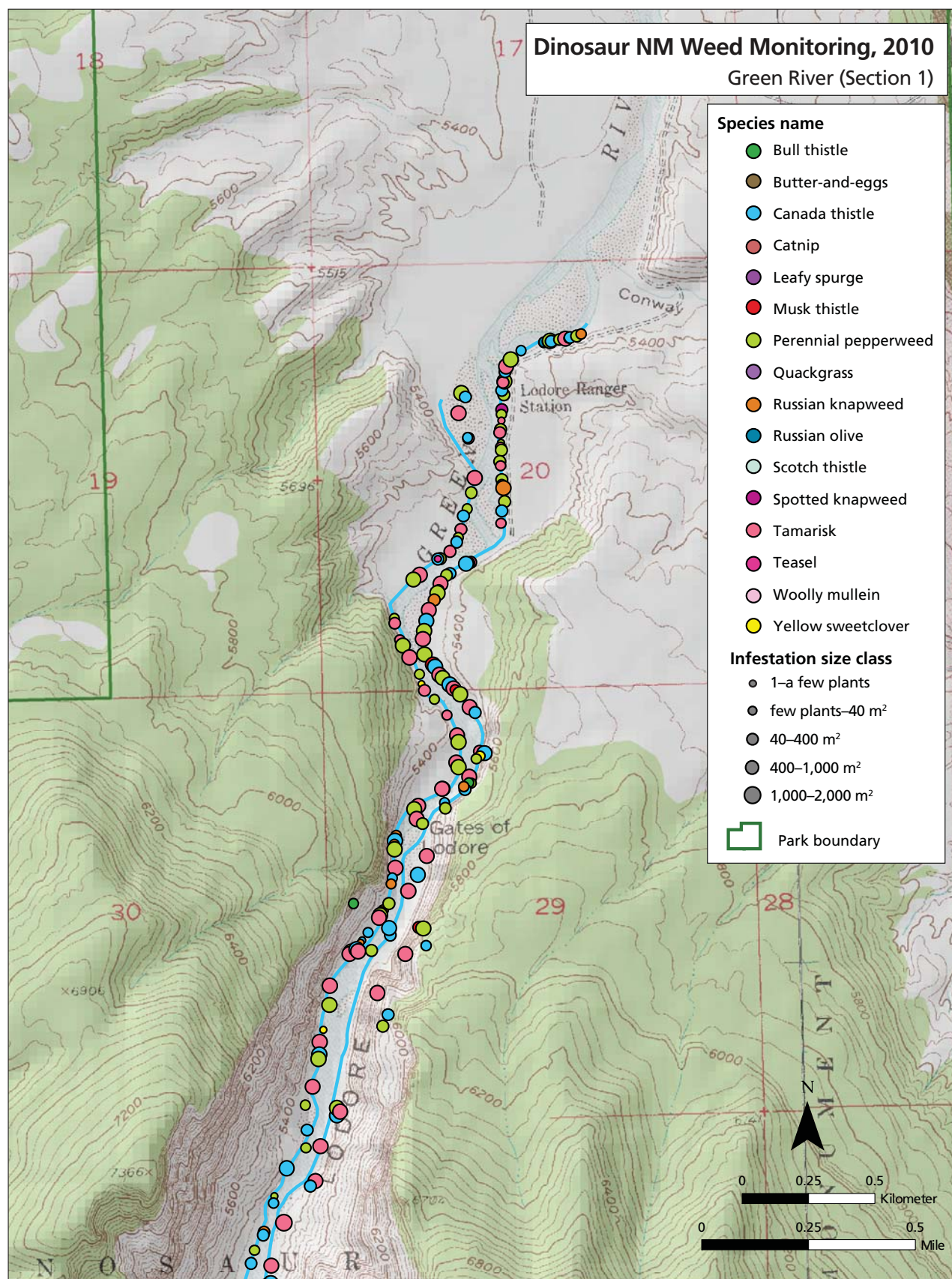


Figure 3-1. Routes surveyed for invasive exotic plants, Dinosaur NM, July 5–24, 2010.



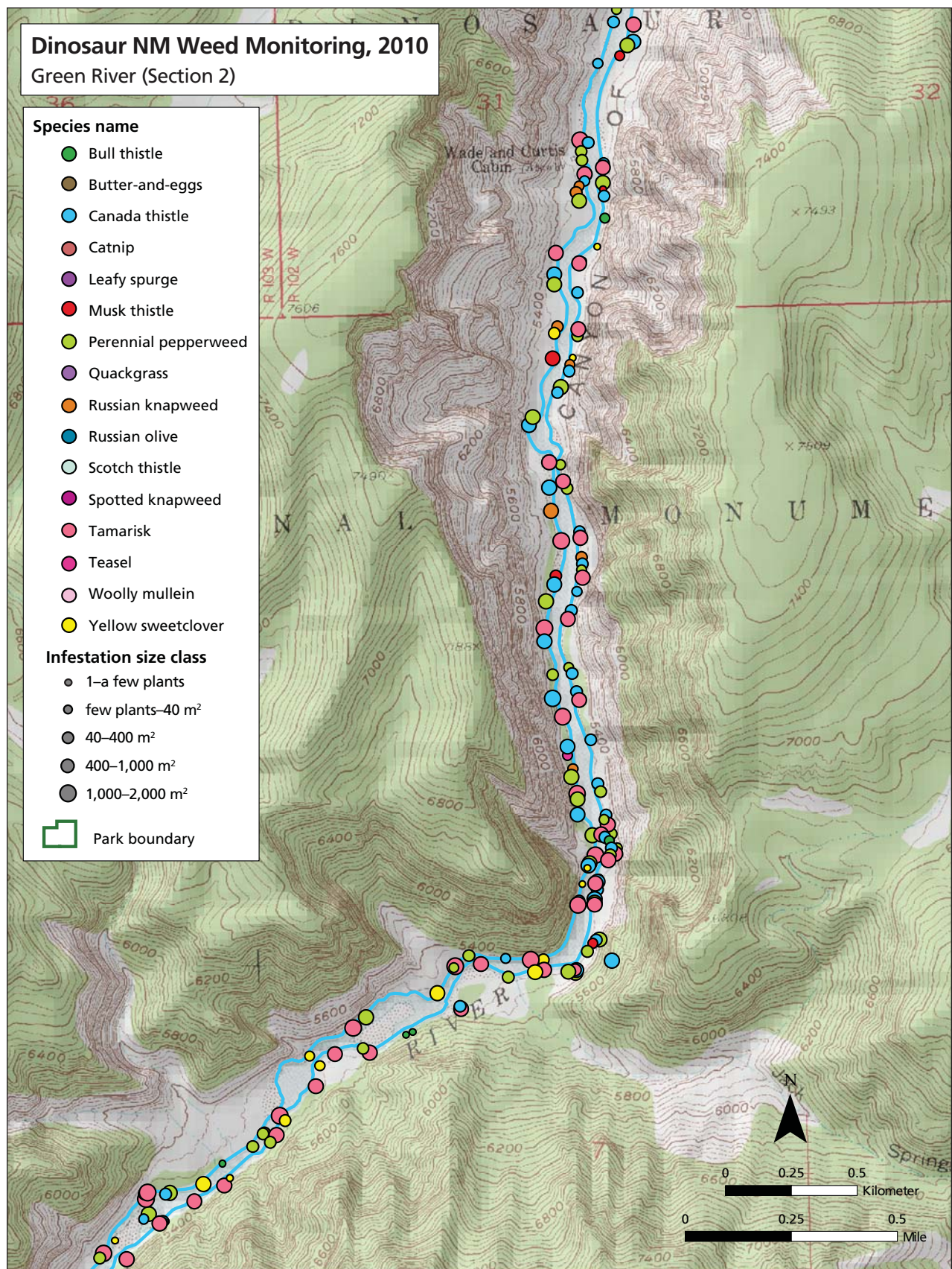


Figure 3-3. Invasive plants detected on monitoring routes along the Green River, Section 2, Dinosaur NM, July 5–24, 2010.

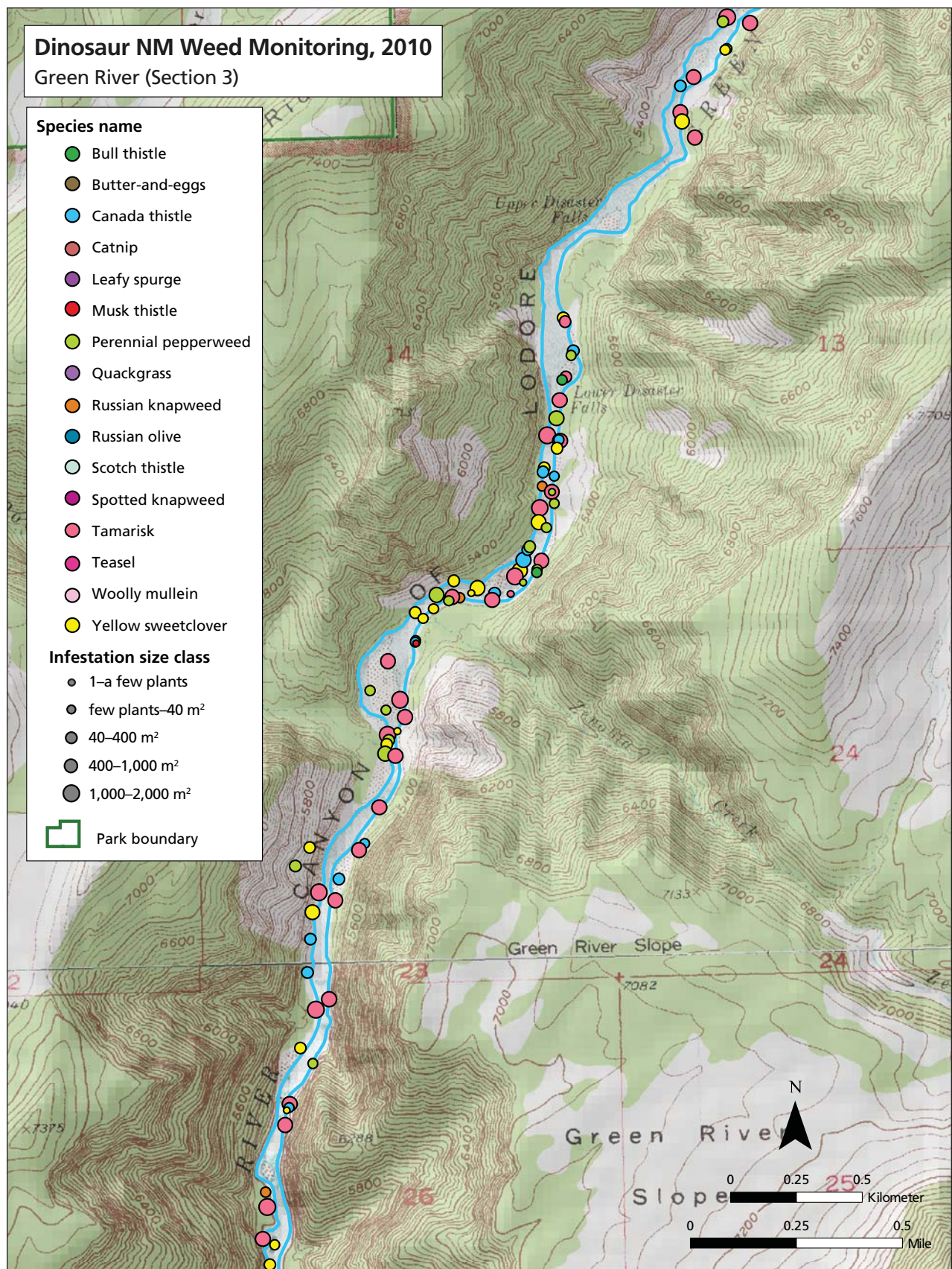


Figure 3-4. Invasive plants detected on monitoring routes along the Green River, Section 3, Dinosaur NM, July 5–24, 2010.

