



Invasive Exotic Plant Monitoring at Dinosaur National Monument

2023 and 2024 Field Seasons



Cheatgrass (*Bromus tectorum*), an invasive species, growing near a badger burrow in northwestern Dinosaur National Monument.

NPS / AMY WASHUTA

Invasive exotic plant monitoring at Dinosaur National Monument: 2023 and 2024 field seasons

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Abstract

Invasive exotic plant (IEP) species are one of the biggest threats 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 11 monitoring protocols to be implemented as part of its long-term monitoring program. This report represents work completed during the 2023 and 2024 field season at Dinosaur National Monument (UT, CO). From August 16–23, 2023, and June 20–26, 2024, we found a total of 12 different priority IEP species during monitoring. A total of 4,683 IEP patches were recorded along 311.2 kilometers (193.4 miles) of 3 monitoring routes. Park managers can use this report to help prioritize IEP treatment. At Dinosaur National Monument, the NCPN monitors IEPs in the Green and Yampa River corridors. This represents the completion of the fourth monitoring rotation of the entire river corridor (2002–2005, 2010–2011, 2017–2019, 2023–2024). NCPN staff detected 12 priority IEP species and six non-priority species in an 84.6-hectare (209-acre) area along 311.2 kilometers (193.4 miles) of the Green and Yampa Rivers. A total of 4,683 IEP patches were detected. Of those patches, 24.9% were smaller than 40 m². Tamarisk (*Tamarix* sp.), broad-leaf pepperwort (*Lepidium latifolium*), yellow sweetclover (*Melilotus officinalis*), and Russian knapweed (*Acroptilon repens*) were the most widespread species. Yellow sweetclover has decreased on all three river reaches during the survey years. Musk thistle (*Carduus nutans*) was found at considerably lower levels than yellow sweetclover but has increased on the Green River above the confluence, while decreasing on the Green River below the confluence and Yampa River. Leafy spurge (*Euphorbia esula*) has remained stable on the Green River above and below the confluence and increased on the Yampa River. Cheatgrass (*Bromus tectorum*) was not monitored in the first rotation but decreased substantially in cover and percent frequency on all three river sections from 2017–2019 to 2023–2024. This increase may be due to recent high-flow scouring events. The highly regulated Green River above the confluence generally has the highest number of IEPs, while the Green River below the confluence has a moderate number of IEPs. The largely unregulated flows of the Yampa River continue to result in a lower number of patches per kilometer, lower percent cover, and lower percent frequency than the Green River above and below the confluence.

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1 Introduction

Invasive exotic species fragment native ecosystems, displace native plants and animals, and alter ecosystem function. Invasive species are among the top threats to biodiversity after species overexploitation and habitat loss (agricultural and urban development) (Maxwell et al. 2016; Scott and Wilcove 1998) and represent one of the most serious threats to natural ecosystem integrity (NRC 2002). Yet, 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, NCPN IEP monitoring 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, such as through cargo containers and air freight, represents a sudden pathway. 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 focuses 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.

At Dinosaur National Monument (NM), the NCPN monitors IEPs in the Green and Yampa River corridors. This report summarizes data from monitoring on the Green River above (“upper”) and below (“lower”) its confluence with the Yampa in 2023–2024, representing the completion of the fourth full monitoring rotation of the entire river corridor by Utah State University (2002–2005) and NCPN (2010–2011, 2017–2019, 2023–2024).

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.

This report summarizes the 2023 and 2024 field seasons and fourth complete monitoring rotation at Dinosaur National Monument (UT, CO).

2 Methods

We followed the invasive plant monitoring protocol developed by the NCPN (Perkins et al. 2016). The protocol emphasizes quick collection of IEP location and abundance data 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 capture the greatest amount of information (i.e., benefit) with the least amount of time and effort (i.e., cost).

To monitor IEPs, we establish a series of monitoring routes and transects. The transects, which are sampled in a quantitative manner, are used to make inferences 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. Extra areas are used to cover areas of management concern that may be susceptible to invasive species invasions.

2.1 Developing a Park Target Invasive Exotic Plant List

In 2010, NCPN and Dinosaur NM staff developed a list of priority IEPs for the park by reviewing past park literature and state and county weed lists, and consulting with park staff and county weed managers. The list was reviewed and updated for the 2011, 2014, 2017, and 2019 field seasons. The current priority list (Table 1) includes 24 existing and potential IEPs of high management concern. One additional species, cheatgrass (*Bromus tectorum*), is only monitored in transects due to its widespread presence.

Table 1. Priority invasive plant list, Dinosaur National Monument, 2023–2024.

Scientific Name	Common Name
<i>Acroptilon repens</i>	Russian knapweed
<i>Aegilops cylindrica</i> ^A	jointed goatgrass
<i>Arctium minus</i>	burdock
<i>Cardaria</i> spp. ^B	whitetop
<i>Carduus nutans</i>	musk thistle
<i>Centaurea diffusa</i>	diffuse knapweed
<i>Centaurea solstitialis</i> ^A	yellow star-thistle
<i>Centaurea stoebe</i>	spotted knapweed
<i>Cirsium arvense</i>	Canada thistle
<i>Cirsium vulgare</i>	bull thistle
<i>Cynoglossum officinale</i>	common hound's tongue

^A Added in 2010–2011. All other IEPs have been on the priority list since 2002–2005.

^B Changed *Cardaria draba*, *Cardaria chalepensis*, and *Cardaria pubescens* to *Cardaria* spp. in 2017.

^C Listed as *T. ramosissima* in 2002–2005 and *T. chinensis* in 2010–2011.

Table 1 (continued). Priority invasive plant list, Dinosaur National Monument, 2023–2024.

Scientific Name	Common Name
<i>Dipsacus fullonum</i> ^A	common teasel
<i>Elaeagnus angustifolia</i>	Russian-olive
<i>Euphorbia esula</i>	leafy spurge
<i>Hyoscyamus niger</i>	black henbane
<i>Lepidium latifolium</i>	broad-leaf pepperwort
<i>Linaria dalmatica</i>	Dalmatian toadflax
<i>Linaria vulgaris</i> ^A	butter-and-eggs
<i>Lythrum salicaria</i>	purple loosestrife
<i>Melilotus officinalis</i>	yellow sweetclover
<i>Onopordum acanthium</i>	Scotch thistle
<i>Taeniatherum caput-medusae</i>	Medusahead
<i>Tamarix</i> sp. ^C	tamarisk
<i>Tribulus terrestris</i>	puncture vine

^A Added in 2010–2011. All other IEPs have been on the priority list since 2002–2005.

^B Changed *Cardaria draba*, *Cardaria chalepensis*, and *Cardaria pubescens* to *Cardaria* spp. in 2017.

^C Listed as *T. ramosissima* in 2002–2005 and *T. chinensis* in 2010–2011.

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.

Prior to the start of monitoring in 2023, NCPN and park staff reviewed the list of high-priority target IEPs (Table 1) that was developed in 2010. No new species were added to the list in 2023 and 2024.

2.2 Monitoring Routes

2.2.1 Minimum Detection Target Size

The minimum detection target size (MDTS) represents the patch size that was large enough to detect 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 that any missed patches smaller than the MDTS could still feasibly be eradicated if not found until the next scheduled monitoring visit. The NCPN has established an MDTS of 40 m² (0.01 acres, or approximately 20 × 20 ft) for all IEPs. Use of the MDTS is necessary because field technicians are 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 tamarisk (*Tamarix* sp.), 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 unless the observer is very close to the patch.

2.2.2 Effective Detection Distance

The effective detection distance (EDD) is the maximum distance from which a searcher can consistently detect (i.e., see and recognize) the MDTs of the least-visible targeted species with at least 90% detection efficiency (Figure 1). Crew members are trained by walking away from fake plants of a targeted size and determining the maximum distance from which they could consistently see and recognize the patch with complete confidence. The size of the EDD is then estimated in the field by crew members. The distance is measured either by pacing or using a laser rangefinder. The EDD for Dinosaur NM was between 5 and 15 meters in 2023 and 2024, depending on vegetation density, topography, and mode of transport (Figure 1).

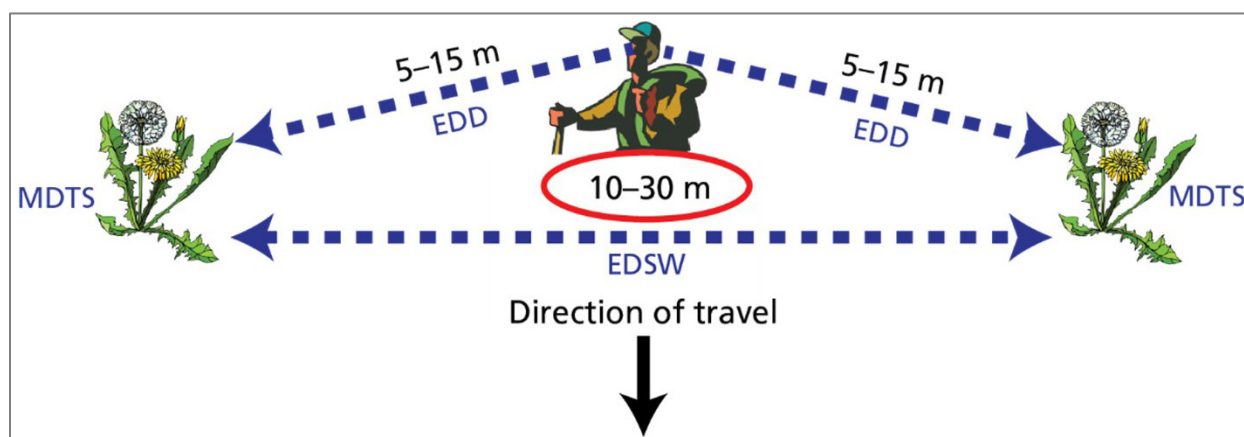


Figure 1. The maximum Effective Detection Distance (EDD) at Dinosaur National Monument ranged from 5 to 15 meters in 2023 and 2024, making the Effective Detection Swath Width (EDSW) 10–30 meters.
NPS / ALICE WONDRAK-BIEL AND ELIOT RENDLEMAN

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. For monitoring routes along the Green River, the EDSW was equal to the EDD because the surveyor was on or near the river's edge and only looking to the right or left, but not both (see Figure 1).

2.2.4 Patch Separation Resolution

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

2.2.5 Data Collection Methods

Only priority species were consistently recorded during monitoring routes. Survey crew members were permitted to record additional species if they were noteworthy. Surveyors walked or searched from a raft, following linear routes on each side of the Green River. While traveling along the route, surveyors searched for IEPs by visually scanning the land within the width of the EDSW. Because the purpose of the monitoring is to detect invasive plants rather than to control them, plants were generally not pulled unless they comprised an isolated population.

When a priority IEP was discovered, we recorded the following information: (1) monitoring route, (2) sequential number of the invasion per monitoring route, (3) patch size class (see below), (4) whether the plant was pulled, and (5) 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 meters apart were considered separate patches and recorded with a separate point.

Patch size class was estimated as follows:

1. 1–3 plants (used for isolated single plants or very small patches ($\leq 2 \times 2$ m)),
2. Four 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 cover class by estimating the amount, or “percentage,” of ground covered by the vertical projection of plant matter in the infestation patch 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. Percent 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 patch: 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

2.3.1 Quadrat Establishment

From 2010 to 2024, we established one transect with three vegetation quadrats perpendicular to the river's edge every kilometer along the monitoring route. We centered vegetation quadrats at 0.5, 5, and 10 meters away from the edge of the river on the side being monitored. A 1-m² sampling frame, used to sample vegetation cover and soil-surface features, was placed on the transect line as the technician walked the monitoring route. In some cases, we leveled the sampling frame by propping up quadrat corners.

2.3.2 Data Collection Methods

In the monitoring quadrats, we recorded all priority IEP species as well as cheatgrass. 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, 100%. We also recorded percent cover 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) using the same classes.

2.4 Analyses

We calculated the mean number of patches per kilometer for monitoring routes. Percent cover estimates for monitoring routes or groups of monitoring routes were generated from the monitoring transect data. We calculated the mean and standard error of percent cover by species for monitoring quadrats. Due to differences in observers' knowledge, only priority species were used when comparing results from year to year.

2.5 Comparisons to Previous Surveys

The Green River corridor in Dinosaur National Monument was surveyed by Utah State University (USU) in 2002–2005 (Dewey and Anderson 2005) and by NCPN in 2010–2011, 2014–2017, and 2023–2024 (Perkins 2012). Since 2002–2005, twenty priority IEP species have been consistently monitored along the Green River (see Table 1). An additional four IEP species have been consistently monitored along the Green and Yampa rivers since 2010–2011. Unless otherwise mentioned, comparisons are only made for priority species monitored consistently between 2002–2005 and 2024. Methods were largely similar across these years, but the USU observers used different patch-area categories, such as polygons and lines, and a PSR of 50 yards in 2002–2005. In contrast, in 2010–2024 transects were completed using the methods outlined in Sections 2.2 and 2.3, and therefore, only broad comparisons should be made between the USU and NCPN surveys..

3 Results

3.1 Target Invasive Exotic Plant List

In 2023–2024, field crews searched monitoring routes for 24 species identified as high-priority at Dinosaur NM (Table 1). Cheatgrass (*Bromus tectorum*) and bulbous bluegrass (*Poa bulbosa*) were also monitored in transects. 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 for the areas searched, but absence data for other species are suspect. We recorded a total of 13 IEP species along 311.2 kilometers (193.4 miles) of monitoring routes and transects in 2023 and 2024 (Table 2).

Table 2. Invasive exotic plants detected at Dinosaur National Monument, August 16–23, 2023 and June 20–26, 2024.

Scientific Name	Common Name	Method Detected	Park Priority
<i>Acroptilon repens</i>	Russian knapweed	Routes, Transects	Yes
<i>Arctium minus</i>	burdock	Routes	Yes
<i>Bromus tectorum</i>	cheatgrass	Transects	No
<i>Cardaria</i> spp.	whitetop	Routes	Yes
<i>Carduus nutans</i>	musk thistle	Routes	Yes
<i>Cirsium arvensis</i>	Canada thistle	Routes, Transects	Yes
<i>Cirsium vulgare</i>	bull thistle	Routes	Yes
<i>Elaeagnus angustifolia</i>	Russian-olive	Routes	Yes
<i>Euphorbia esula</i>	leafy spurge	Routes, Transects	Yes
<i>Hyoscyamus niger</i>	black henbane	Routes	Yes
<i>Lepidium latifolium</i>	broad-leaf pepperwort	Routes, Transects	Yes
<i>Melilotus alba</i>	white sweetclover	Routes	No
<i>Melilotus officinalis</i>	yellow sweetclover	Routes, Transects	Yes
<i>Salsola</i> sp.	Russian thistle	Routes	No
<i>Sisymbrium altissimum</i>	tumble mustard	Routes	No
<i>Tamarix</i> sp.	tamarisk	Routes, Transects	Yes
<i>Ulmus pumila</i>	Siberian elm	Routes	No
<i>Verbascum thapsus</i>	woolly mullein	Routes	No

3.2 Monitoring Routes

We surveyed all the monitoring routes at Dinosaur NM in 2023 and 2024. A total of 4,683 patches of 12 different priority species were detected along the monitoring routes (Tables 3 and 4; Figures 2–35; NPS 2025a). Tamarisk (*Tamarix* sp.), Canada thistle (*Cirsium arvensis*), broad-leaf pepperwort (*Lepidium latifolium*), yellow sweet clover (*Melilotus officinalis*), Russian knapweed (*Acroptilon repens*), leafy spurge (*Euphorbia esula*), and musk thistle (*Carduus nutans*) were the most

widespread species (Table 4). Routes with the highest density of invasive plant patches were the Green River above the confluence (24.22 patches/km), followed by the Green River below the confluence with the Yampa (19.94 patches/km). The Yampa River had the lowest density of invasive plants (8.11 patches/km) (Table 3). Black henbane (*Hyoscyamus niger*) was found on the Yampa River in 2017 and 2024, but not on the Green River in 2019 or 2023.

Table 3. Monitoring routes surveyed, route type, length, number of IEP infestations, and number of infestations/km, Dinosaur NM, August 16–23, 2023 and June 20–26, 2024.

Dinosaur NM Route	Type of Route	Length (km)	Area (ha)	# of Infestations	Infestations/km
Yampa River	Drainage	152.56	229.37	1,237	8.11
Upper Green River	Drainage	65.89	52.78	1,596	24.22
Lower Green River	Drainage	92.76	92.91	1,850	19.94
Total	–	311.21	375.07	4,683	15.05

Table 4. Species observed and infestation size class detected along all monitoring routes, Dinosaur NM, August 16–23, 2023 and June 20–26, 2024.

Species	Total Infestations	1 to Few Plants	Few Plants– 40 m²	40– 400 m²	400– 1000 m²	>1000 m²
<i>Arctium minus</i>	4	1	1	2	0	0
<i>Cardaria</i> spp.	9	0	6	3	0	0
<i>Carduus nutans</i>	107	16	33	21	6	31
<i>Centaurea repens</i>	271	1	61	106	80	23
<i>Cirsium arvense</i>	261	2	48	141	44	26
<i>Cirsium vulgare</i>	9	3	5	1	0	0
<i>Elaeagnus angustifolia</i>	9	9	0	0	0	0
<i>Euphorbia esula</i>	159	1	13	84	38	2
<i>Hyoscyamus niger</i>	1	1	0	0	0	0
<i>Lepidium latifolium</i>	365	9	74	124	81	77
<i>Melilotus officinalis</i>	319	12	126	99	67	15
<i>Tamarix</i> sp.	3,169	200	545	1,184	979	261
Priority Species, Total	4,683	255	912	1,765	1,295	435

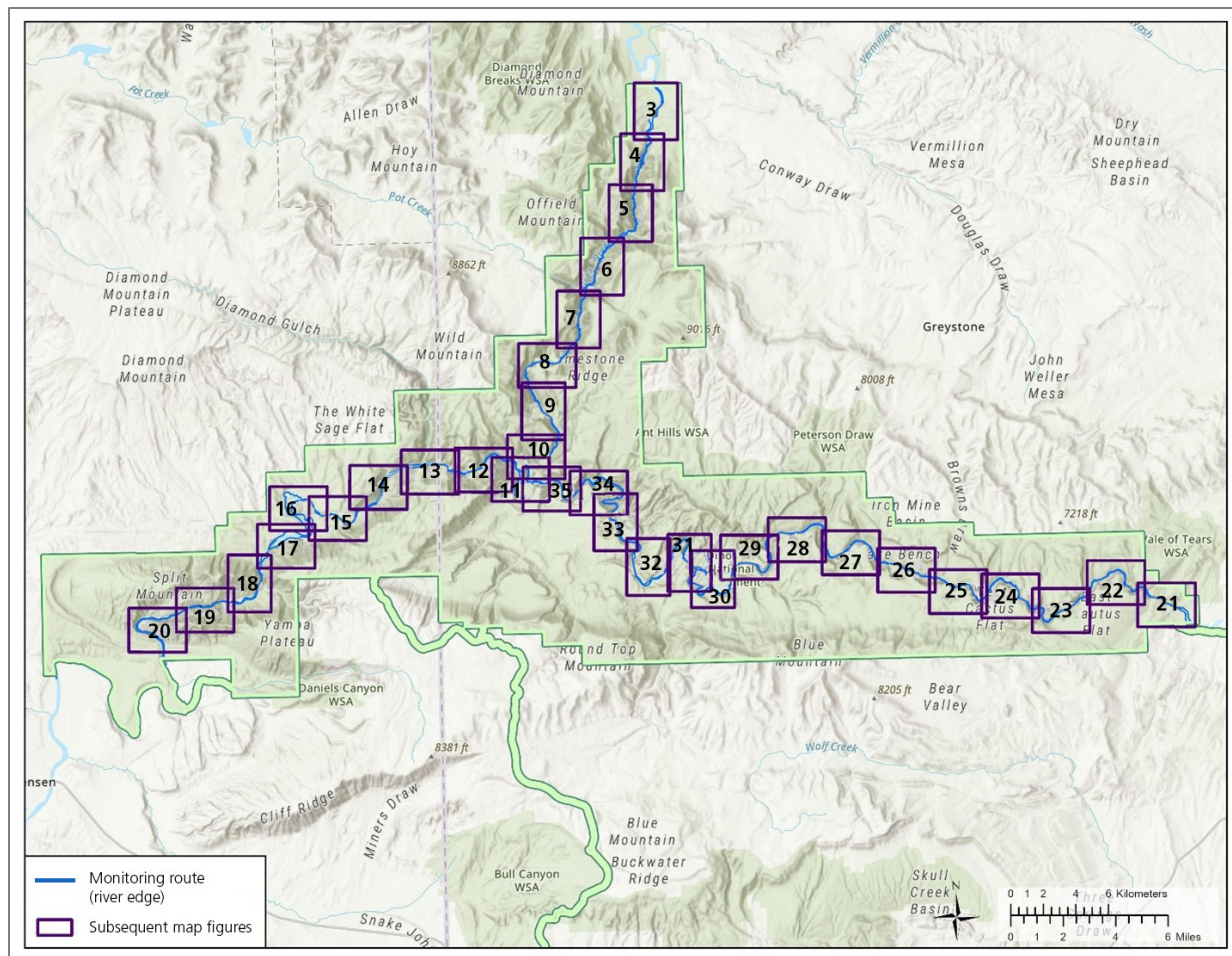


Figure 2. Index map of invasive plant monitoring routes by figure number, Dinosaur National Monument, August 16–23, 2023 and June 20–26, 2024.

