



# Invasive Exotic Plant Monitoring in Dinosaur National Monument

*2010–2011 Field Seasons*

Natural Resource Technical Report NPS/NCPN/NRTR—2012/569



## ON THE COVER

Leafy spurge (*Euphorbia esula*). Photo by Richard Old, XID Services, Inc., Bugwood.org

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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 5–24, 2010, and July 19–26, 2011, NCPN staff detected 14 priority IEP species and 15 additional IEP species on monitoring routes and transects along 171 kilometers (727 hectares) of the Green and Yampa rivers. Tamarisk (*Tamarix chinensis*), broad-leaf 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. Invasive species were generally higher along the upper Green River, followed by the lower Green River. They were lowest on the Yampa River, according to mapping of infestations both along monitoring routes and more quantitative plots. Infestations of tamarisk were smaller on the Yampa than on the upper and lower Green. However, more analysis is planned to remove areas that have been targeted for control, compare stage discharges during sampling, and make comparisons between alluvial parks and canyon reaches to determine what may be causing these differences. Comparison to results from surveys completed from 2002 to 2005 showed that infestations generally increased along the Yampa River, while declining or remaining at similar levels along the upper and lower Green.



# 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       |



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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 priority 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. Data from 2010 were summarized in Perkins (2011). This report summarizes data collected in both 2010 and 2011 to give a complete summary of IEPs along the river corridor at Dinosaur National Monument (DINO). An additional, more intensive analytical report is also underway looking at effects of river regulation on invasive plants in alluvial parks and canyon reaches at DINO.

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 established a series of monitoring routes for the park. The transects, 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 priority invasive exotic plant list

Prior to beginning monitoring in 2011, NCPN and DINO staff reviewed and updated the list of priority invasive plants developed for the park in 2010. 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 priority IEP list (Table 2-1) includes existing IEPs and potential IEPs of high management concern.

**Table 2-1. Priority invasive exotic plant list, Dinosaur National Monument, 2010–2011.**

| Species name (Utah)               | Common name           | Species 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>Breea 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>        | broad-leaf 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 loosestrife    | <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>          | tamarisk              | <i>Tamarix ramosissima</i>                        |
| <i>Tribulus terrestris</i>        | puncturevine          | <i>Tribulus terrestris</i>                        |

Because these methods were designed to be rapid, field crews were trained to develop a focused search image on the priority plants, instead of looking for every possible invasive plant species. The likelihood of eradicating these priority species, or containing them within a park, is generally high. There were no changes to the priority list between 2010 and 2011. The list of priority 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 m<sup>2</sup> (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 priority 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 an observer could consistently detect (i.e., see and recognize) the MDTS of the least-visible priority 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 rangefinder. The EDD for DINO was between 1 and 60 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 priority 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 1 to 60 meters (Figure 2-1).

### 2.2.4 Patch separation resolution

We defined patch separation resolution (PSR) as the minimum distance between

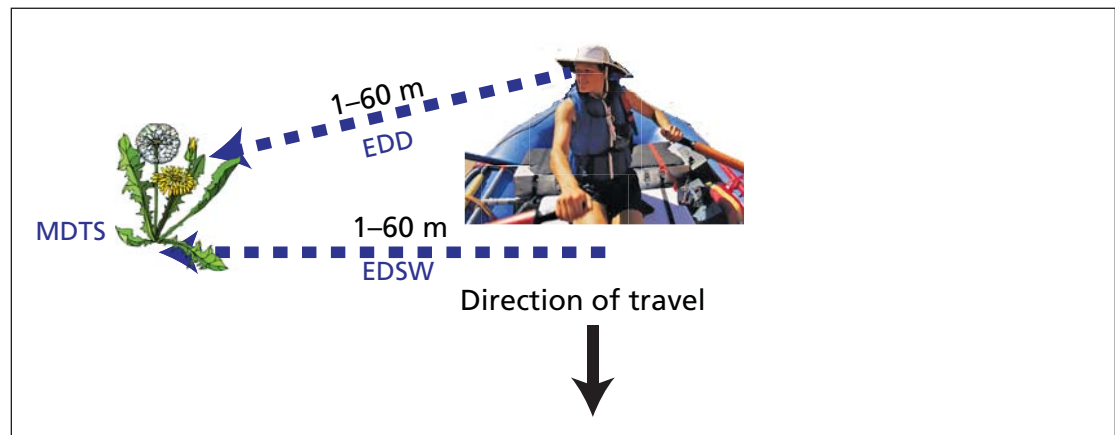


Figure 2.1. At Dinosaur NM, the maximum effective detection distance (EDD) and effective detection swath width (EDSW) were both 1–60 meters.

plants that must be considered members of separate patches or infestations. Individuals or clusters of a priority 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 1–60 m (the length of one EDSW) and visually scanned the area. 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. As monitoring routes were traversed (Figure 2-2), locations of all priority species were documented using global positioning system (GPS) units with at least five-meter accuracy.

Only priority species 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 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.

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 m<sup>2</sup> (48 yd<sup>2</sup>),
3. 40–400 m<sup>2</sup> (48–478 yd<sup>2</sup>),
4. 400–1,000 m<sup>2</sup> (0.1–0.25 acre), and
5. 1,000–2,000 m<sup>2</sup> (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 tree), evidence of prior treatment, and evidence of disturbances (e.g., recent fire, flood, small mammal disturbance).

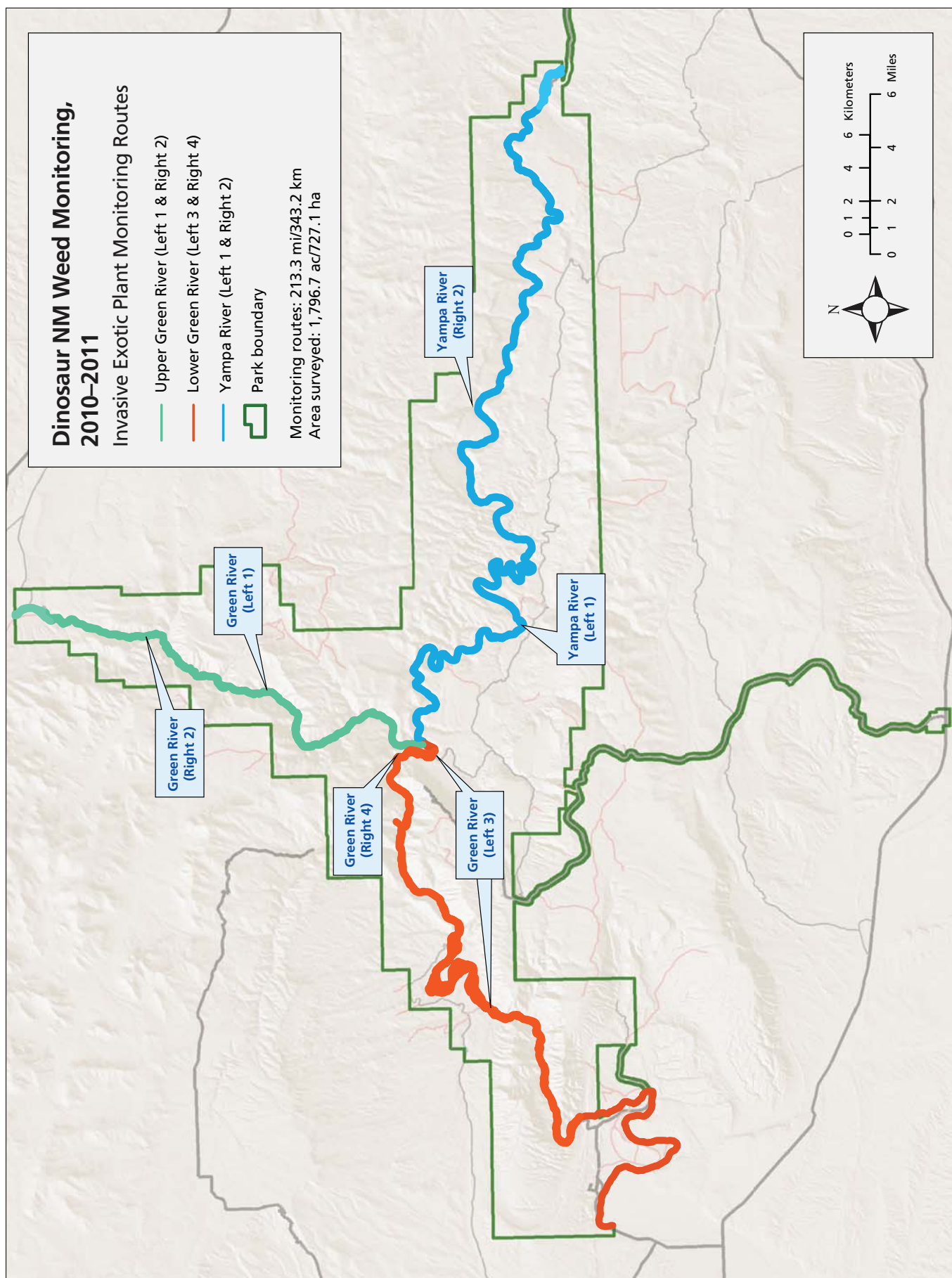


Figure 2-2. Overview of invasive plant monitoring routes surveyed at Dinosaur National Monument, July 5–24, 2010 and July 19–26, 2011.

## 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 (Appendix A). However, due to swift currents, canyon walls, and river safety in some portions of the river, some transects were missed. 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.

### 2.3.1 Quadrat establishment

We centered vegetation quadrats at 0.5, 5, and 10 m away from the water's edge on the same side as the route that was being walked or rafted. A 1-m<sup>2</sup> 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 transects, all priority 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, 20, 30, 40, 50, 60, 70, 80, 90, or 100%. 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 transects. Due to differences in observers' knowledge, only priority species should be used when comparing results from year to year.

We used one-way ANOVAs to test for differences between total IEPs, tamarisk, cheatgrass, Canada thistle, and broad-leaf pepperwort on the upper Green, lower Green, and Yampa rivers. If there was a difference, we used Tukey's Honest Significant Difference test to see where the differences were.

## 2.5 Comparisons to earlier surveys (2002–2005)

Dewey and others (2004) and Dewey and Anderson (2005a, b) surveyed the same sections of the river corridor between 2002 and 2005 as were surveyed in 2010–2011. Fourteen species that were priority species in both 2002–2005 and 2010–2011 were detected in at least one of the two sampling periods (see Table 3-6). However, in the earlier surveys, crews mapped some infestations of tamarisk along the upper Green and some infestations of tamarisk, broad-leaf pepperwort, and Russian olive along the lower Green with a combination of points, lines, and polygons. In 2010 and 2011, the crew used points exclusively. To account for these differences, we converted these lines and polygons to points. In 2010 and 2011, crews were instructed to place points every 50 m if the infestation was larger than 50 m. Therefore, for the lines and polygons of 2002–2005, we divided the length by 50 m and added 1 to turn the length into a number of points (line that was 225 m long became 5 points). Infestations of the following species were also mapped as lines in 2002–2005: Canada thistle (3 infestations), broad-leaf pepperwort (21), yellow sweet-clover (2), Russian olive (23), and tamarisk (214). In addition, eight polygons of tamarisk were mapped. For species not listed and for the Yampa River, where no polygons or lines were drawn, the methods were the same between the two sampling periods. All polygon infestations were found on the lower Green River. For lines, 98.5% of the infestations were found on the lower Green, while only 1.5% were found on the upper Green.



## 3 Results

### 3.1 Priority invasive exotic plant list

Twenty-six species were identified as priority for the DINO priority IEP list (see Table 2-1). Observers were trained to recognize priority species, but given the freedom to map additional species; therefore, presence and absence data for priority species are reliable, but absence data for other species are suspect. A total of 14 priority IEP species plus 15 non-priority IEP species were recorded on monitoring routes and transects in 2010–2011 (Table 3-1). Fourteen priority IEP species were recorded on monitoring routes and six in monitoring transects. We covered 727 hectares (1,797 acres) along 171 km (107 miles) of river monitoring routes in 2010–2011. Because each side of the river was monitored, the actual length of river covered was closer to 342 km (213 miles).

### 3.2 Monitoring routes

A total of 4,065 infestations of 14 different priority species were detected along the monitoring routes (Table 3-2, Figures 3-1 through 3-24, Electronic Appendix B). This resulted in 5.59 priority infestations per hectare. The upper Green had the highest number of IEPs per hectare, followed by the lower Green and the Yampa. Tamarisk (2.50 infestations/ha), broad-leaf pepperwort (*Lepidium latifolium*) (1.24/ha), yellow sweetclover (*Melilotus officinalis*) (0.82), and Canada thistle (*Cirsium arvense*) (0.49/ha) had the highest numbers of infestations. On the upper Green, tamarisk averaged 3.50 infestations per hectare. On the lower Green, 80.3% of the infestations were larger than 40 m<sup>2</sup> (Table 3-3), while on the upper Green and Yampa, 70.8% and 53.1% were larger than 40 m<sup>2</sup>, respectively. These numbers were largely driven by tamarisk. On the upper Green, 96.6% of tamarisk infestations were larger than 40 m<sup>2</sup>. That number was 89.3% on the lower Green, and on the Yampa, 56.7% of tamarisk infestations were larger than 40 m<sup>2</sup>. Infestation rates by species were generally highest along the upper Green, followed by the lower Green and the Yampa. Leafy spurge (highest on Yampa) and Russian olive (highest on lower Green) were the notable exceptions.

Growth stage was noted for 102 infestations of Russian olive and 1,718 infestations of tamarisk (Table 3-4). For Russian olive, the majority of infestations were saplings or seedlings, while for tamarisk the majority of infestations were mature trees or old growth. Estimates of trees/old growth were similar across the lower Green and Yampa for Russian olive. However, there was a much higher percentage of tamarisk present as mature trees/old growth along the upper Green than along the Yampa or lower Green river segments.

### 3.3 Monitoring transects

A total of 288 transects were sampled in 2010 and 2011 (Table 3-5, Electronic Appendix C). Seven priority IEP species were detected in transects (cheatgrass is counted as a priority species here, as it was recorded consistently in plots but not mapped on monitoring routes). IEPs were present in 15.3%, 58.0%, and 71.8% of transects (set of three quadrats) along the Yampa, lower Green, and upper Green rivers, respectively. An average of 0.16, 0.78 and 1.04 priority IEP species was detected per plot along the Yampa, lower Green, and upper Green, respectively. Three species—tamarisk ( $F=3.26$ ,  $df=2$ ,  $p=0.04$ ), cheatgrass ( $F=3.13$ ,  $df=2$ ,  $p=0.04$ ) and Canada thistle ( $F=2.99$ ,  $df=2$ ,  $p=0.05$ )—and the total number of IEPs ( $F=4.58$ ,  $df=2$ ,  $p=0.004$ ) were detected in sufficient numbers to test for differences between the three river segments. All were significantly different (Table 3-6). Total IEPs, Canada thistle, and tamarisk infestations were significantly higher in percent cover along the upper Green River than the Yampa River, while the lower Green River was not significantly different from the Yampa or upper Green (Table 3-7). Cheatgrass infestations were higher on the lower Green than on the Yampa or upper Green rivers.

### 3.4 Comparison to previous surveys

When compared to results from the 2002–2005 surveys, the total number of infestations decreased 27% and 33% along the upper and lower Green River, respectively, while infestations increased on the Yampa River by 35% (Table 3-8). If the species for which more than 20 infestations were mapped as either

**Table 3-1. Invasive exotic plants detected at Dinosaur NM from July 5–24, 2010 and July 19–26, 2011.**

| Scientific name               | Common name            | Method detected |           | Priority? |
|-------------------------------|------------------------|-----------------|-----------|-----------|
|                               |                        | Routes          | Transects |           |
| <i>Arctium minus</i>          | burdock                | X               |           | Yes       |
| <i>Carduus nuttans</i>        | musk thistle           | X               |           | Yes       |
| <i>Centaurea maculosa</i>     | spotted knapweed       | X               |           | Yes       |
| <i>Centaurea repens</i>       | Russian knapweed       | X               | X         | Yes       |
| <i>Cirsium arvense</i>        | Canada thistle         | X               | X         | Yes       |
| <i>Cirsium vulgare</i>        | bull thistle           | X               |           | Yes       |
| <i>Dipsacus sylvestris</i>    | teasel                 | X               |           | Yes       |
| <i>Elaeagnus angustifolia</i> | Russian olive          | X               | X         | Yes       |
| <i>Euphorbia esula</i>        | leafy spurge           | X               |           | Yes       |
| <i>Lepidium latifolium</i>    | broad-leaf pepperwort  | X               | X         | Yes       |
| <i>Linaria vulgaris</i>       | butter-and-eggs        | X               |           | Yes       |
| <i>Melilotus officinalis</i>  | yellow sweetclover     | X               | X         | Yes       |
| <i>Onopordum acanthium</i>    | Scotch thistle         | X               |           | Yes       |
| <i>Tamarix chinensis</i>      | tamarisk               | X               | X         | Yes       |
| <i>Bromus tectorum</i>        | cheatgrass             |                 | X         | No*       |
| <i>Alyssum desertorum</i>     | desert madwort         |                 | X         | No        |
| <i>Bromus inermis</i>         | smooth brome           |                 | X         | No        |
| <i>Cirsium arizonicum</i>     | Arizona thistle        |                 | X         | No        |
| <i>Convolvulus arevensis</i>  | field bindweed         | X               |           | No        |
| <i>Elymus repens</i>          | quackgrass             | X               |           | No        |
| <i>Eremopyrum triticeum</i>   | annual wheatgrass      |                 | X         | No        |
| <i>Lactuca serriola</i>       | prickly lettuce        |                 | X         | No        |
| <i>Lepidium lasiocarpum</i>   | shaggyfruit pepperweed |                 | X         | No        |
| <i>Nepeta cataria</i>         | catnip                 | X               |           | No        |
| <i>Poa pratensis</i>          | Kentucky bluegrass     |                 | X         | No        |
| <i>Sisymbrium altissimum</i>  | tumble mustard         |                 | X         | No        |
| <i>Taraxacum officinale</i>   | common dandelion       |                 | X         | No        |
| <i>Tragopogon dubius</i>      | yellow salsify         |                 | X         | No        |
| <i>Verbascum thapsus</i>      | wooly mullein          | X               |           | No        |

\*Only priority species were mapped and recorded in transects throughout DINO. Species not on the list were opportunistic observations.

Cheatgrass was recorded consistently in transects but not along monitoring routes.

polygons or lines in the early sampling period (Russian olive, broad-leaf pepperwort, and tamarisk) are removed, infestations on the upper Green are shown to increase by 24%, while those on the lower Green decrease by 22% and those on the Yampa River increase by 202% (Table 3-8).

Yellow sweetclover (+408%) and Russian knapweed (45%) showed the largest increases on the upper Green, while tamarisk increased by 53%. On the lower Green River, musk thistle increased from 2 to 34 infesta-

tions and only one other species increased, broad-leaf pepperwort. Several species declined dramatically on the lower Green River: Russian olive (-57%), tamarisk (-44%), Canada thistle (-41%) and Russian knapweed (-31%). On the Yampa River, four of the six species with significant numbers increased, led by yellow sweetclover (+336%), leafy spurge (+260%), Canada thistle (+64%), and tamarisk (+24%). Only broad-leaf pepperwort (-11%) and Russian knapweed (-7%) had small declines (Table 3-8).