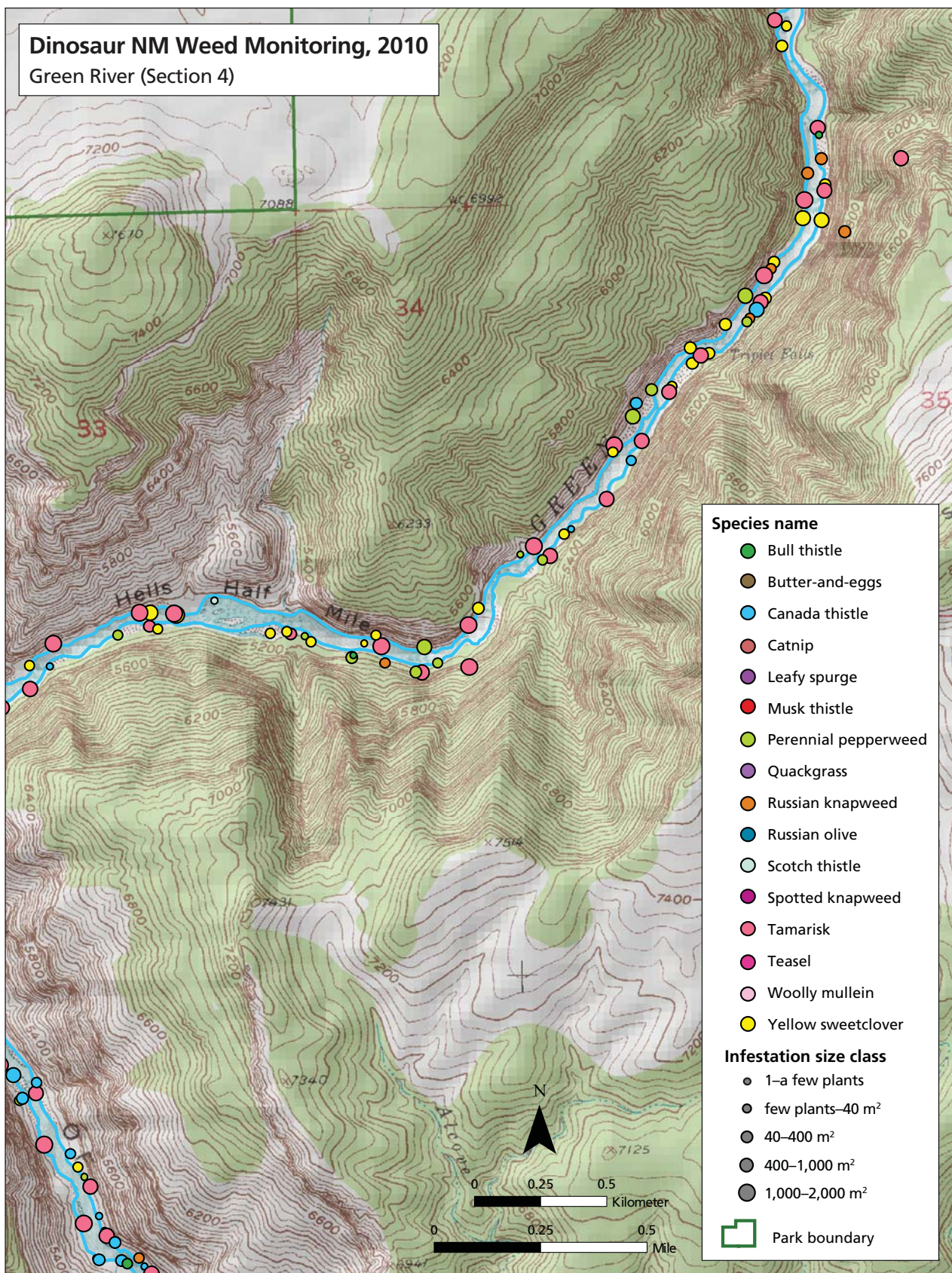
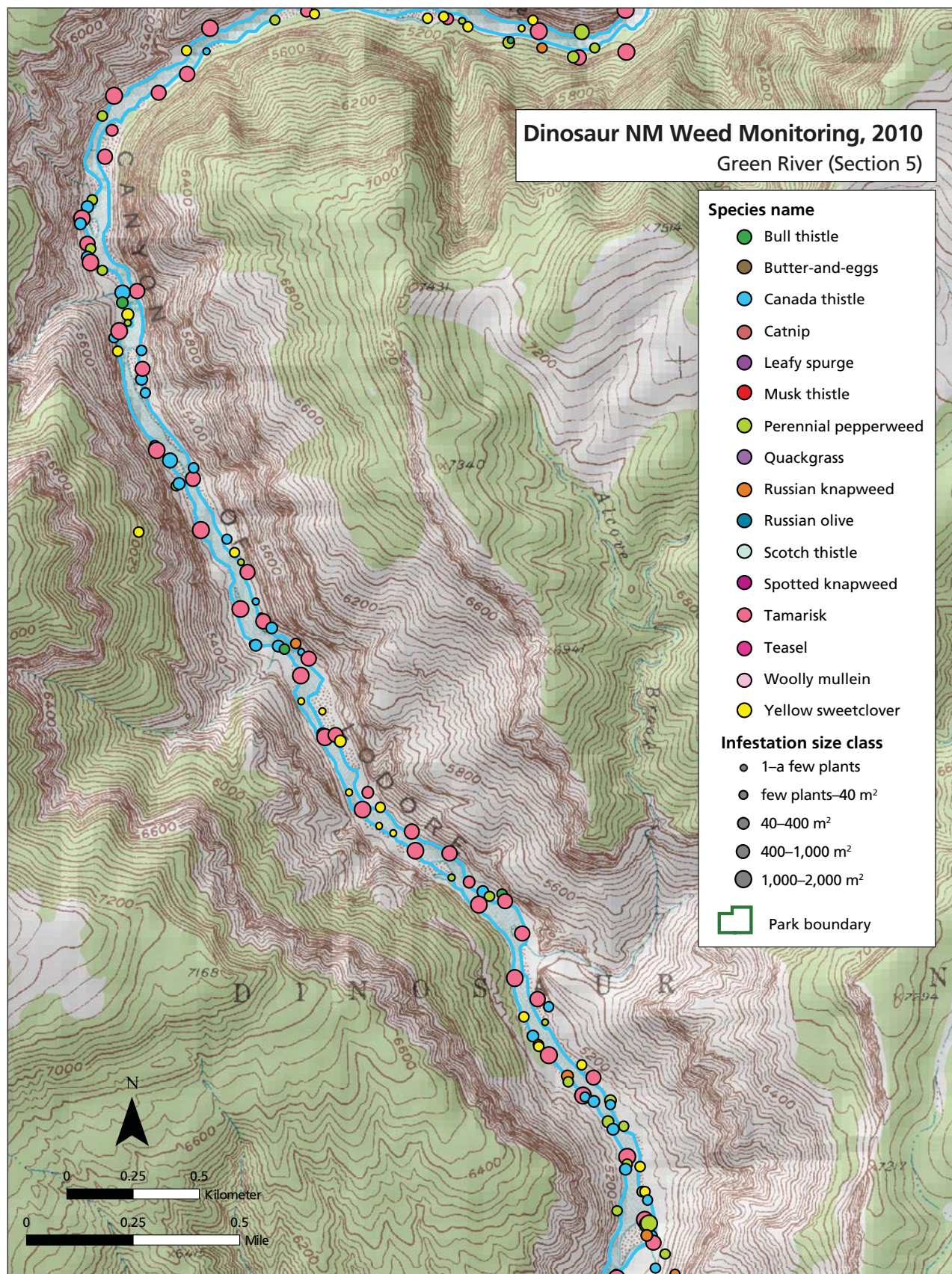


Figure 3-5. Invasive plants detected on monitoring routes along the Green River, Section 4, Dinosaur NM, July 5–24, 2010.