NPS / ANETH WIGHT

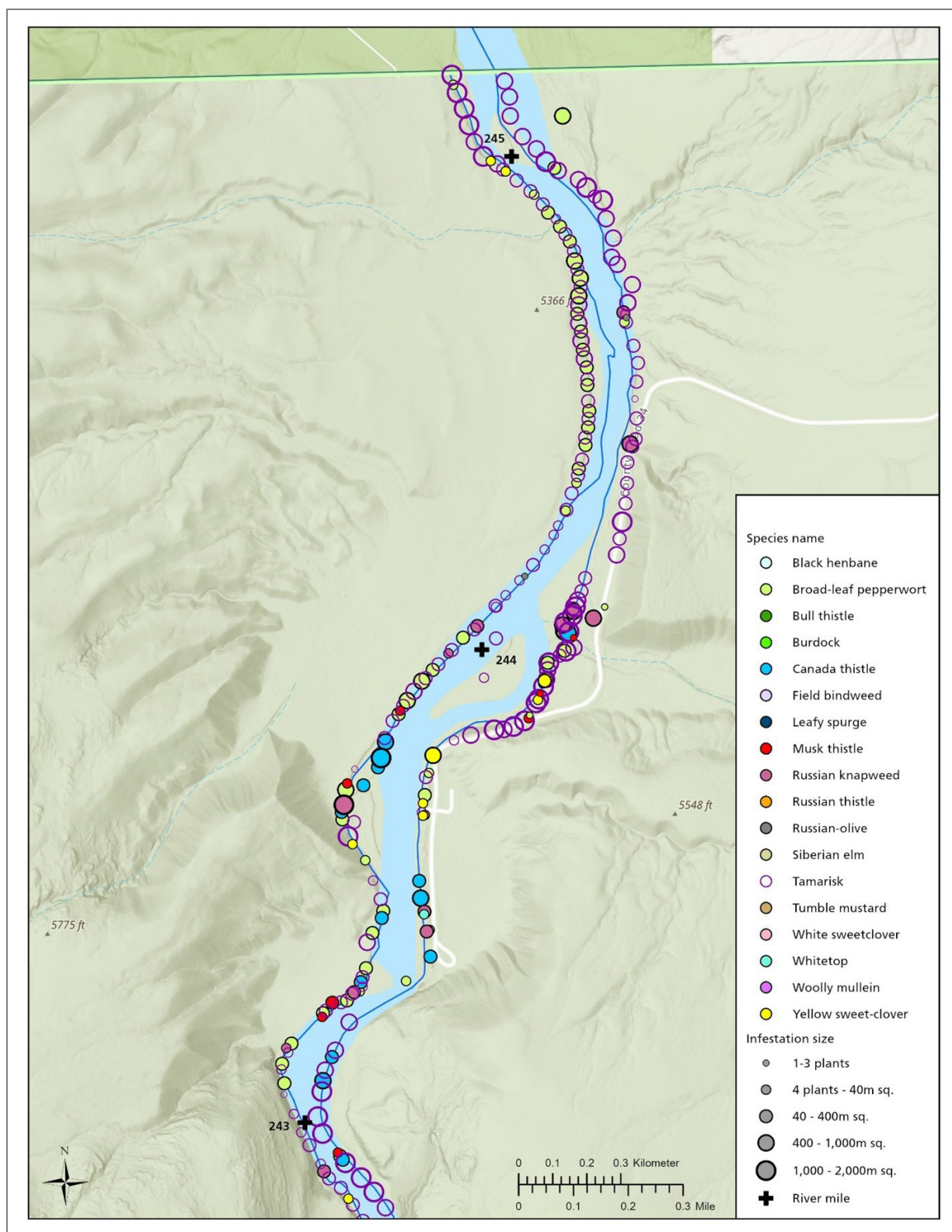


Figure 3. Invasive plants detected on monitoring routes around Gates of Lodore Campground area of the upper Green River at Dinosaur National Monument, August 16–23, 2023.

NPS / ANETH WIGHT

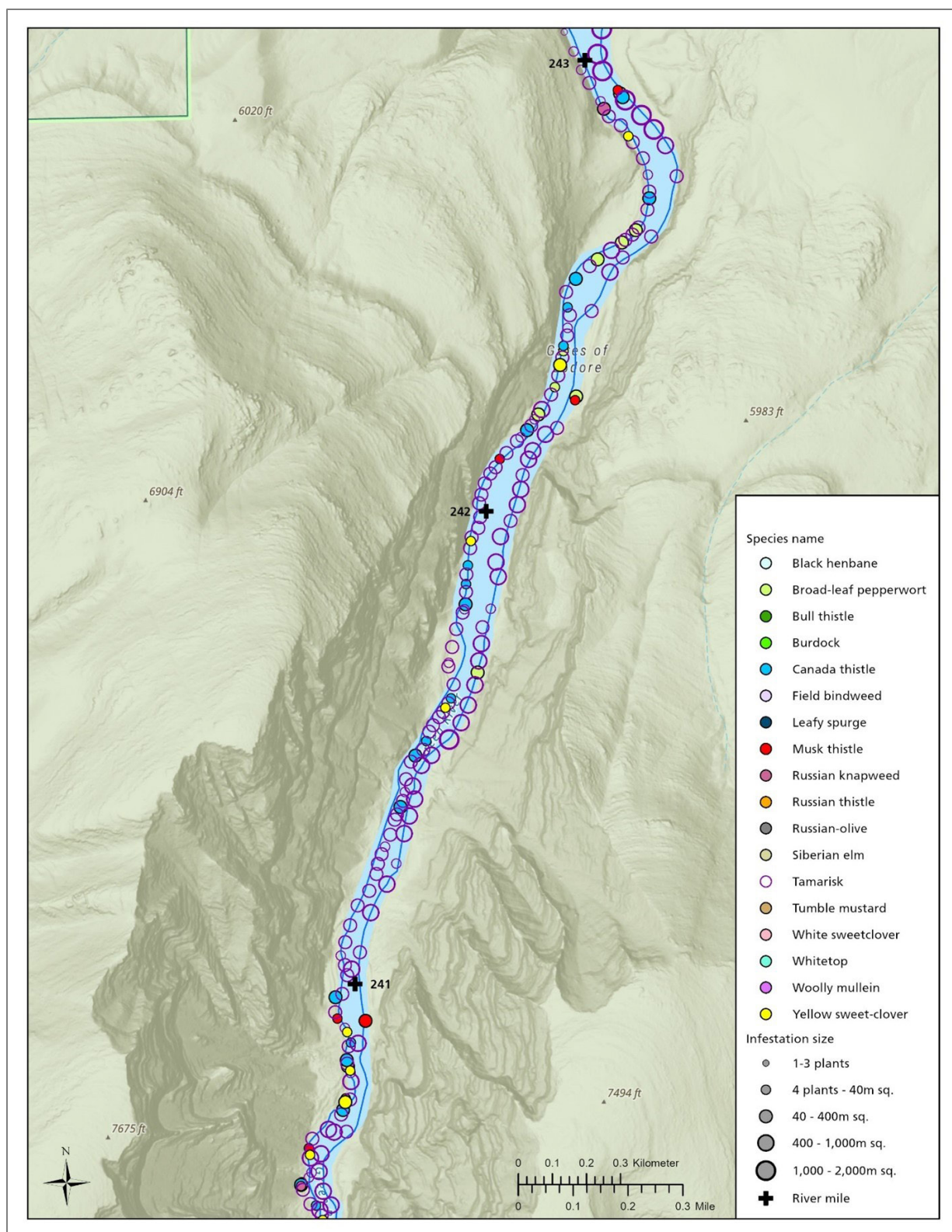


Figure 4. Invasive plants detected on monitoring routes around Wade and Curtis area on the upper Green River at Dinosaur National Monument, August 16–23, 2023.

NPS / ANETH WIGHT

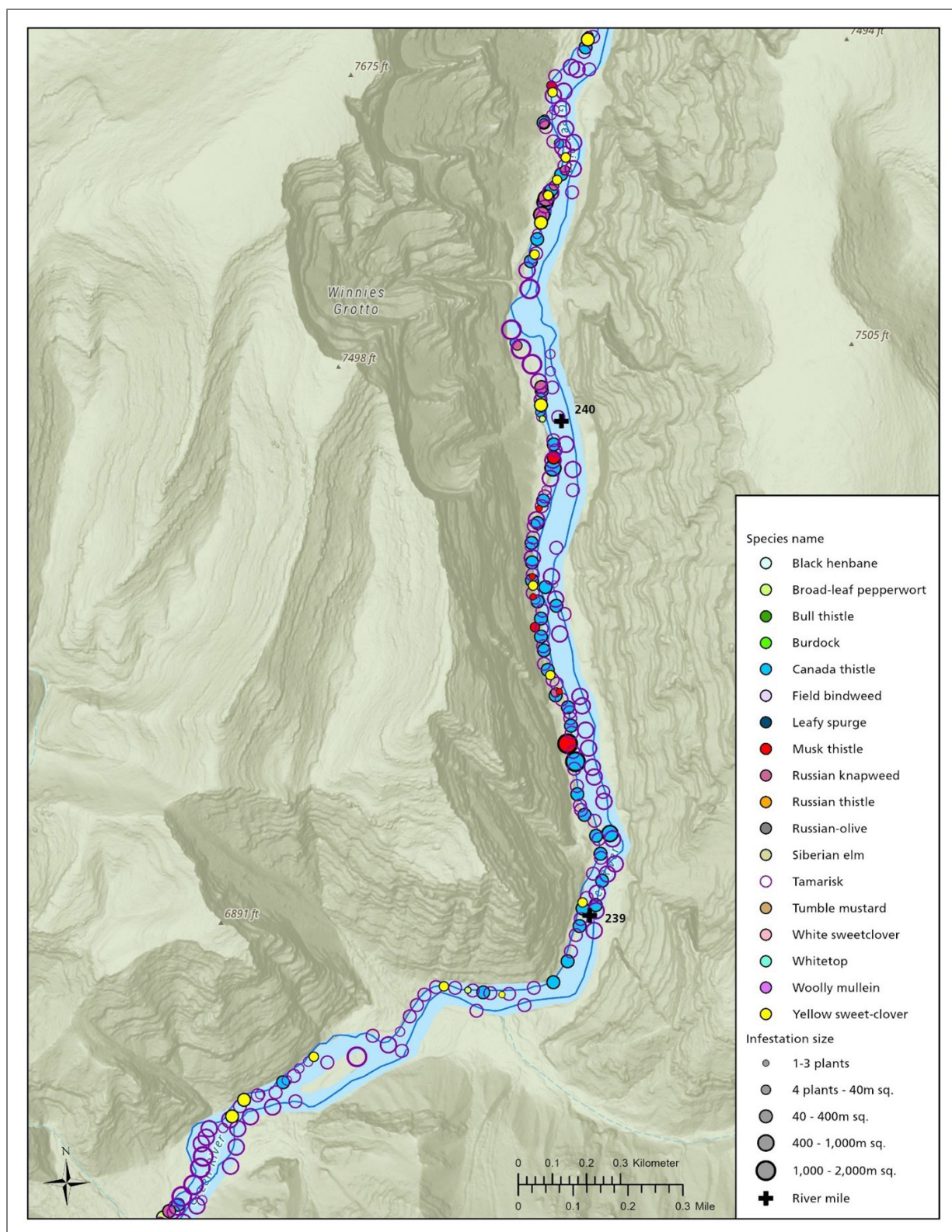


Figure 5. Invasive plants detected on monitoring routes near Winnie’s Rapid on the upper Green River at Dinosaur National Monument, August 16–23, 2023.

NPS / ANETH WIGHT

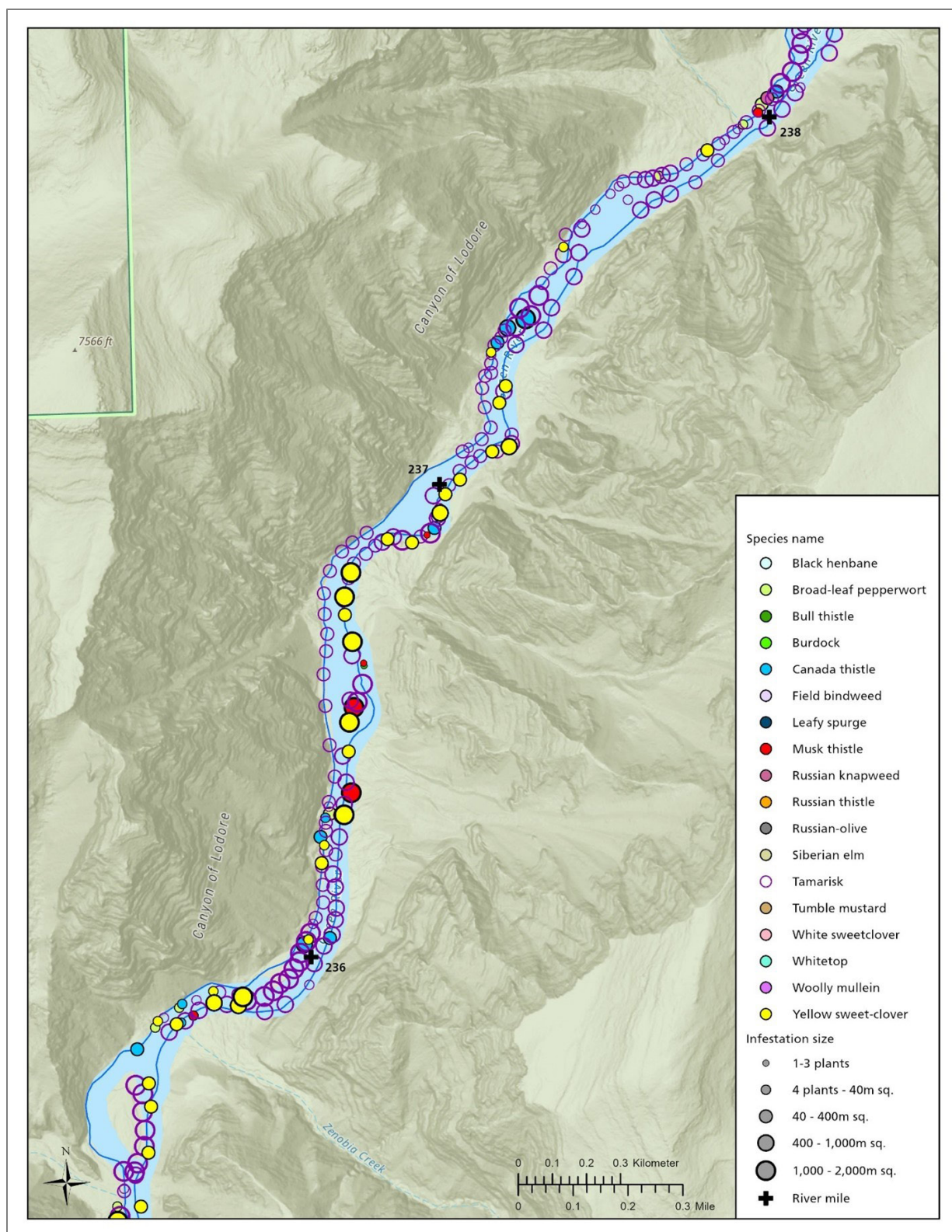


Figure 6. Invasive plants detected on monitoring routes around Upper and Lower Disaster Falls area on the upper Green River at Dinosaur National Monument, August 16–23, 2023.

NPS / ANETH WIGHT

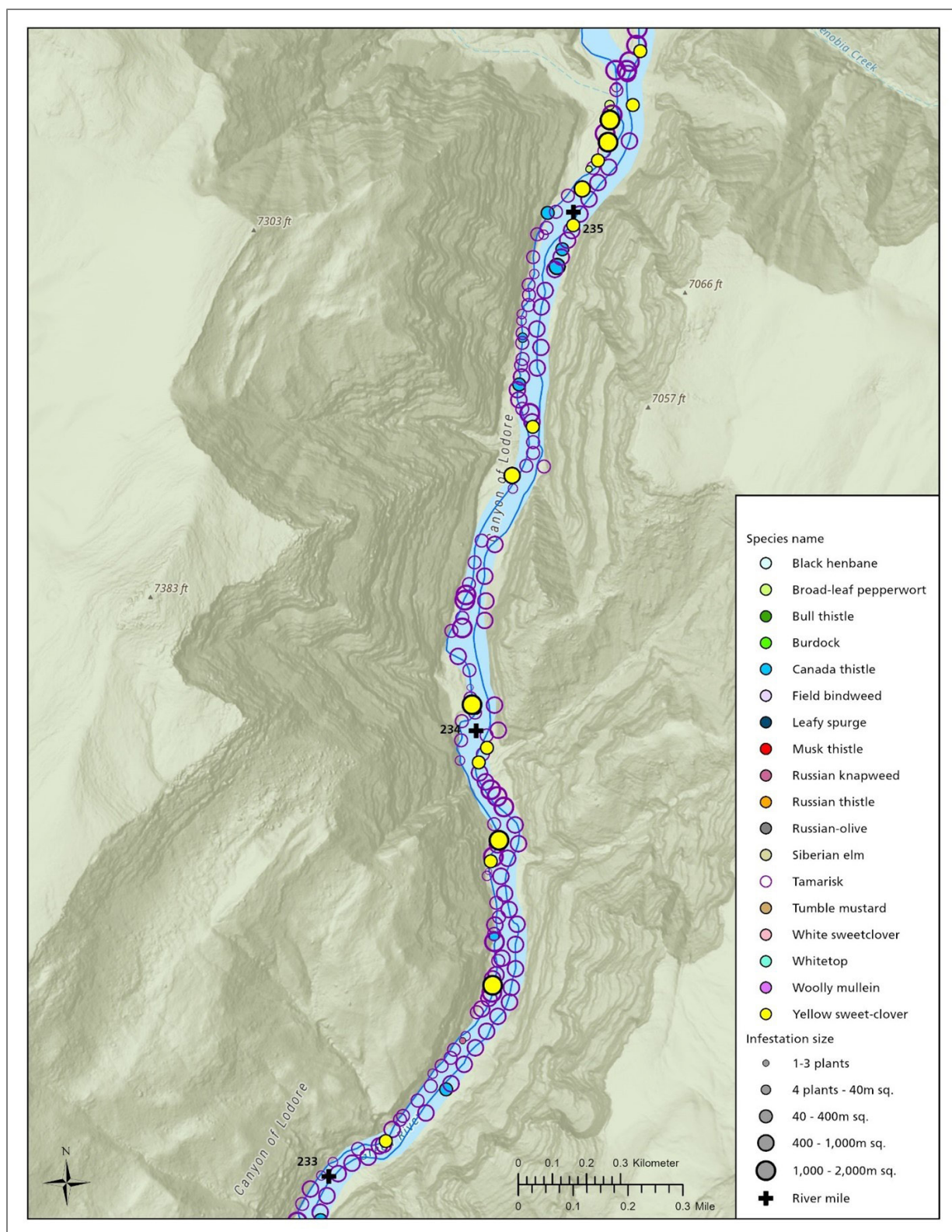


Figure 7. Invasive plants detected on monitoring routes near Kolb Campsite and Harp Falls on the upper Green River at Dinosaur National Monument, August 16–23, 2023.

NPS / ANETH WIGHT

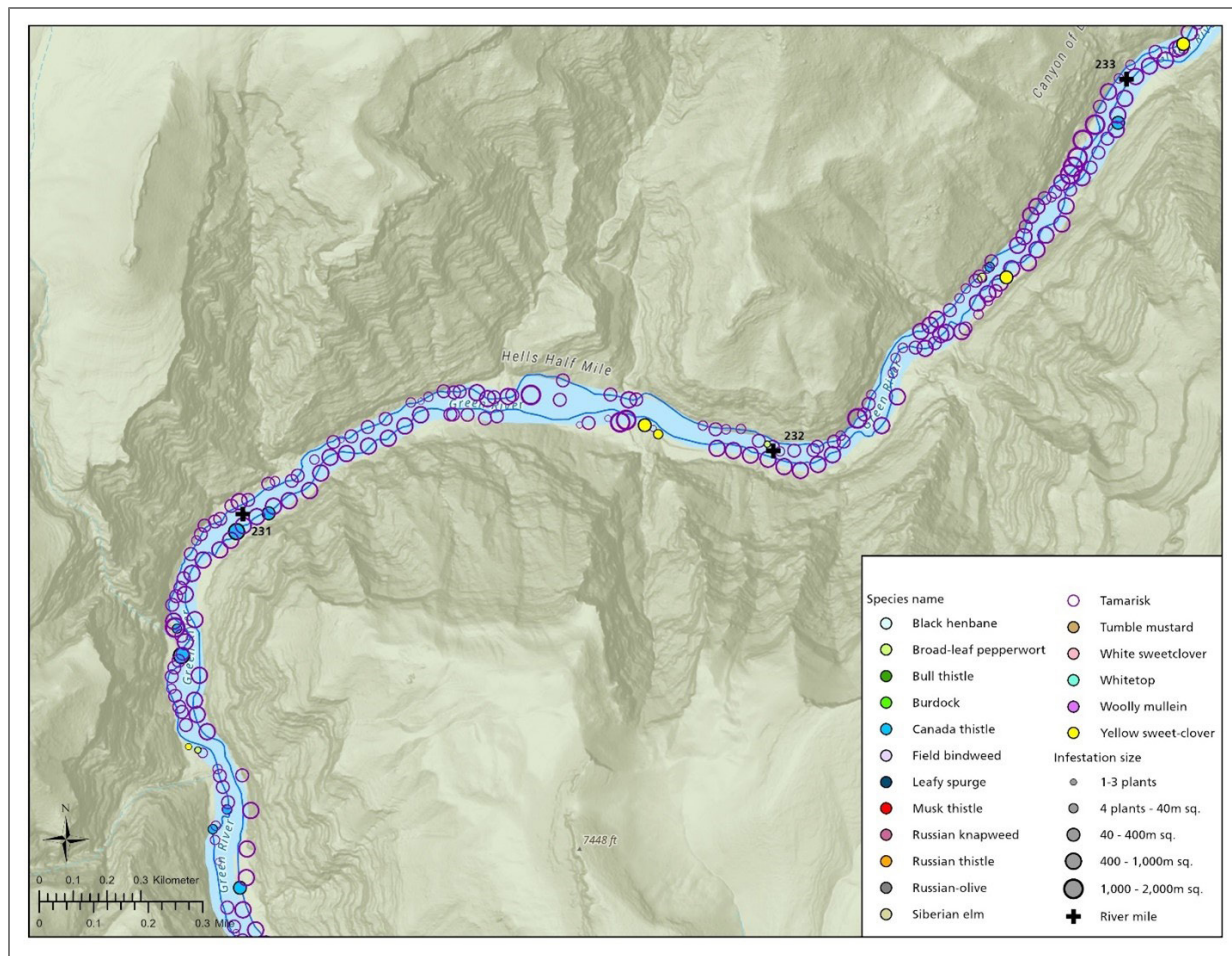


Figure 8. Invasive plants detected on monitoring routes around Hell's Half Mile on the upper Green River at Dinosaur National Monument, August 16–23, 2023.