**Table 3-2. Number of priority IEP infestations per route surveyed, Dinosaur NM, July 5–24, 2010 and July 19–26, 2011.**

| Route             | Length (m)     | ha            | Infestations | Infestations/ha |
|-------------------|----------------|---------------|--------------|-----------------|
| Upper Green River | 66,004         | 74.77         | 856          | 11.45           |
| Lower Green River | 122,817        | 336.51        | 2,076        | 6.17            |
| Yampa River       | 152,840        | 315.82        | 1,133        | 3.59            |
| <b>Total</b>      | <b>341,661</b> | <b>727.10</b> | <b>4,065</b> | <b>5.59</b>     |

**Table 3-3. Species observed and size of infestations detected along monitoring routes on the upper Green (UG, 74.77 ha), lower Green (LG, 336.51 ha), and Yampa (YA, 315.82 ha) rivers, Dinosaur NM, July 5–24, 2010 and July 19–26, 2011.**

| Scientific name               | Common name      | River | Infestations/<br>ha | Infestation size class |    |     |    |   |
|-------------------------------|------------------|-------|---------------------|------------------------|----|-----|----|---|
|                               |                  |       |                     | 1                      | 2  | 3   | 4  | 5 |
| Priority species              |                  |       |                     |                        |    |     |    |   |
| <i>Arctium minus</i>          | burdock          | UG    | 0 (0.00)            | 0                      | 0  | 0   | 0  | 0 |
|                               |                  | LG    | 3 (0.01)            | 0                      | 1  | 2   | 0  | 0 |
|                               |                  | YA    | 0 (0.00)            | 0                      | 0  | 0   | 0  | 0 |
|                               |                  | ALL   | 3 (0.004)           | 0                      | 1  | 2   | 0  | 0 |
| <i>Carduus nutans</i>         | musk thistle     | UG    | 14 (0.19)           | 5                      | 4  | 3   | 2  | 0 |
|                               |                  | LG    | 34 (0.10)           | 14                     | 7  | 6   | 6  | 1 |
|                               |                  | YA    | 5 (0.02)            | 3                      | 2  | 0   | 0  | 0 |
|                               |                  | ALL   | 53 (0.07)           | 22                     | 13 | 9   | 8  | 1 |
| <i>Centaurea maculosa</i>     | spotted knapweed | UG    | 1 (0.01)            | 0                      | 0  | 1   | 0  | 0 |
|                               |                  | LG    | 1 (0.002)           | 1                      | 0  | 0   | 0  | 0 |
|                               |                  | YA    | 0 (0.00)            | 0                      | 0  | 0   | 0  | 0 |
|                               |                  | ALL   | 2 (0.003)           | 1                      | 0  | 1   | 0  | 0 |
| <i>Centaurea repens</i>       | Russian knapweed | UG    | 45 (0.60)           | 1                      | 24 | 14  | 6  | 0 |
|                               |                  | LG    | 42 (0.12)           | 1                      | 6  | 25  | 8  | 2 |
|                               |                  | YA    | 66 (0.21)           | 5                      | 23 | 15  | 21 | 2 |
|                               |                  | ALL   | 153 (0.21)          | 7                      | 53 | 54  | 35 | 4 |
| <i>Cirsium arvense</i>        | Canada thistle   | UG    | 178 (2.38)          | 7                      | 47 | 74  | 49 | 1 |
|                               |                  | LG    | 131 (0.39)          | 9                      | 33 | 67  | 22 | 0 |
|                               |                  | YA    | 46 (0.15)           | 6                      | 15 | 22  | 3  | 0 |
|                               |                  | ALL   | 355 (0.49)          | 22                     | 95 | 163 | 74 | 1 |
| <i>Cirsium vulgare</i>        | bull thistle     | UG    | 21 (0.28)           | 9                      | 11 | 1   | 0  | 0 |
|                               |                  | LG    | 4 (0.01)            | 0                      | 2  | 2   | 0  | 0 |
|                               |                  | YA    | 5 (0.02)            | 4                      | 1  | 0   | 0  | 0 |
|                               |                  | ALL   | 30 (0.04)           | 13                     | 14 | 3   | 0  | 0 |
| <i>Dipsacus sylvestris</i>    | teasel           | UG    | 7 (0.09)            | 5                      | 1  | 1   | 0  | 0 |
|                               |                  | LG    | 0 (0.00)            | 0                      | 0  | 0   | 0  | 0 |
|                               |                  | YA    | 0 (0.00)            | 0                      | 0  | 0   | 0  | 0 |
|                               |                  | ALL   | 7 (0.01)            | 5                      | 1  | 1   | 0  | 0 |
| <i>Elaeagnus angustifolia</i> | Russian olive    | UG    | 1 (0.01)            | 0                      | 1  | 0   | 0  | 0 |
|                               |                  | LG    | 96 (0.29)           | 48                     | 14 | 16  | 16 | 2 |
|                               |                  | YA    | 7 (0.02)            | 6                      | 0  | 1   | 0  | 0 |
|                               |                  | ALL   | 104 (0.14)          | 54                     | 15 | 17  | 16 | 2 |

**Table 3-3. Species observed and size of infestations detected along monitoring routes on the upper Green (UG, 74.77 ha), lower Green (LG, 336.51 ha), and Yampa (YA, 315.82 ha) rivers, Dinosaur NM, July 5–24, 2010 and July 19–26, 2011, cont.**

| Scientific name               | Common name           | River | Infestations/<br>ha | Infestation size class |              |               |               |             |
|-------------------------------|-----------------------|-------|---------------------|------------------------|--------------|---------------|---------------|-------------|
|                               |                       |       |                     | 1                      | 2            | 3             | 4             | 5           |
| <i>Euphorbia esula</i>        | leafy spurge          | UG    | 1 (0.01)            | 0                      | 0            | 1             | 0             | 0           |
|                               |                       | LG    | 8 (0.02)            | 1                      | 5            | 2             | 0             | 0           |
|                               |                       | YA    | 36 (0.11)           | 9                      | 23           | 4             | 0             | 0           |
|                               |                       | ALL   | 45 (0.06)           | 10                     | 28           | 7             | 0             | 0           |
| <i>Lepidium latifolium</i>    | broad-leaf pepperwort | UG    | 223 (2.98)          | 15                     | 55           | 84            | 68            | 1           |
|                               |                       | LG    | 491 (1.46)          | 11                     | 69           | 237           | 147           | 27          |
|                               |                       | YA    | 189 (0.60)          | 13                     | 68           | 73            | 35            | 0           |
|                               |                       | ALL   | 903 (1.24)          | 39                     | 192          | 394           | 250           | 28          |
| <i>Melilotus officinalis</i>  | yellow sweetclover    | UG    | 98 (1.31)           | 19                     | 36           | 27            | 14            | 2           |
|                               |                       | LG    | 233 (0.69)          | 24                     | 52           | 118           | 38            | 1           |
|                               |                       | YA    | 262 (0.83)          | 29                     | 100          | 107           | 24            | 2           |
|                               |                       | ALL   | 593 (0.82)          | 72                     | 188          | 252           | 76            | 5           |
| <i>Onopordum acanthium</i>    | Scotch thistle        | UG    | 1 (0.01)            | 1                      | 0            | 0             | 0             | 0           |
|                               |                       | LG    | 0 (0.00)            | 0                      | 0            | 0             | 0             | 0           |
|                               |                       | YA    | 0 (0.00)            | 0                      | 0            | 0             | 0             | 0           |
|                               |                       | ALL   | 1 (0.001)           | 1                      | 0            | 0             | 0             | 0           |
| <i>Tamarix chinensis</i>      | tamarisk              | UG    | 266 (3.56)          | 3                      | 6            | 49            | 141           | 67          |
|                               |                       | LG    | 1,033 (3.07)        | 34                     | 76           | 533           | 309           | 81          |
|                               |                       | YA    | 517 (1.64)          | 133                    | 91           | 176           | 109           | 8           |
|                               |                       | ALL   | 1,816 (2.50)        | 170                    | 173          | 758           | 559           | 156         |
| Total priority species        |                       | UG    | 856 (11.45)         | 65<br>(8%)             | 185<br>(22%) | 255<br>(30%)  | 280<br>(33%)  | 71<br>(8%)  |
|                               |                       | LG    | 2,076 (6.17)        | 143<br>(7%)            | 265<br>(13%) | 1008<br>(49%) | 546<br>(26%)  | 114<br>(5%) |
|                               |                       | YA    | 1,133 (3.59)        | 208<br>(18%)           | 323<br>(29%) | 398<br>(35%)  | 192<br>(17%)  | 12<br>(1%)  |
|                               |                       | ALL   | 4,065 (5.59)        | 416<br>(10%)           | 773<br>(19%) | 1661<br>(41%) | 1018<br>(25%) | 197<br>(5%) |
| Non-priority species          |                       |       |                     |                        |              |               |               |             |
| <i>Convolvulus arvensis</i> * | field bindweed        | UG    | 1 (0.01)            | 0                      | 0            | 1             | 0             | 0           |
|                               |                       | YA    | 1 (0.003)           | 1                      | 0            | 0             | 0             | 0           |
| <i>Elymus repens</i> *        | quackgrass            | YA    | 2 (0.01)            | 0                      | 2            | 0             | 0             | 0           |
| <i>Linaria vulgaris</i> *     | Dalmatian toadflax    | LG    | 1 (0.002)           | 0                      | 1            | 0             | 0             | 0           |
| <i>Nepeta cataria</i> *       | catnip                | YA    | 1 (0.003)           | 1                      | 0            | 0             | 0             | 0           |
| <i>Verbascum thapsus</i> *    | woolly mullein        | UG    | 1 (0.02)            | 0                      | 0            | 0             | 1             | 0           |
|                               |                       | YA    | 4 (0.01)            | 0                      | 1            | 3             | 0             | 0           |

\*Not a priority species so may not have been surveyed completely across the park.

**Table 3.4. Infestations by growth stage (percentage of total infestations) along the upper Green, lower Green, and Yampa rivers, Dinosaur NM, July 5–24, 2010 and July 19–26, 2011.**

| Scientific name                | Common name   | River       | Growth stage       |                        | Total        |
|--------------------------------|---------------|-------------|--------------------|------------------------|--------------|
|                                |               |             | Seedling/Sapling   | Mature tree/Old growth |              |
| <i>Elaeagnus angustifolium</i> | Russian olive | Upper Green | 0 (NA)             | 0 (NA)                 | 0            |
|                                |               | Lower Green | 81 (84.4%)         | 15 (15.6%)             | 96           |
|                                |               | Yampa       | 5 (83.3%)          | 1 (16.7%)              | 6            |
|                                |               | <b>ALL</b>  | <b>86 (84.3%)</b>  | <b>16 (15.7%)</b>      | <b>102</b>   |
| <i>Tamarix chinensis</i>       | tamarisk      | Upper Green | 41 (16.4%)         | 208 (83.5%)            | 249          |
|                                |               | Lower Green | 440 (44.6%)        | 547 (55.4%)            | 987          |
|                                |               | Yampa       | 168 (34.9%)        | 314 (65.1%)            | 482          |
|                                |               | <b>ALL</b>  | <b>649 (37.8%)</b> | <b>1,069 (62.2%)</b>   | <b>1,718</b> |

**Table 3-5. Number of monitoring transects where IEPs were detected, mean percent cover, and standard error, Dinosaur NM, July 5–24, 2010 and July 19–26, 2011.**

| Scientific name                 | Common name           | Upper Green River (72) |                    | Lower Green River (131) |                    | Yampa River (85) |                    |
|---------------------------------|-----------------------|------------------------|--------------------|-------------------------|--------------------|------------------|--------------------|
|                                 |                       | Transects              | Percent cover (SE) | Transects               | Percent cover (SE) | Transects        | Percent cover (SE) |
| <i>Bromus tectorum</i>          | cheatgrass            | 6                      | 0.11 (0.05)        | 50                      | 0.67 (0.23)        | 5                | 0.13 (0.09)        |
| <i>Centaurea repens</i>         | Russian knapweed      | 2                      | 0.12 (0.10)        | 0                       | 0.00 (0.00)        | 0                | 0.00 (0.00)        |
| <i>Cirsium arvense</i>          | Canada thistle        | 13                     | 0.31 (0.15)        | 2                       | <0.01 (<0.01)      | 0                | 0.00 (0.00)        |
| <i>Elaeagnus angustifolium</i>  | Russian olive         | 0                      | 0.00 (0.00)        | 1                       | 0.01 (0.01)        | 0                | 0.00 (0.00)        |
| <i>Lepidium latifolium</i>      | broad-leaf pepperwort | 15                     | 0.40 (0.28)        | 7                       | 0.16 (0.08)        | 0                | 0.00 (0.00)        |
| <i>Melilotus officinalis</i>    | yellow sweetclover    | 1                      | <0.01 (<0.01)      | 3                       | 0.01 (<0.01)       | 2                | 0.02 (0.02)        |
| <i>Tamarix chinensis</i>        | tamarisk              | 38                     | 3.59 (1.04)        | 39                      | 2.00 (0.60)        | 7                | 0.58 (0.29)        |
| <b>Total priority IEP cover</b> |                       | <b>51</b>              | <b>4.54 (1.06)</b> | <b>76</b>               | <b>2.84 (0.67)</b> | <b>13</b>        | <b>0.68 (0.30)</b> |

Total number of transects per route are listed in parentheses in the header row.

**Table 3.6. Results of one-way ANOVAs to test for differences between IEPs along the upper Green, lower Green, and Yampa rivers, Dinosaur NM, July 5–24, 2010 and July 19–26, 2011.**

| Scientific name            | Common name           | Sum of squares | df       | Mean square   | F-ratio     | p            |
|----------------------------|-----------------------|----------------|----------|---------------|-------------|--------------|
| <i>Bromus tectorum</i>     | cheatgrass            | 21.35          | 2        | 10.68         | 3.13        | 0.04         |
| <i>Cirsium arvense</i>     | Canada thistle        | 4.89           | 2        | 2.44          | 2.99        | 0.05         |
| <i>Lepidium latifolium</i> | broad-leaf pepperwort | 6.38           | 2        | 3.19          | 1.76        | 0.17         |
| <i>Tamarix chinensis</i>   | tamarisk              | 264.10         | 2        | 132.04        | 3.26        | 0.04         |
| <b>All priority IEPs</b>   |                       | <b>536.10</b>  | <b>2</b> | <b>268.04</b> | <b>5.58</b> | <b>0.004</b> |

**Table 3.7. Results of Tukey's honest significant difference test to determine where differences were among invasive exotic plants along the Upper Green, Lower Green, and Yampa Rivers at Dinosaur National Monument, July 5–24, 2010 and July 19–26, 2011.**

| Scientific name          | Common name    | River       | Percent cover (mean) | SD   | n   | Tukey |
|--------------------------|----------------|-------------|----------------------|------|-----|-------|
| <i>Cirsium arvense</i>   | Canada thistle | Upper Green | 0.35                 | 1.27 | 72  | A     |
|                          |                | Lower Green | 0.16                 | 0.95 | 131 | AB    |
|                          |                | Yampa       | 0.00                 | 0.00 | 85  | B     |
| <i>Bromus tectorum</i>   | cheatgrass     | Upper Green | 0.11                 | 0.42 | 72  | A*    |
|                          |                | Lower Green | 0.67                 | 2.64 | 131 | B     |
|                          |                | Yampa       | 0.13                 | 0.80 | 85  | A     |
| <i>Tamarix chinensis</i> | tamarisk       | Upper Green | 3.16                 | 8.24 | 72  | A     |
|                          |                | Lower Green | 2.00                 | 6.88 | 131 | AB    |
|                          |                | Yampa       | 0.58                 | 2.65 | 85  | B     |
| All priority IEPs        |                | Upper Green | 4.42                 | 9.09 | 72  | A**   |
|                          |                | Lower Green | 2.25                 | 7.44 | 131 | AB    |
|                          |                | Yampa       | 0.72                 | 2.74 | 85  | B     |

\*Differences only significant for cheatgrass when  $\alpha = 0.10$ . There were no significant differences when  $\alpha$  was 0.05.

\*\*If  $\alpha = 0.10$ , then all three river segments would have been significantly different.

**Table 3-8. Priority species observed and size of infestations detected along the upper Green River, lower Green River and Yampa River at Dinosaur National Monument from July 5–24, 2010 and July 19–26, 2011, compared to data collected from May to September 2002–2005, along the same route.**

| Scientific name                                                                                                                     | Common name           | Number of Infestations |           |          |                   |           |          |             |           |          |
|-------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------------------------|-----------|----------|-------------------|-----------|----------|-------------|-----------|----------|
|                                                                                                                                     |                       | Upper Green River      |           |          | Lower Green River |           |          | Yampa River |           |          |
|                                                                                                                                     |                       | 2002–2005              | 2010–2011 | ±%Change | 2002–2005         | 2010–2011 | ±%Change | 2002–2005   | 2010–2011 | ±%Change |
| <i>Arctium minus</i>                                                                                                                | burdock               | 2                      | 0         | -100%    | 13                | 3         | -77%     | 4           | 0         | -100%    |
| <i>Cardaria draba</i>                                                                                                               | whitetop              | 3                      | 0         | -100%    | 0                 | 0         | NA       | 7           | 0         | -100%    |
| <i>Carduus nutans</i>                                                                                                               | musk thistle          | 22                     | 14        | -36%     | 2                 | 34        | +1700%   | 8           | 5         | -38%     |
| <i>Centaurea maculosa</i>                                                                                                           | spotted knapweed      | 0                      | 1         | +        | 0                 | 1         | -100%    | 0           | 0         | NA       |
| <i>Centaurea repens</i>                                                                                                             | Russian knapweed      | 31                     | 45        | +45%     | 64                | 42        | -31%     | 71          | 66        | -7%      |
| <i>Cirsium arvense</i> *                                                                                                            | Canada thistle        | 178                    | 178       | 0%       | 221               | 131       | -41%     | 28          | 46        | +64%     |
| <i>Cirsium vulgare</i>                                                                                                              | bull thistle          | 30                     | 21        | -30%     | 10                | 4         | -60%     | 1           | 5         | +500%    |
| <i>Euphorbia esula</i>                                                                                                              | leafy spurge          | 0                      | 1         | +        | 12                | 8         | -25%     | 10          | 36        | +260%    |
| <i>Linaria dalmatica</i>                                                                                                            | Dalmatian toadflax    | 0                      | 0         | NA       | 0                 | 0         | NA       | 1           | 0         | -100%    |
| <i>Melilotus officinalis</i> *                                                                                                      | yellow sweetclover    | 24                     | 98        | +408%    | 261               | 233       | -11%     | 78          | 262       | +336%    |
| <i>Onopordum acanthium</i>                                                                                                          | Scotch thistle        | 0                      | 1         | +        | 0                 | 0         | NA       | 0           | 0         | NA       |
| Totals (excluding species for which more than 20 infestations were mapped as either polygons or lines in the early sampling period) |                       | 290                    | 359       | +24%     | 583               | 456       | -22%     | 208         | 420       | +202%    |
| <i>Elaeagnus angustifolia</i> *                                                                                                     | Russian olive         | 0                      | 1         | +        | 221               | 96        | -57%     | 4           | 7         | +75%     |
| <i>Lepidium latifolium</i> *                                                                                                        | broad-leaf pepperwort | 307                    | 223       | -27%     | 460               | 491       | +7%      | 212         | 189       | -11%     |
| <i>Tamarix chinensis</i> *                                                                                                          | tamarisk              | 569                    | 266       | -53%     | 1,831             | 1,033     | -44%     | 416         | 517       | +24%     |
| Totals (including species for which more than 20 infestations were mapped as either polygons or lines in the early sampling period) |                       | 1,166                  | 849       | -27%     | 3,095             | 2,076     | -33%     | 840         | 1,133     | +35%     |

\*Infestations of the following species were also mapped as lines: *Cirsium arvense* (3), *Lepidium latifolium* (21), *Melilotus officinalis* (2), *Elaeagnus angustifolia* (23), and *Tamarix chinensis* (214). *Tamarix chinensis* was also mapped as polygons (8) in the earlier surveys. All polygon infestations were found on the lower Green River. For lines, 98.5% of the infestations were found on the lower Green, while only 1.5% were found on the upper Green. None were found on the Yampa.

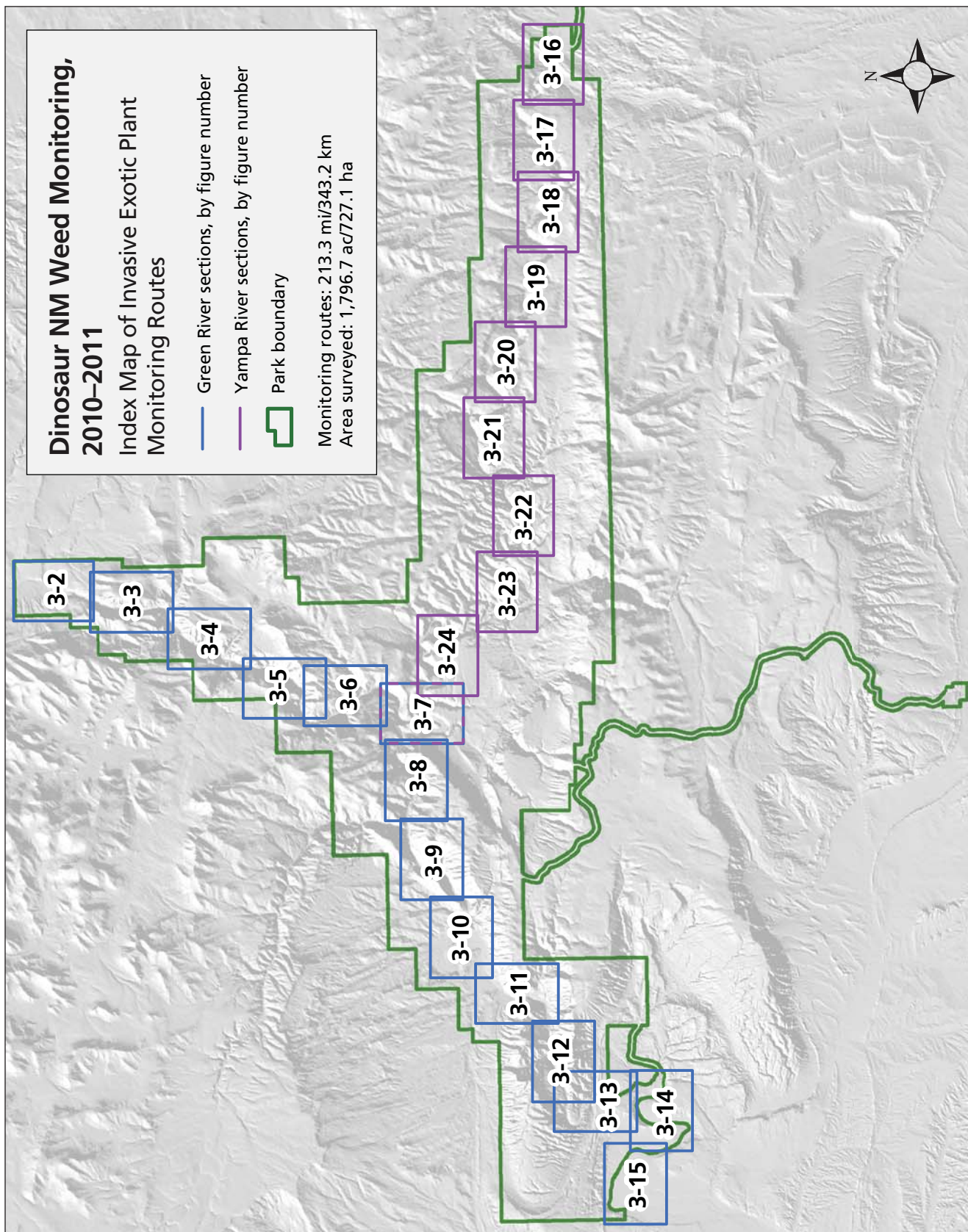


Figure 3-1. Index map of IEP monitoring routes, Dinosaur NM, July 5–24, 2010 and July 19–26, 2011.