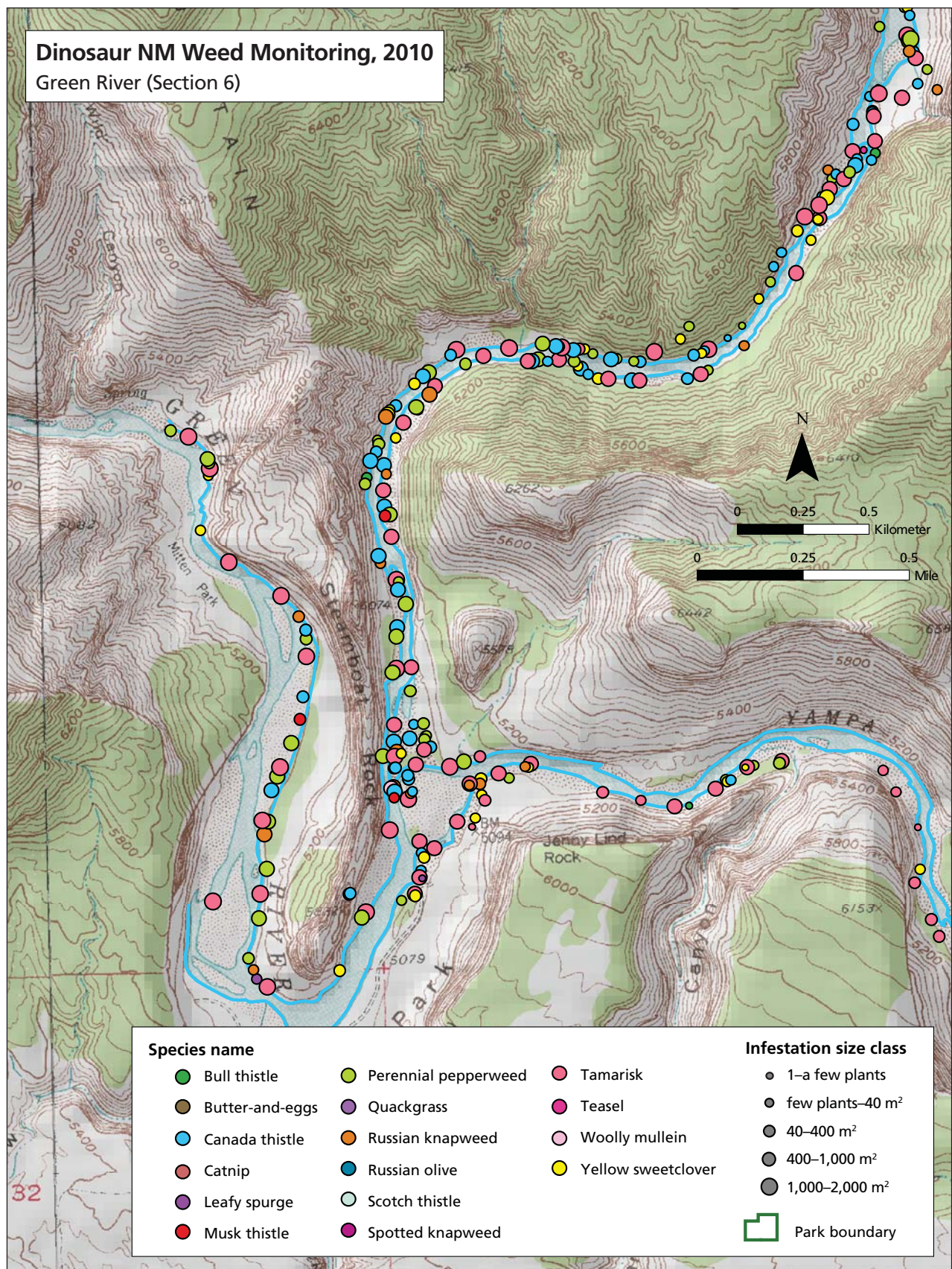


Figure 3-7. Invasive plants detected on monitoring routes along the Green River, Section 6, Dinosaur NM, July 5–24, 2010.

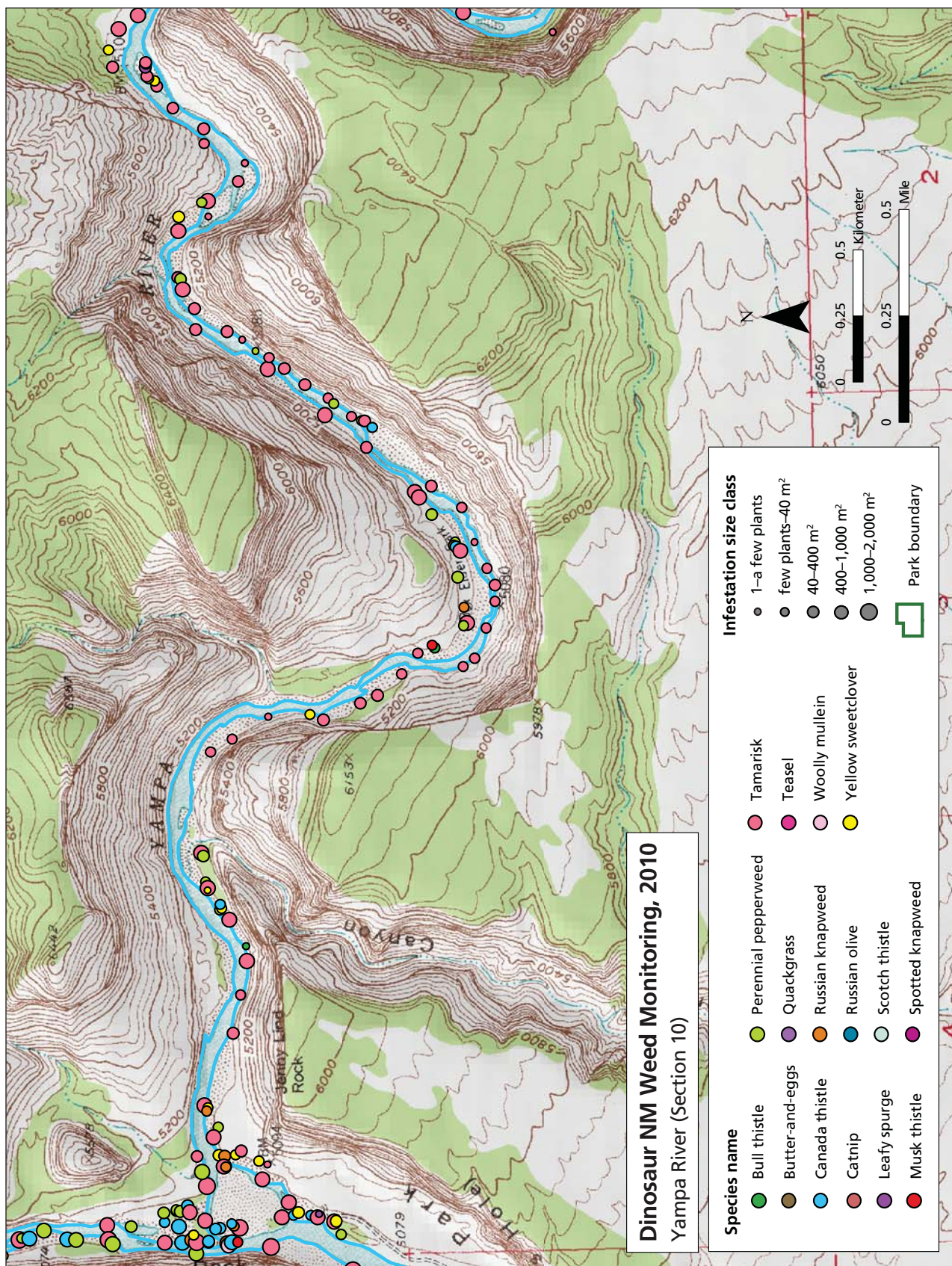


Figure 3-8. Invasive plants detected on monitoring routes along the Yampa River, Section 10, Dinosaur NM, July 5-24, 2010.

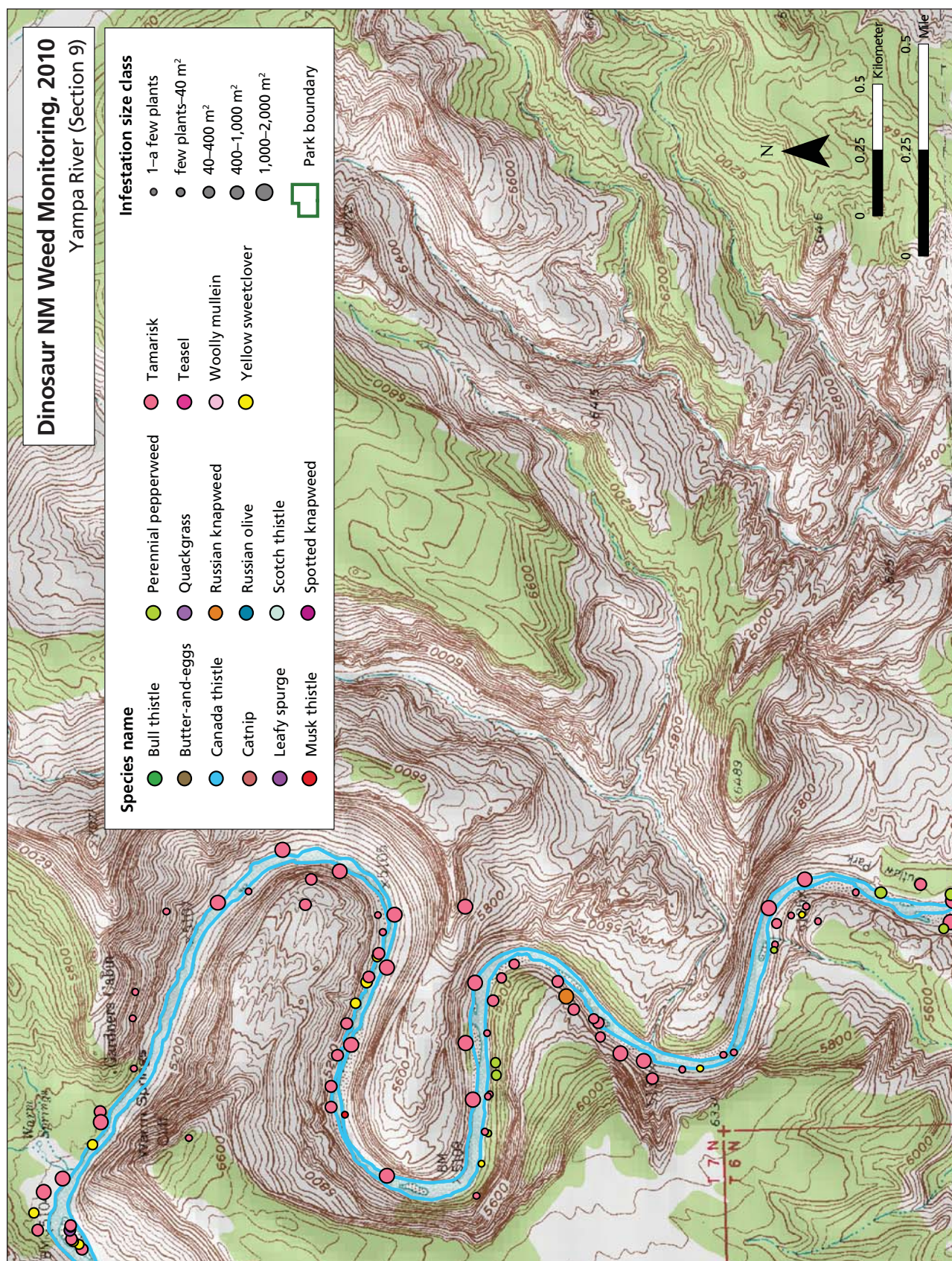


Figure 3-9. Invasive plants detected on monitoring routes along the Yampa River, Section 9, Dinosaur NM, July 5-24, 2010.