NPS / ANETH WIGHT

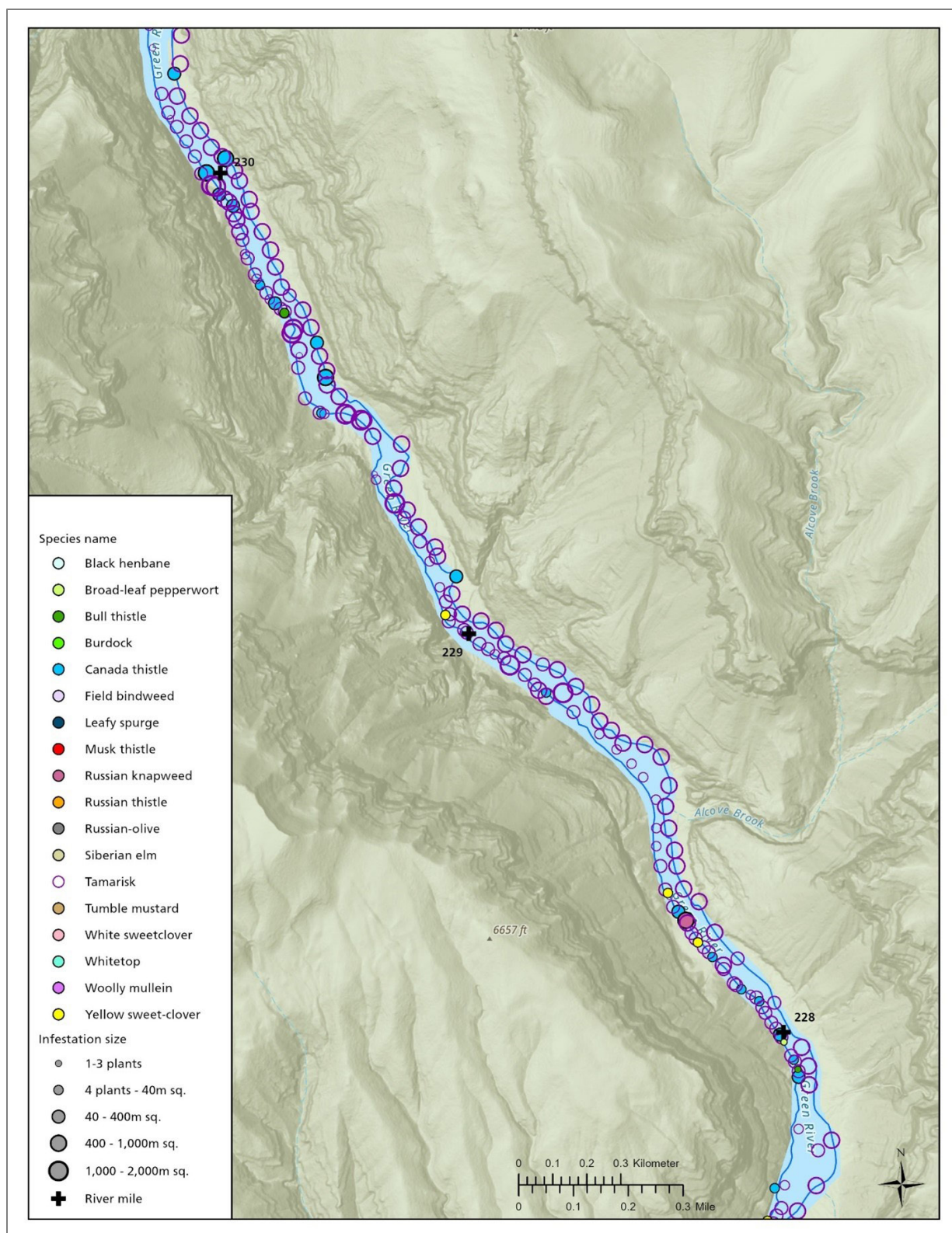


Figure 9. Invasive plants detected on monitoring routes around Wild Mountain and Limestone Campsites on the upper Green River at Dinosaur National Monument, August 16–23, 2023.

NPS / ANETH WIGHT

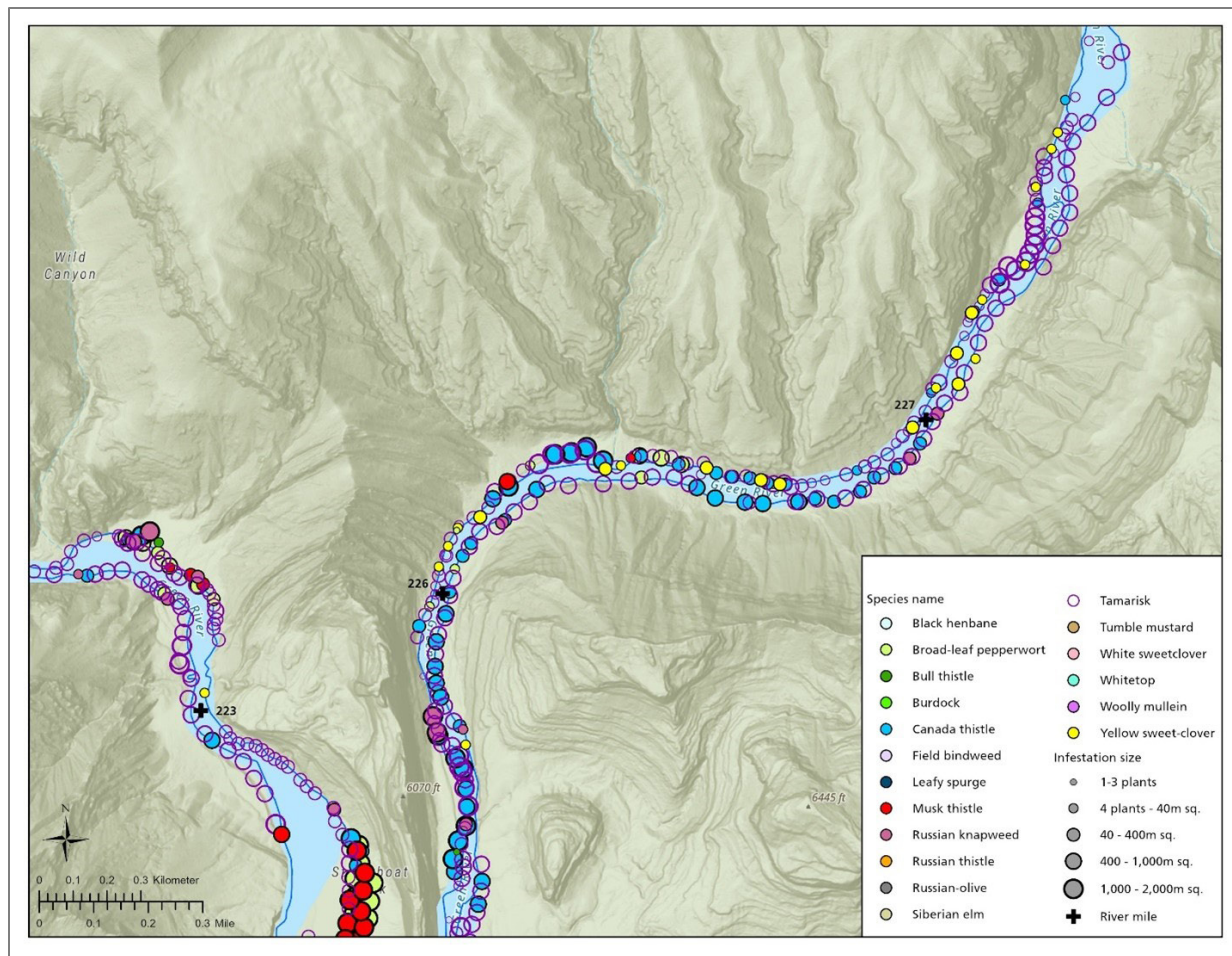


Figure 10. Invasive plants detected on monitoring routes just above the confluence of the Green and Yampa Rivers at Dinosaur National Monument, August 16–23, 2023.

NPS / ANETH WIGHT

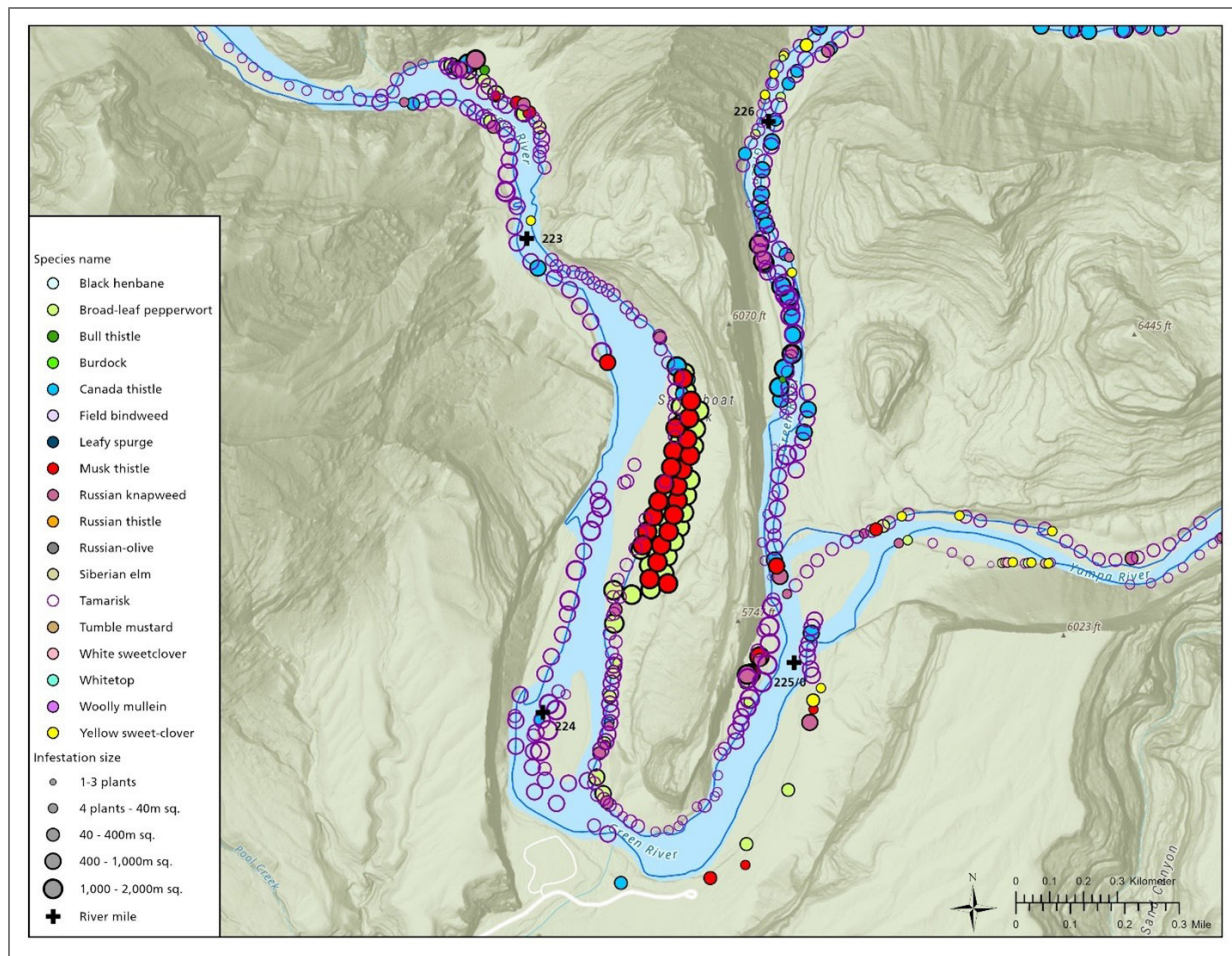


Figure 11. Invasive plants detected on monitoring routes around the confluence of the Green and Yampa Rivers at Dinosaur National Monument, August 16–23, 2023 and June 20–26, 2024.

NPS / ANETH WIGHT

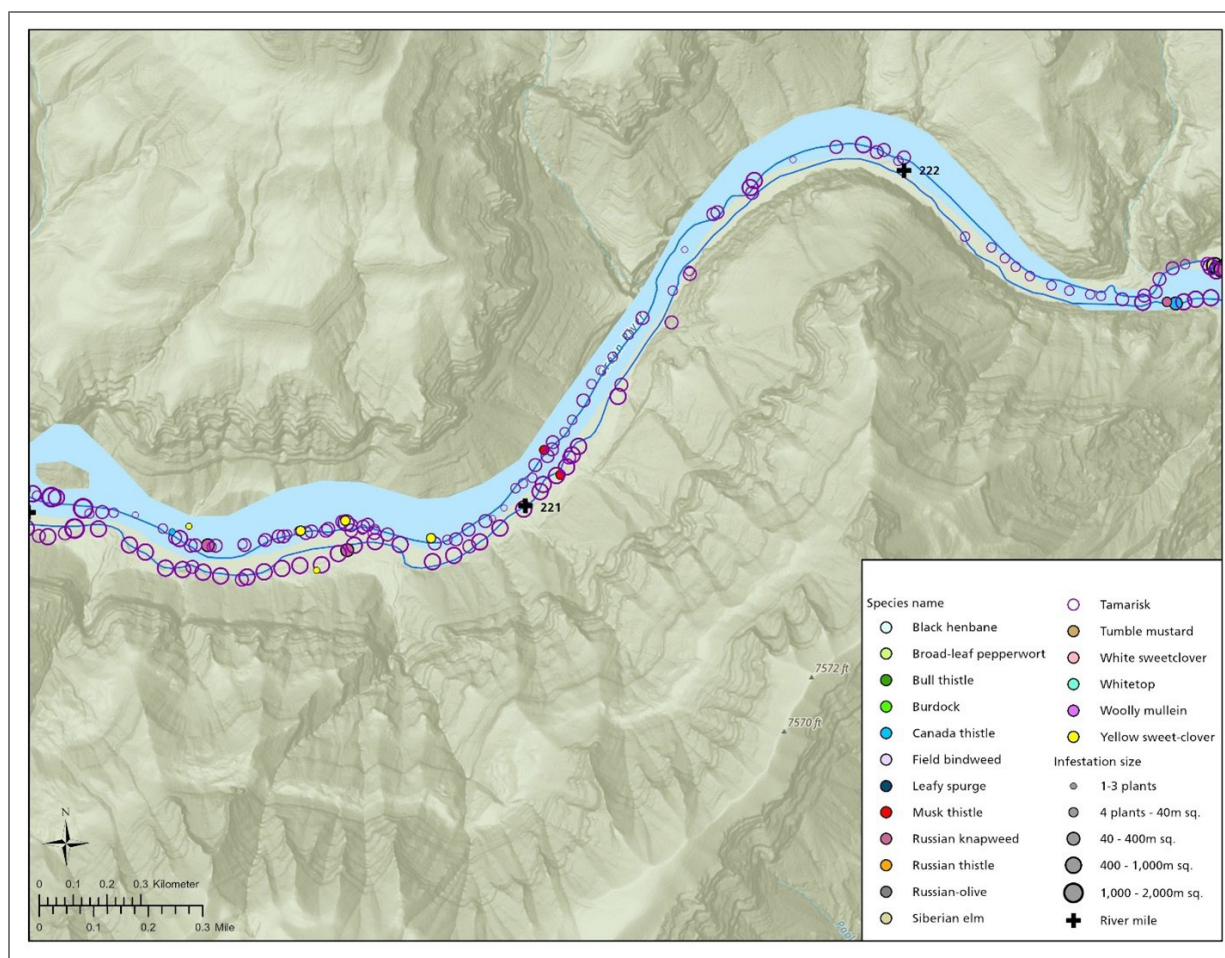


Figure 12. Invasive plants detected on monitoring routes around Wild Canyon area on the lower Green River at Dinosaur National Monument, August 16–23, 2023.

NPS / ANETH WIGHT

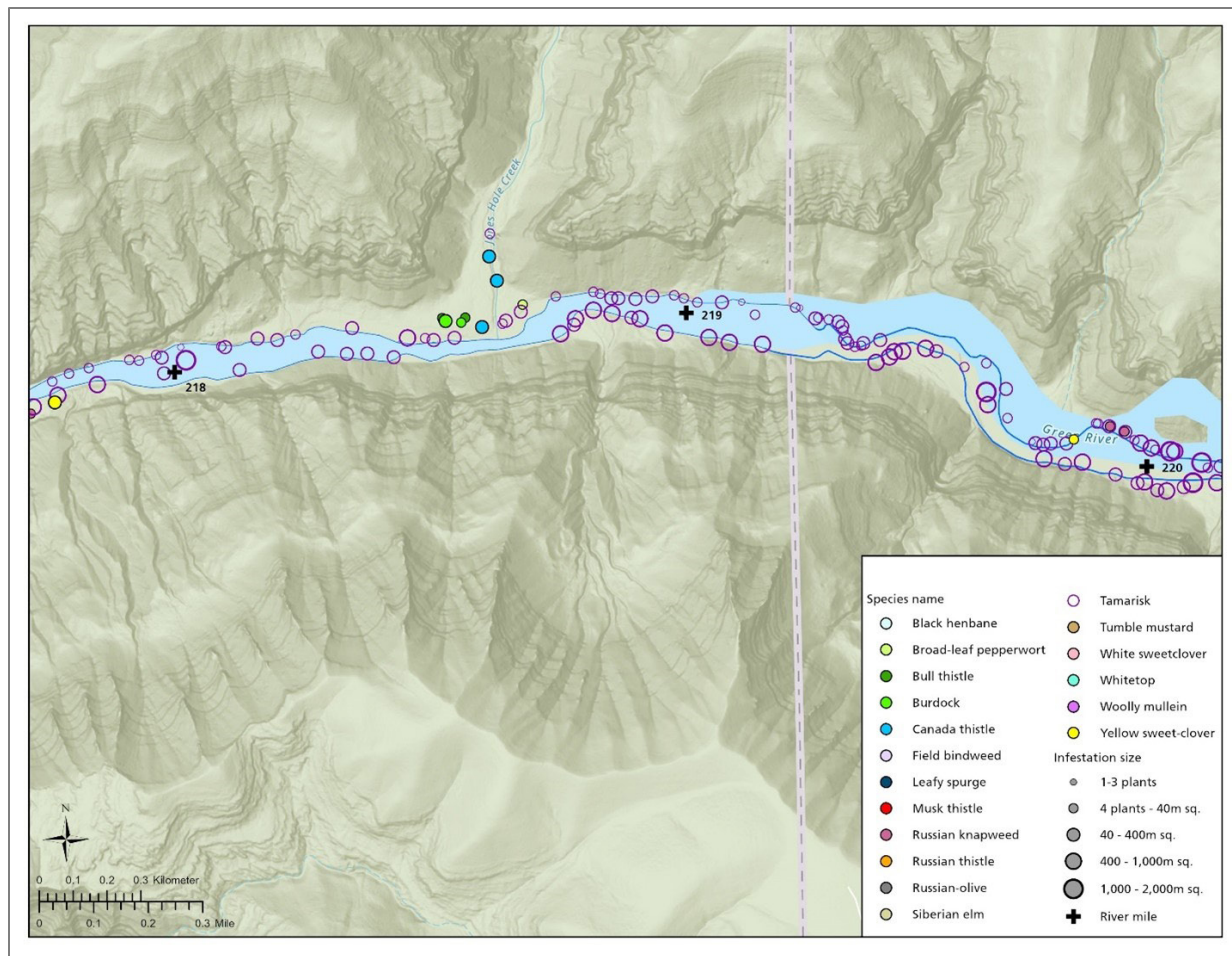


Figure 13. Invasive plants detected on monitoring routes around Jones Hole area on the lower Green River at Dinosaur National Monument, August 16–23, 2023.