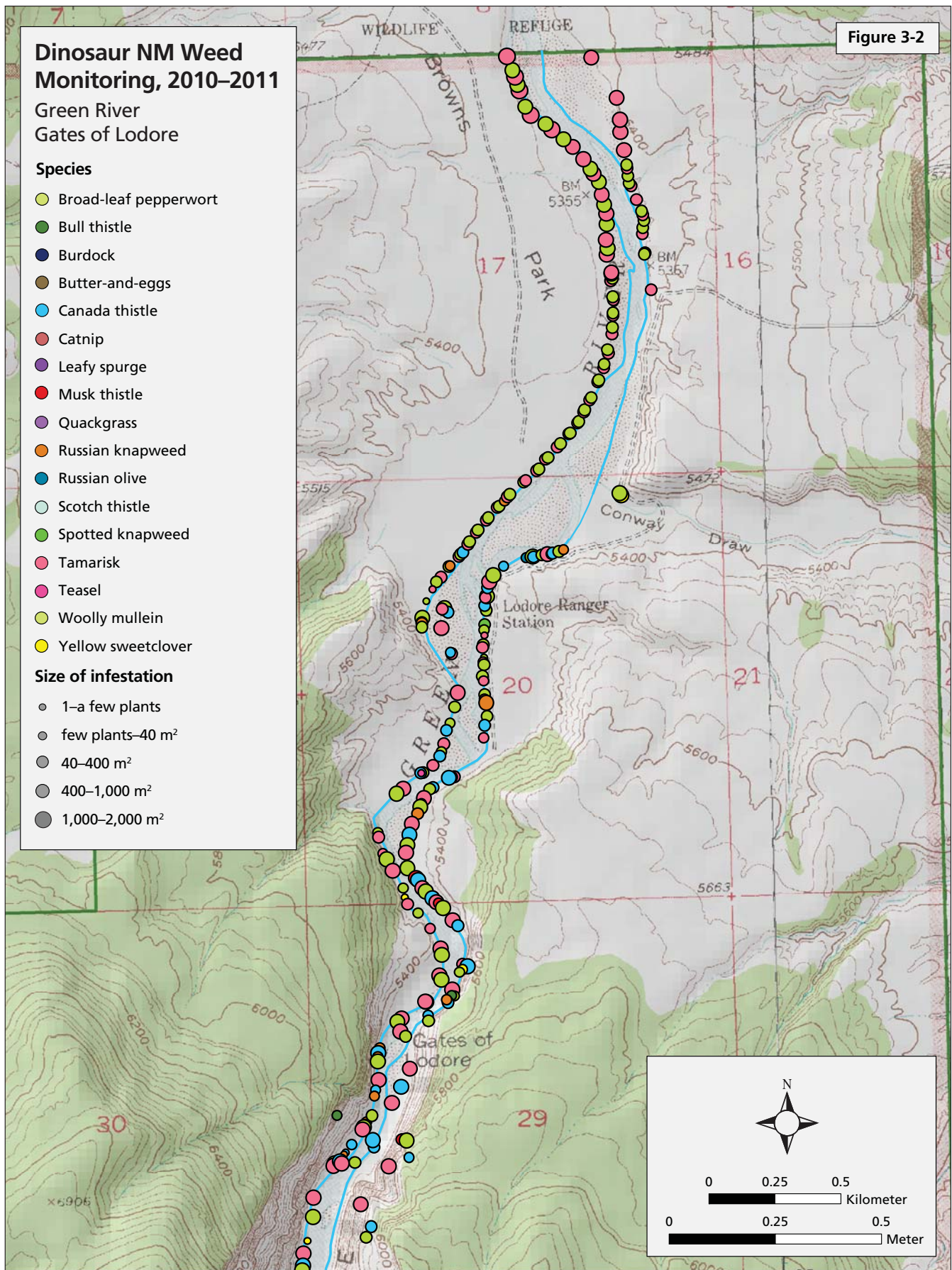


Figure 3-2. Invasive plants detected on monitoring routes around Gates of Lodore, Green River, Dinosaur NM, July 5–24, 2010 and July 19–26, 2011.

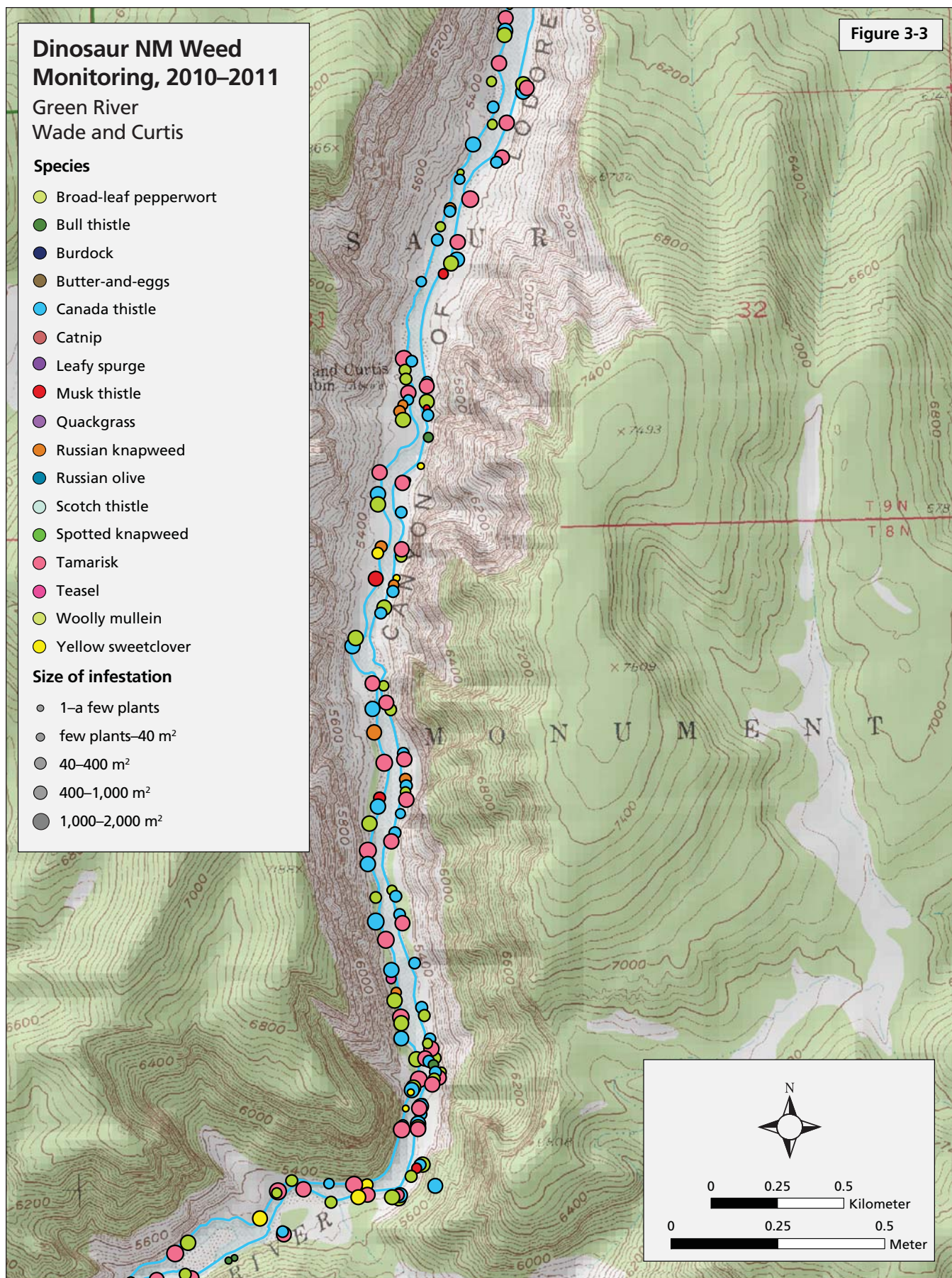


Figure 3-3. Invasive plants detected on monitoring routes around Wade and Curtis, Green River, Dinosaur NM, July 5–24, 2010.

Figure 3-4

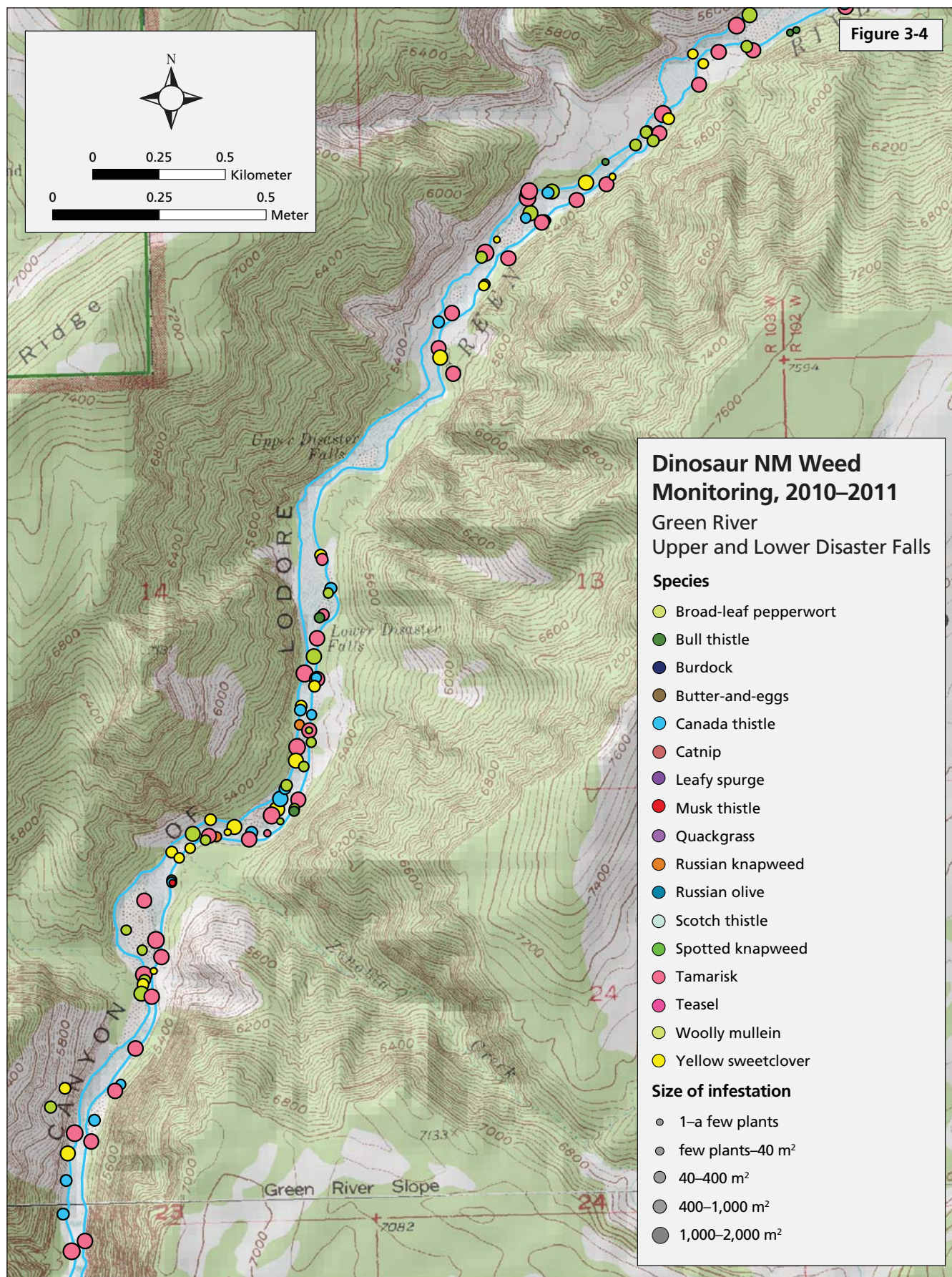


Figure 3-4. Invasive plants detected on monitoring routes around Upper and Lower Disaster Falls, Green River, Dinosaur NM, July 5–24, 2010.

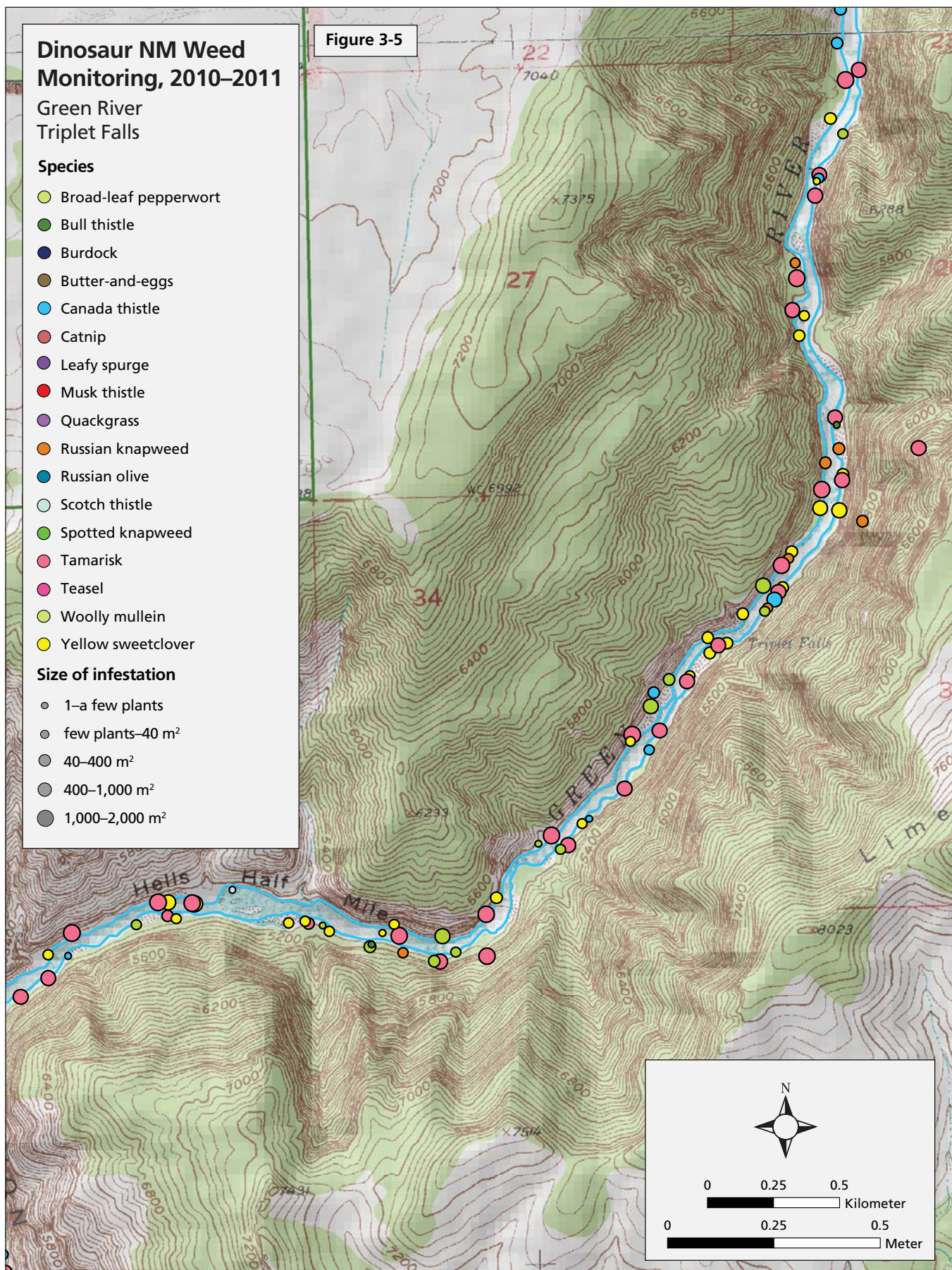


Figure 3-5. Invasive plants detected on monitoring routes around Triplet Falls, Green River, Dinosaur NM, July 5–24, 2010.

Figure 3-6

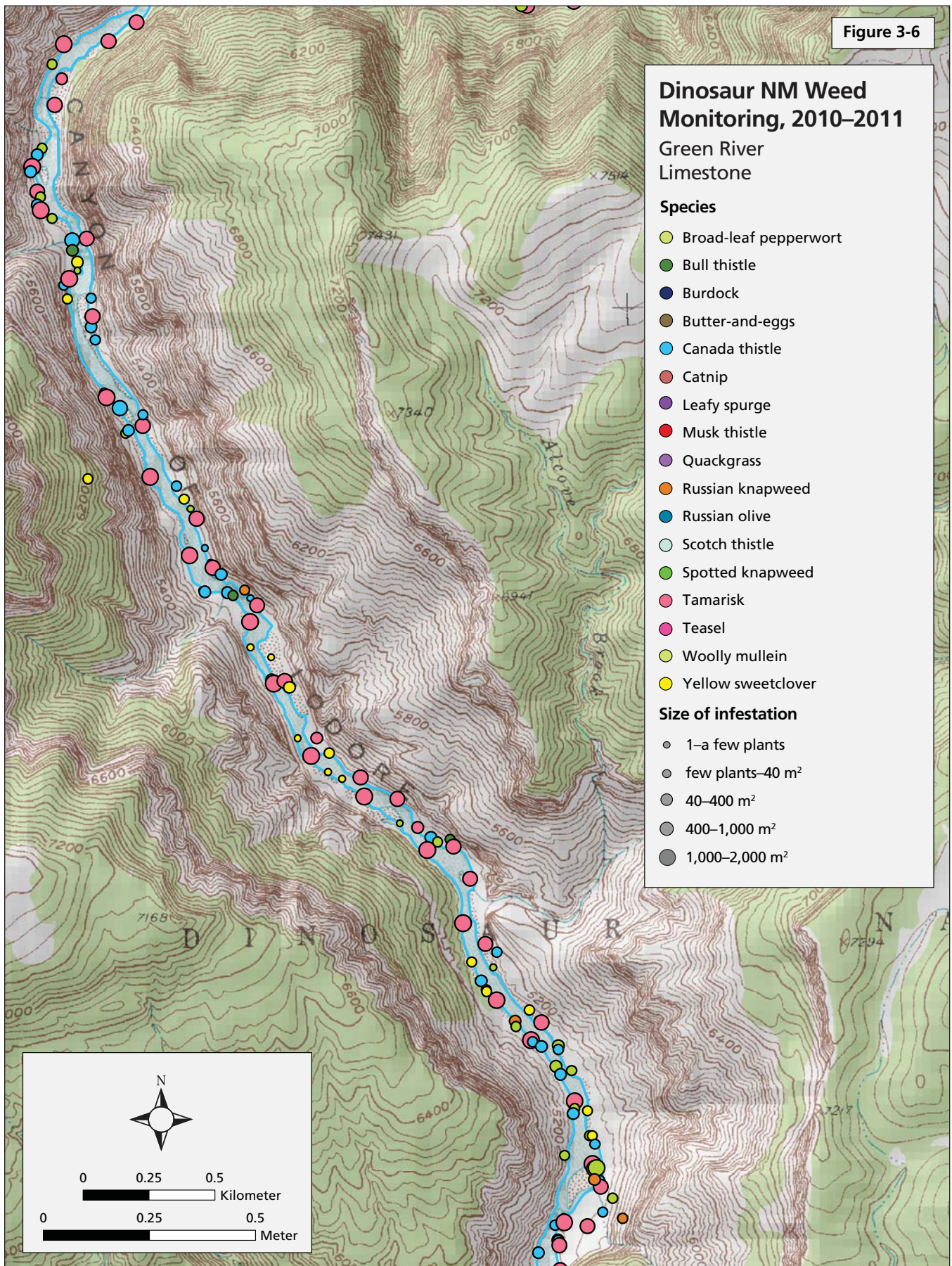


Figure 3-6. Invasive plants detected on monitoring routes around Limestone, Green River, Dinosaur NM, July 5–24, 2010.

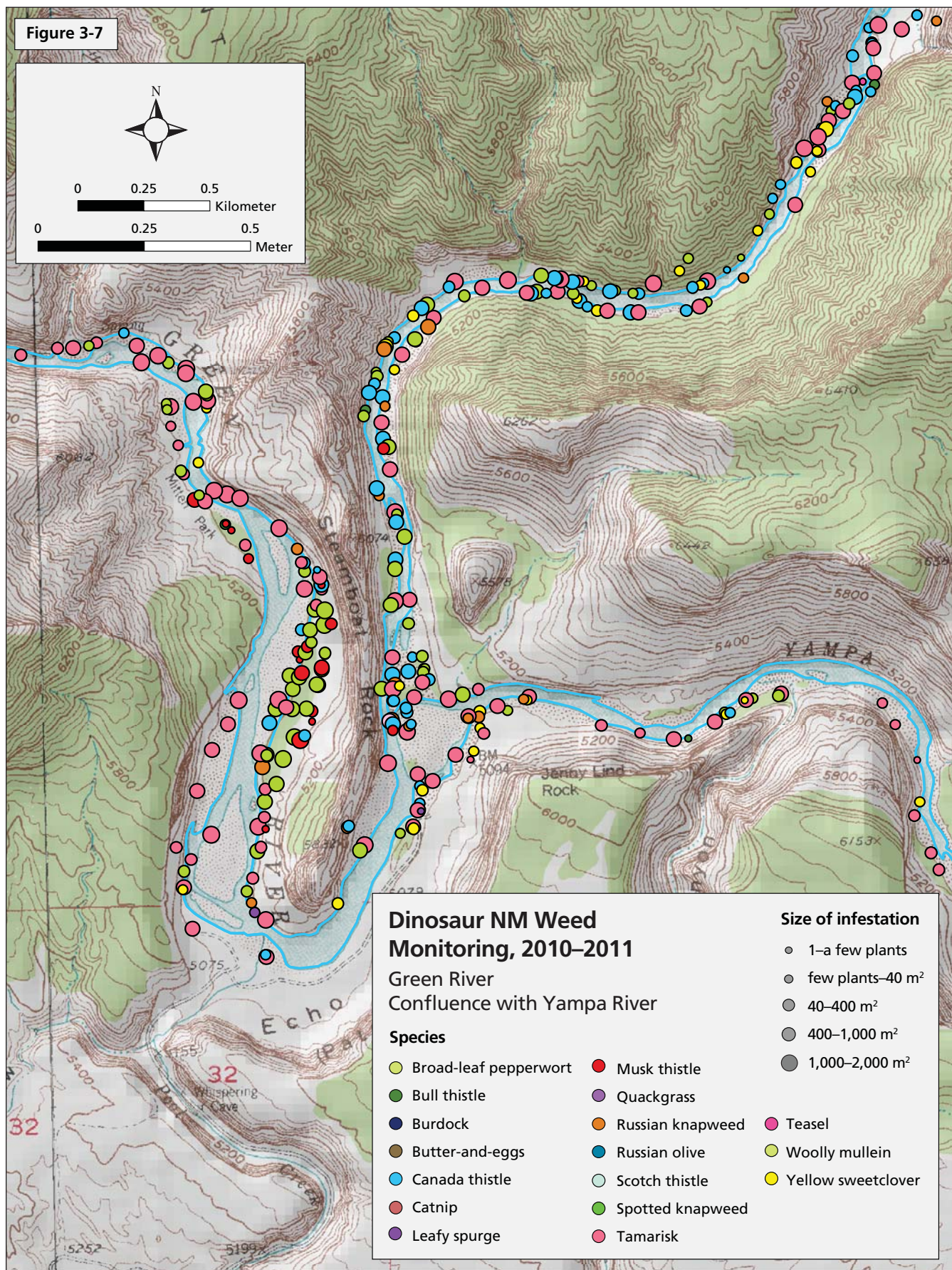


Figure 3-7. Invasive plants detected on monitoring routes at the confluence of the Yampa and Green rivers, Dinosaur NM, July 5–24, 2010 and July 19–26, 2011.