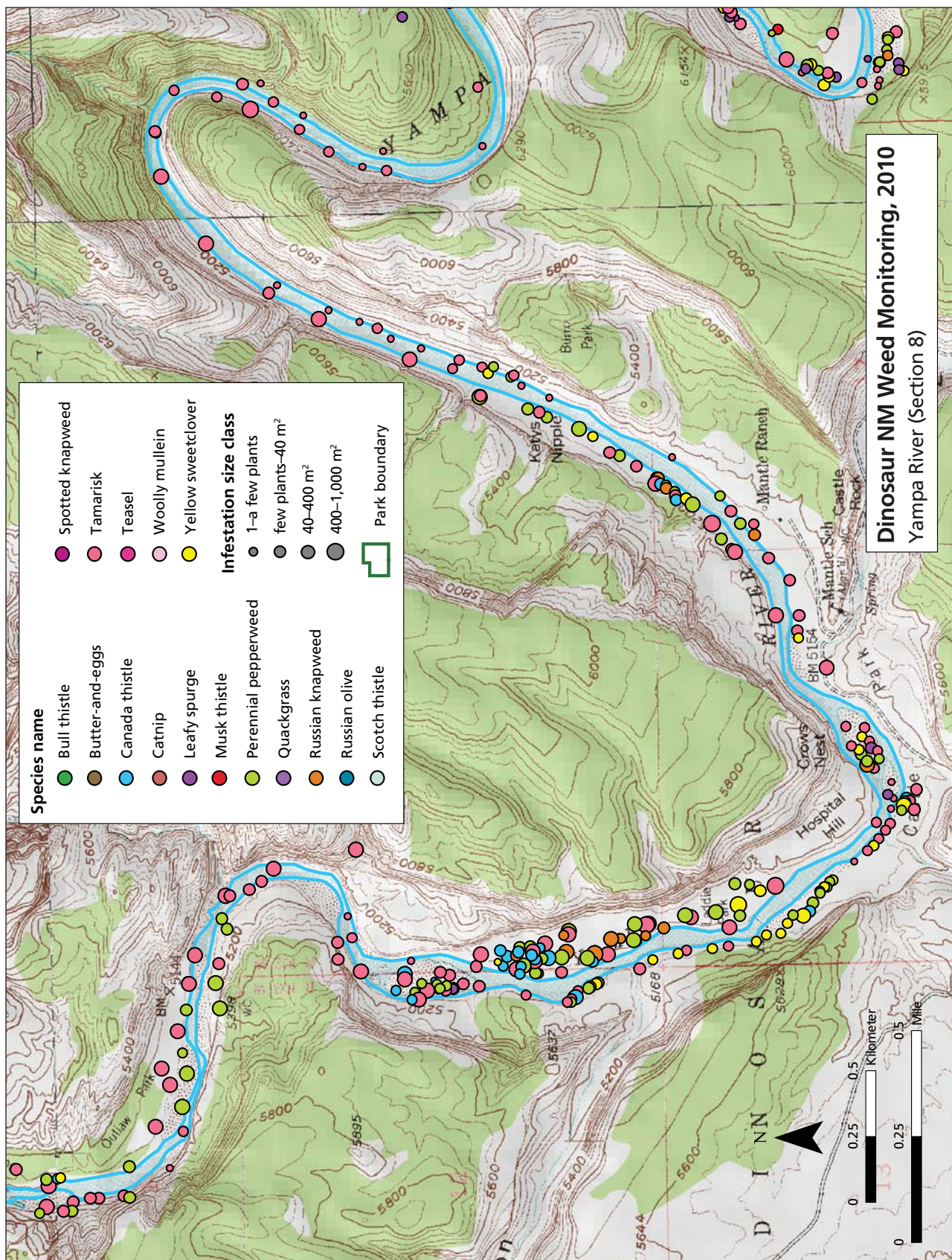


Figure 3-10. Invasive plants detected on monitoring routes along the Yampa River, Section 8, Dinosaur NM, July 5-24, 2010.

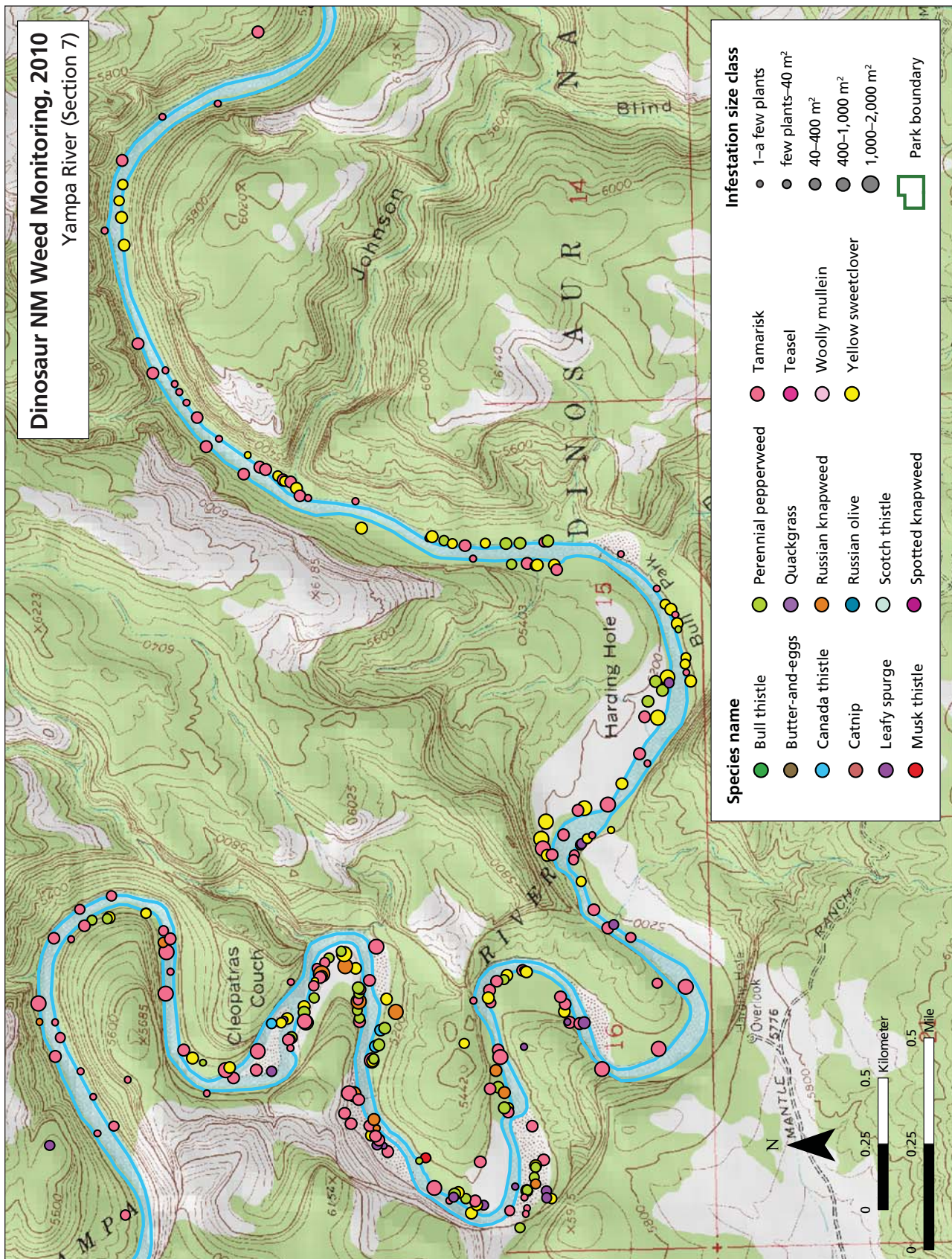


Figure 3-11. Invasive plants detected on monitoring routes along the Yampa River, Section 7, Dinosaur NM, July 5-24, 2010.

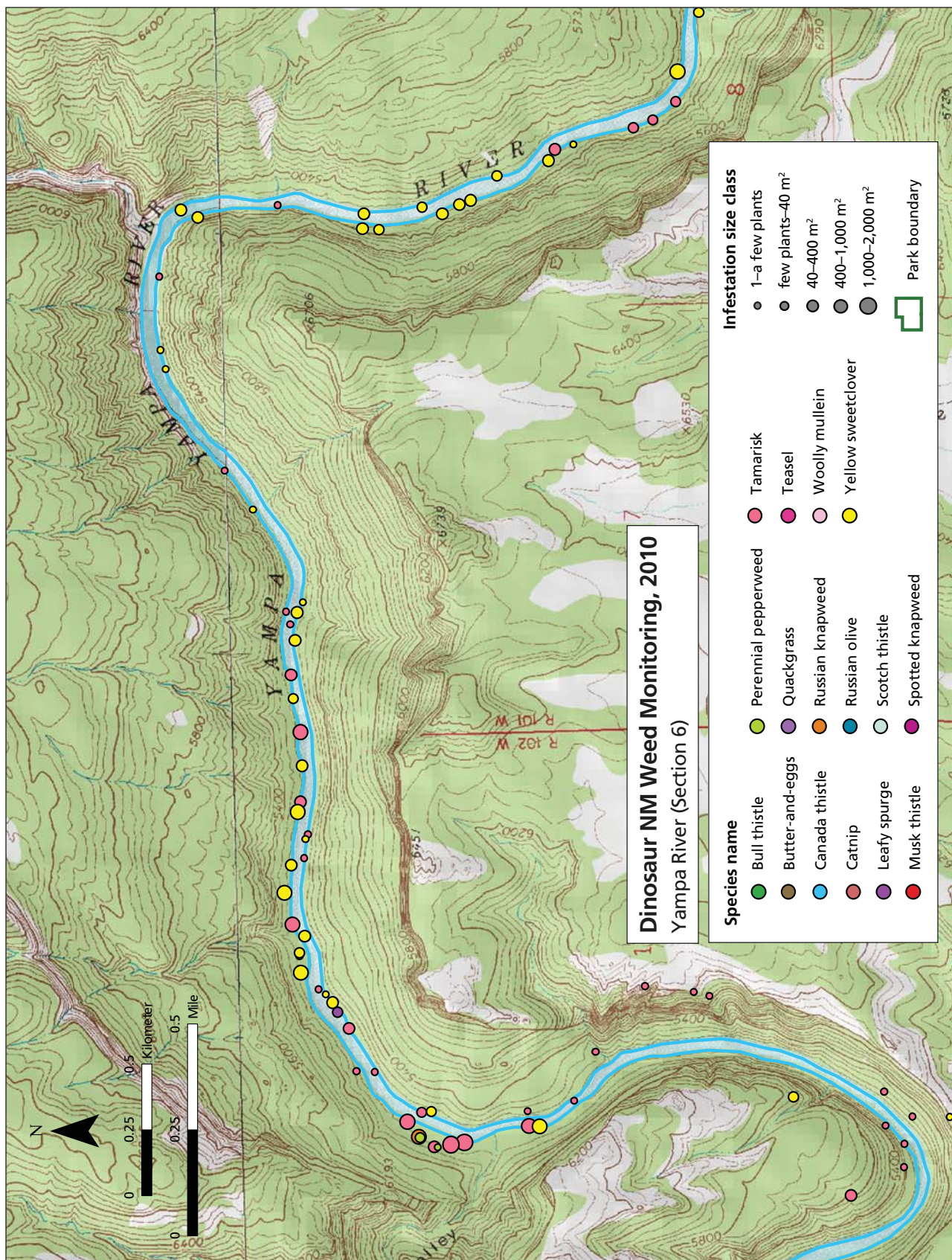


Figure 3-12. Invasive plants detected on monitoring routes along the Yampa River, Section 6, Dinosaur NM, July 5-24, 2010.