NPS / ANETH WIGHT

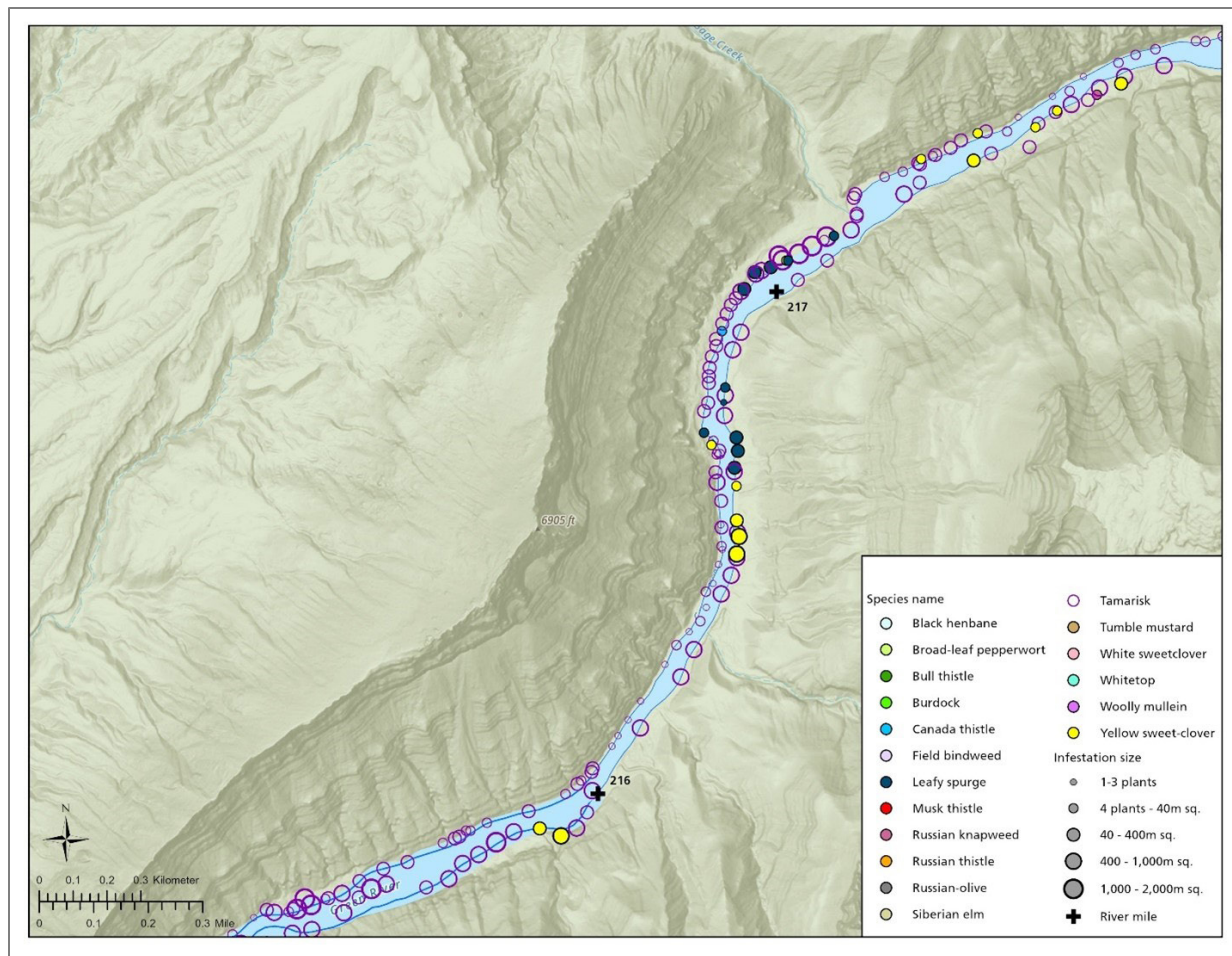


Figure 14. Invasive plants detected on monitoring routes around Sage Creek on the lower Green River at Dinosaur National Monument, August 16–23, 2023.

NPS / ANETH WIGHT

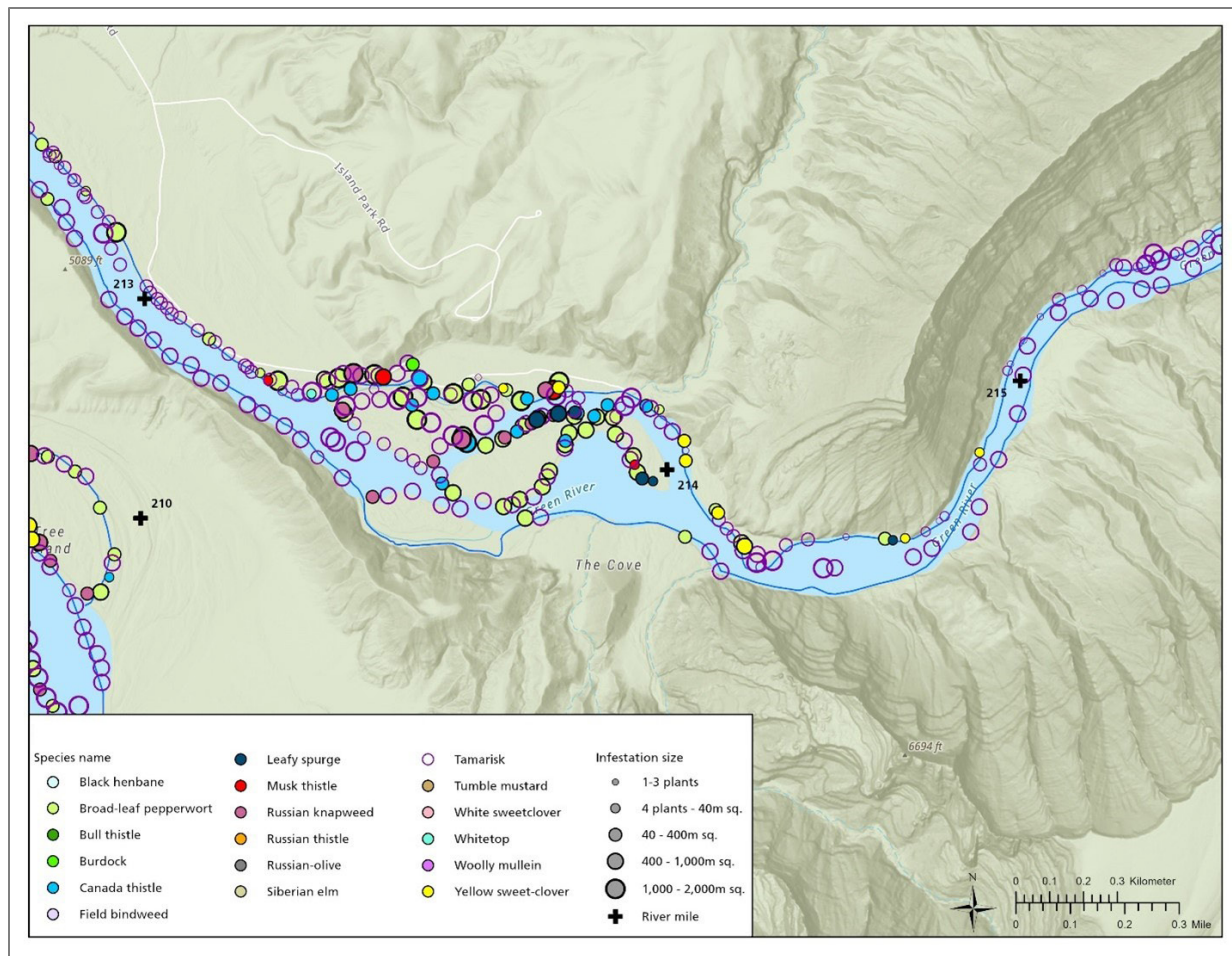


Figure 15. Invasive plants detected on monitoring routes around Big Island on the lower Green River at Dinosaur National Monument, August 16–23, 2023.

NPS / ANETH WIGHT

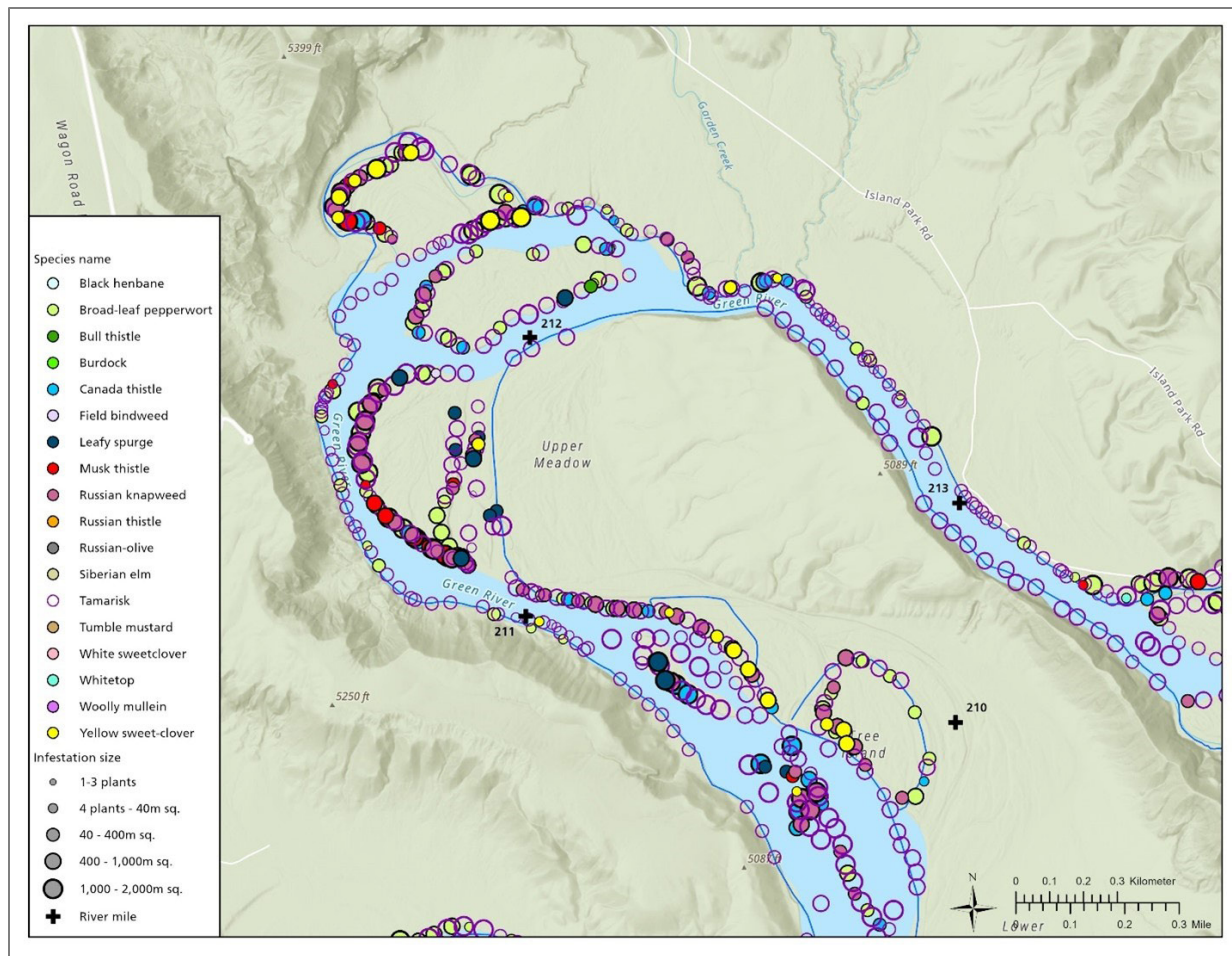


Figure 16. Invasive plants detected on monitoring routes around Ford Island on the lower Green River at Dinosaur National Monument, August 16–23, 2023.

NPS / ANETH WIGHT

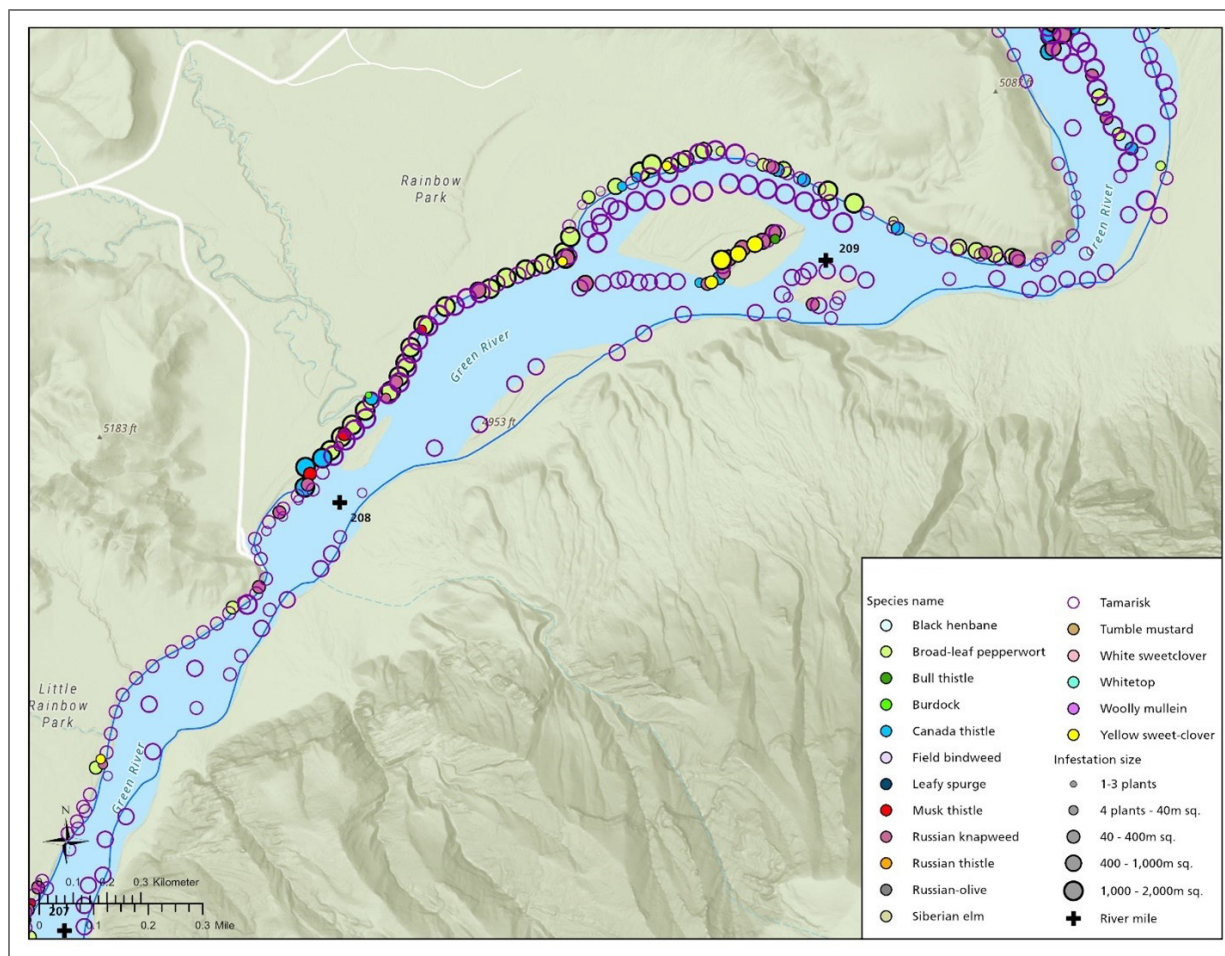


Figure 17. Invasive plants detected on monitoring routes around Rainbow Park on the lower Green River at Dinosaur National Monument, August 16–23, 2023.

NPS / ANETH WIGHT

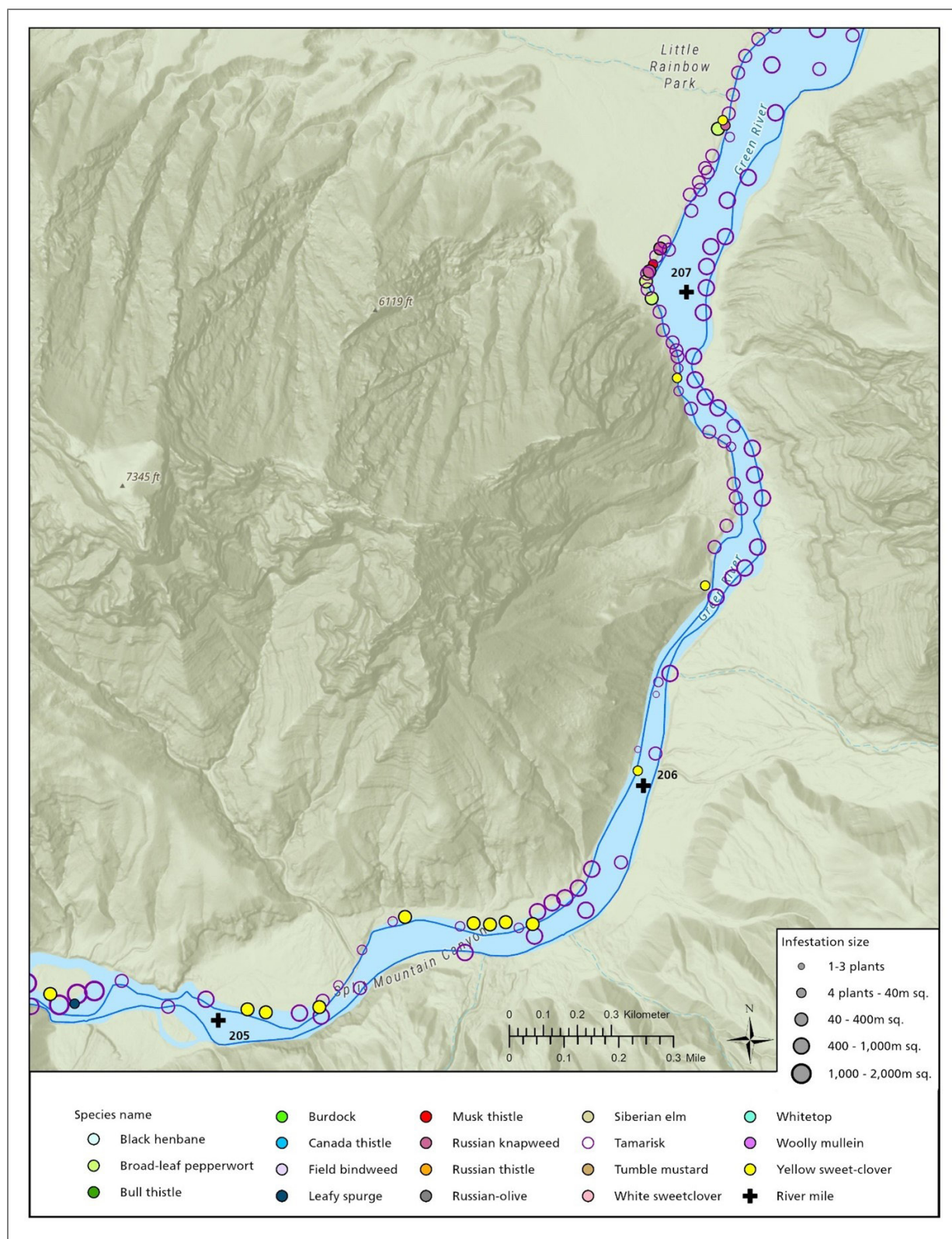


Figure 18. Invasive plants detected on monitoring routes around Moonshine Rapids on the lower Green River at Dinosaur National Monument, August 16–23, 2023.

NPS / ANETH WIGHT

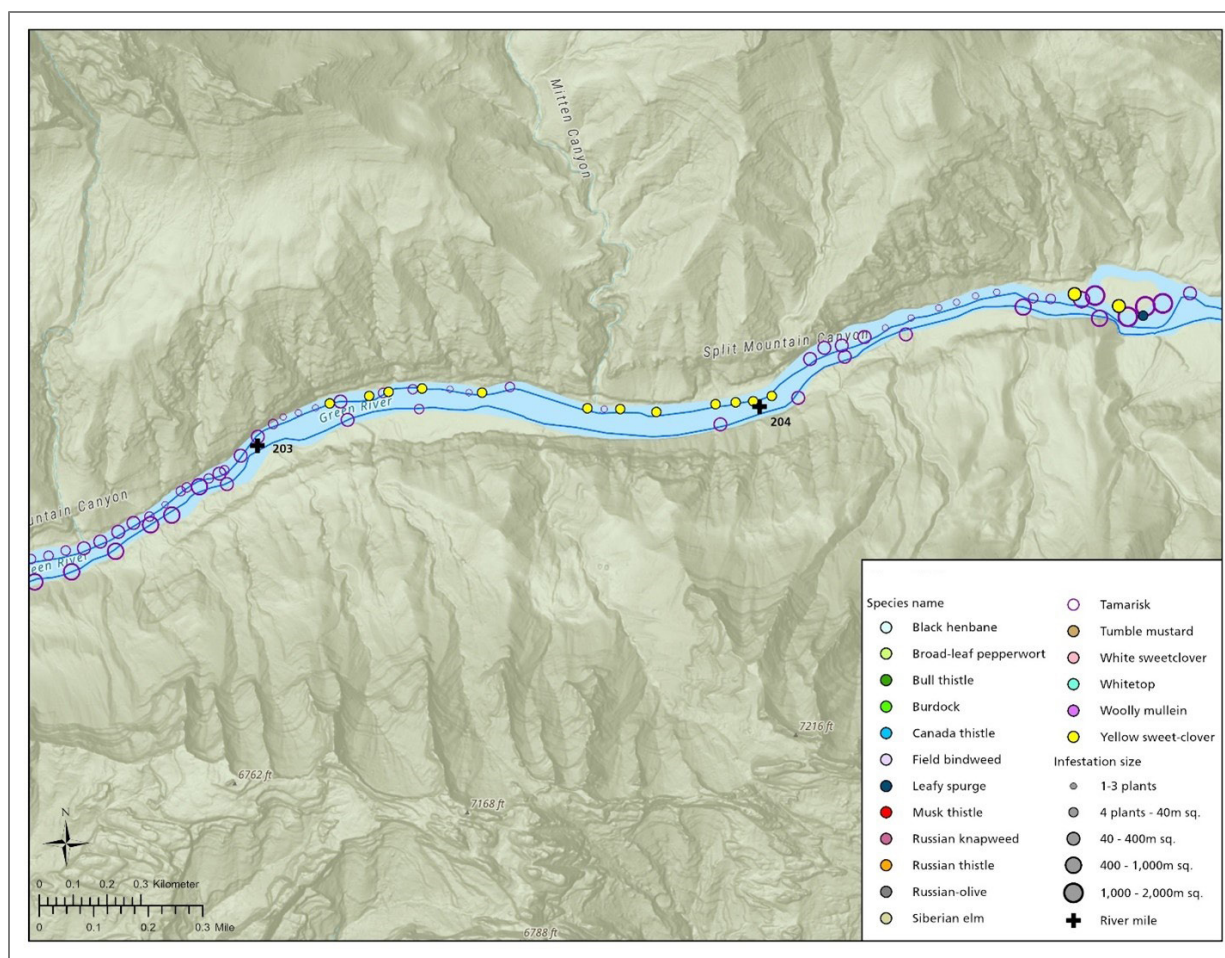


Figure 19. Invasive plants detected on monitoring routes around Mitten Canyon on the lower Green River at Dinosaur National Monument, August 16–23, 2023.