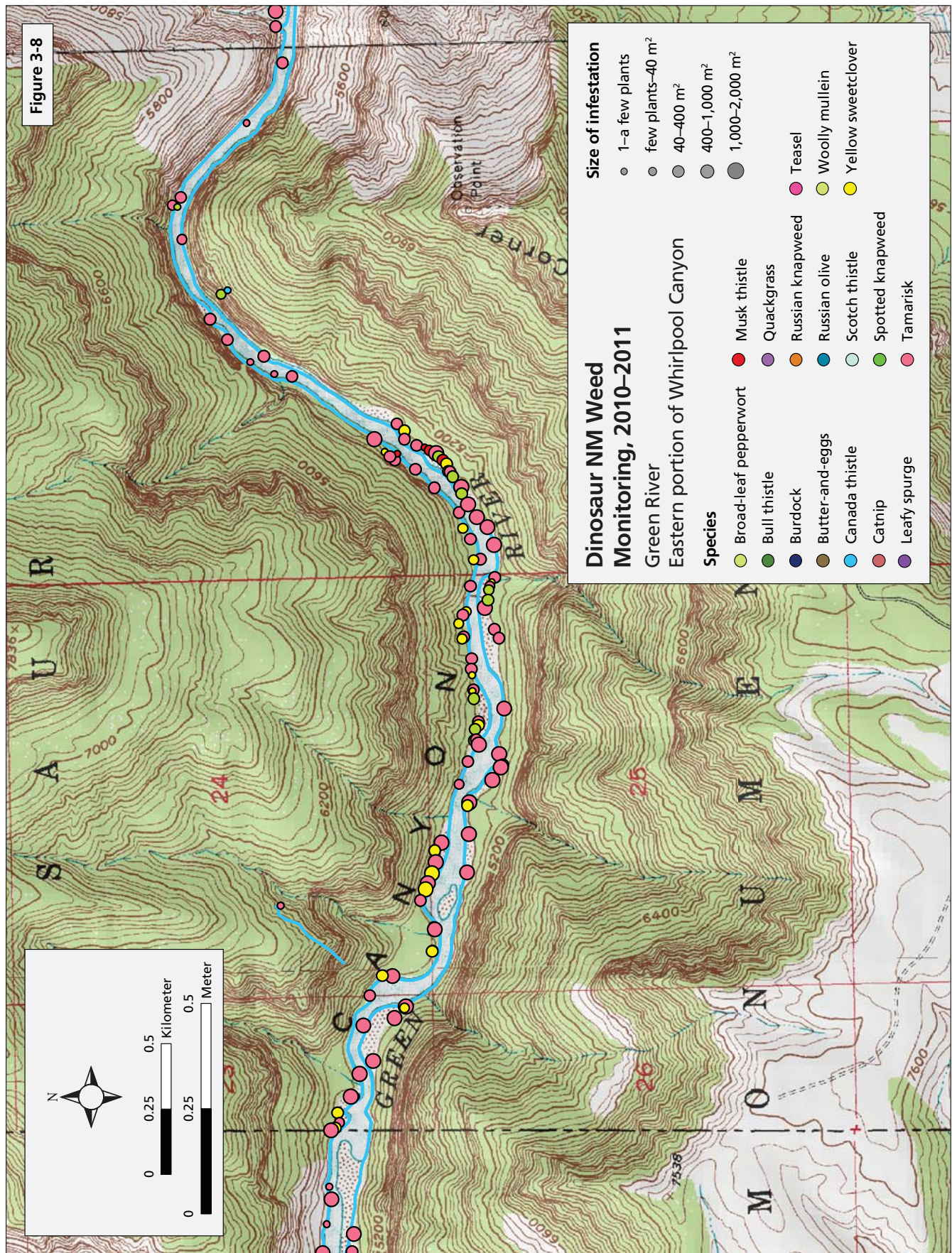


Figure 3-8. Invasive plants detected on monitoring routes around eastern portion of Whirlpool Canyon, Green River, Dinosaur NM, July 19–26, 2011.

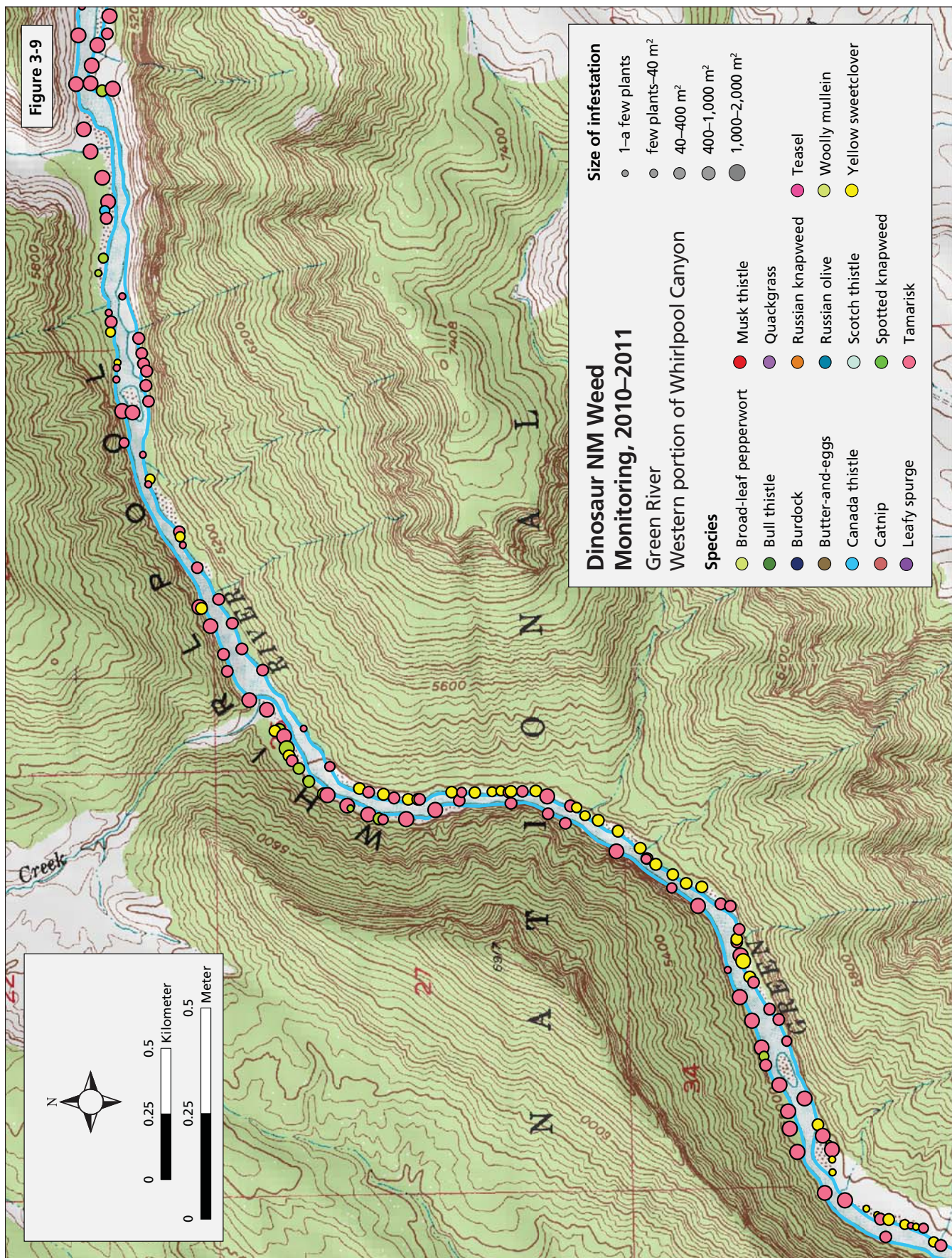


Figure 3-9. Invasive plants detected on monitoring routes around the western portion of Whirlpool Canyon, Green River, Dinosaur NM, July 19–26, 2011.

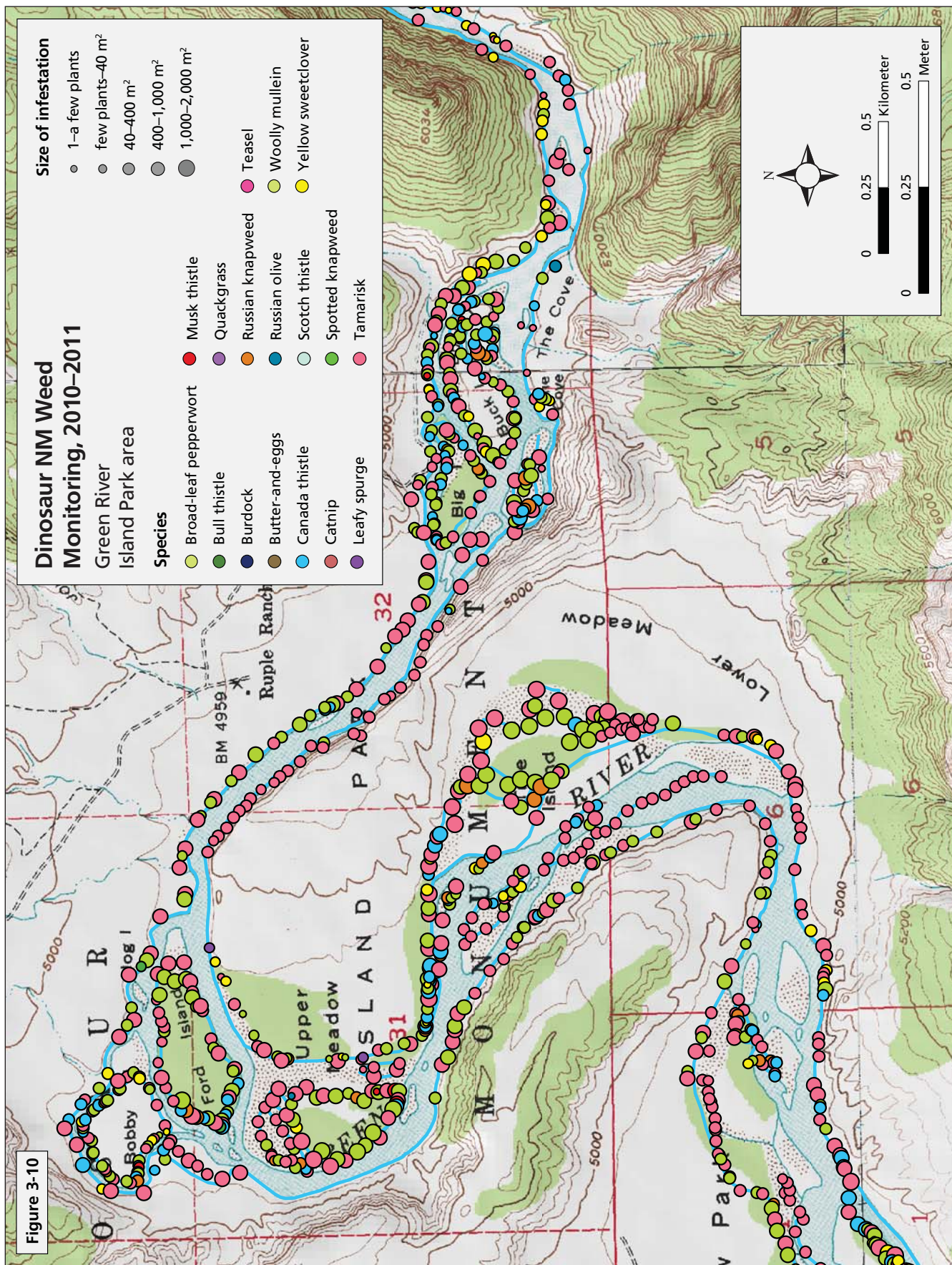


Figure 3-10. Invasive plants detected on monitoring routes around Island Park, Green River, Dinosaur NM, July 19–26, 2011.

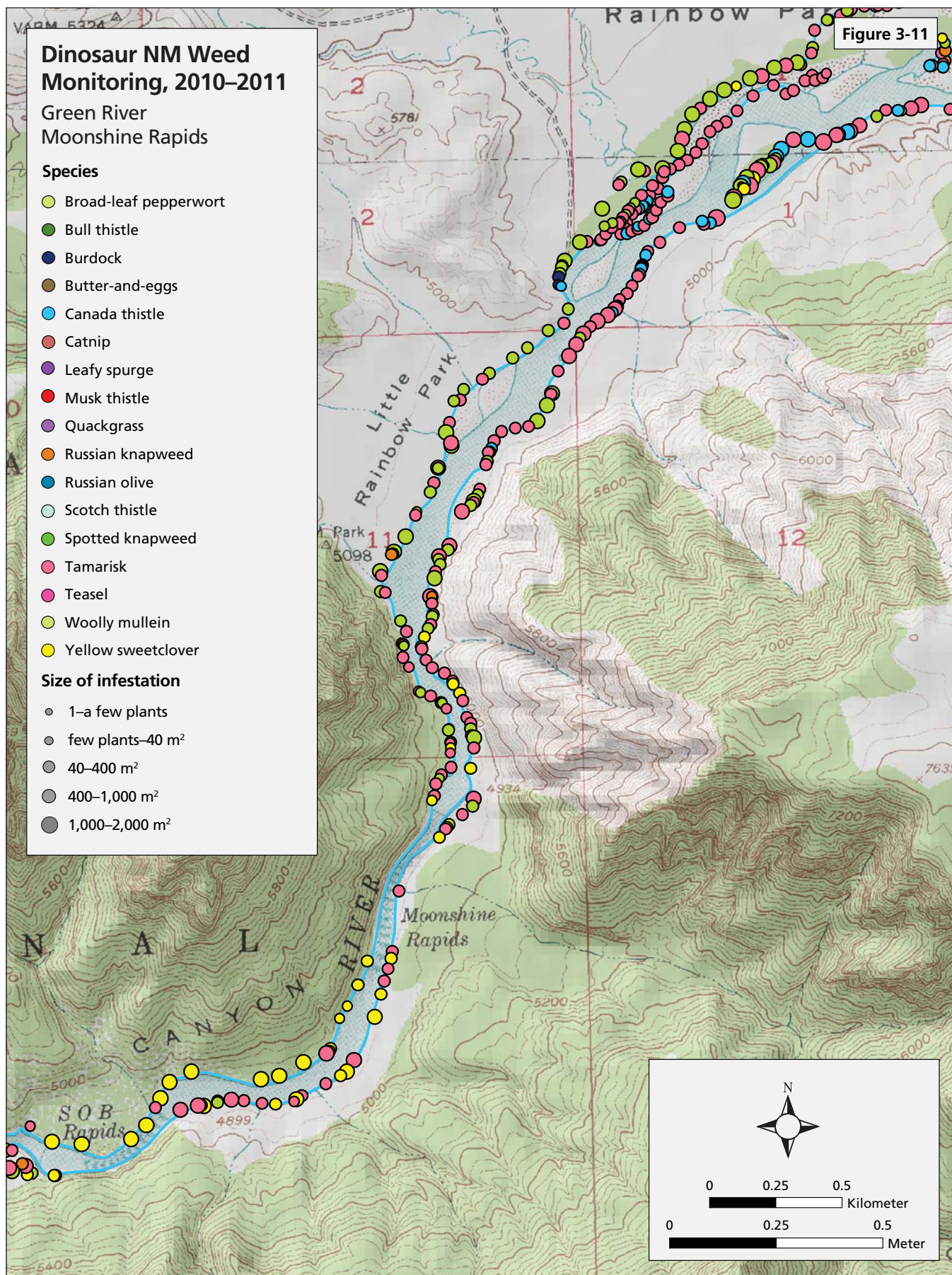


Figure 3-11. Invasive plants detected on monitoring routes around Moonshine Rapids, Green River, Dinosaur NM, July 19–26, 2011.

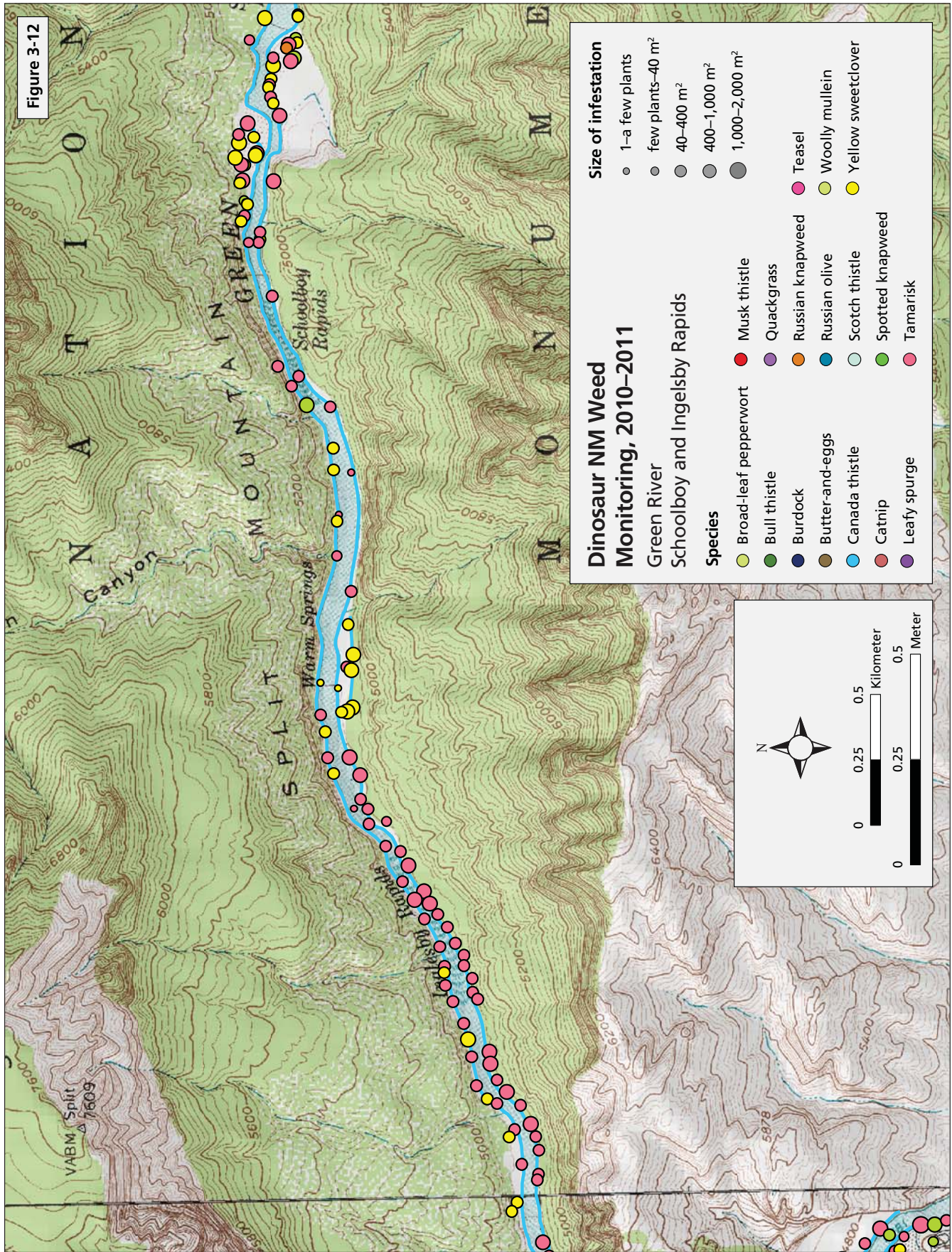


Figure 3-12. Invasive plants detected on monitoring routes around Schoolboy and Ingelsby Rapids, Green River, Dinosaur NM, July 19–26, 2011.

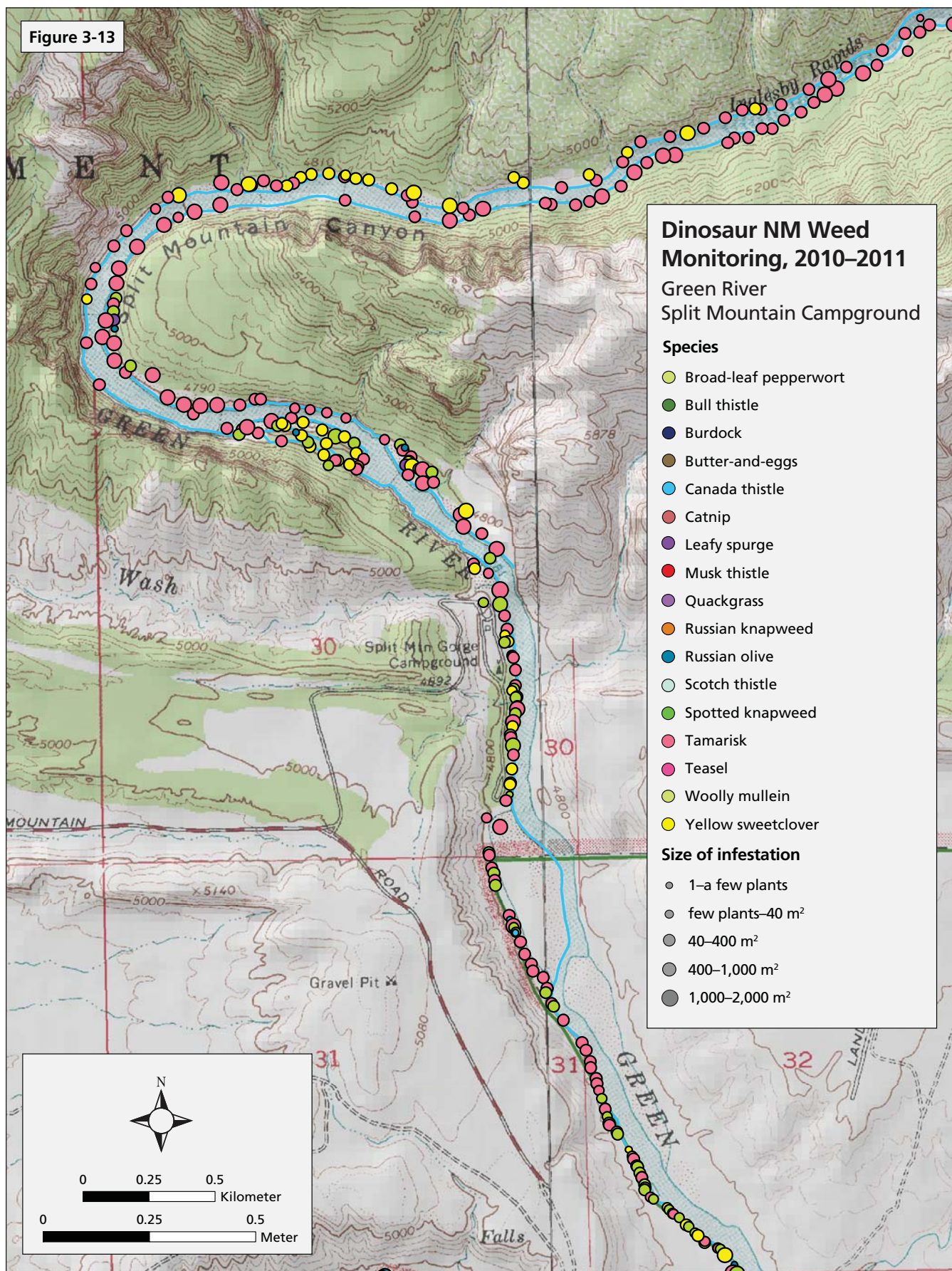


Figure 3-13. Invasive plants detected on monitoring routes around Split Mountain Campground, Green River, Dinosaur NM, July 5–24, 2010 and July 19–26, 2011.