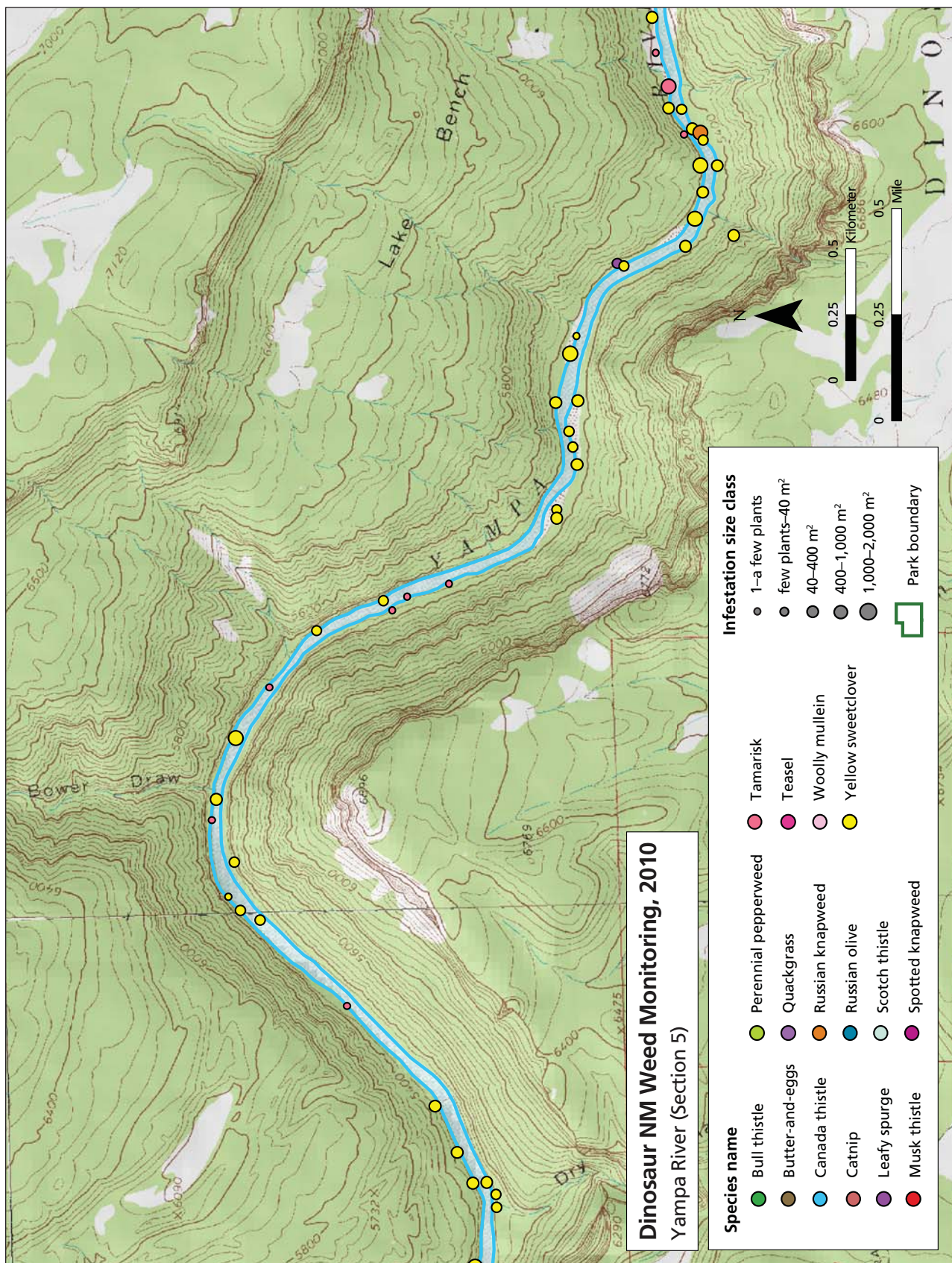


Figure 3-13. Invasive plants detected on monitoring routes along the Yampa River, Section 5, Dinosaur NM, July 5-24, 2010.

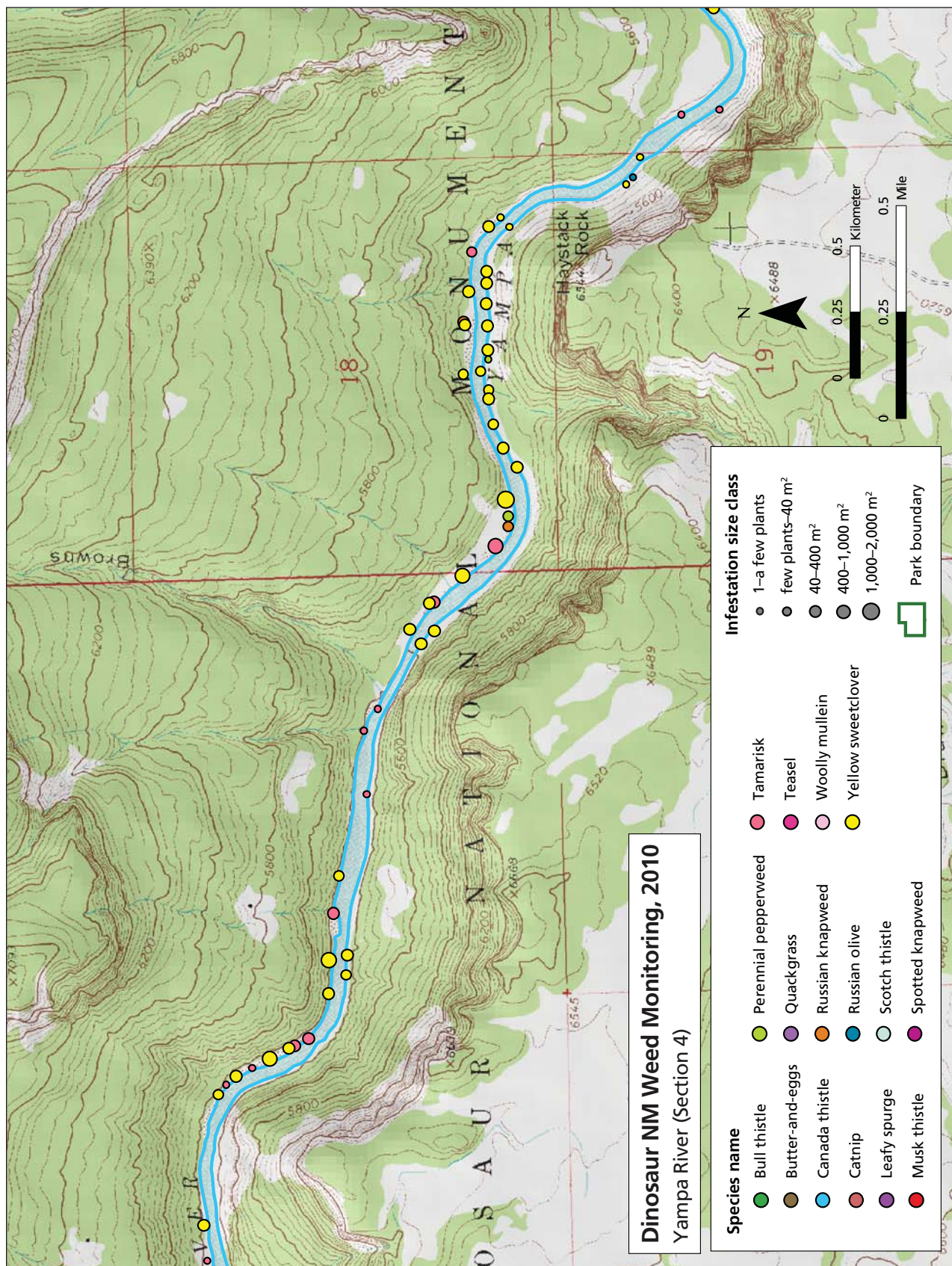


Figure 3-14. Invasive plants detected on monitoring routes along the Yampa River, Section 4, Dinosaur NM, July 5-24, 2010.