NPS / ANETH WIGHT

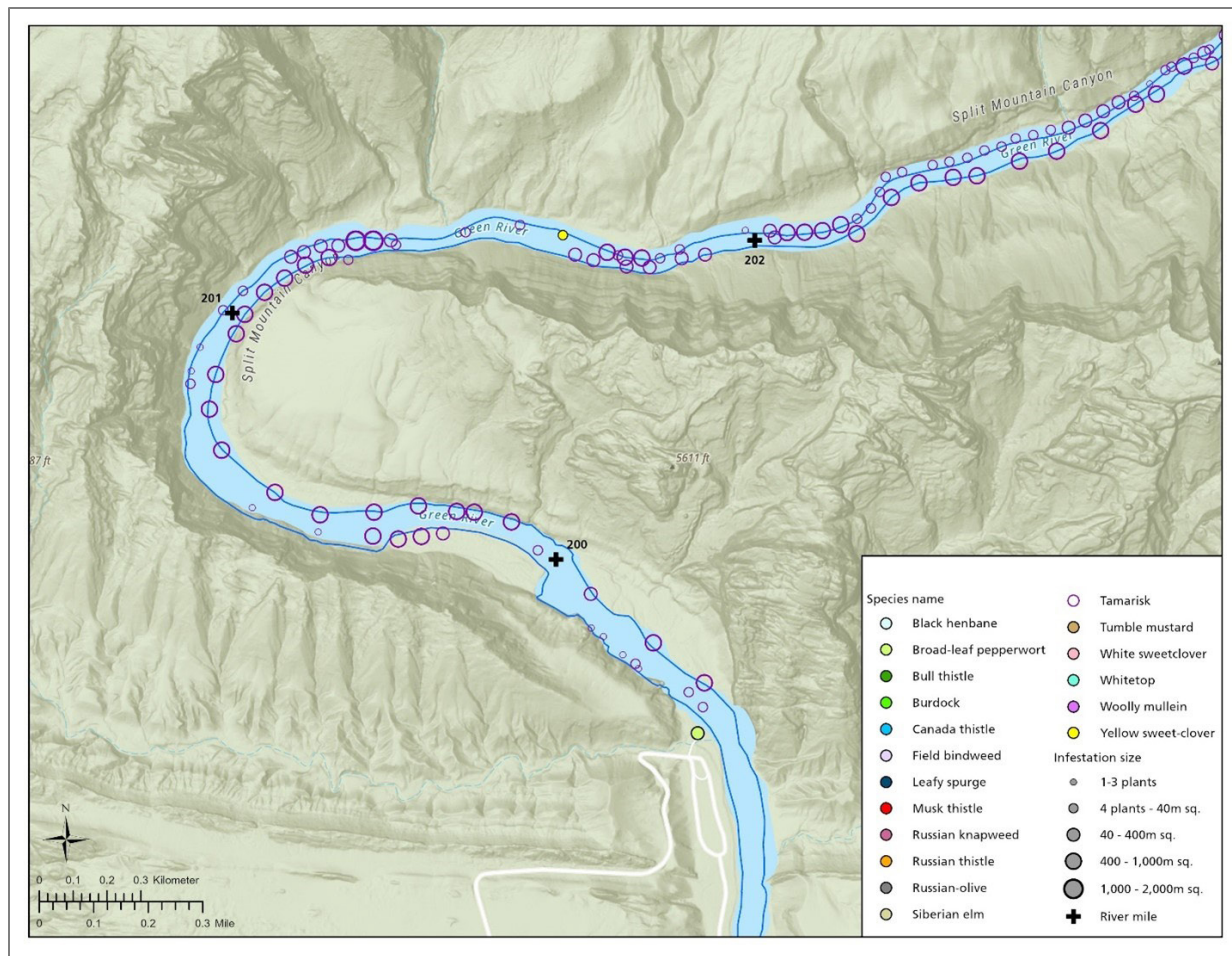


Figure 20. Invasive plants detected on monitoring routes around Ingelsby Rapid on the lower Green River at Dinosaur National Monument, August 16–23, 2023.

NPS / ANETH WIGHT

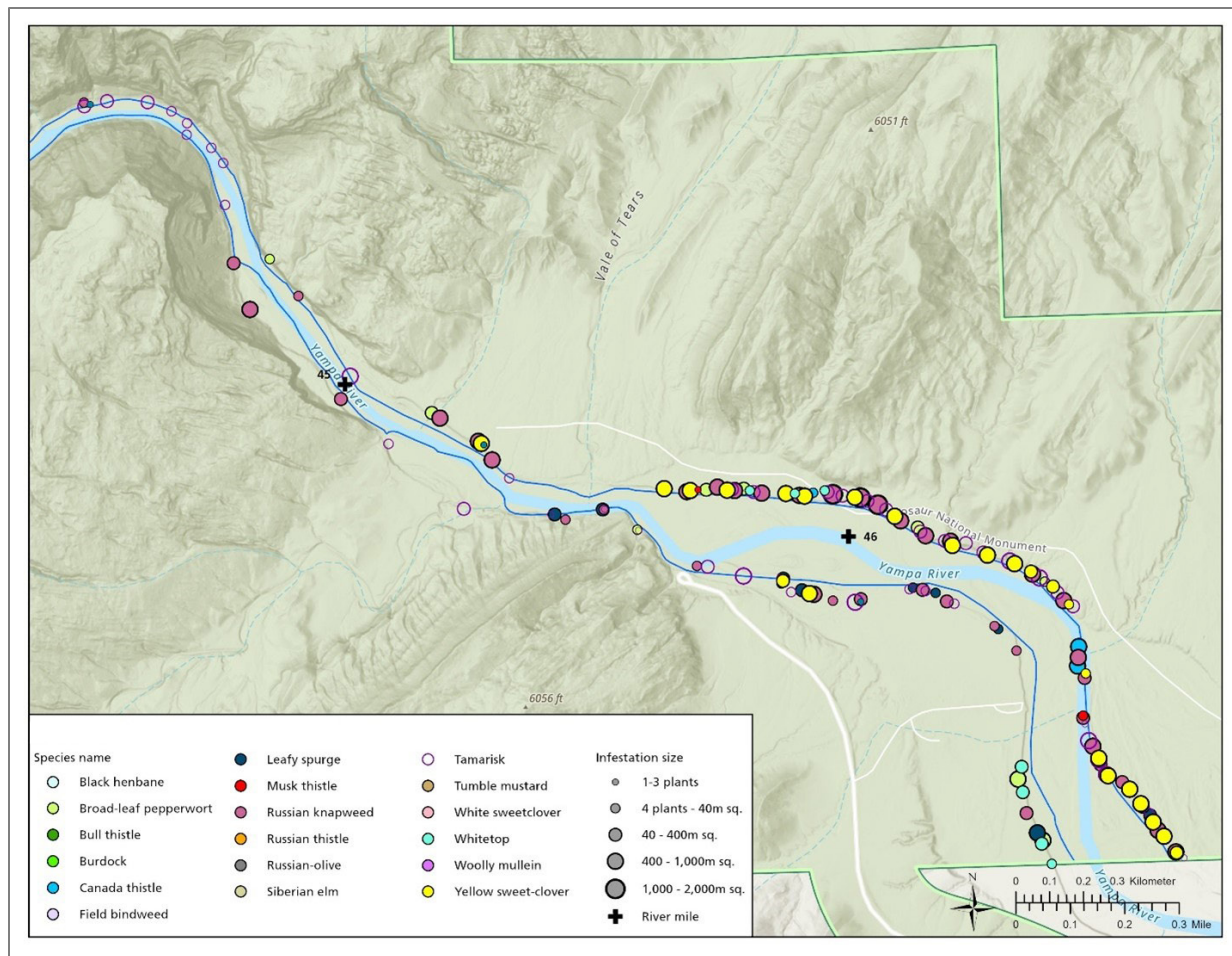


Figure 21. Invasive plants detected on monitoring routes around the Deerlodge Park Campground on the eastern portion of the Yampa River at Dinosaur National Monument, June 20–26, 2024.

NPS / ANETH WIGHT

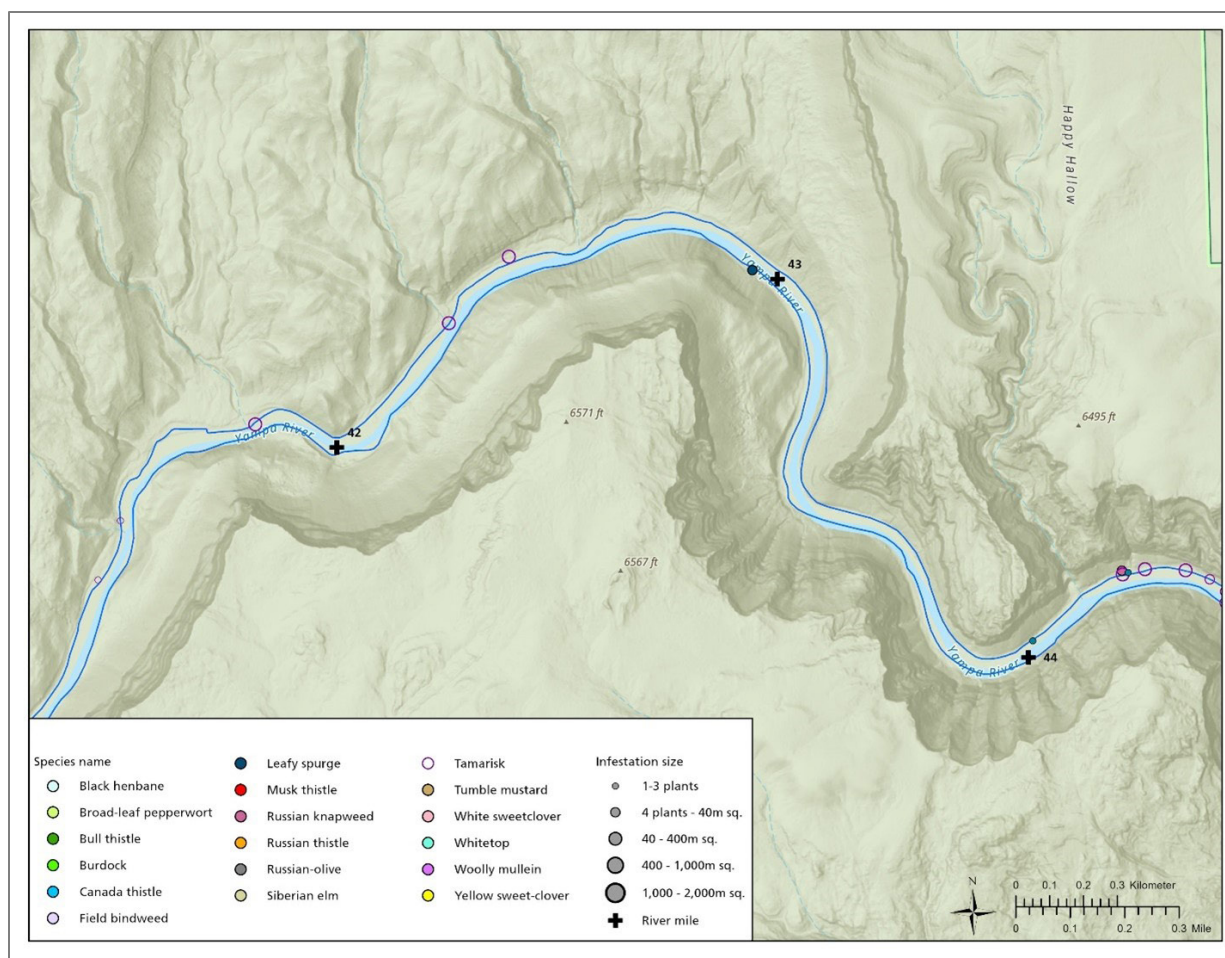


Figure 22. Invasive plants detected on monitoring routes around Anderson Hole on the eastern portion of the Yampa River at Dinosaur National Monument, June 20–26, 2024.

NPS / ANETH WIGHT

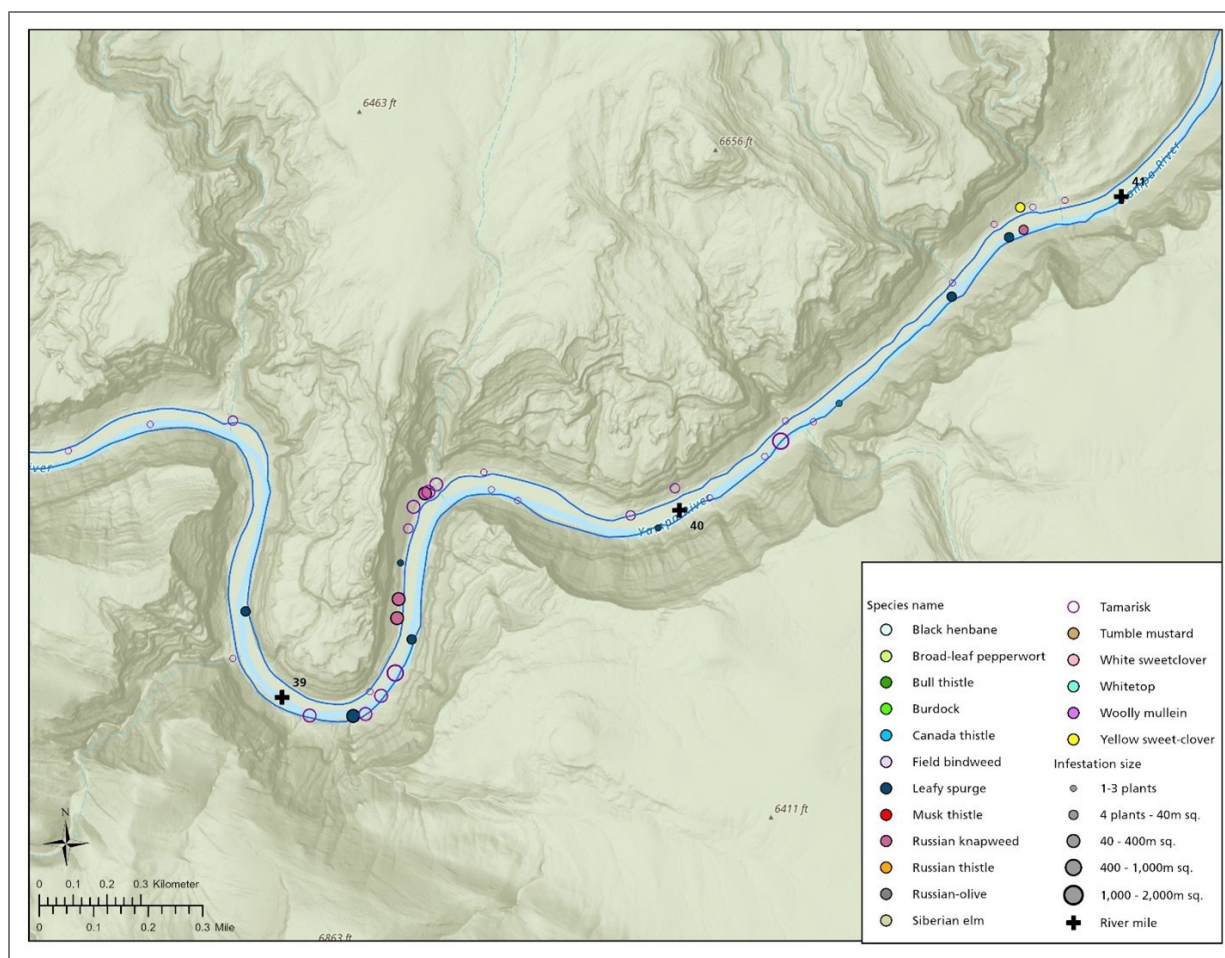


Figure 23. Invasive plants detected on monitoring routes around Thanksgiving Gorge on the eastern portion of the Yampa River at Dinosaur National Monument, June 20–26, 2024.

NPS / ANETH WIGHT

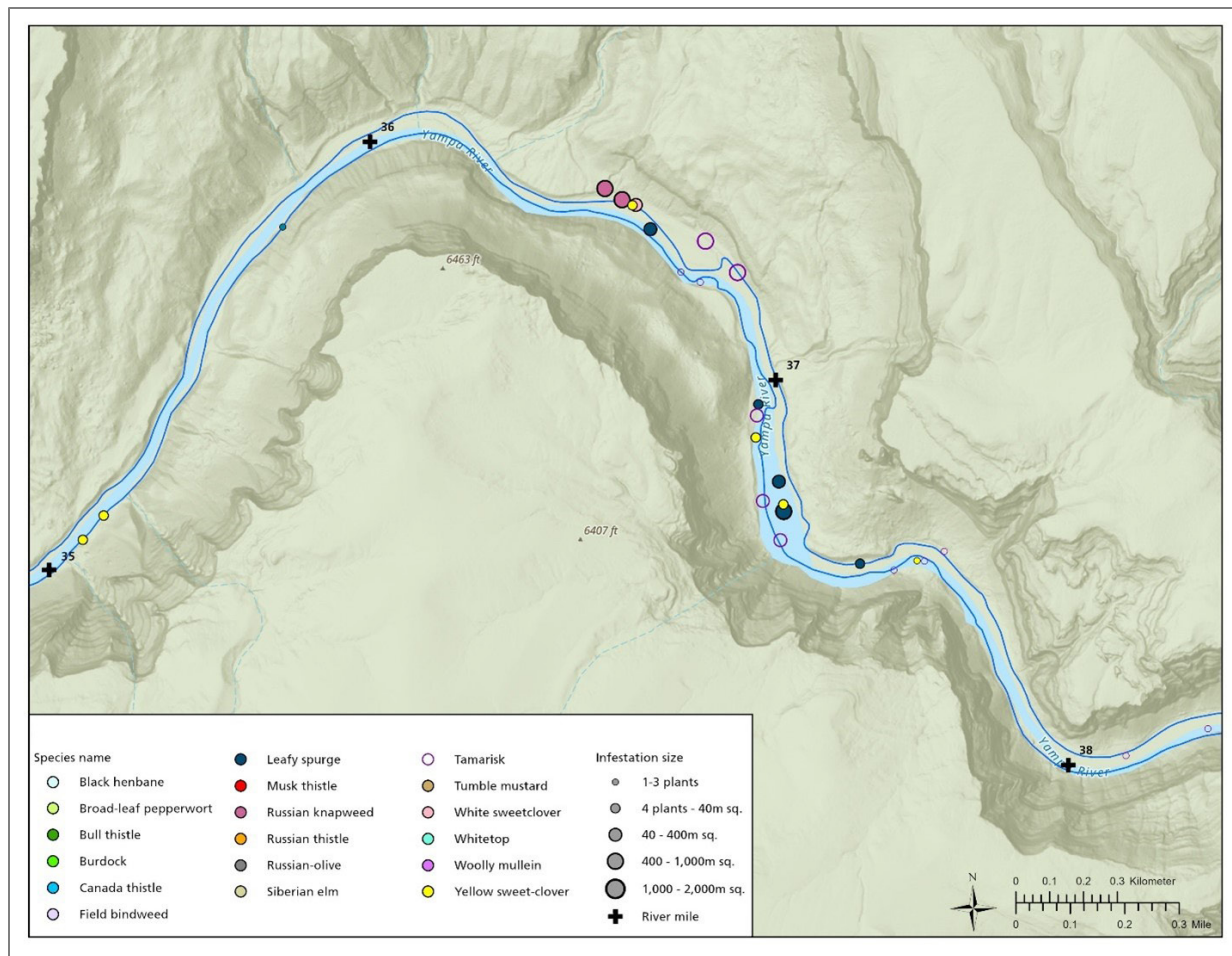


Figure 24. Invasive plants detected on monitoring routes around Tepee Hole on the eastern portion of the Yampa River at Dinosaur National Monument, June 20–26, 2024.