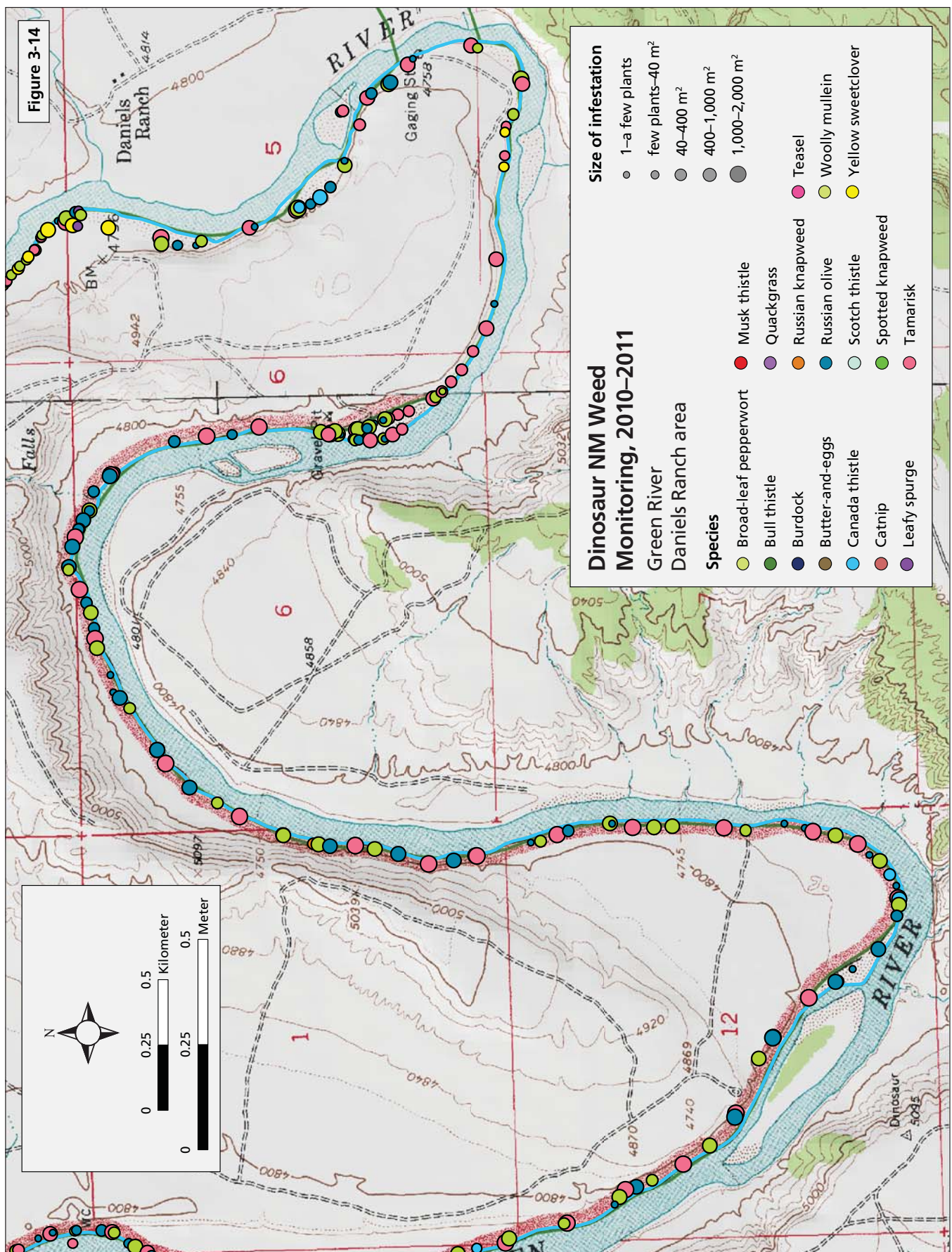
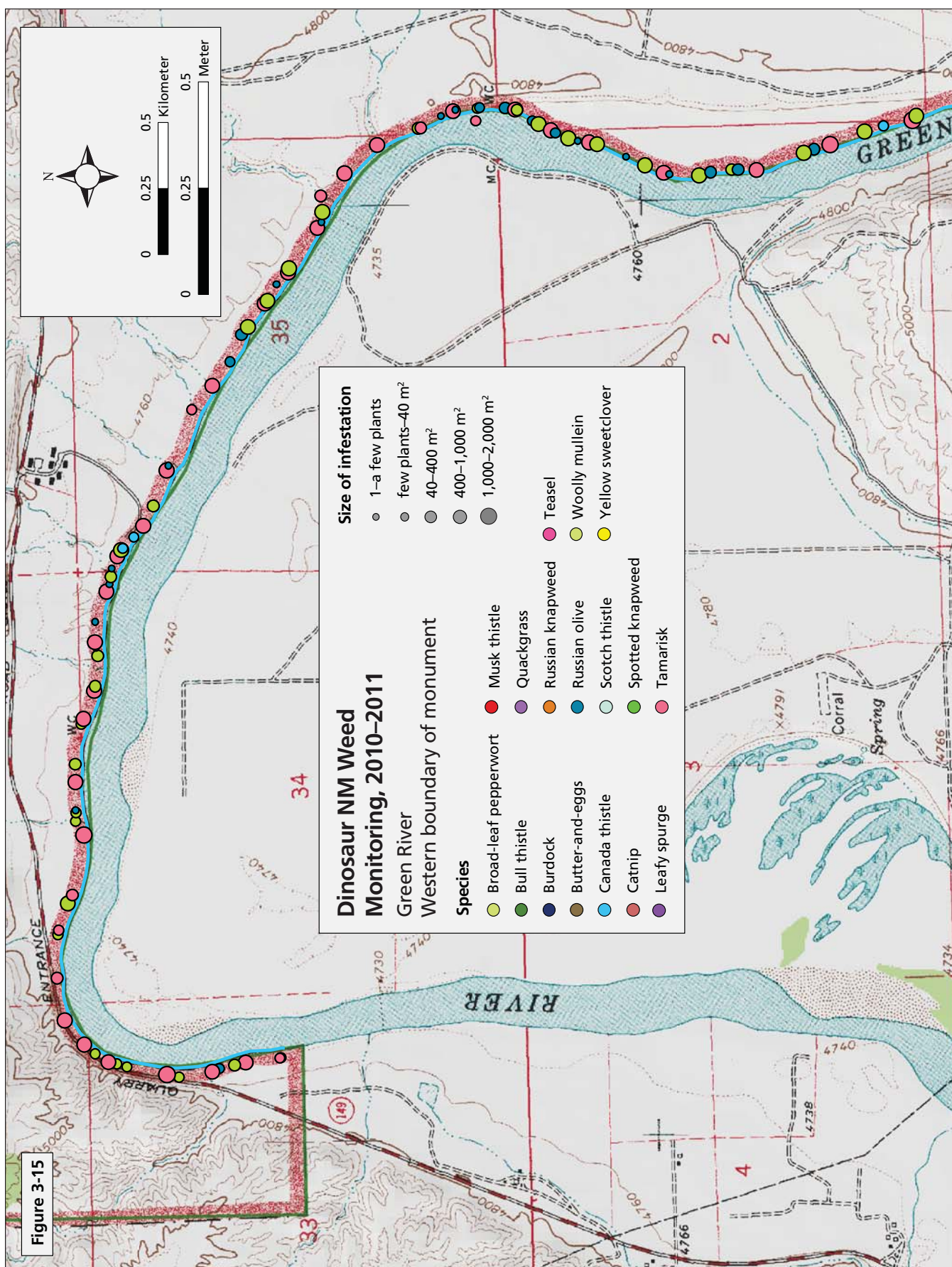


Figure 3-14. Invasive plants detected on monitoring routes around the Daniels Ranch, Green River, Dinosaur NM, July 5–24, 2010.



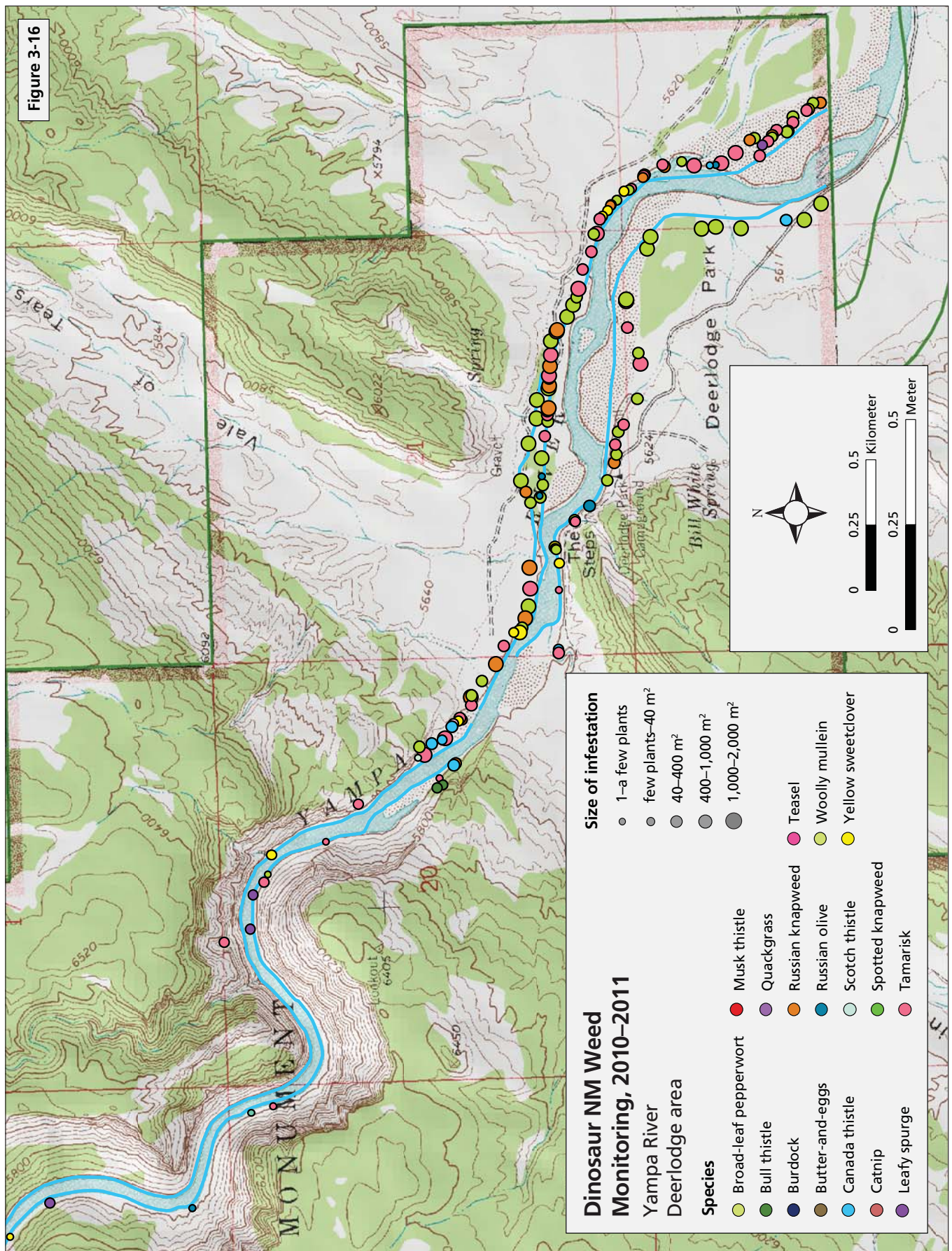


Figure 3-16. Invasive plants detected on monitoring routes around Deerlodge, Yampa River, Dinosaur NM, July 5–24, 2010 and July 19–26, 2011.

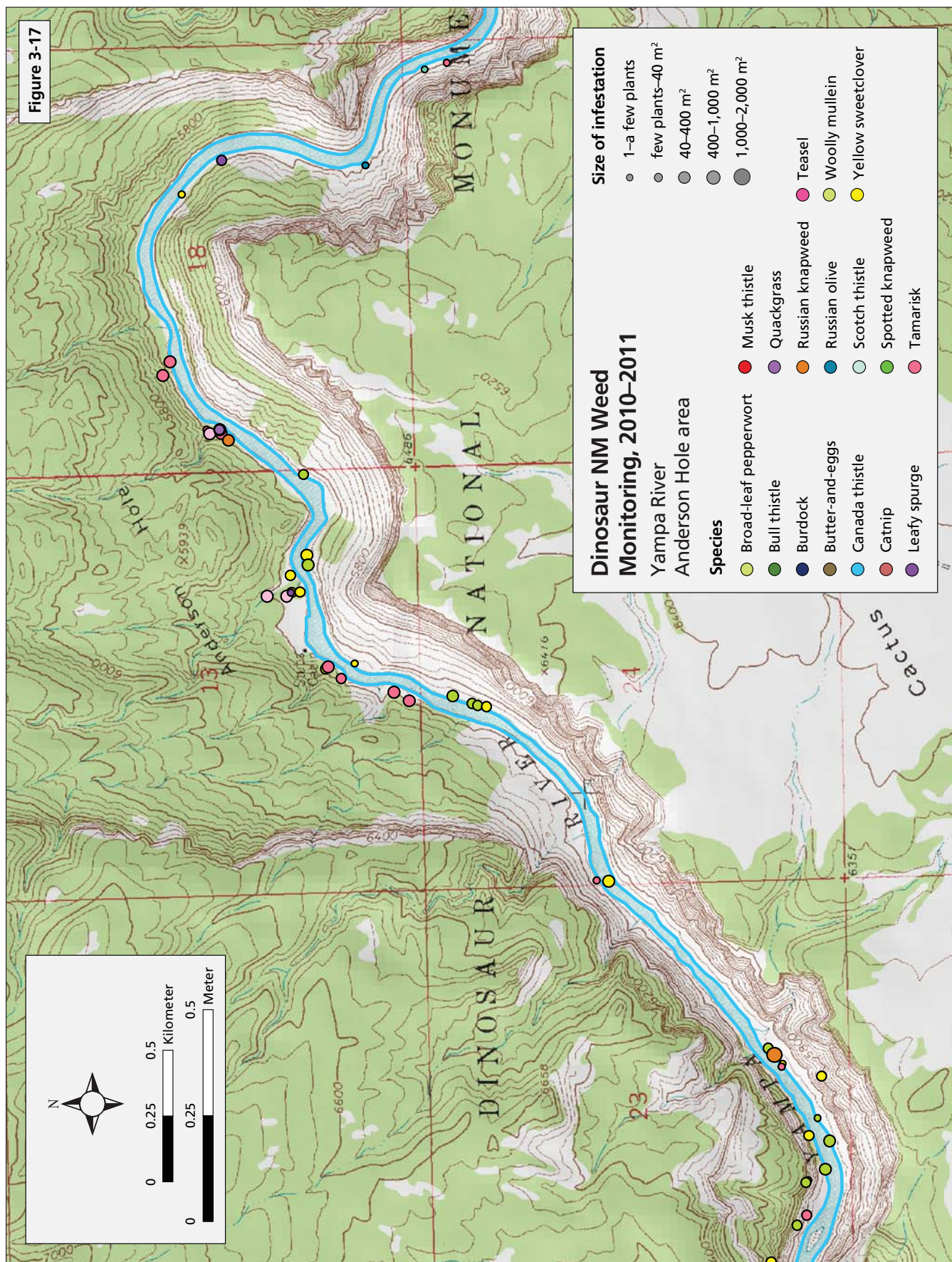


Figure 3-17. Invasive plants detected on monitoring routes around Anderson Hole, Yampa River, Dinosaur NM, July 5–24, 2010.

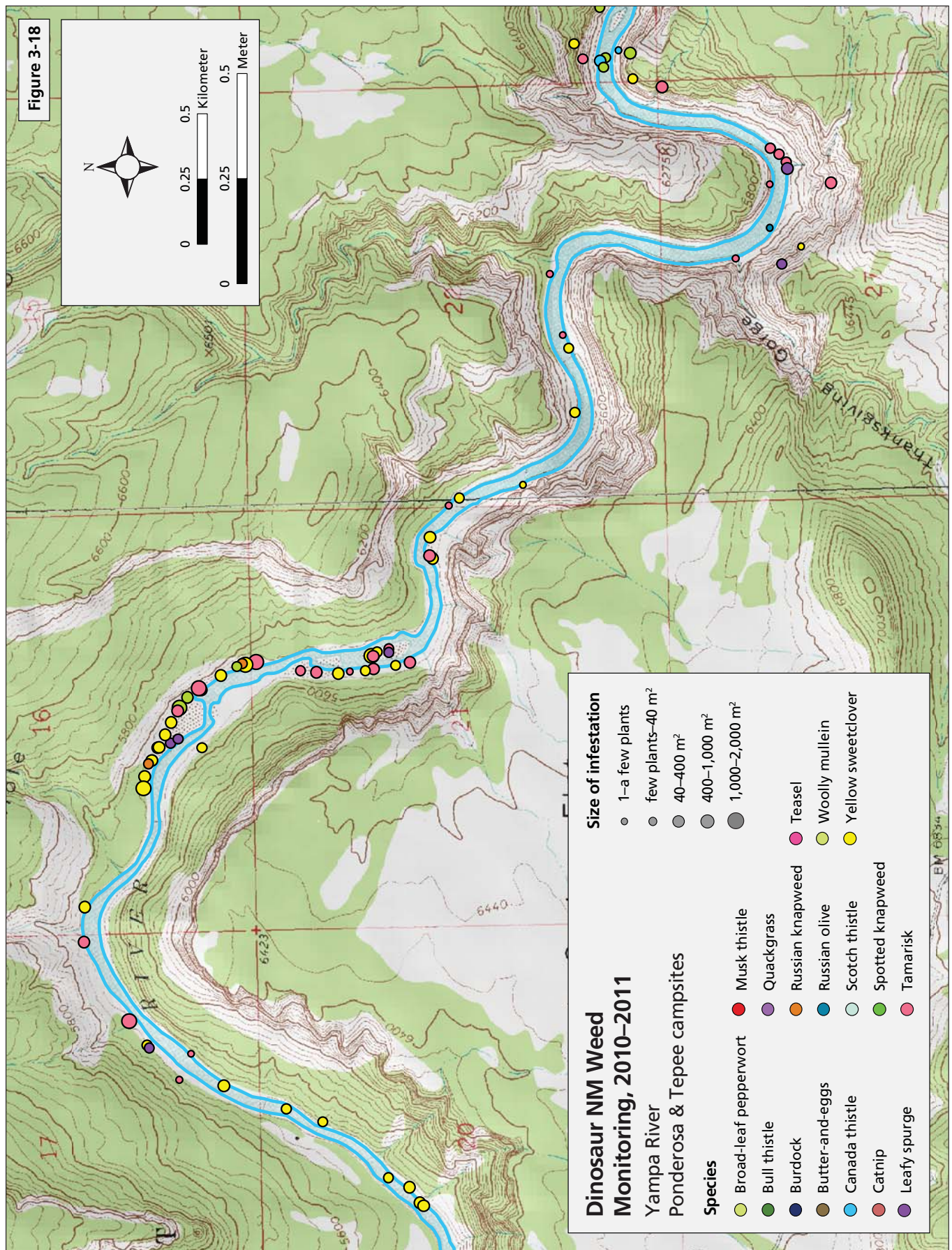


Figure 3-18. Invasive plants detected on monitoring routes around Ponderosa and Tepee campsites, Yampa River, Dinosaur NM, July 5–24, 2010.

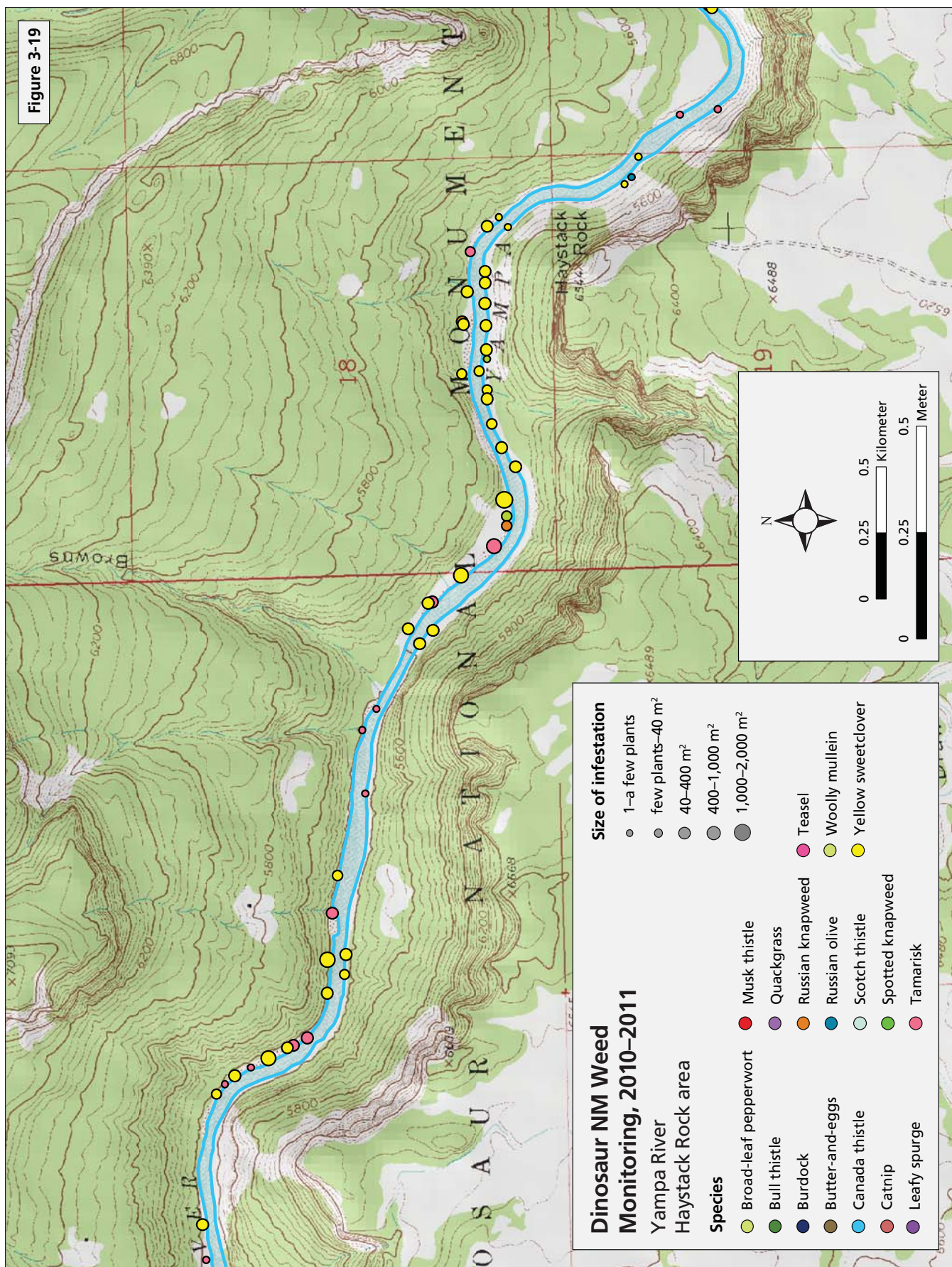


Figure 3-19. Invasive plants detected on monitoring routes around Haystack Rock, Yampa River, Dinosaur NM, July 5–24, 2010.