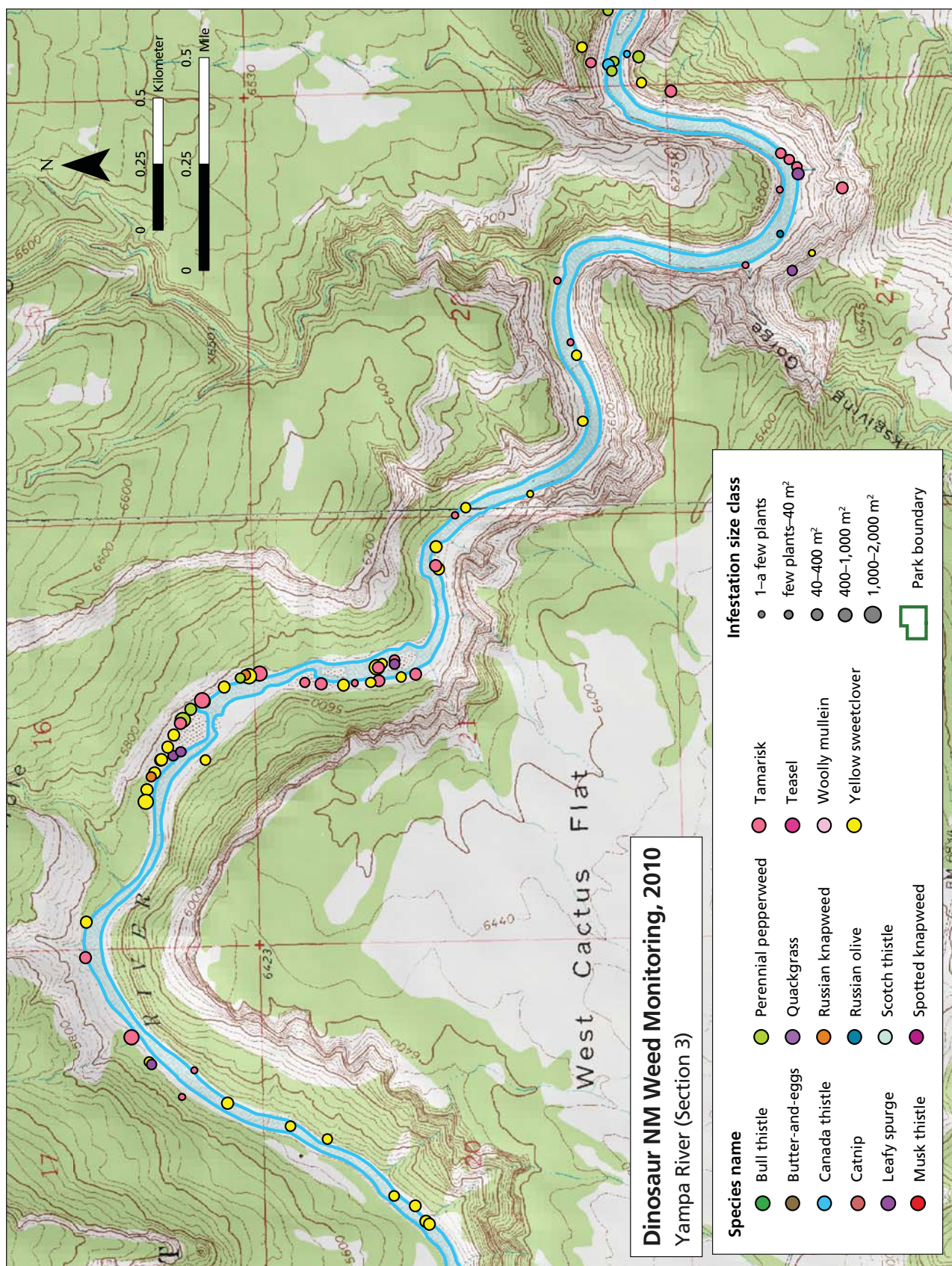


Figure 3-15. Invasive plants detected on monitoring routes along the Yampa River, Section 3, Dinosaur NM, July 5-24, 2010.

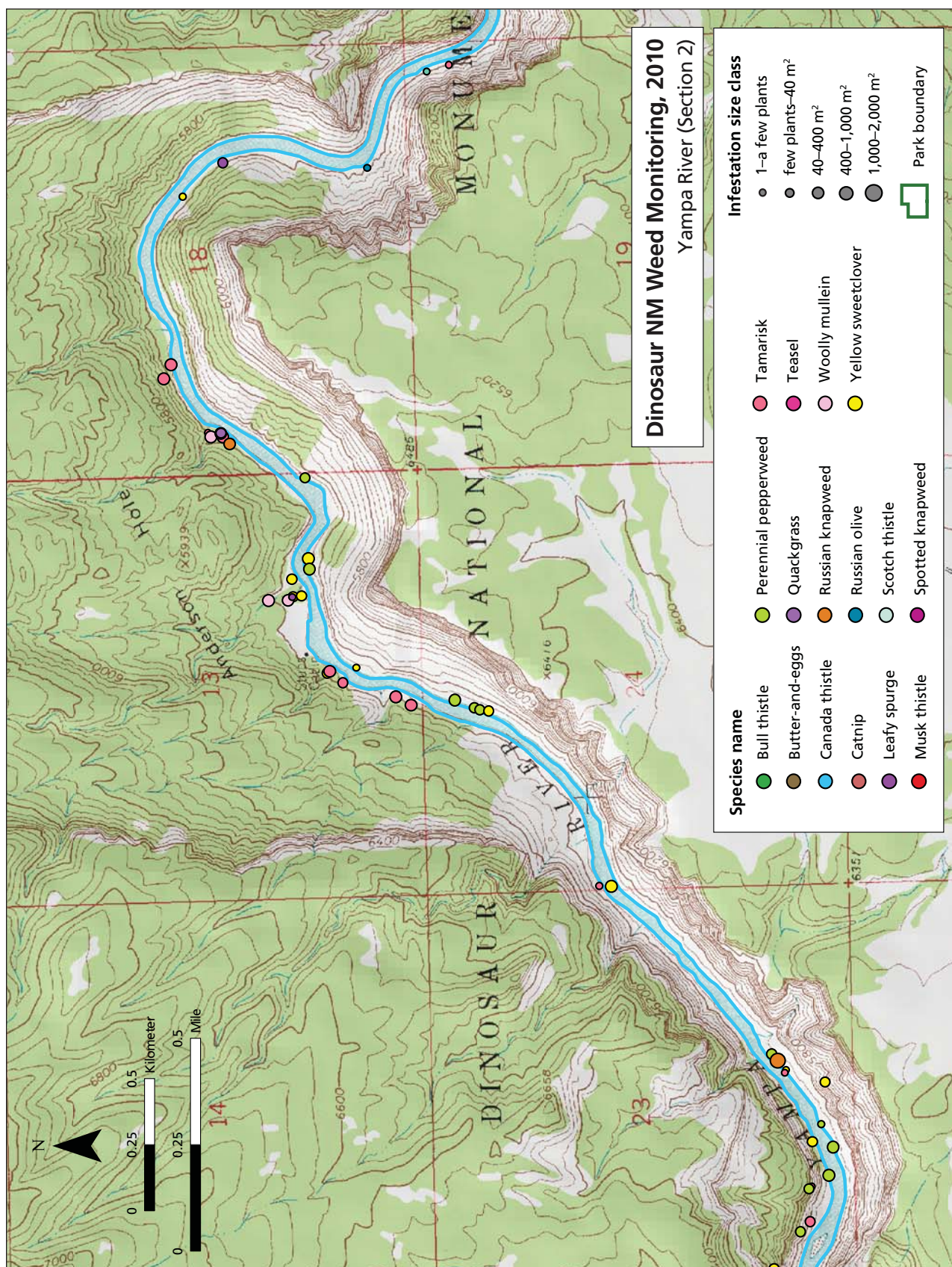


Figure 3-16. Invasive plants detected on monitoring routes along the Yampa River, Section 2, Dinosaur NM, July 5-24, 2010.

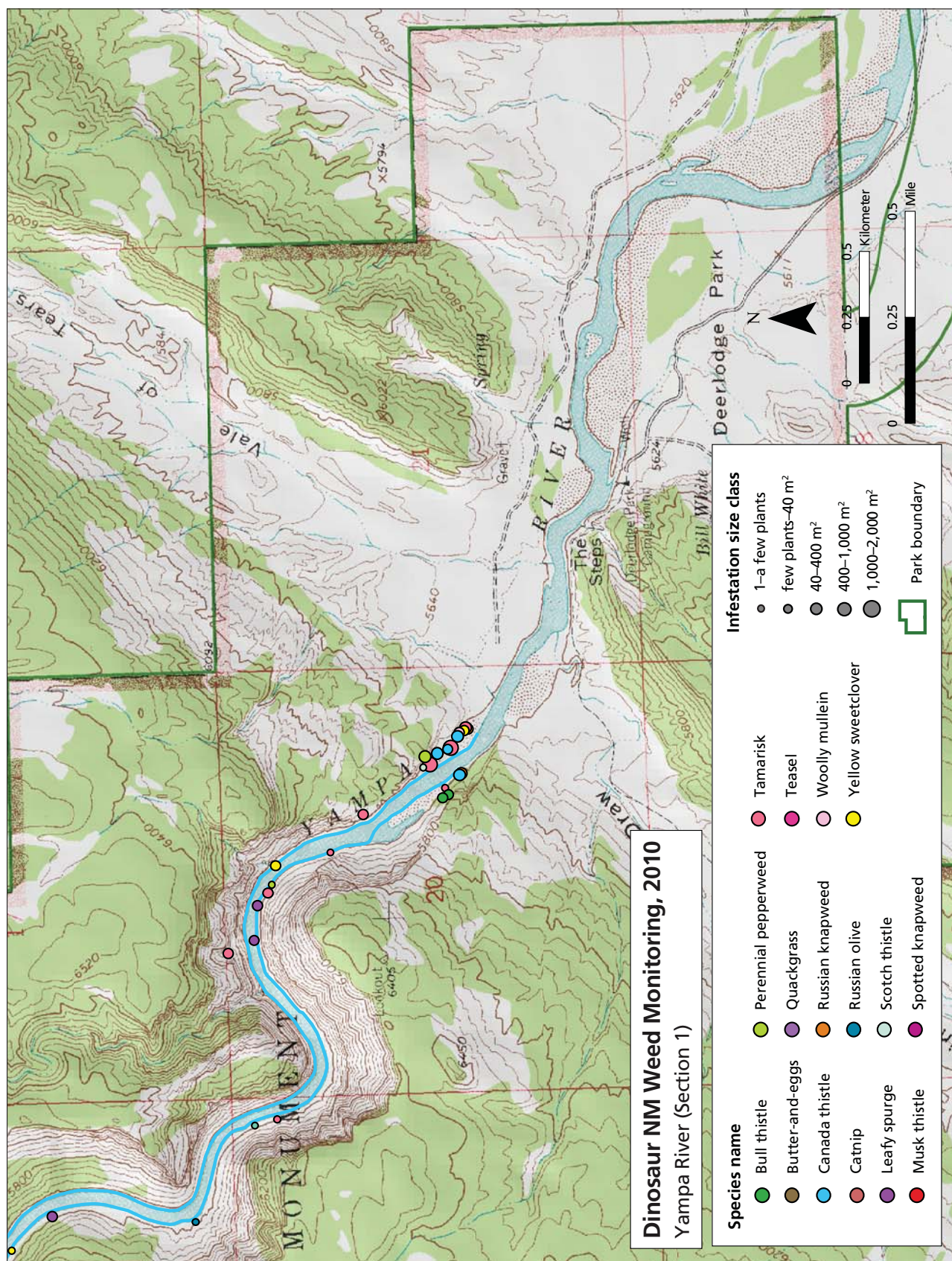


Figure 3-17. Invasive plants detected on monitoring routes along the Yampa River, Section 1, Dinosaur NM, July 5-24, 2010.