NPS / ANETH WIGHT

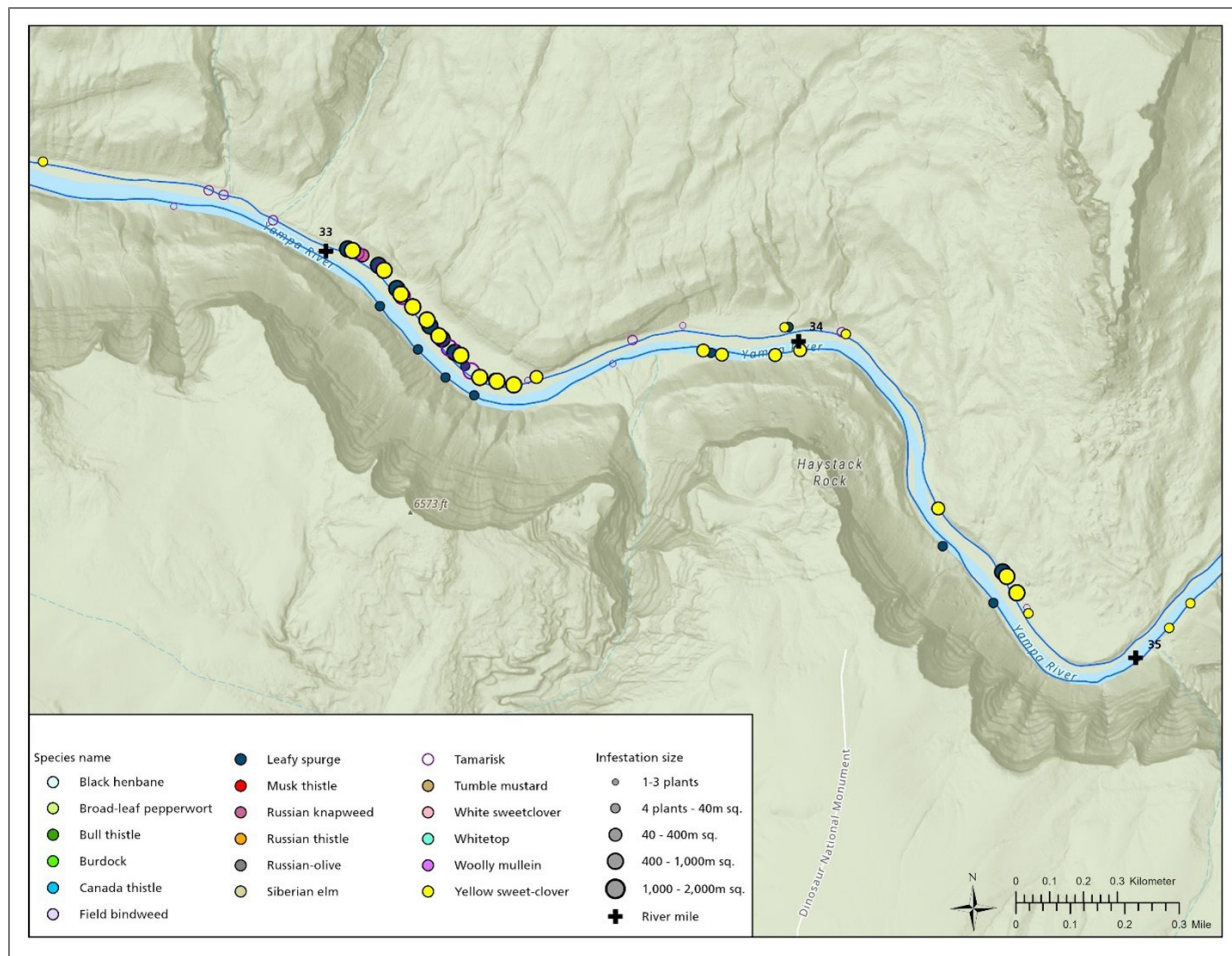


Figure 25. Invasive plants detected on monitoring routes around Bear Draw on the eastern portion of the Yampa River at Dinosaur National Monument, June 20–26, 2024.

NPS / ANETH WIGHT

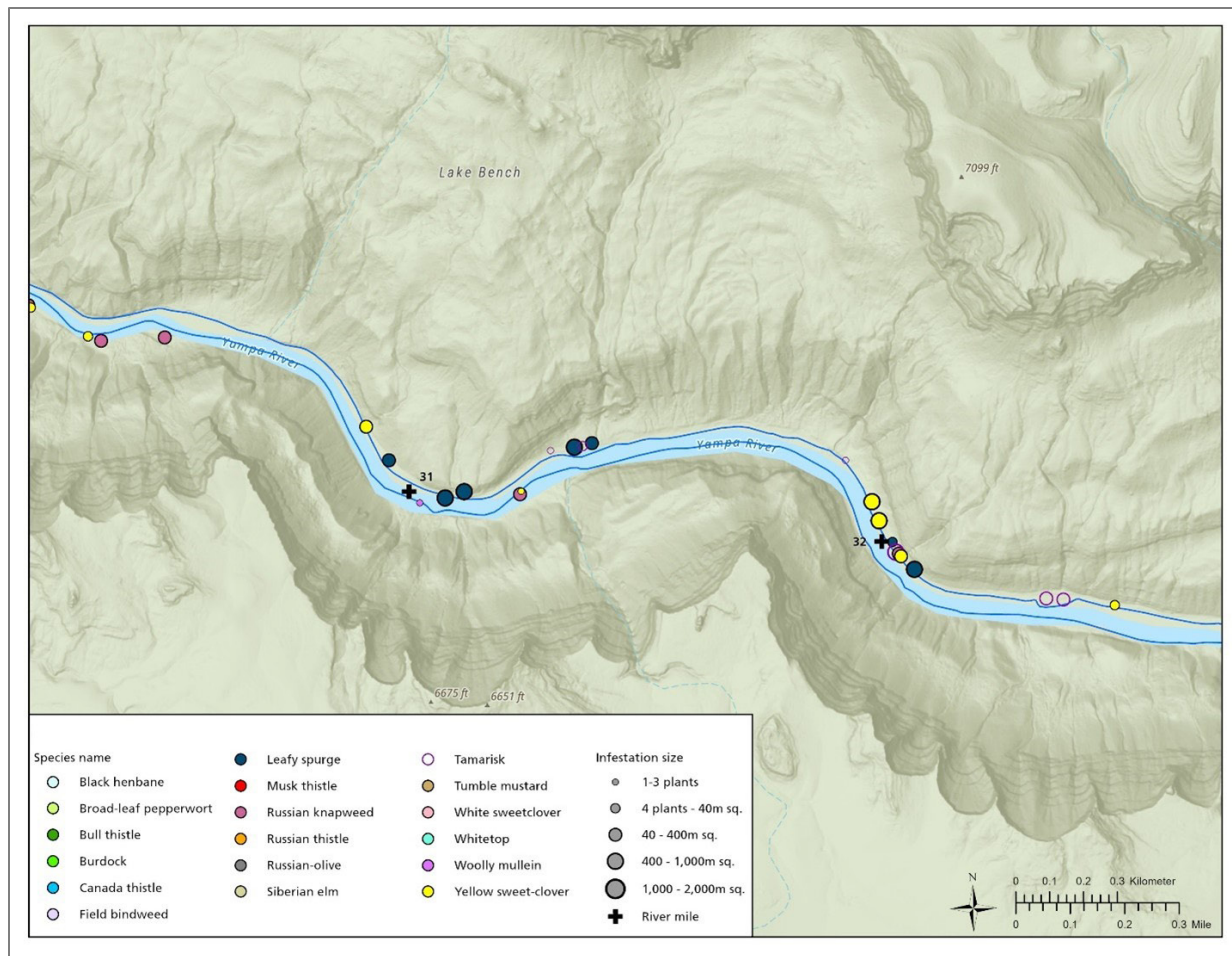


Figure 26. Invasive plants detected on monitoring routes around the Lake Bench area on the eastern portion of the Yampa River at Dinosaur National Monument, June 20–26, 2024.

NPS / ANETH WIGHT

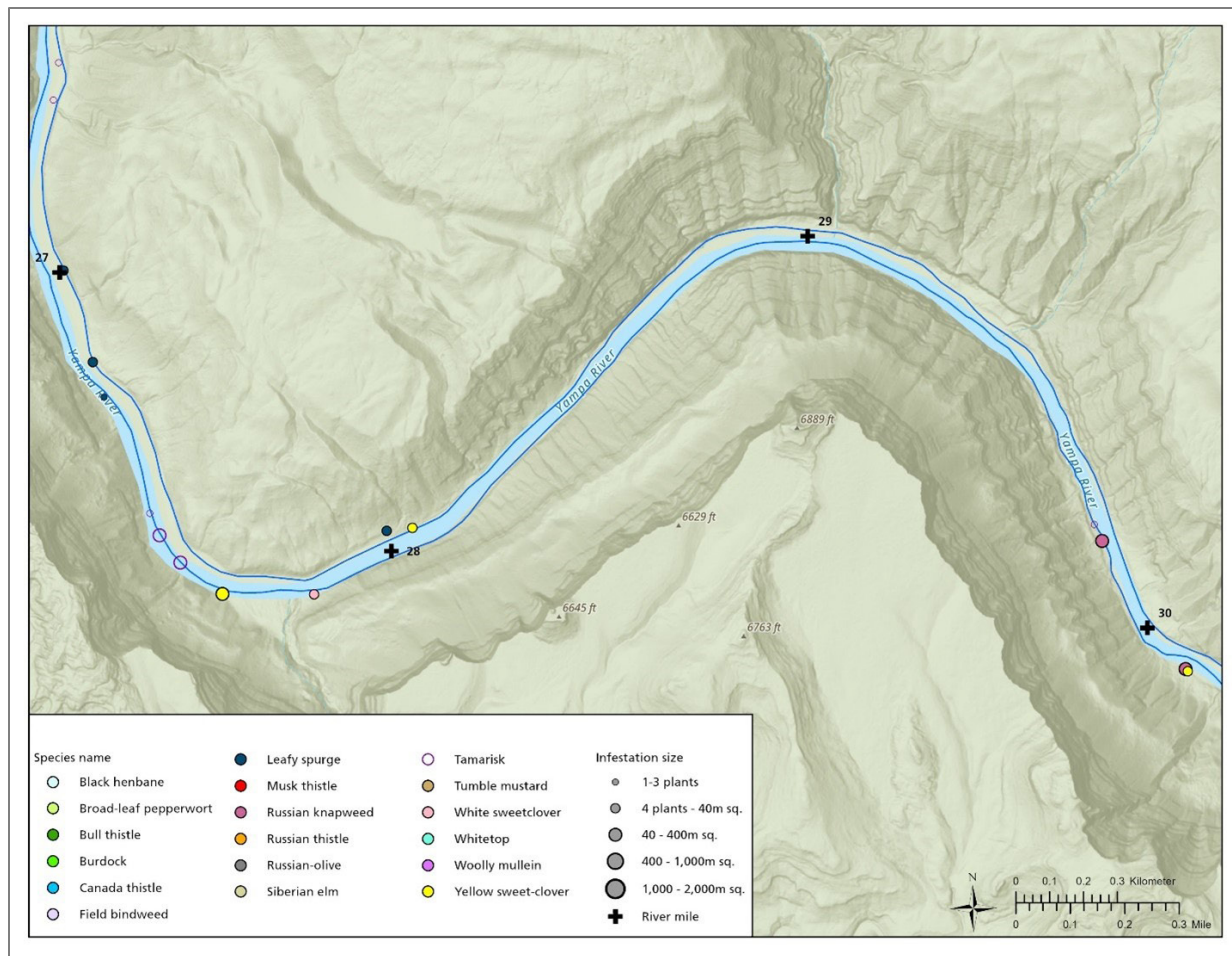


Figure 27. Invasive plants detected on monitoring routes around Little Joe Rapid on the central portion of the Yampa River at Dinosaur National Monument, June 20–26, 2024.

NPS / ANETH WIGHT

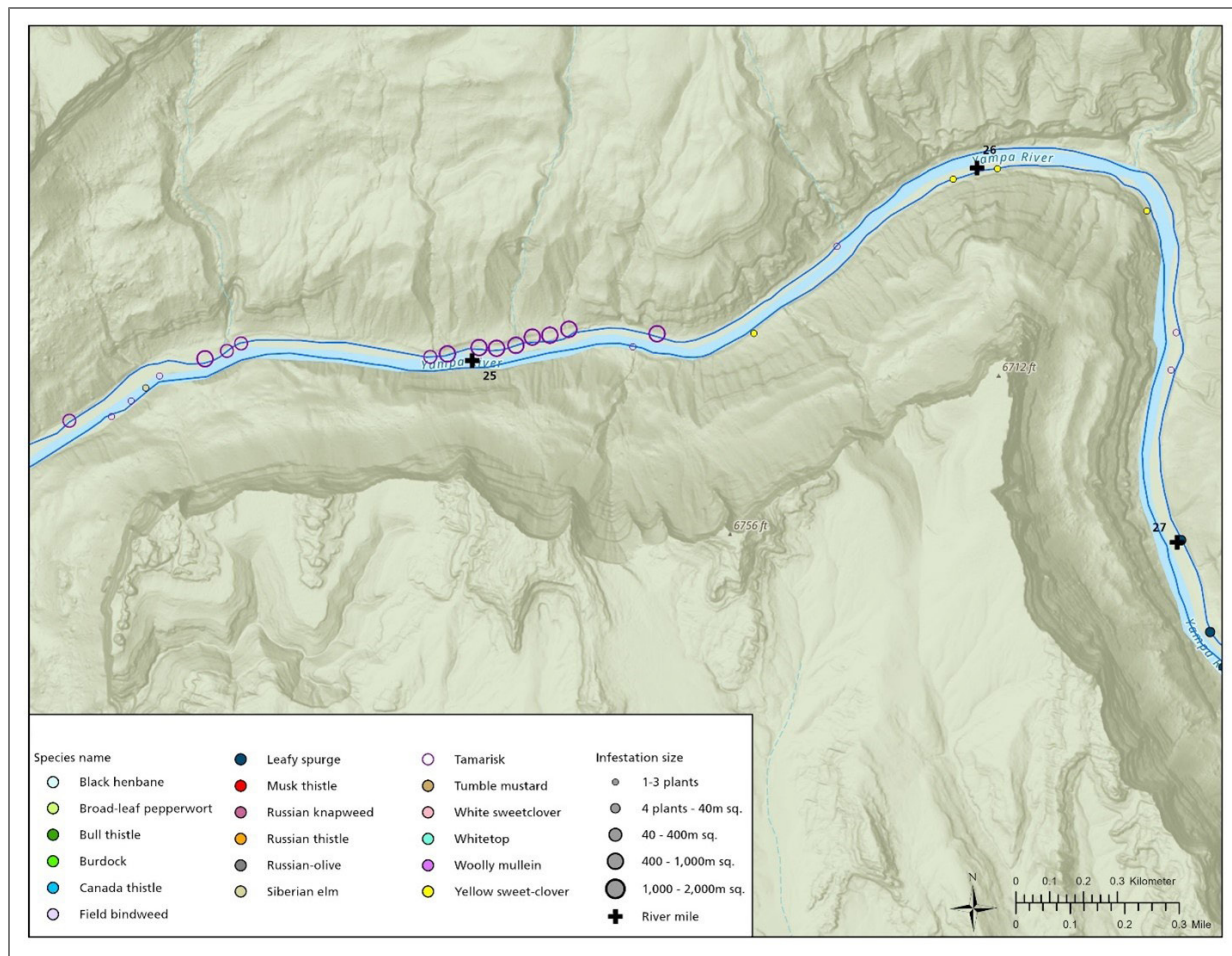


Figure 28. Invasive plants detected on monitoring routes around the Five Springs Rapid area on the central portion of the Yampa River at Dinosaur National Monument, June 20–26, 2024.

NPS / ANETH WIGHT

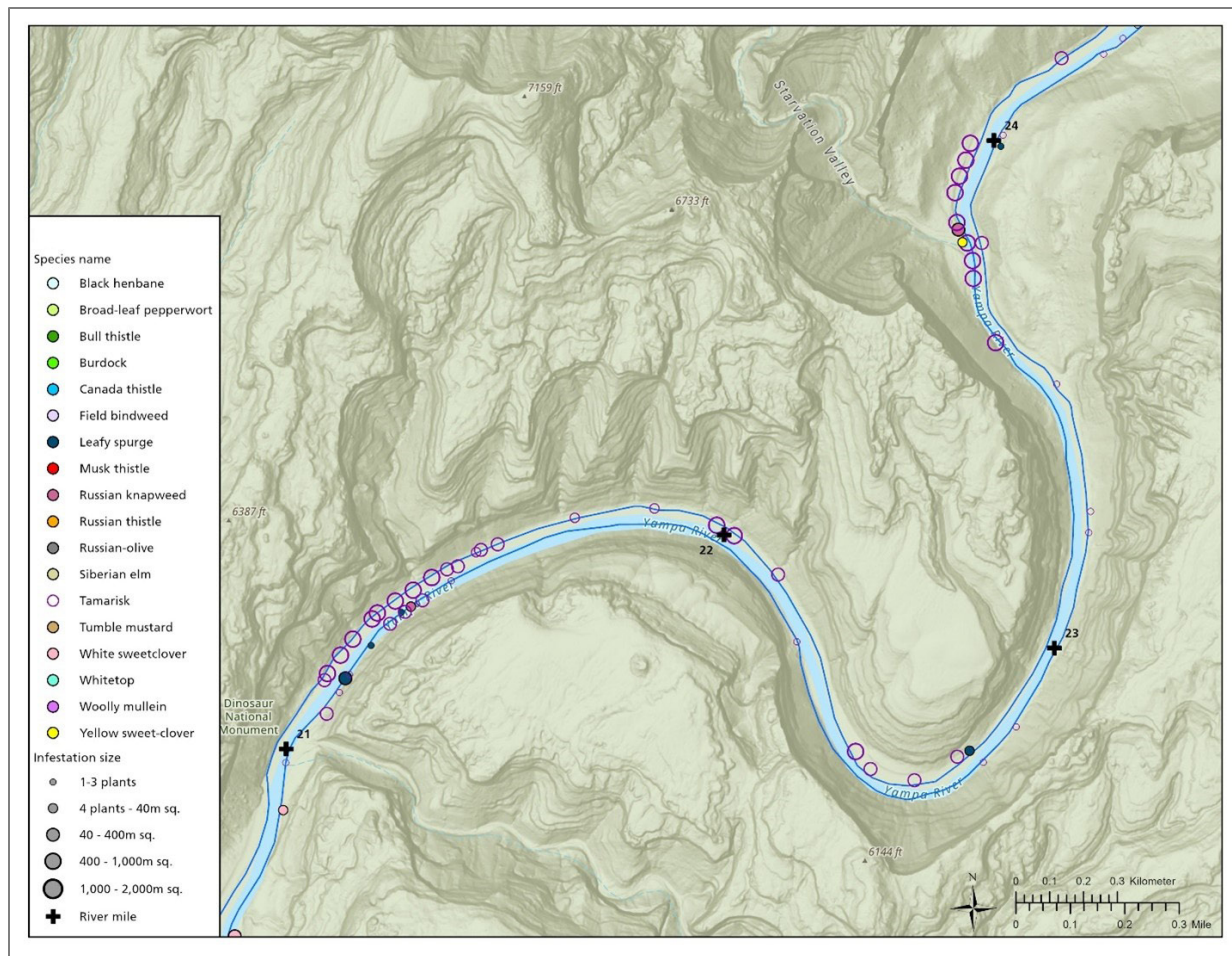


Figure 29. Invasive plants detected on monitoring routes around the Starvation Valley area on the central portion of the Yampa River at Dinosaur National Monument, June 20–26, 2024.

NPS / ANETH WIGHT

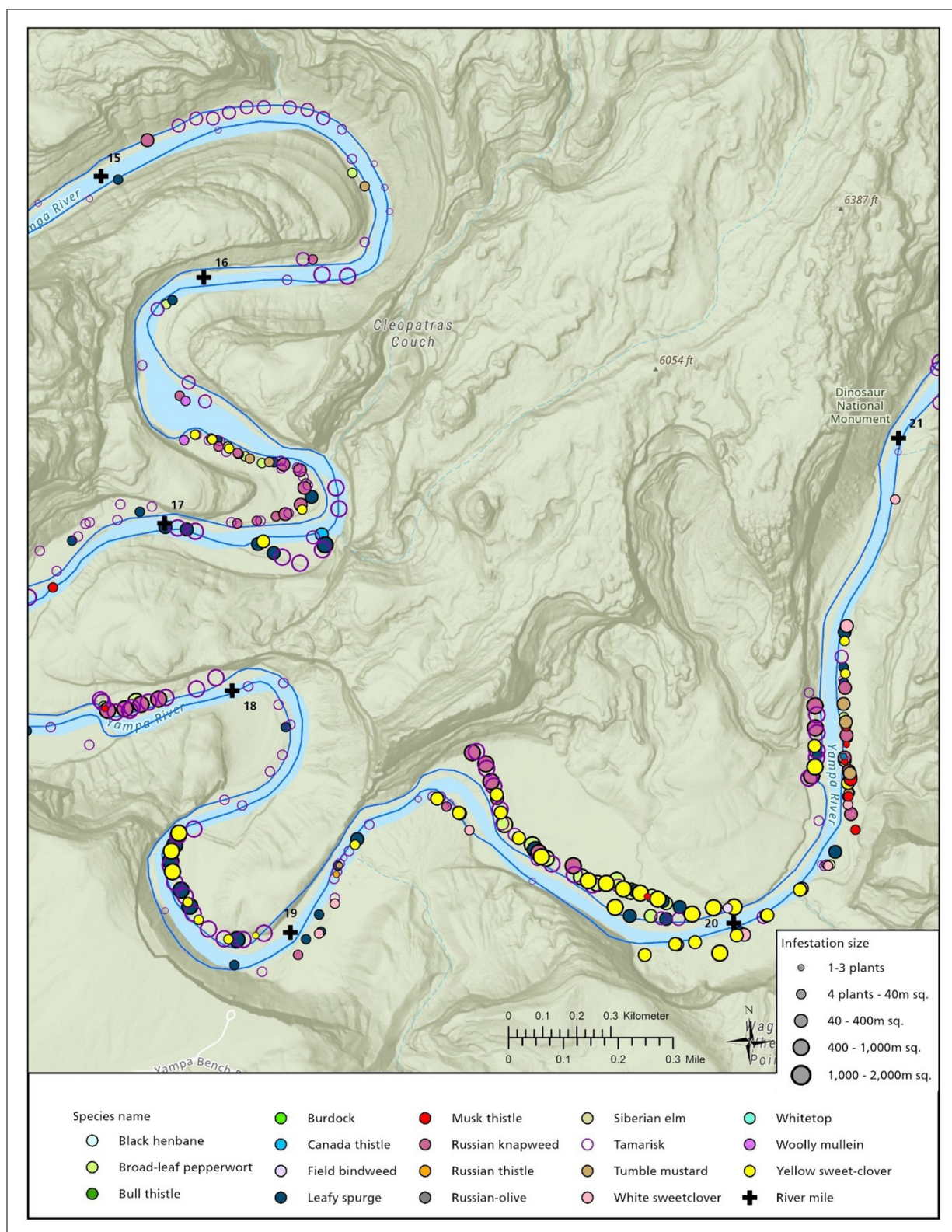


Figure 30. Invasive plants detected on monitoring routes around the Harding Hole area on the central portion of the Yampa River at Dinosaur National Monument, June 20–26, 2024.