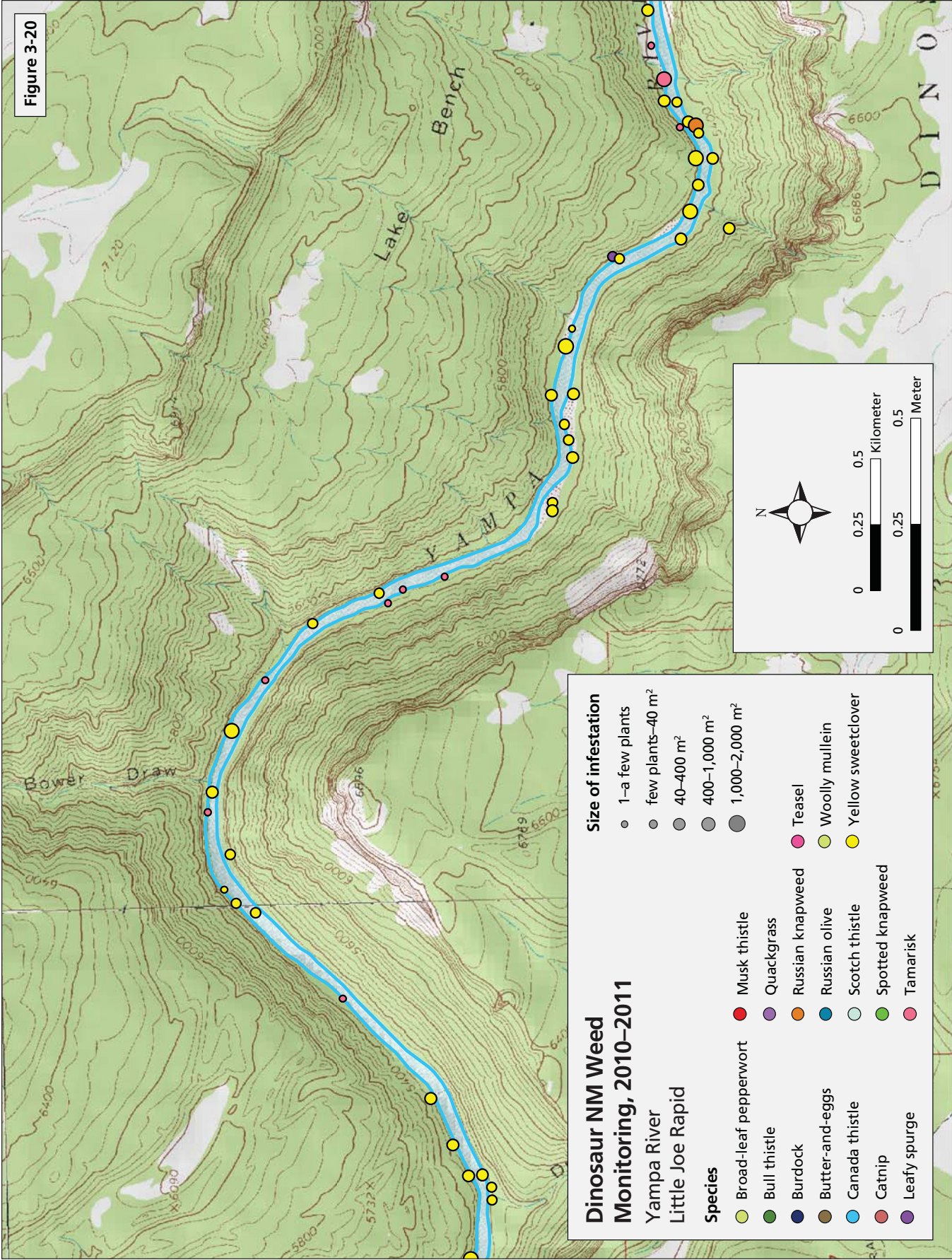


Figure 3-20. Invasive plants detected on monitoring routes around Little Joe Rapid, Yampa River, Dinosaur NM, July 5–24, 2010.

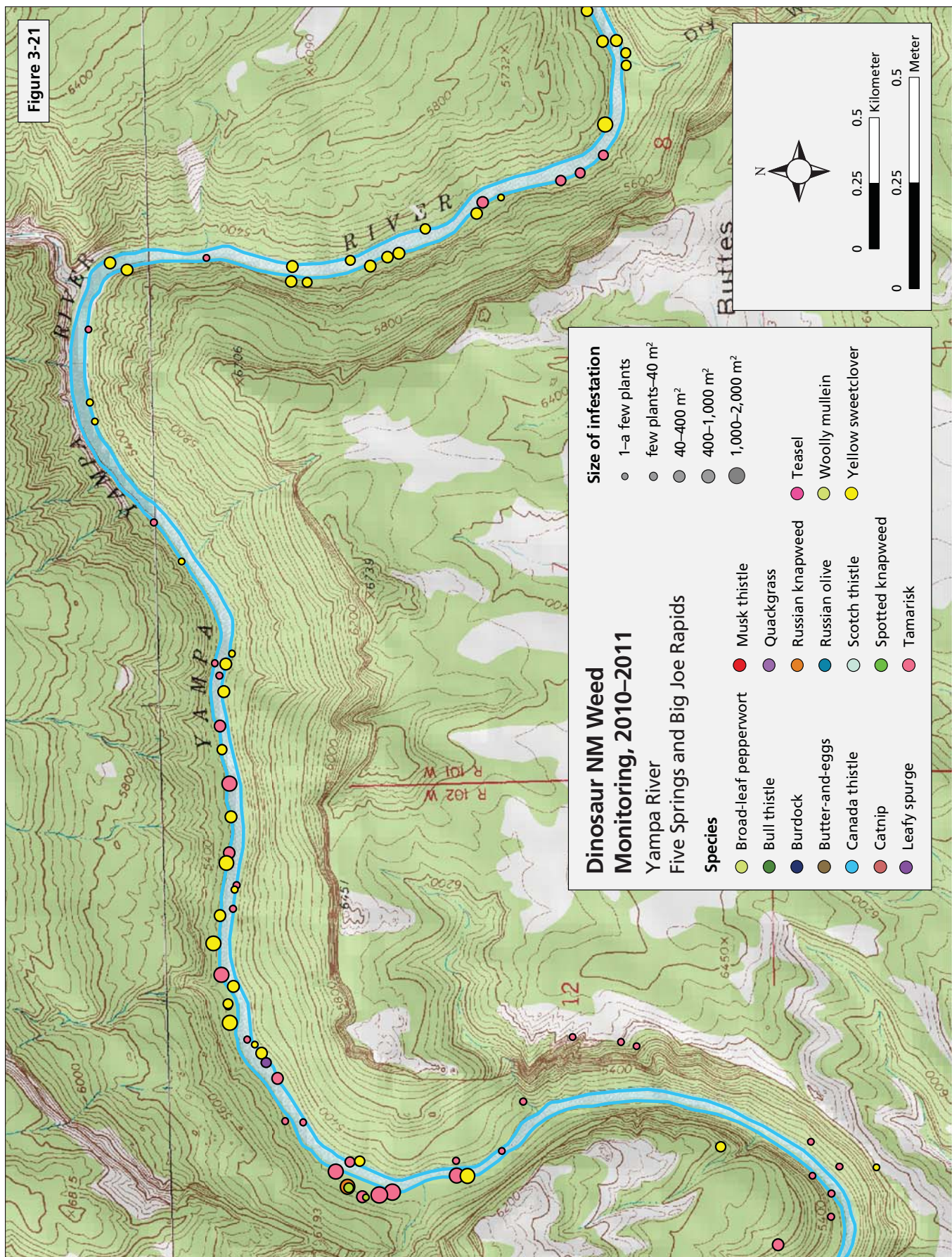


Figure 3-21. Invasive plants detected on monitoring routes around Five Springs and Big Joe Rapids, Yampa River, Dinosaur NM, July 5–24, 2010.

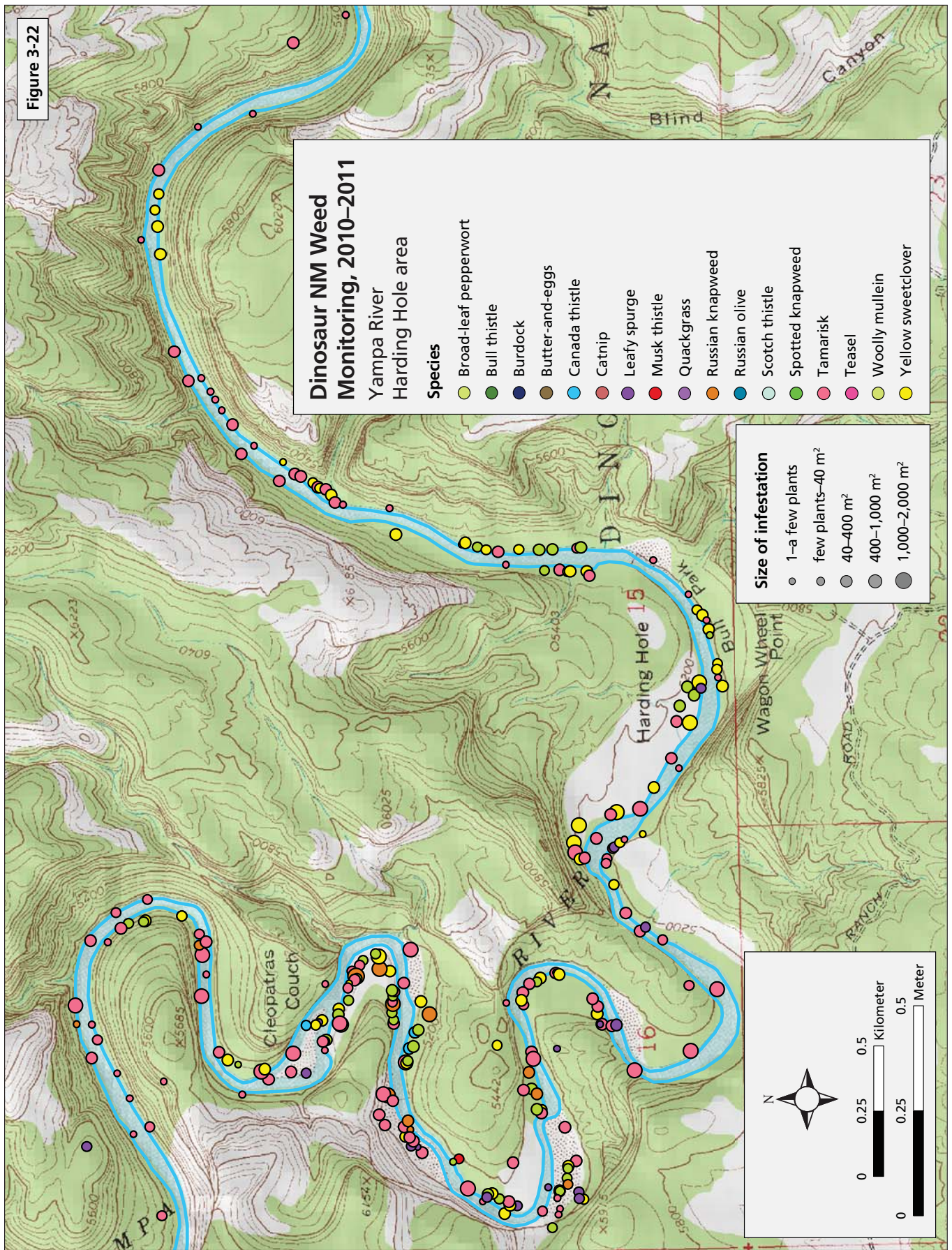


Figure 3-22. Invasive plants detected on monitoring routes around Harding Hole, Yampa River, Dinosaur NM, July 5-24, 2010.

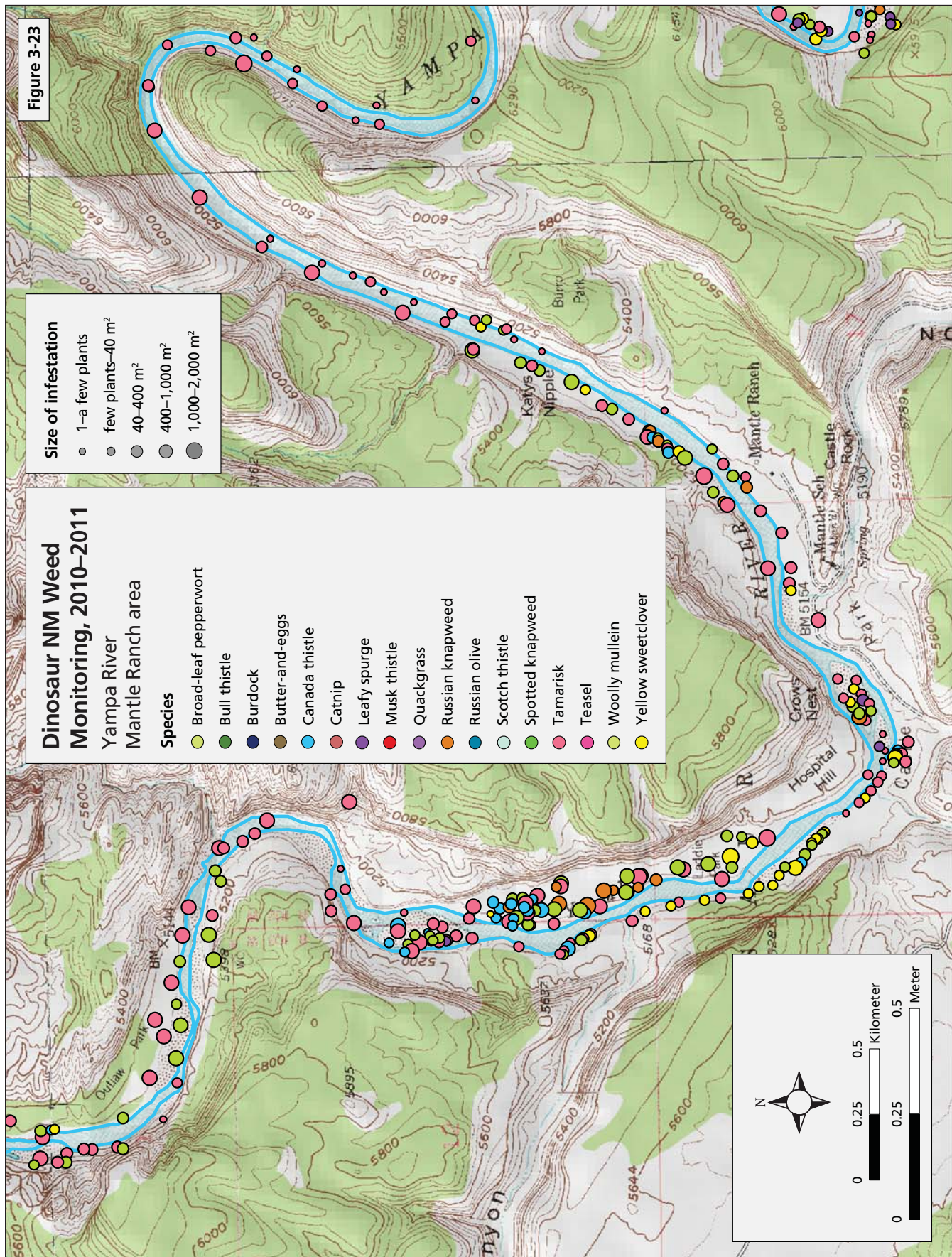


Figure 3-23. Invasive plants detected on monitoring routes around the Mantle Ranch, Yampa River, Dinosaur NM, July 5–24, 2010.

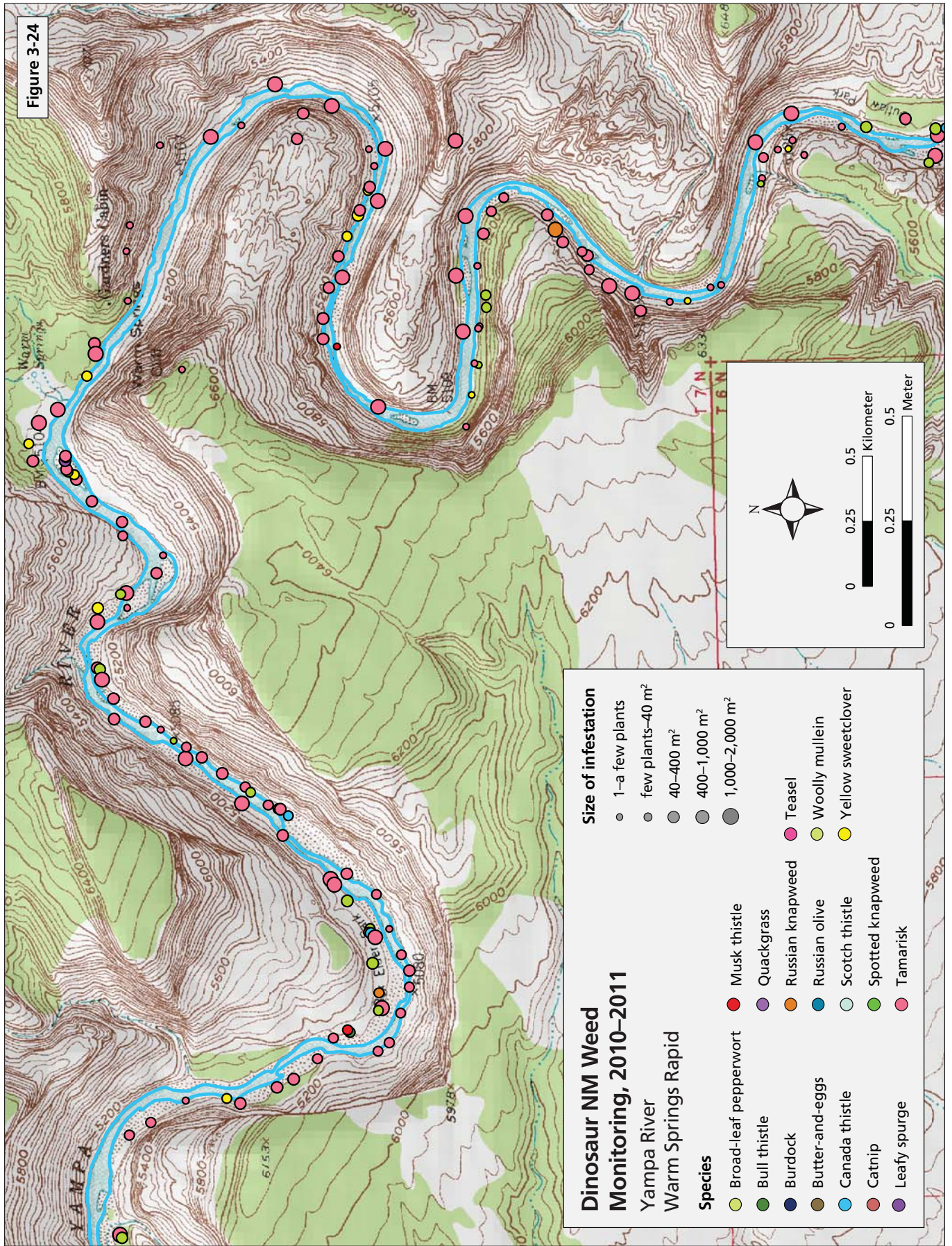


Figure 3-24. Invasive plants detected on monitoring routes around Warm Springs Rapid, Yampa River, Dinosaur NM, July 5–24, 2010.



## 4 Discussion

### 4.1 Priority invasive exotic plant list

The NCPN will continue to work with DINO staff and area weed experts to review and update the list of priority species each year.

### 4.2 Possibilities for management control

The Yampa River has fewer infestations per hectare than the upper and lower Green River for all IEP infestations and for almost all individual species that were detected in sufficient numbers along monitoring routes and on monitoring transects. One notable exception was leafy spurge, which was found at the highest levels on the Yampa River. There are several large infestations of leafy spurge upstream of the park on the Yampa River, while on the Green River upstream from the park there are fewer infestations. The upper Green generally had the highest infestations of individual species and the highest number of total priority infestations. Infestation numbers on the lower Green were usually between those on the upper Green and Yampa. The only exceptions to this were leafy spurge and Russian olive (highest on the lower Green). Nearly all of the Russian olive infestations found at DINO were located between the Split Mountain takeout and the western park boundary, along a broad alluvial plain where the water slows and sediment and seeds are deposited. This area has been subject to heavy eradication efforts by park staff and NPS Exotic Plant Management Teams since 2006.