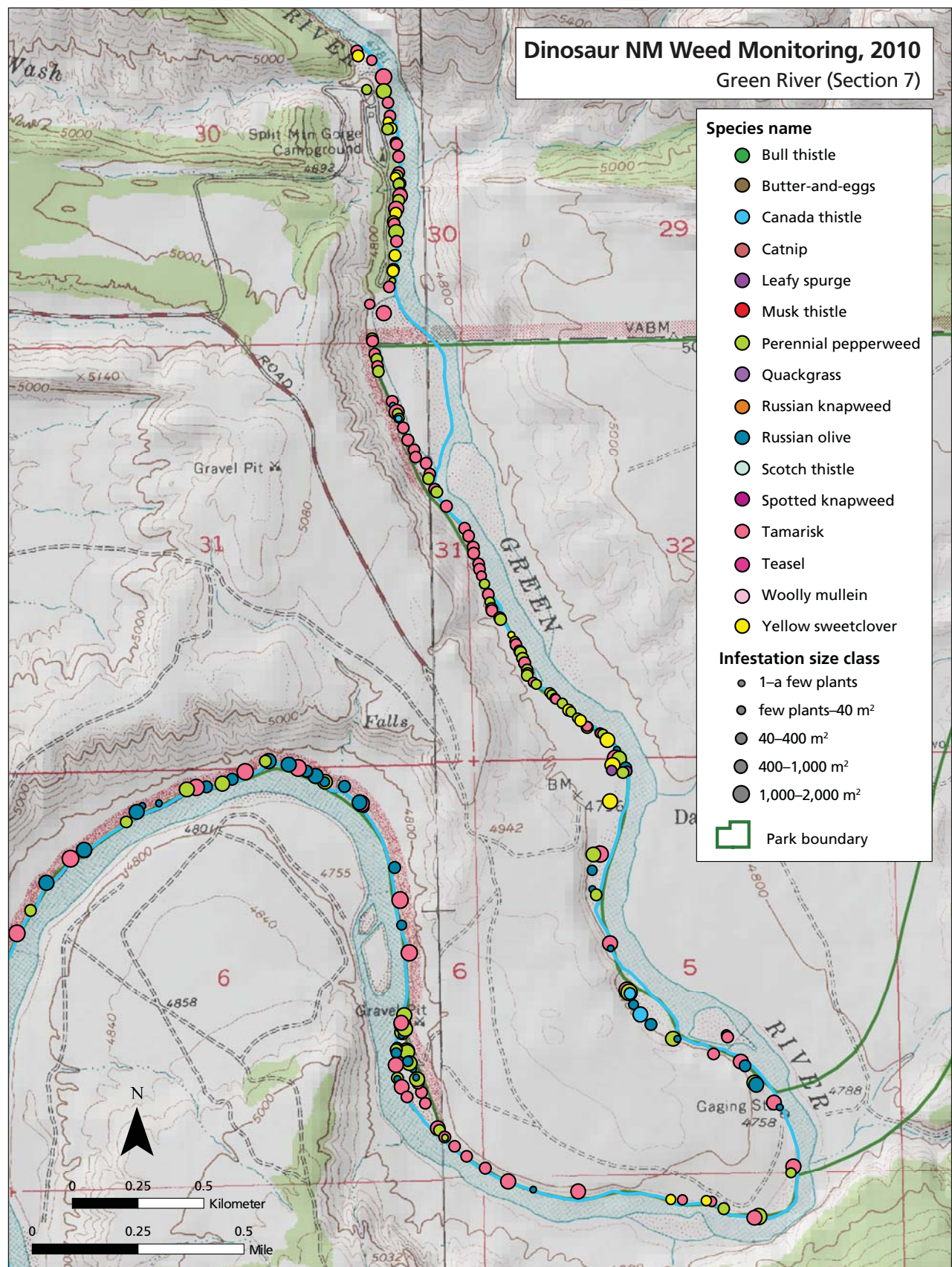
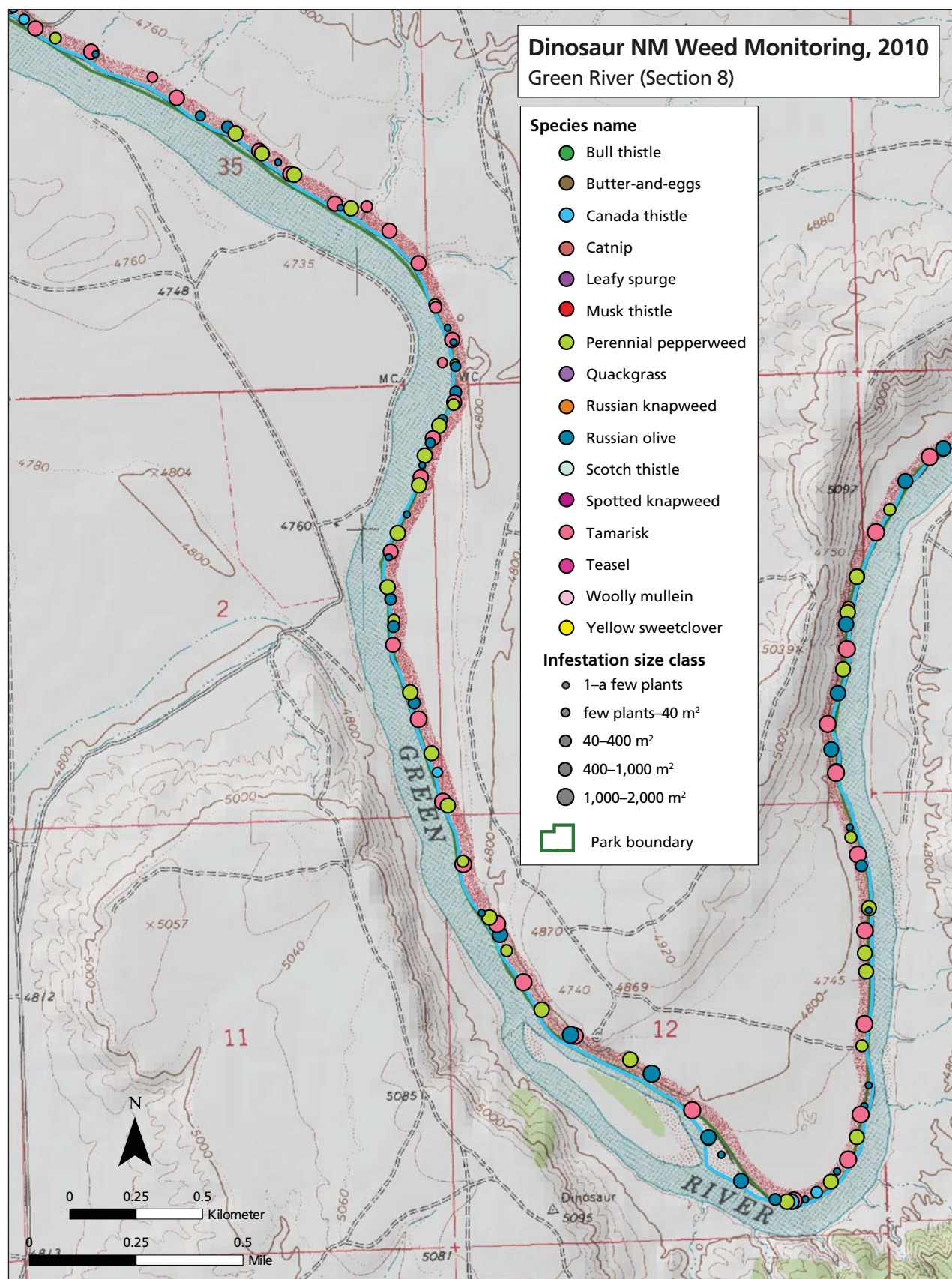


Figure 3-18. Invasive plants detected on monitoring routes along the Green River, Section 7, Dinosaur NM, July 5–24, 2010.



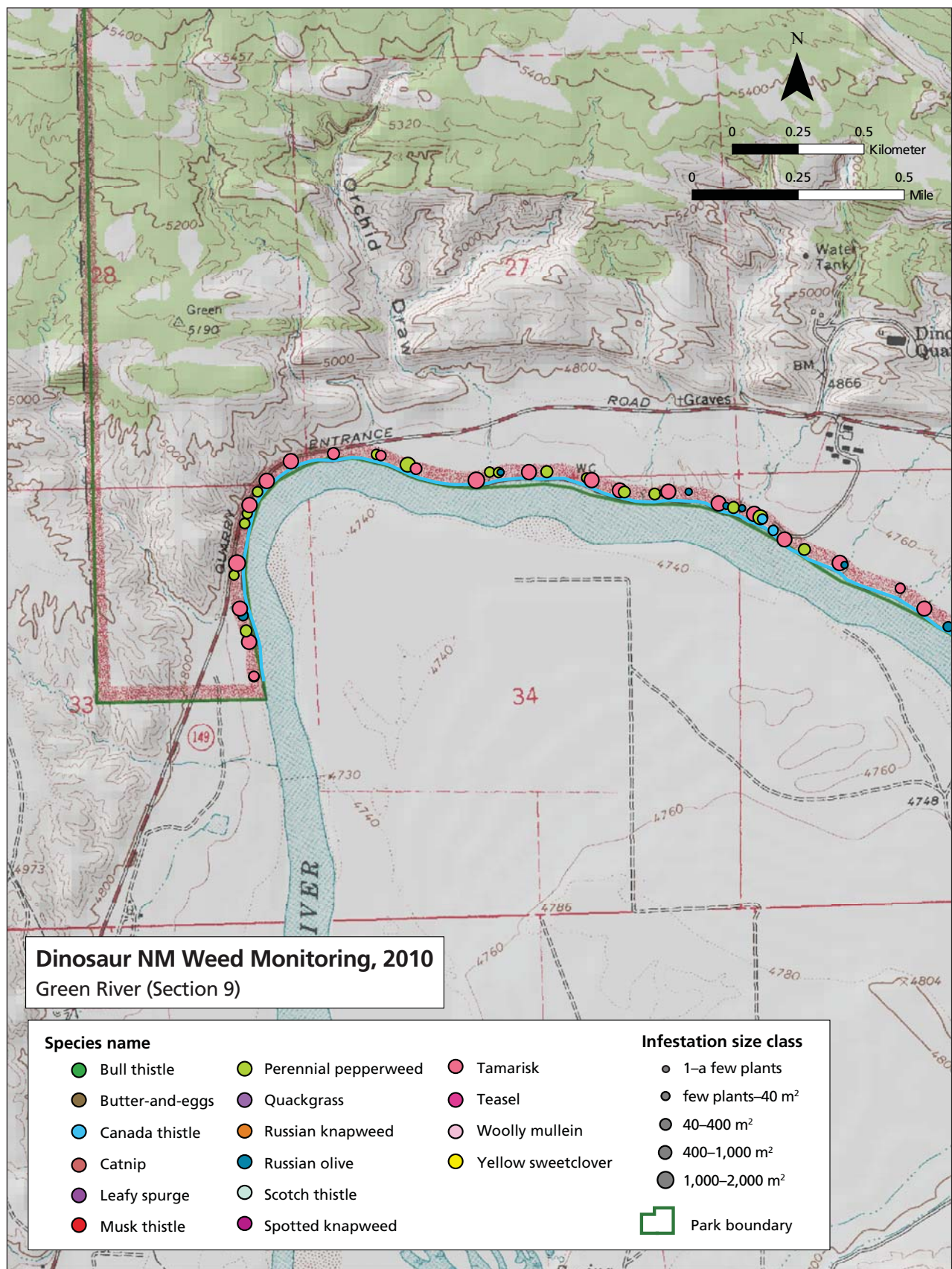


Figure 3-20. Invasive plants detected on monitoring routes along the Green River, Section 9, Dinosaur NM, July 5–24, 2010.