NPS / ANETH WIGHT

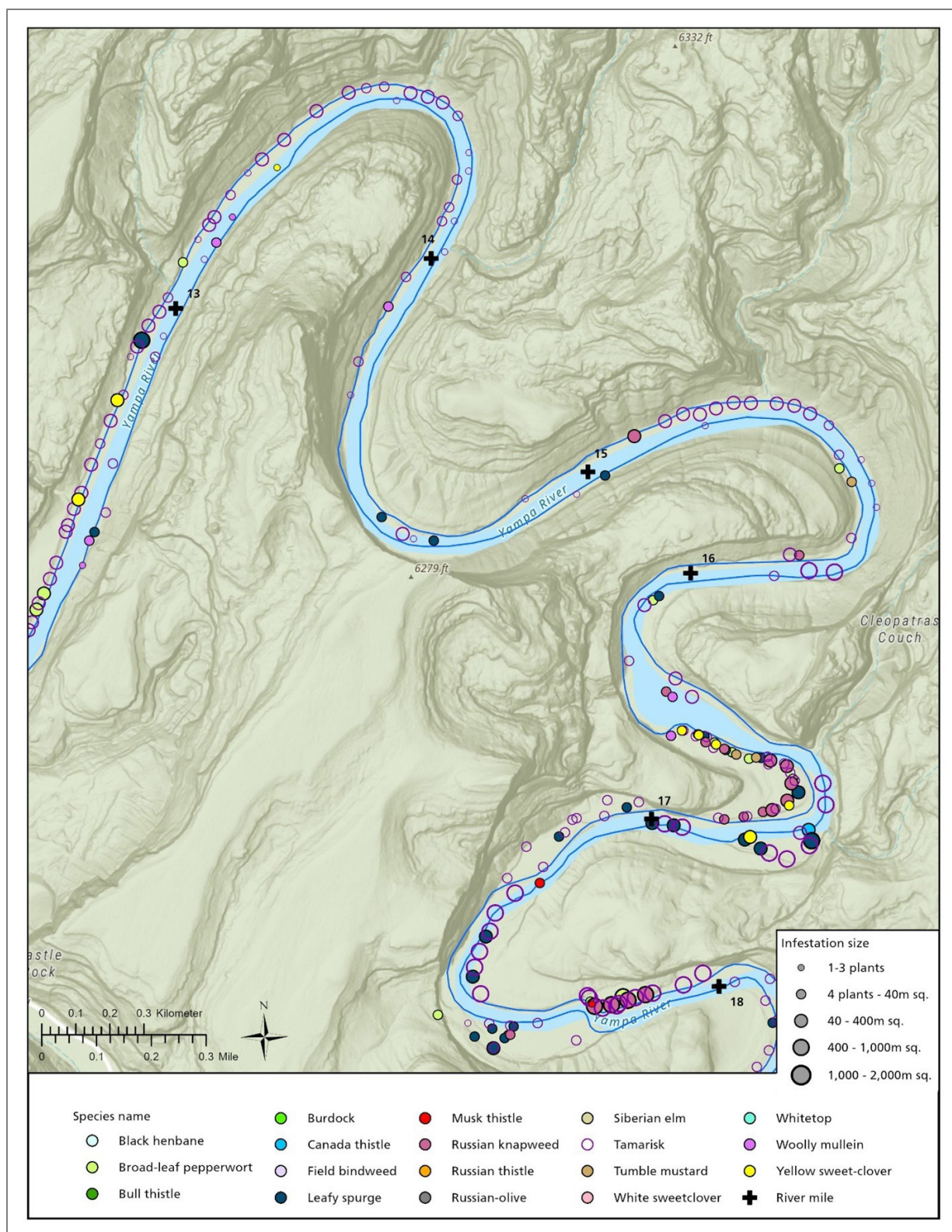


Figure 31. Invasive plants detected on monitoring routes around Cleopatra's Couch on the central portion of the Yampa River at Dinosaur National Monument, June 20–26, 2024.

NPS / ANETH WIGHT

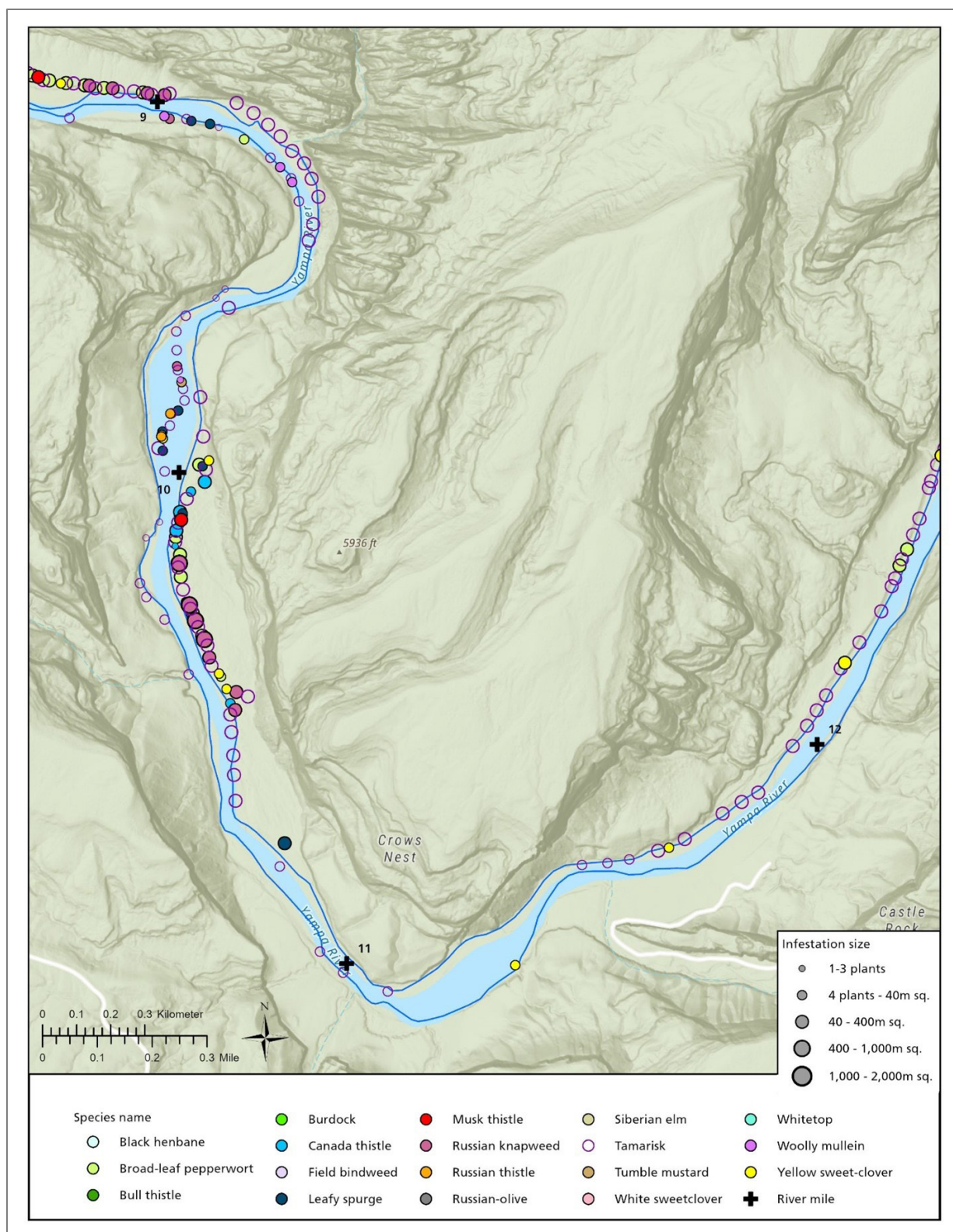


Figure 32. Invasive plants detected on monitoring routes around the Laddie Campground on the western portion of the Yampa River at Dinosaur National Monument, June 20–26, 2024.

NPS / ANETH WIGHT

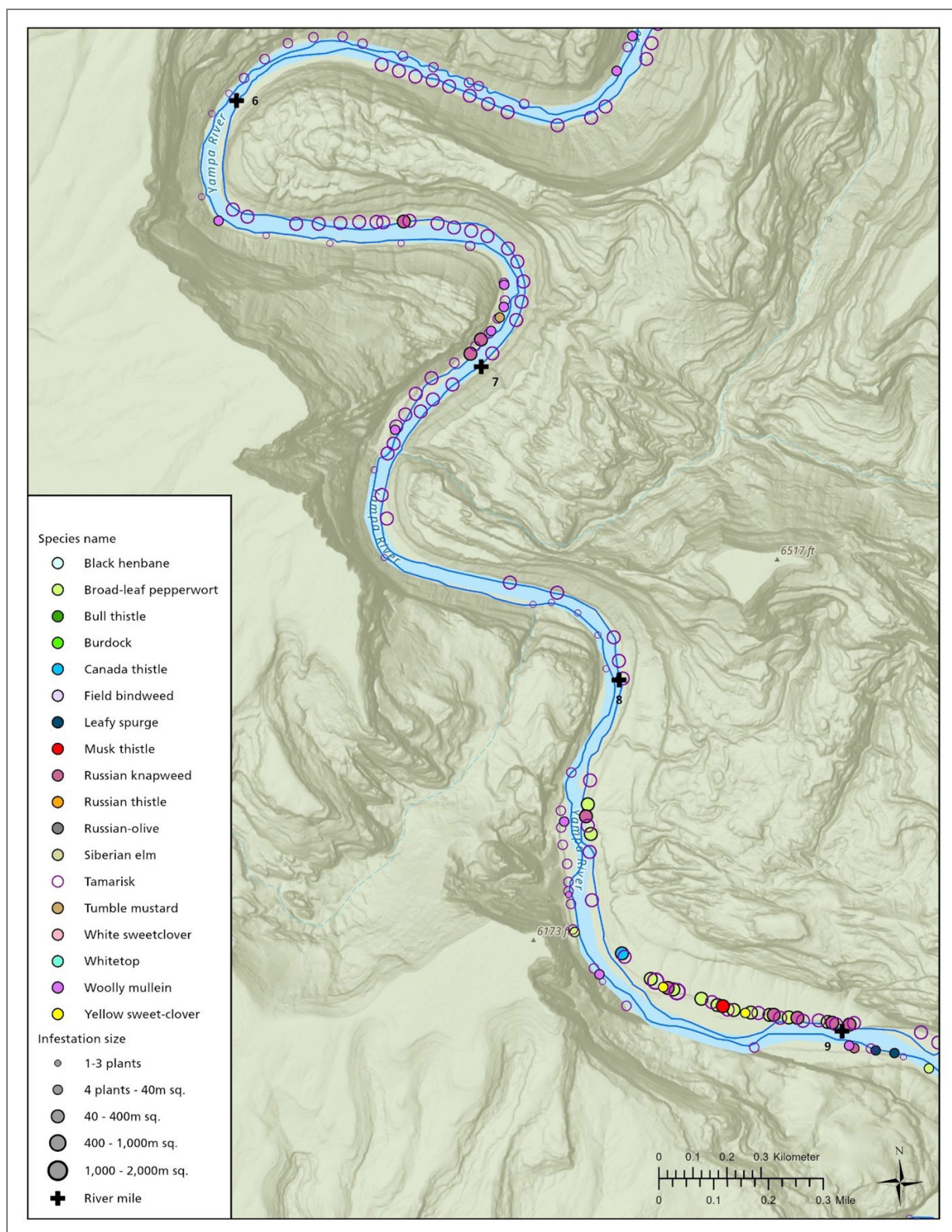


Figure 33. Invasive plants detected on monitoring routes along the Tiger Wall area on the western portion of the Yampa River at Dinosaur National Monument, June 20–26, 2024.

NPS / ANETH WIGHT

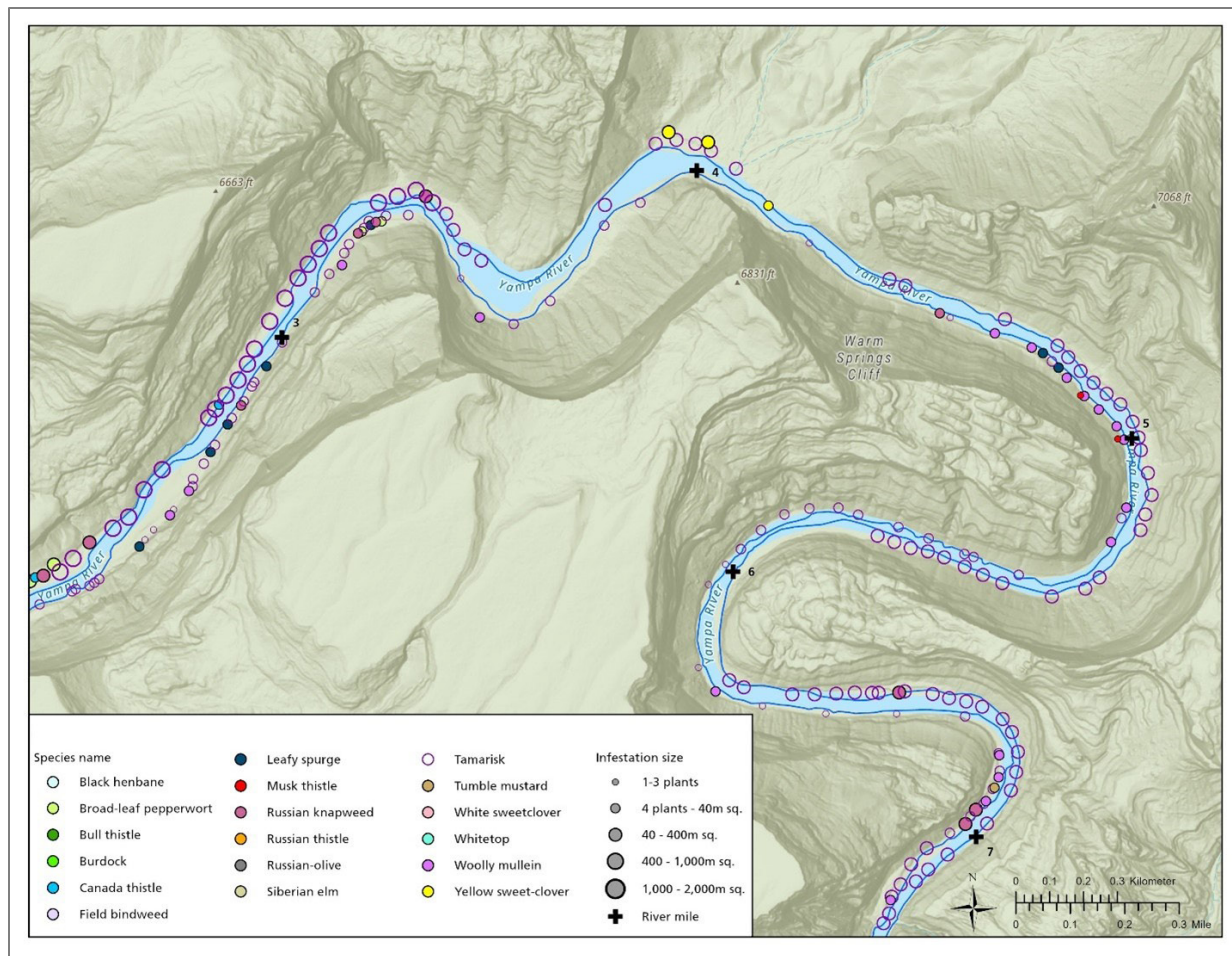


Figure 34. Invasive plants detected on monitoring routes around Warm Springs Rapid on the western portion of the Yampa River at Dinosaur National Monument, June 20–26, 2024.

NPS / ANETH WIGHT

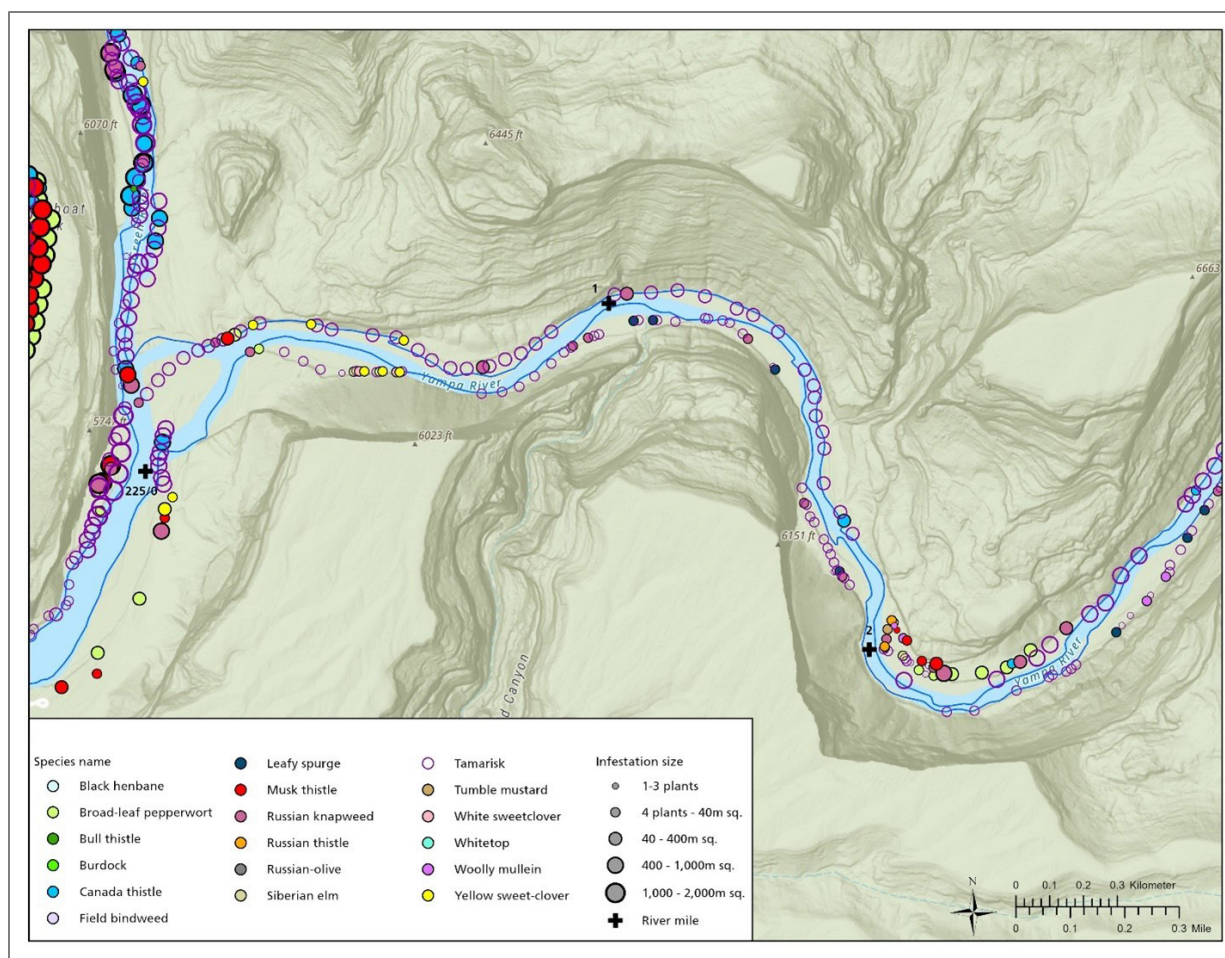


Figure 35. Invasive plants detected on monitoring routes east of the confluence of the Green and Yampa Rivers at Dinosaur National Monument, August 16–23, 2023 and June 20–26, 2024.

NPS / ANETH WIGHT

3.3 Monitoring Transects

A total of 7 species were detected in 148 transects, divided equally across the Green and Yampa Rivers, in 2023 and 2024 (Table 5; NPS 2025b). IEPs were found on 69%, 60%, and 34% of transects around the Green River above the confluence, the Green River below the confluence, and the Yampa River, respectively, with an average of 0.69, 0.65, and 0.33 IEP species detected per plot. Percent cover of tamarisk (1.44%) in the Green River routes above the confluence was the highest of any area. While there were 5 invasive species recorded in transects around the Yampa River, the percent cover of all invasive species combined was 0.55%. Six invasive species were recorded on the Green River above the confluence, and a percent cover of all invasive species combined was 2.05%. Three invasive species were recorded on the Green River below the confluence, and a percent cover of all invasive species combined was 0.67%.