Both on the river routes and in the more quantitative plots, we found the most invasives on the upper Green, medium amounts on the lower Green, and the least on the Yampa. Tamarisk, Canada thistle, and all priority IEPs combined were found in significantly higher numbers on the upper Green than the Yampa. Cheatgrass was found in significantly higher numbers on the lower Green than the Yampa and the upper Green, most likely due to the larger number of large alluvial valleys (parks) present on the lower Green compared to the mostly narrow canyon reaches of the Yampa and upper Green. The Yampa also generally had infestations of

smaller size than the upper or lower Green. This was most noticeable for tamarisk. On the Yampa, 57% of the tamarisk infestations were larger than 40 m<sup>2</sup>, while 97% and 90% of the infestations on the upper and lower Green were larger than 40 m<sup>2</sup>.

There are major differences in river regulation on these three river segments. The Yampa River is the largest free-flowing river left in the Colorado River Basin and has a mostly natural hydrograph. Large flood events result in scouring that keeps the active channel and active floodplain sparsely vegetated. The upper Green River is highly regulated by the Flaming Gorge Dam, which is approximately 45 miles upstream of DINO and has been operational since 1962. Grams and Schmidt (2002) found that Flaming Gorge Dam reduced the mean annual peak flow by 42% of the pre-1963 value, while the magnitude of the two-year return flow on the inflows to Flaming Gorge Reservoir decreased by only 12%. Below the confluence with the Yampa, the influences of regulation are partially mitigated by the wild Yampa. Peak flows on the lower Green River below the confluence with the Yampa River have been reduced by approximately 26%. Flaming Gorge Dam regulation has increased upper and lower Green River low (base) flows to approximately 220% and 230% of their pre-dam values, respectively (Cooper et al. 1999). However, more work is needed, and is planned, before we can say that river regulation is affecting invasive plant infestations on these river reaches. We plan to remove stretches of river that have been targeted for IEP eradication and control, stratify results by alluvial park and canyon settings, and compare daily discharge rates for additional analysis and statistical comparisons. A more in-depth report on the effects of river regulation on invasive plants at DINO is planned for the coming year.

### 4.3 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 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. 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 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.

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## Appendix A. Locations of Monitoring Transects at Dinosaur National Monument

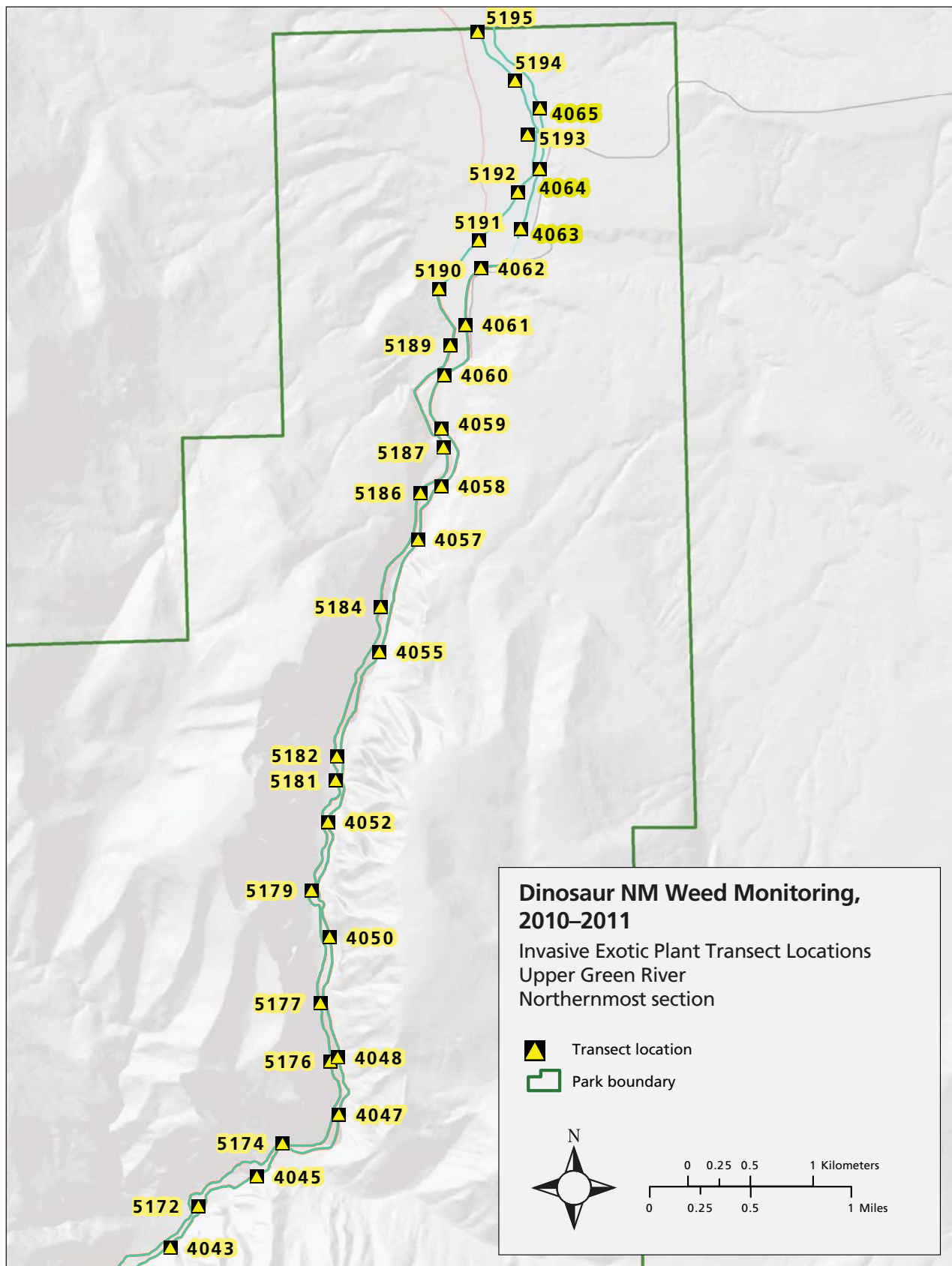


Figure B-1. Invasive plant monitoring transects along the northernmost section of the upper Green River, Dinosaur NM, July 5–24, 2010 and July 19–26, 2011.

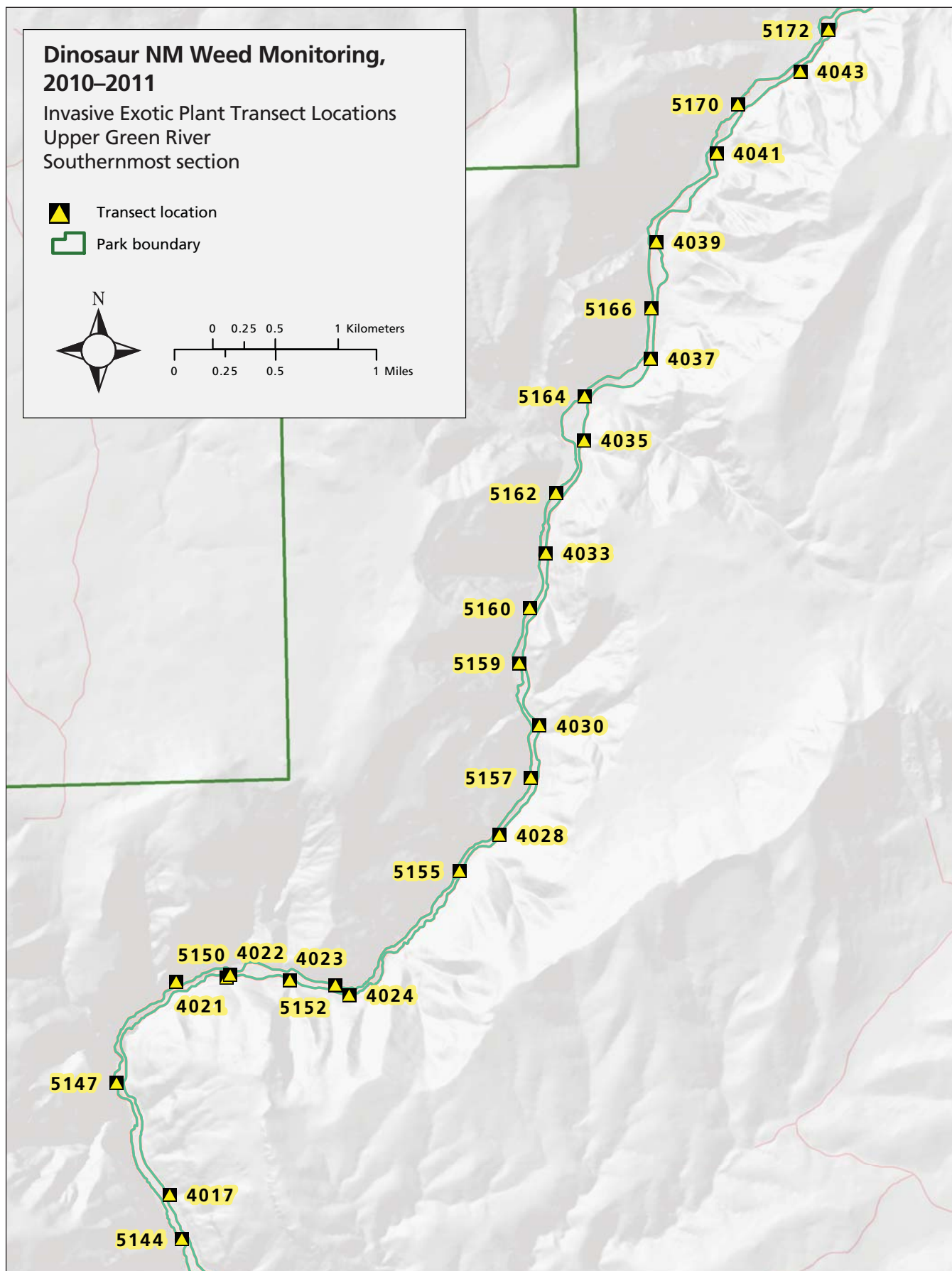


Figure B-2. Invasive plant monitoring transects along the southernmost section of the upper Green River, Dinosaur NM, July 5–24, 2010 and July 19–26, 2011.

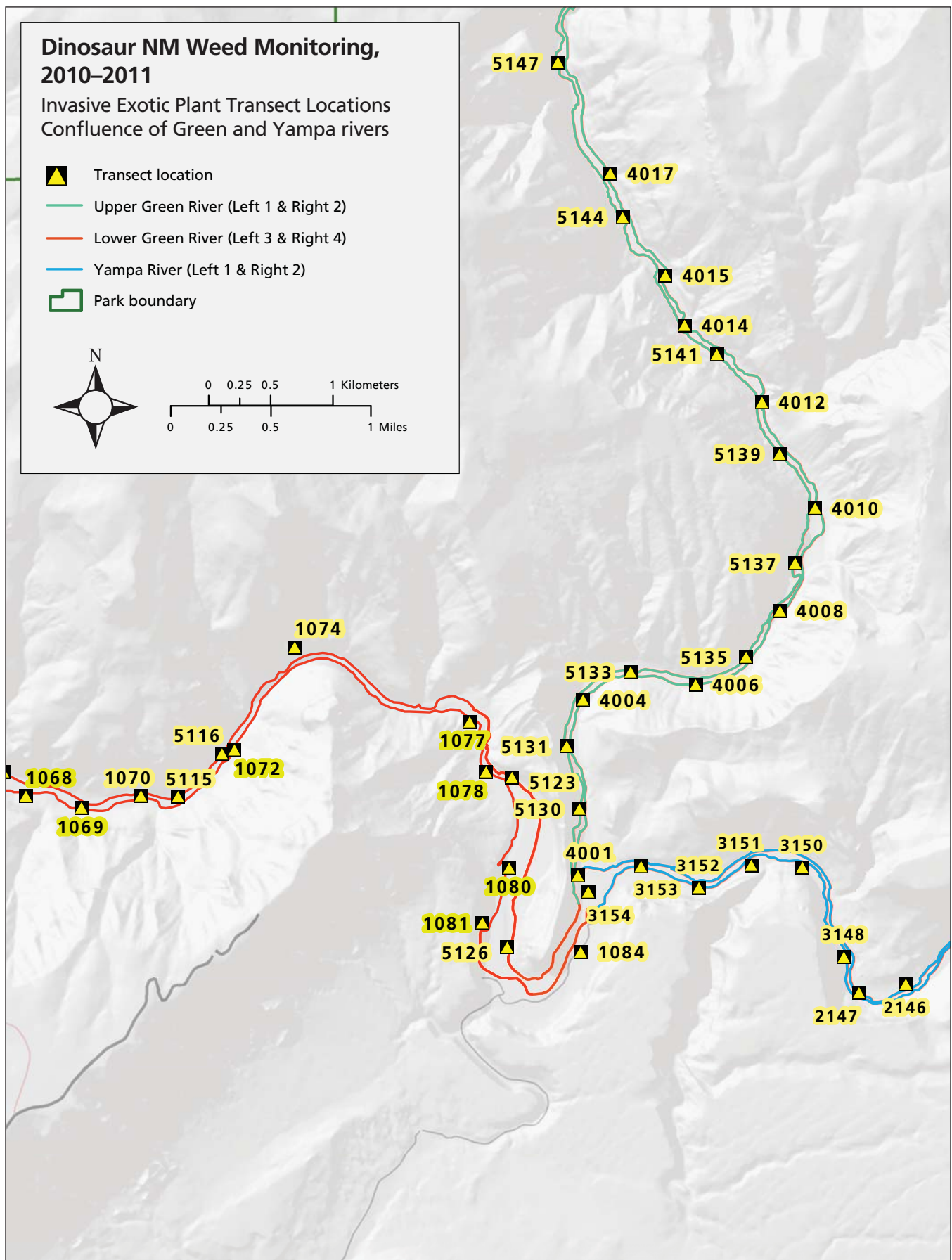


Figure B-3. Invasive plant monitoring transects around the confluence of the Yampa and Green Rivers, Dinosaur NM, July 5–24, 2010 and July 19–26, 2011.

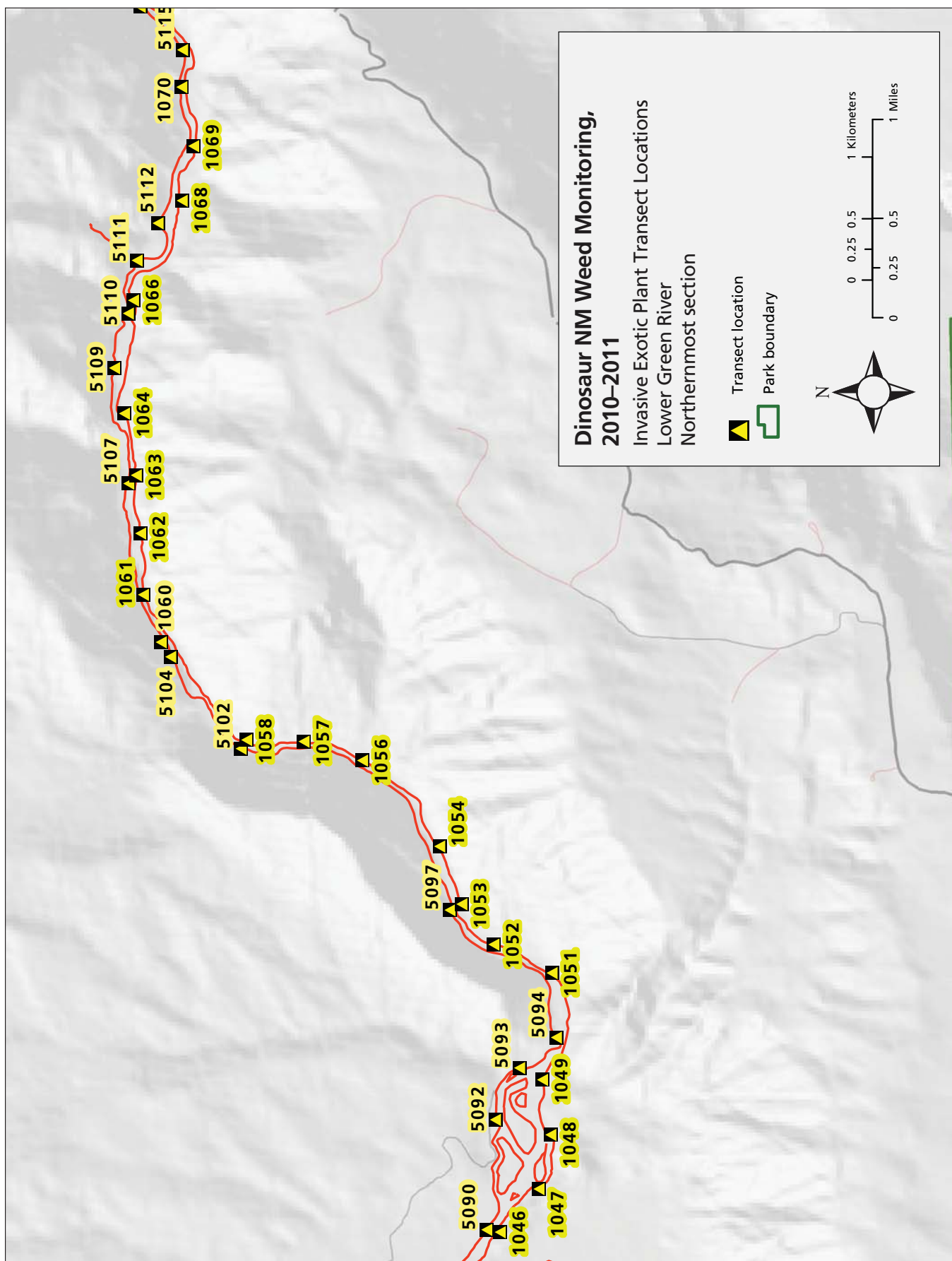
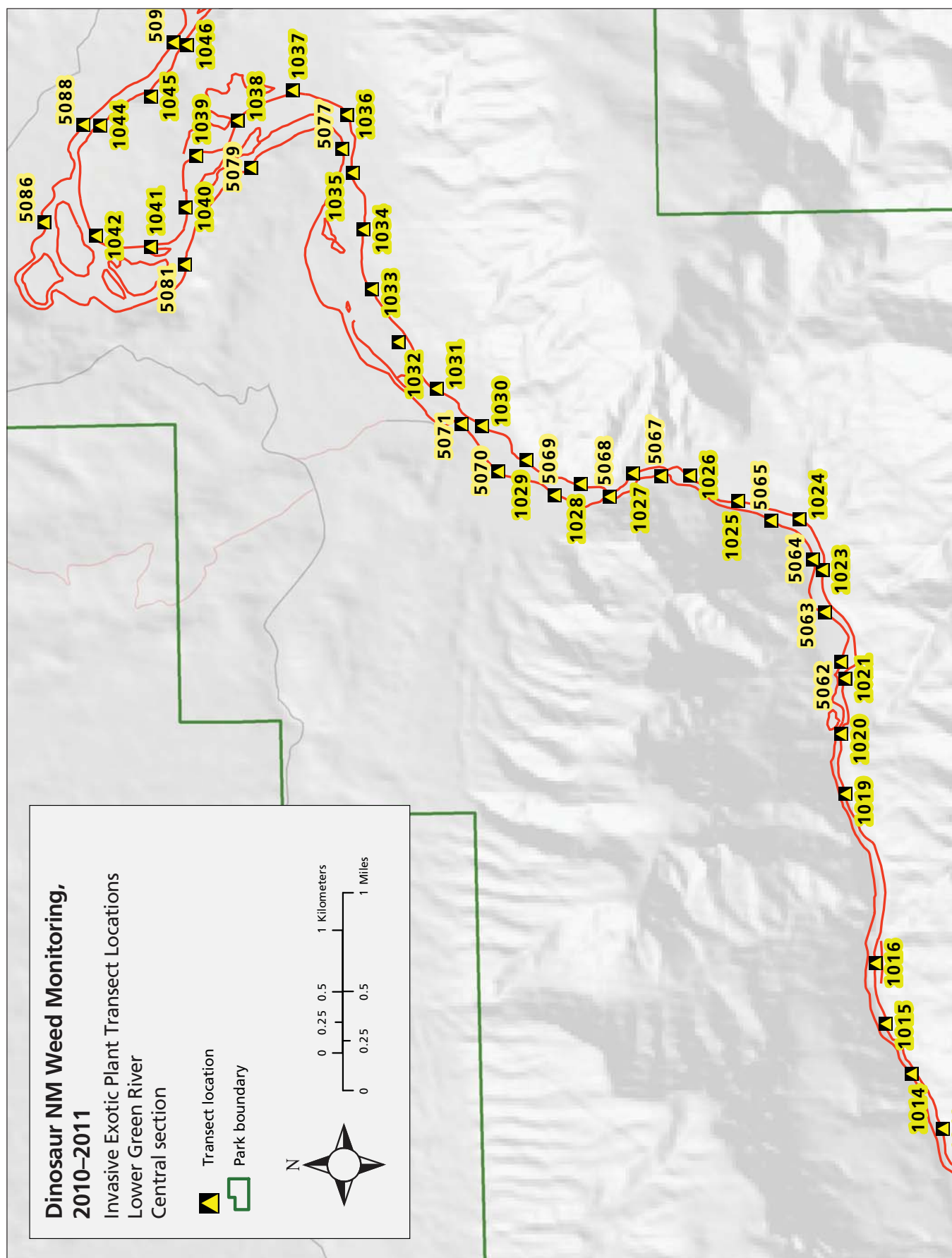


Figure B-4. Invasive plant monitoring transects along the northernmost section of the lower Green River, Dinosaur NM, July 19-26, 2011.