4 Discussion

The NCPN will continue to work with DINO staff and area weed experts to review and update the list of priority species each year. Presence and absence data for Priority 1 species, and presence data for other species, should be reliable for the areas searched; however, absence data for non-Priority 1 species are suspect, because not all observers recorded all of these species.

Infestations at DINO were generally larger than those detected at other parks. This may indicate that exotics at DINO have been established for longer than at other parks, or that conditions at DINO are more favorable for exotics than elsewhere, due to the moist environment. Infestations along the Fremont River, at Capitol Reef National Park (Perkins and Lenhart 2011), were of similar size. Another contributing factor could be that much of the surveying was conducted by boat in this park, making it harder to detect infestations in the smallest size category than when surveys are conducted on foot.

Although NCPN staff do not regularly control invasives while monitoring, they are instructed to pull IEPs found in areas that require a significant amount of time to access. Crews pulled almost all of the leafy spurge infestations detected along the Yampa River, as ours was the last boat trip of the year for the park. T. Naumann also pulled several infestations as other crew members conducted monitoring work on shore (see Appendix B in electronic format).

4.1 Future monitoring efforts

IEPs 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 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 complete monitoring along the river corridor from the Gates of Lodore put-in to the northern park boundary on the upper Green River, from the Deerlodge put-in on the Yampa River to the eastern boundary, and from Echo Park to Split Mountain on the lower Green River (see Figure 2-2). The information for the entire river corridor will then be published as a Natural Resource Technical Report in 2012. Long-term trend reporting will focus on trends in species distributions and trends in percent cover of Priority 1 species. 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.

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Appendix A. Priority 1 Invasive Exotic Plant List, Dinosaur National Monument

Scientific name (Utah)	Common name	Scientific name (Colorado)
<i>Aegilops cylindrica</i>	jointed goatgrass	<i>Aegilops cylindrica</i>
<i>Arctium minus</i>	burdock	<i>Arctium minus</i>
<i>Cardaria chalepensis</i>	orbicular whitetop	<i>Cardaria chalepensis</i>
<i>Cardaria draba</i>	hoary cress	<i>Cardaria draba</i>
<i>Cardaria pubescens</i>	hairy whitetop	<i>Cardaria pubescens</i>
<i>Carduus nutans</i>	musk thistle	<i>Carduus nutans</i> var. <i>macrolepis</i>
<i>Centaurea diffusa</i>	diffuse knapweed	<i>Acosta diffusa</i>
<i>Centaurea maculosa</i>	spotted knapweed	<i>Acosta maculosa</i>
<i>Centaurea repens</i>	Russian knapweed	<i>Acroptilon repens</i>
<i>Centaurea solstitialis</i>	yellow starthistle	<i>Centaurea solstitialis</i>
<i>Cirsium arvense</i>	Canada thistle	<i>Breia arvensis</i>
<i>Cirsium vulgare</i>	bull thistle	<i>Cirsium vulgare</i>
<i>Cynoglossum officinale</i>	common hound's-tongue	<i>Cynoglossum officinale</i>
<i>Dipsacus sylvestris</i>	teasel	<i>Dipsacus fullonum</i>
<i>Elaeagnus angustifolia</i>	Russian-olive	<i>Elaeagnus angustifolia</i>
<i>Euphorbia esula</i>	leafy spurge	<i>Tithymalus esula</i>
<i>Hyoscyamus niger</i>	black henbane	<i>Hyoscyamus niger</i>
<i>Lepidium latifolium</i>	broadleaf pepperwort	<i>Cardaria latifolia</i>
<i>Linaria dalmatica</i>	Dalmatian toadflax	<i>Linaria genistifolia</i> ssp. <i>dalmatica</i>
<i>Linaria vulgaris</i>	butter-and-eggs	<i>Linaria vulgaris</i>
<i>Lythrum salicaria</i>	purple looserife	<i>Lythrum salicaria</i>
<i>Melilotus officinalis</i>	yellow sweetclover	<i>Melilotus officinale</i>
<i>Onopordum acanthium</i>	Scotch thistle	<i>Onopordum acanthium</i>
<i>Taeniatherum caput-medusae</i>	Medusahead	<i>Taeniatherum caput-medusae</i>
<i>Tamarix chinensis</i>	five-stamen tamarisk	<i>Tamarix ramosissima</i>
<i>Tribulus terrestris</i>	puncturevine	<i>Tribulus terrestris</i>

Appendix B. Exotic Plant Invasions Detected on the River Corridor, Dinosaur NM, July 5–24, 2010 (example of data available in electronic version)

River Section	Species	Master_Common_Name	Pulled	Growth_Stage	Size_Class	N_Coord	E_Coord
Yampa	<i>Carduus nutans</i>	Musk thistle	TRUE		1	4481392	709003.6
Yampa	<i>Carduus nutans</i>	Musk thistle	FALSE		1	4483467	677274.8
Yampa	<i>Carduus nutans</i>	Musk thistle	FALSE		1	4487670	675545.8
Yampa	<i>Carduus nutans</i>	Musk thistle	FALSE		2	4482593	680749.5
Yampa	<i>Carduus nutans</i>	Musk thistle	FALSE		2	4487628	672921.8
Yampa	<i>Centaurea repens</i>	Russian knapweed	FALSE	Mature Tree(s)	3	4482681	678831.2
Yampa	<i>Centaurea repens</i>	Russian knapweed	FALSE	Mature Tree(s)	3	4482775	706198.1
Yampa	<i>Centaurea repens</i>	Russian knapweed	FALSE		1	4482778	680860.8
Yampa	<i>Centaurea repens</i>	Russian knapweed	FALSE		2	4488480	671160.9
Yampa	<i>Centaurea repens</i>	Russian knapweed	FALSE		2	4488409	670949.7
Yampa	<i>Centaurea repens</i>	Russian knapweed	FALSE		2	4482175	680650.9
Yampa	<i>Centaurea repens</i>	Russian knapweed	FALSE		2	4483589	681566.8
Yampa	<i>Centaurea repens</i>	Russian knapweed	FALSE		3	4488413	670990.3
Yampa	<i>Centaurea repens</i>	Russian knapweed	FALSE		3	4481245	708943.8
Yampa	<i>Centaurea repens</i>	Russian knapweed	FALSE		3	4482788	680893.8
Yampa	<i>Centaurea repens</i>	Russian knapweed	FALSE		4	4482865	680990.5
Yampa	<i>Centaurea repens</i>	Russian knapweed	FALSE		4	4486830	675993.8
Yampa	<i>Centaurea repens</i>	Russian knapweed	FALSE		4	4482898	681476.4
Yampa	<i>Centaurea repens</i>	Russian knapweed	FALSE		4	4480701	703864.6
Yampa	<i>Centaurea repens</i>	Russian knapweed	FALSE		4	4483046	681262.6
Yampa	<i>Centaurea repens</i>	Russian knapweed	FALSE		4	4483036	693589.4
Yampa	<i>Centaurea repens</i>	Russian knapweed	FALSE		4	4482847	681341.7
Yampa	<i>Centaurea repens</i>	Russian knapweed	FALSE		5	4482987	681448.1

Appendix C. Invasive Exotic Plant Percent Cover Detected by Monitoring Transects, Dinosaur NM, July 5–24, 2010 (*example of data available in electronic version*)

River Section	Transect	Species	Master_Common_Name	Cover_Average	E_Coord	N_Coord
Lower Green	5002	<i>Bromus tectorum</i>	Cheatgrass	1.666666667	641616.2	4476911
Lower Green	5003	<i>Bromus tectorum</i>	Cheatgrass	1.666666667	641621.5	4477412
Lower Green	5003	<i>Tamarix chinensis</i>	Five-stamen tamarisk	4.666666667	641621.5	4477412
Lower Green	5005	<i>Tamarix chinensis</i>	Five-stamen tamarisk	7.333333333	642550.2	4477532
Lower Green	5006	<i>Lepidium latifolium</i>	Broad-leaf pepperwort	3.333333333	643037.9	4477461
Lower Green	5006	<i>Tamarix chinensis</i>	Five-stamen tamarisk	33.33333333	643037.9	4477461
Lower Green	5007	<i>Bromus tectorum</i>	Cheatgrass	1.333333333	643524.1	4477377
Lower Green	5009	<i>Lepidium latifolium</i>	Broad-leaf pepperwort	6.666666667	644388.4	4476897
Lower Green	5009	<i>Tamarix chinensis</i>	Five-stamen tamarisk	50	644388.4	4476897
Lower Green	5010	<i>Tamarix chinensis</i>	Five-stamen tamarisk	10	644796.5	4476609
Lower Green	5012	<i>Elaeagnus angustifolia</i>	Russian-olive	0.666666667	645171.1	4475788
Lower Green	5012	<i>Lepidium latifolium</i>	Broad-leaf pepperwort	8	645171.1	4475788
Lower Green	5012	<i>Tamarix chinensis</i>	Five-stamen tamarisk	2.666666667	645171.1	4475788
Lower Green	5013	<i>Tamarix chinensis</i>	Five-stamen tamarisk	1	644993.2	4475327
Lower Green	5015	<i>Tamarix chinensis</i>	Five-stamen tamarisk	1	645188.6	4474362
Lower Green	5016	<i>Tamarix chinensis</i>	Five-stamen tamarisk	1.666666667	645344.8	4473925
Lower Green	5027	<i>Lepidium latifolium</i>	Broad-leaf pepperwort	0.666666667	647689.4	4475998
Lower Green	5027	<i>Tamarix chinensis</i>	Five-stamen tamarisk	0.666666667	647689.4	4475998
Lower Green	5030	<i>Lepidium latifolium</i>	Broad-leaf pepperwort	0.666666667	648256.4	4474842
Lower Green	5030	<i>Tamarix chinensis</i>	Five-stamen tamarisk	6.666666667	648256.4	4474842
Lower Green	5039	<i>Bromus tectorum</i>	Cheatgrass	6.666666667	648719.4	4476474