Table 5. Number of monitoring transects where exotic plant species were detected/total number of transects monitored, mean percent cover, and standard error by area at Dinosaur NM, August 16–23, 2023 and June 20–26, 2024.

Species	Upper Green River		Lower Green River		Yampa River	
	Detected /Total ^A	Percent Cover (SE)	Detected /Total	Percent Cover (SE)	Detected /Total	Percent Cover (SE)
<i>Acroptilon repens</i>	–	–	–	–	1/74	0.01 (0.01)
<i>Bromus tectorum</i> ^B	11/54	0.22 (0.13)	4/20	0.04 (0.02)	15/74	0.18 (0.07)
<i>Cirsium arvense</i>	6/54	0.36 (0.17)	–	–	1/74	0.09 (0.09)
<i>Euphorbia esula</i>	–	–	1/20	0.18 (0.19)	–	–
<i>Lepidium latifolium</i>	3/54	0.03 (0.02)	–	–	–	–
<i>Melilotus officinalis</i>	1/54	0.00 (0.00)	–	–	2/74	0.01 (0.01)
<i>Tamarix</i> sp.	16/54	1.44 (0.69)	7/20	0.45 (0.35)	5/74	0.34 (0.21)
All Invasive Species	37/54	2.05 (0.70)	12/20	0.67 (0.38)	24/74	0.63 (0.24)

^A En dash (–) indicates species was not detected on transects.

^B Not on priority list, but a species that is consistently looked for and recorded, if present, in all transects.

3.4 Results Comparison: 2002–2005, 2010–2011, 2014–2019, and 2023–2024

The upper and lower Green River and Yampa River through Dinosaur National Monument have now been monitored four times (Dewey and Anderson 2005; Perkins 2012; Washuta et al. 2018; Perkins 2021). Fifteen species from the IEP priority lists were found during one or more surveys (Table 6). The most common species included broad-leaf pepperwort, yellow sweet clover, and tamarisk.

Table 6. Monitoring routes surveyed by year, species, length, number of priority IEP infestations, and number of infestations/km, Dinosaur NM, 2010–2024.

Dinosaur NM Route	Year	Species	Length (km)	# of Infestations	Infestations/km
Upper Green River	2010–2011	All	66.00	856	12.97
Upper Green River	2014–2019	All	70.43	1,570	22.29
Upper Green River	2023–2024	All	65.89	1,596	24.22
Lower Green River	2010–2011	All	124.49	2,077	16.68
Lower Green River	2014–2019	All	86.78	1,233	14.21
Lower Green River	2023–2024	All	92.76	1,850	19.94
Yampa River	2010–2011	All	152.76	1,133	7.42
Yampa River	2014–2019	All	151.91	1,354	8.91
Yampa River	2023–2024	All	152.56	1,237	8.11

Due to differences in methodology, only broad comparisons can be made between the surveys conducted by USU in 2002–2005 and the three more recent sampling periods completed by NCPN staff (Figures 36–38). When there are similar patterns between the monitoring routes and the monitoring transects, there is more confidence that these results are biologically meaningful.

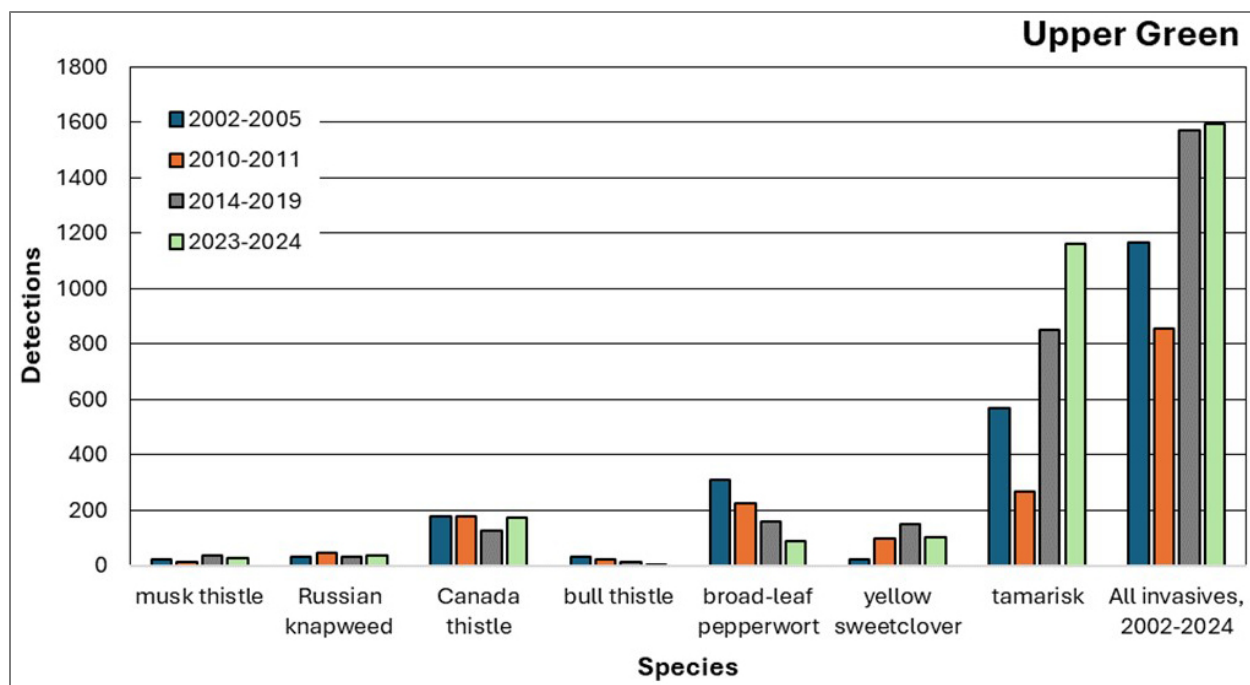


Figure 36. Invasive plants detected on four rotations of monitoring routes along the Green River above the confluence with the Yampa River from 2002 to 2023. Only species with more than 50 total detections are shown.

NPS / TIFFANY NASH

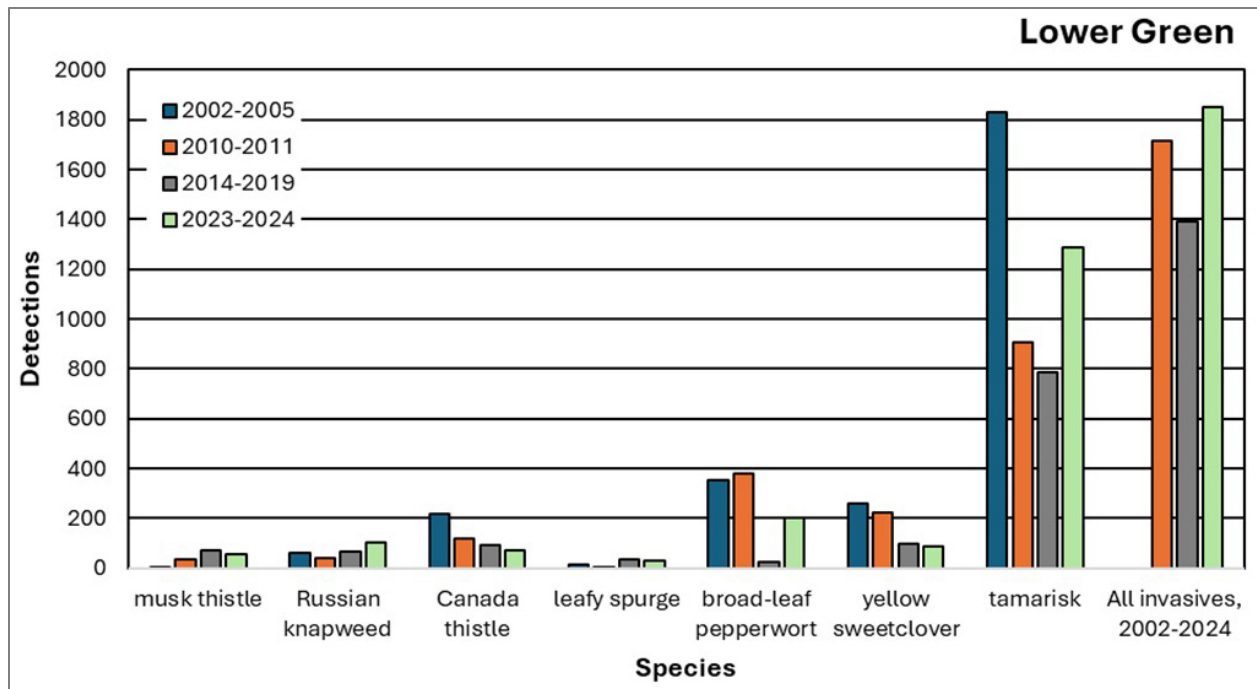


Figure 37. Invasive plants detected on four rotations of monitoring routes along the Green River below the confluence with the Yampa River from 2002 to 2023. Only species with more than 50 total detections are shown.

NPS / TIFFANY NASH

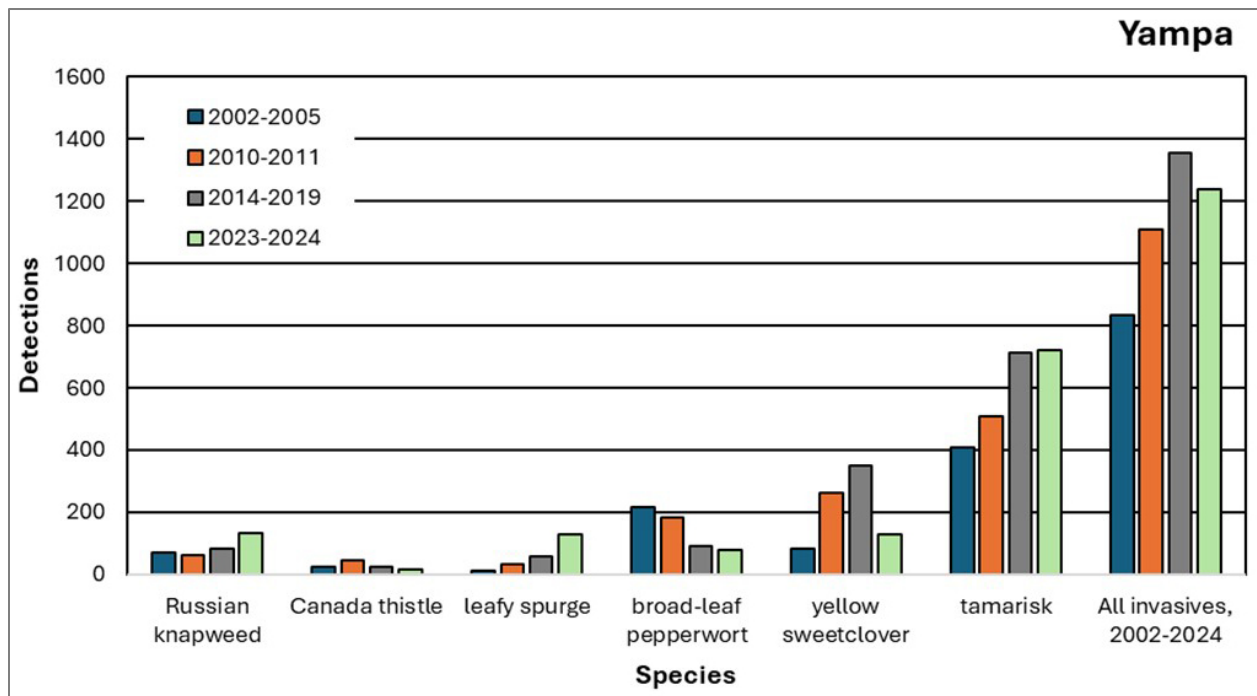


Figure 38. Invasive plants detected on four rotations of monitoring routes along the Yampa River from 2002 to 2024. Only species with more than 50 total detections are shown.

NPS / TIFFANY NASH

Of the routes at Dinosaur NM, there were 343.2 kilometers monitored in 2010–2011, 309.1 kilometers monitored in 2014–2019, and 311.2 kilometers monitored in 2023–2024. In addition, a total of 28 species were on the priority list in 2010–2011, 27 species in 2014, and 24 species in 2017–2019 and 2023–2024. The number of IEP patches increased dramatically along the shores of the Green River above and below the confluence. Russian knapweed (*Acroptilon repens*), leafy spurge (*Euphorbia esula*), broad-leaf pepperwort (*Lepidium latifolium*), and tamarisk (*Tamarix* sp.) all had large increases. Burdock (*Arctium minus*) has increased in number of patches. Musk thistle (*Carduus nutans*), bull thistle (*Cirsium vulgare*), Russian-olive (*Elaeagnus angustifolia*), and yellow sweet clover (*Melilotus officinalis*) have decreased in number of patches.

The total number of IEP patches has slightly decreased on the Yampa River, while increasing on the Green River (see Table 6). While not mapped on the monitoring routes, percent cover and percent frequency of cheatgrass decreased on all three river sections between 2017–2019 and 2023–2024. The number of musk thistle patches decreased on all three river reaches over the three sample periods.

Overall, on the Green River above and below the confluence, yellow sweet clover has decreased in percent cover, percent frequency, and number of patches. Tamarisk has notably increased in patch numbers but not in percent cover or percent frequency since 2010–2011. Conversely, broad-leaf pepperwort patches have generally increased in number of patches but decreased in percent cover and percent frequency. In 2019, NCPN monitoring detected teasel for the first time on the Green River above the confluence, but it was not detected during 2023–2024 monitoring.

4 Discussion

4.1 Priority IEP List

The NCPN will continue to work with park staff and area IEP experts to review and update the list of priority species each year. Presence and absence data for most priority species, and presence data for other species, should be reliable for the area surveyed. Absence data for non-priority species are less reliable, because not all observers recorded all of these species in all years.

4.2 Management Control

In 2006, Dinosaur NM completed an invasive plant management plan and environmental assessment that established procedures and outlined areas for priority management (NPS 2005). That plan identified “threats to native plant communities and the wildlife that depend on them; threats to natural river processes and aquatic resources; and concerns from downriver agricultural producers regarding the increased invasion of perennial pepperweed [broad-leaf pepperwort] and Russian knapweed into irrigated pastures” as primary management concerns. It further identified the Yampa and Green River corridors as the highest priority areas for “future management prescription development.”

The largely unregulated flows of the Yampa River continue to maintain a more native riparian vegetation community than that of the regulated Green River, as reported by Perkins and others (2015). The Yampa River continues to have lower numbers of IEP patches, lower percent cover, and lower percent frequency of IEPs. The lower Green River, which is partially restored (less regulated) below its confluence with the Yampa, has moderate numbers of IEPs, while the highly regulated upper Green River has the highest numbers of IEPs. The upper Green River has nearly three times as many IEP patches per kilometer as the Yampa River. The Green River also has a higher percentage of large ($> 40 \text{ m}^2$) patches than the Yampa.

Tamarisk has consistently been the most prevalent IEP species on all monitoring routes. From 2002 to 2017, tamarisk generally increased on the Yampa River, while remaining more stable on the upper and lower Green River—perhaps even decreasing on the lower Green River. From 2017 to 2024, tamarisk has slightly decreased on the upper and lower Green River and slightly increased on the Yampa River. The number of patches along the Yampa continues to be lower than on the Green River. The increases on the Yampa likely indicate there is still niche space available for invasives to colonize there, while on the upper Green River, most spaces are already occupied with invasives. It should be noted that the tamarisk beetle (*Diorhabda elongata*) was released as a biocontrol in the monument in 2006 and 2007 and is now widespread throughout the monument. Dinosaur NM staff and Colorado Department of Agriculture Palisade Insectary have performed annual tamarisk beetle monitoring on both the Green and Yampa Rivers since 2006. The study is scheduled to end in 2026 and will represent the longest continuous data set on tamarisk beetles post-release in the country. It is also likely that removal efforts by monument staff and volunteers between 2010 and 2018 have affected tamarisk populations, particularly in the more dense patches on the Green River. Dinosaur NM staff and volunteers are active once again in tamarisk removal, with a focus on removal in high-value ecological (e.g., fish spawning bars) and recreational (river camps, day-use areas) sites.

However, increases on the Yampa River should continue to be monitored and controlled where possible.

More recently, the monument has coordinated with the Colorado Department of Agriculture Palisade Insectary to release biological control insects for several other invasive plants. In 2021 releases began of a gall midge (*Jaapiella ivannikovi*) and a gall wasp (*Aulacidea acroptilonica*) for the long-term suppression of Russian knapweed. As of July 2024, 175,000 gall wasps and 1,000 gall midges have been spatially distributed along the river corridors and in Cub Creek. Establishment of these insects has been very successful and the insects are spreading as hoped. In 2022 large-scale releases began of the leafy spurge flea beetle (*Aphthona* sp.) and the leafy spurge stem boring beetle (*Oberea erythrocephala*) for the long-term control of leafy spurge, also along the river corridors. As of August 2024, 44,200 flea beetles and 500 stem boring beetles have been deployed. Limited post-release monitoring occurs for all biocontrol insects to determine establishment success and long-term effectiveness. Limited releases of a rust fungus (*Puccinia punctiformis*) for suppression of Canada thistle occurred in Lodore Canyon and at Echo Park in 2022. Evidence of the rust fungus expanding was documented at the confluence in June 2024. However, additional rust fungus releases are paused until USDA Animal and Plant Health Inspection Service (APHIS) or EPA permitting resumes. Future opportunities for biocontrol may include the musk thistle rosette weevil (*Trichosirocalus horridus*) in Lodore Canyon.

Herbicide work in the monument is largely limited to front country sites, such as Echo Park and Cub Creek. A combined Invasive Plant Management Team (IPMT) from Glacier National Park (NP), Grand Teton NP, and Colorado NM continues to support fall treatments for Russian knapweed, thistles, pepperweed, and Russian olives each year. More recently, the monument has acquired funding for post-fire restoration on the Green River and HQ fires to restore native perennial grasslands by controlling invasive annuals (cheatgrass, Russian thistle [*Salsola* sp.], and kochia [*Bassia* spp.]). A pilot project that began in Echo Park in 2019 showed great success in passive restoration of native grasses and annuals following a cheatgrass treatment with Rejuvra. A secondary invasion of Russian thistle followed a couple years later and has now become the primary target of additional treatments. Bulbous bluegrass is treated with herbicides opportunistically and continues to be a challenge, as it is widespread in many river camps, facilitating its spread throughout the river corridors and beyond.

Yellow sweet clover is widespread across monitoring areas and has decreased on all three river reaches over the survey years. It appears to be ubiquitous and is encountered frequently but tends to have low percent cover. Cheatgrass became substantially more widespread and increased in cover from 2010–2011 to 2017–2019. When higher covers occur, this fire-prone species can alter the fire regime. From 2017–2019 to 2023–2024, cheatgrass occurrence and percent cover have significantly decreased across all three monitoring routes.

The increase in cheatgrass could be related to a comparative lack of flood-stage events sufficient to have scoured grasses from the banks prior to monitoring in 2017 and 2019. On the Yampa River, there was one peak above 20,000 cfs and four peaks above 15,000 cfs in the six years prior to 2010.

But in the six years prior to 2017, there were no floods above 20,000 cfs and just two above 15,000 cfs. A large (27,400 cfs) flood in 2011 likely scoured away vegetation, but the next surveys did not take place until six years later, in 2017. In the six years prior to 2024, there was only one flood above 20,000 cfs in 2023. Similarly, on the Green River (below the confluence), there were four peaks above 20,000 cfs in the six years prior to summer sampling in 2011, including the largest flood in the last 20 years (32,200 cfs, in 2011). But in the eight years prior to 2019, the gage at Jensen, Utah, recorded just three flows above 20,000 cfs. The gage at Jensen, Utah, recorded three floods above 17,000 cfs between 2020 and 2023. The gage in Greendale, Utah, had no floods above 9,500 cfs due to dam-restricted flows. Changes in precipitation could also have influenced the amount of cheatgrass, an annual plant.

Russian thistle is increasingly becoming a concern for park management. Annual plants have a shorter life cycle than perennial plants and are more easily suppressed by perennials. However, sightings of Russian thistle have become more common, and the species has been observed invading and persisting in both disturbed and relatively undisturbed sites within the inner park. Our observations originate from the Green and Yampa Rivers and do not reflect IEP populations within the inner park. For the first time, Russian thistle was detected on the Yampa River in 2024. Five Russian thistle patches were found along the Yampa River. The largely unregulated flows of the Yampa River may have transported Russian thistle. High peak floods may destroy or remove the species from the area; however, only one peak above 20,000 cfs was recorded between 2018 and 2024. We recommend potentially adding Russian thistle to the IEP list and continuing observation and efforts to eradicate invasive plant patches.

Several IEPs with rising or steady populations are potential candidates for control or are already being treated:

- Musk thistle has increased on the lower Green River and decreased on the upper Green River and the Yampa River.
- Yellow sweetclover has decreased on all three river reaches.
- Leafy spurge has remained stable on the upper and lower Green River, and increased on the Yampa River.
- Teasel has always been a concern to park managers because of its prevalence 45 miles upstream of Dinosaur NM, especially in the reaches below Flaming Gorge Reservoir. It appeared for the first time in NCPN monitoring in 2019, with four patches on the upper Green River. Teasel was not recorded on routes or transects across the Green and Yampa Rivers in 2023–2024.
- Russian thistle was detected for the first time in 2024 on the Yampa River.

4.3 Future Monitoring Efforts

IEPs at Dinosaur NM will generally be monitored at the same time of year in future monitoring efforts. Consistency in timing of monitoring should ensure consistency in detection probabilities and cover estimates for most species. For many species, sampling any time from May through September

is not expected to drastically alter the chances of detecting invasive species larger than the MDTs. Extra-area surveys will also be considered for inventories at the park's request.

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