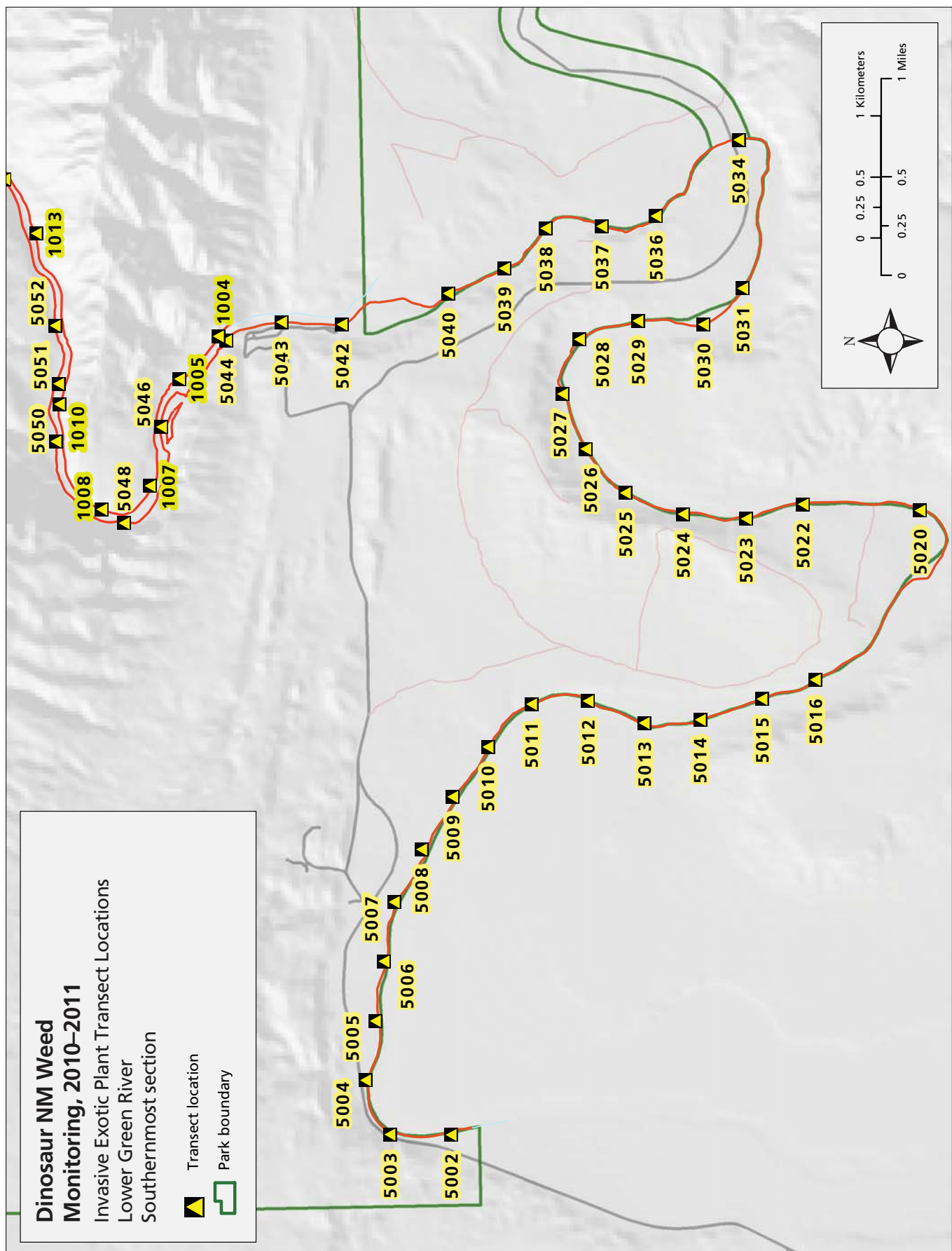


Figure B-6. Invasive plant monitoring transects along the southernmost section of the lower Green River, Dinosaur NM, July 5-24, 2010 and July 19-26, 2011.

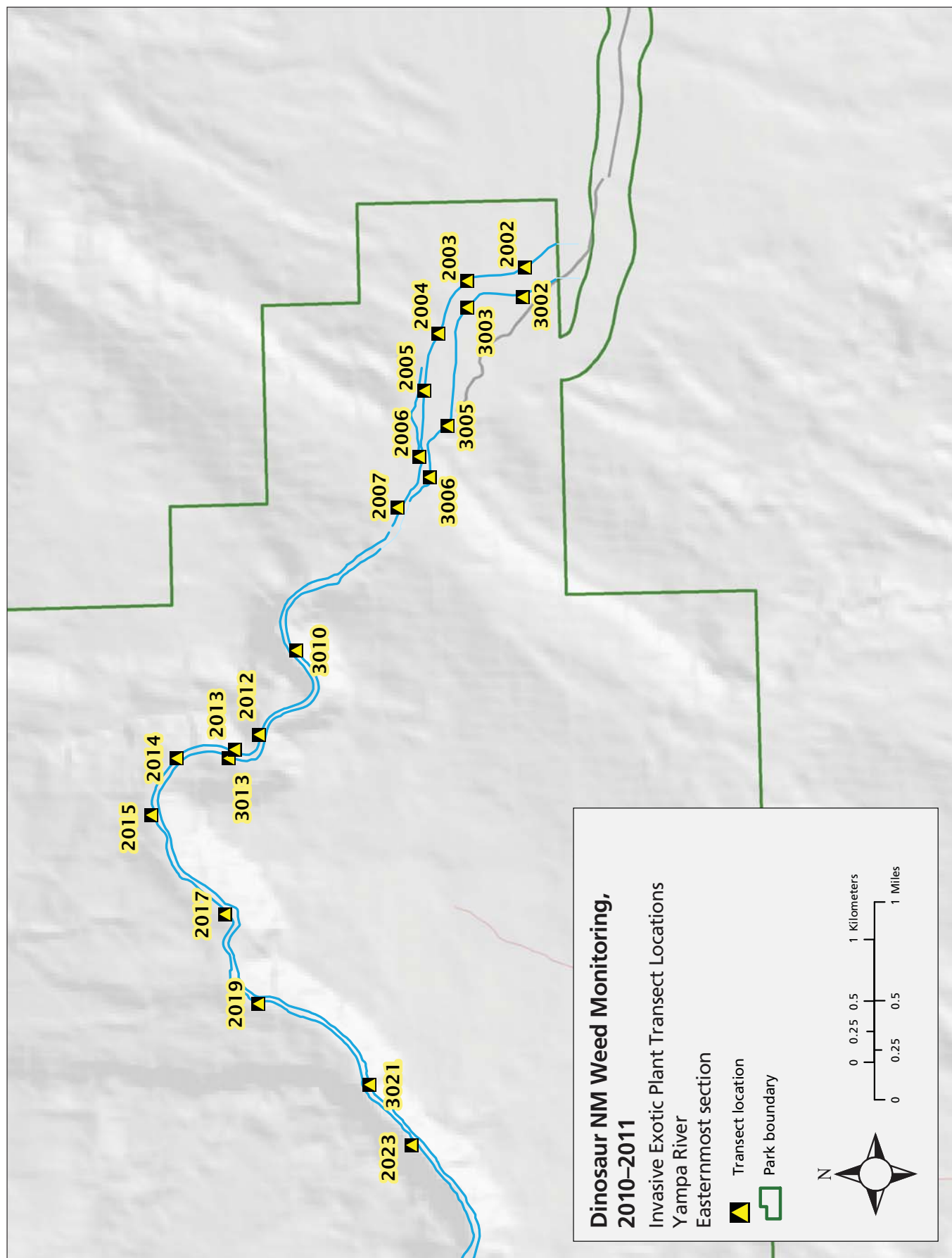


Figure B-7. Invasive plant monitoring transects along the easternmost section of the Yampa River, Dinosaur NM, July 5–24, 2010 and July 19–26, 2011.

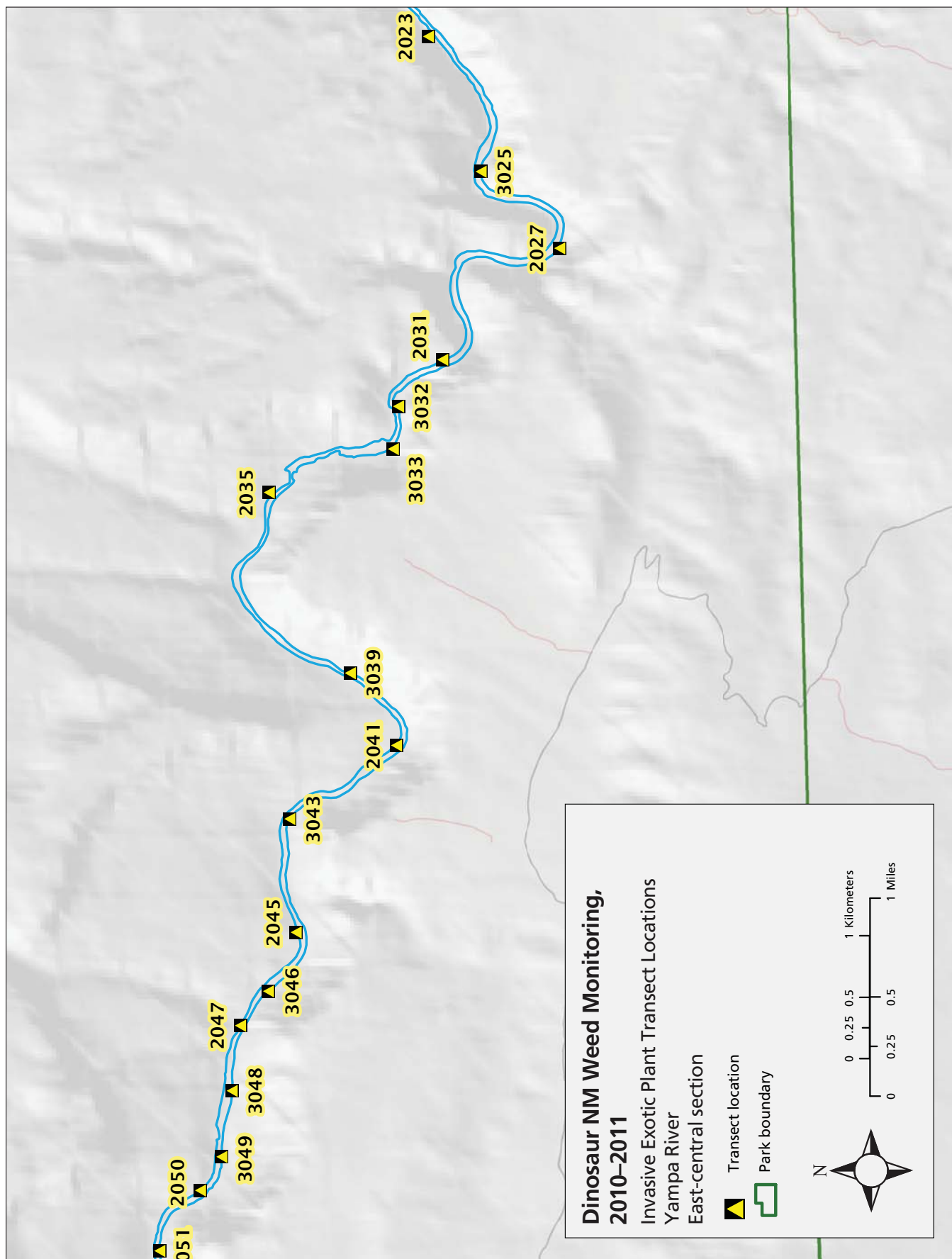


Figure B-8. Invasive plant monitoring transects along the east-central section of the Yampa River, Dinosaur NM, July 5–24, 2010 and July 19–26, 2011.

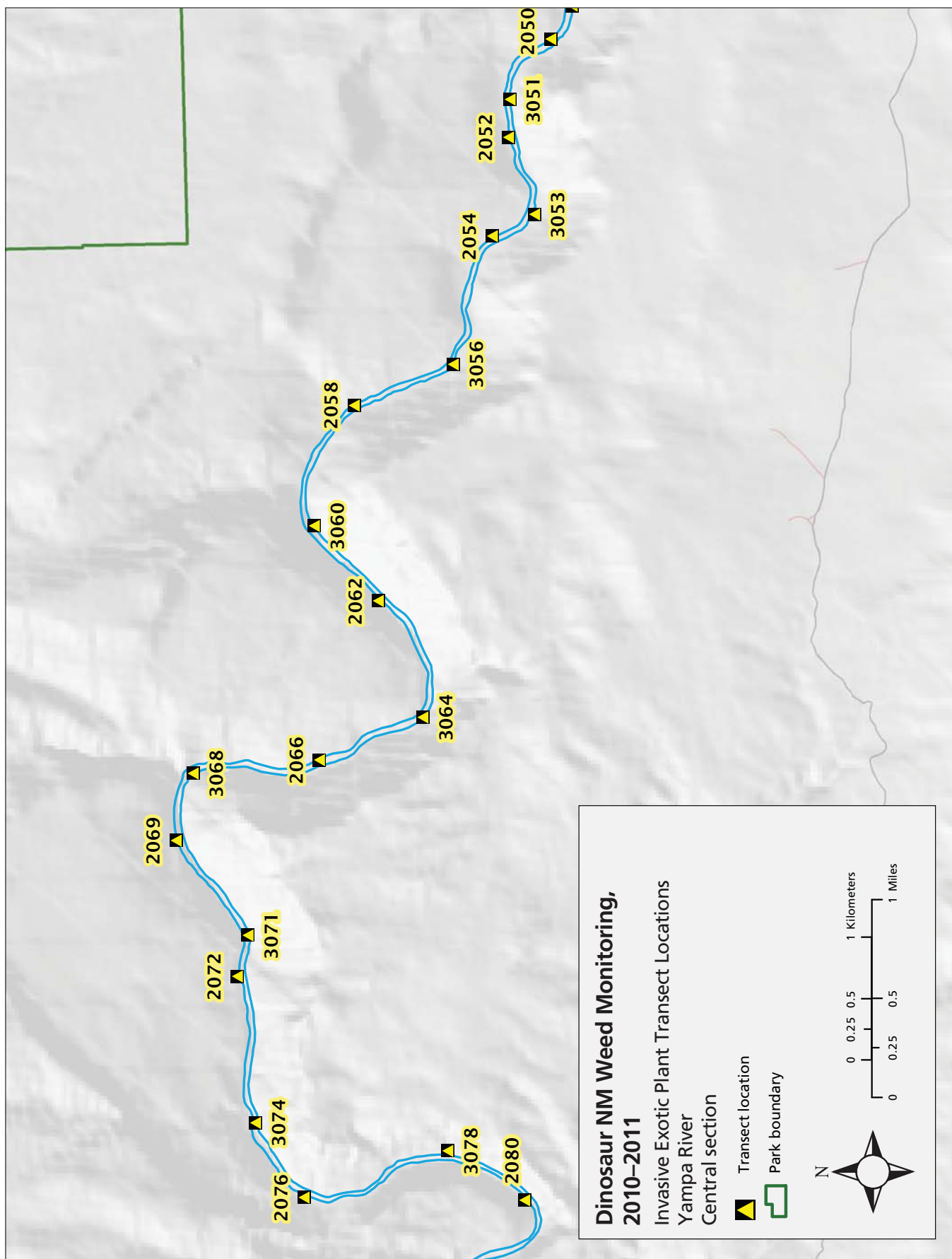
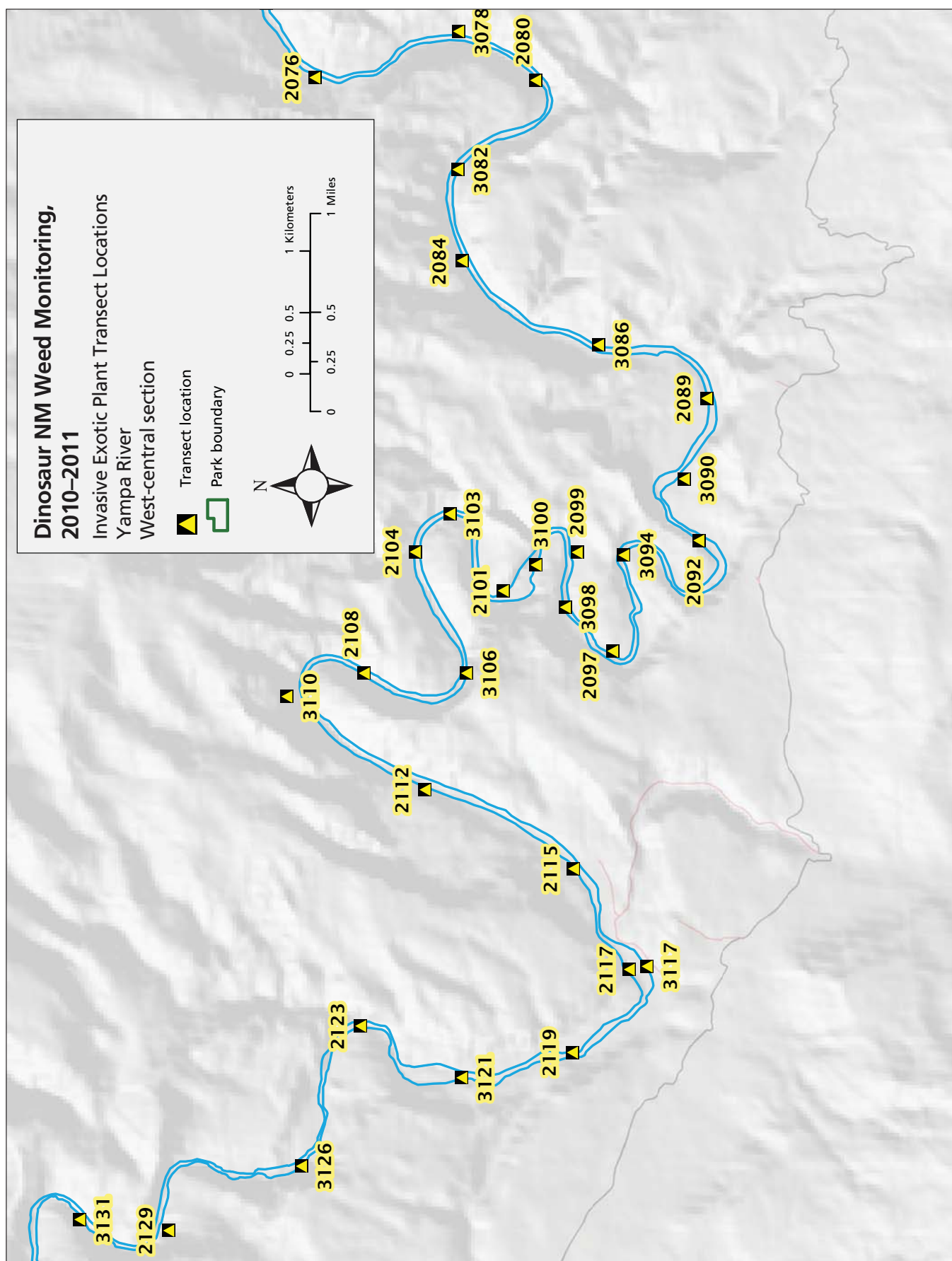


Figure B-9. Invasive plant monitoring transects along the central section of the Yampa River, Dinosaur NM, July 5-24, 2010.



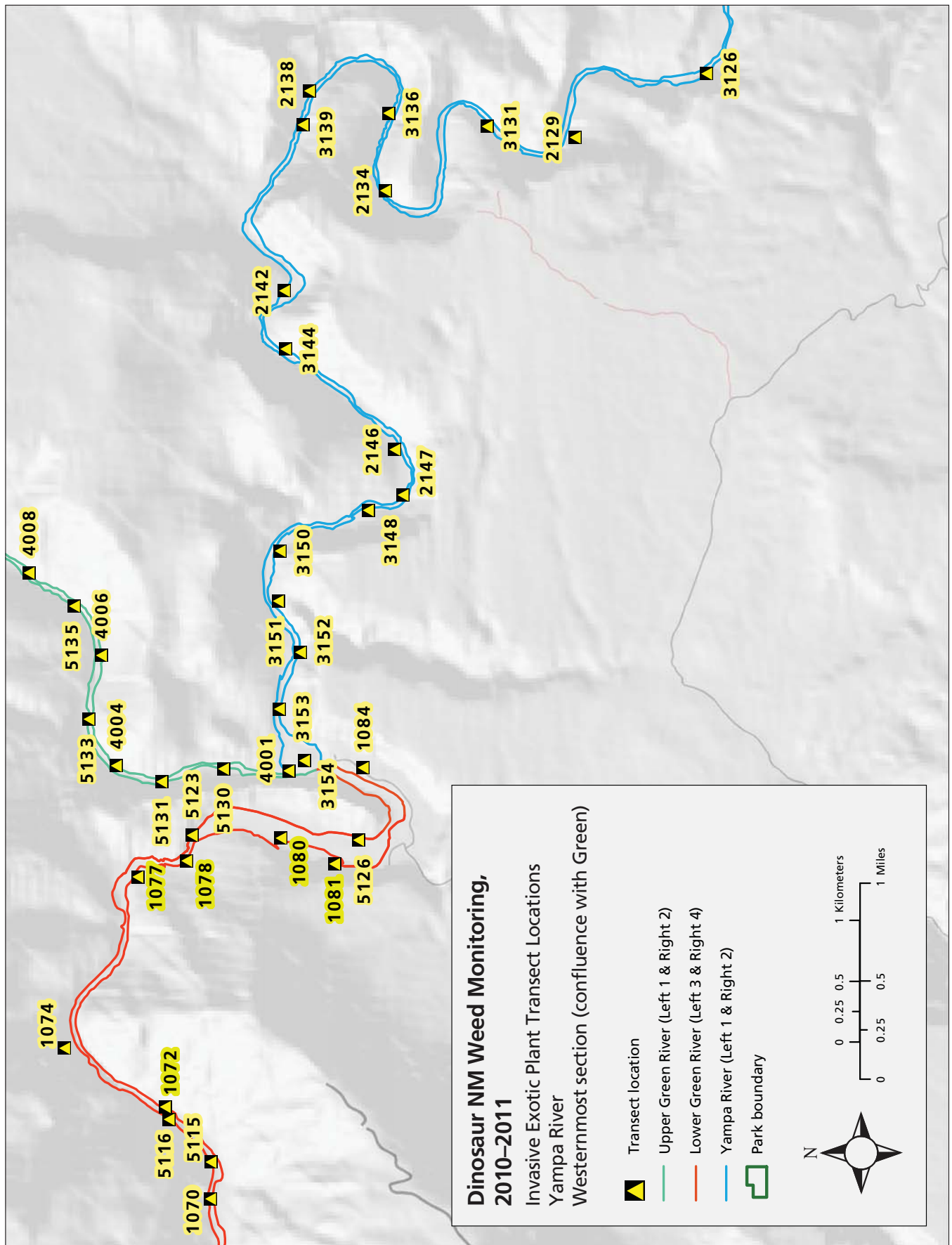


Figure B-11. Invasive plant monitoring transects along the westernmost section of the Yampa River, Dinosaur NM, July 5–24, 2010.

## **Appendix B. Exotic Plant Invasions Detected on Monitoring Routes, Dinosaur National Monument, July 5–24, 2010 and July 19–26, 2011**

See attached Excel spreadsheet.

## **Appendix C. Invasive Exotic Plant Percent Cover Detected on Monitoring Transects, Dinosaur National Monument, July 5–24, 2010 and July 19–26, 2011**

See attached Excel spreadsheet.

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NPS 122/113631, April 2012

**National Park Service**  
**U.S. Department of the Interior**



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