



Invasive Exotic Plant Monitoring at Curecanti National Recreation Area

2023 Field Season



Oxeye daisies (*Leucanthemum vulgare*), an invasive species, inundated by the 2023 runoff of the Blue Mesa Reservoir in Curecanti National Recreation Area.

NPS / AMY WASHUTA

Invasive exotic plant monitoring at Curecanti National Recreation Area: 2023 field season

Science Report NPS/SR—2025/262

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Abstract

Invasive exotic plant (IEP) species are one of the biggest threats to natural ecosystem integrity and biodiversity, and their control is a high priority for the National Park Service. The Northern Colorado Plateau Network (NCPN) selected early detection of IEPs as one of the 11 monitoring protocols implemented as part of its long-term monitoring program. This report represents work completed during the 2023 field season at Curecanti National Recreation Area (NRA). From June 21 to 27, 2023, we recorded 18 different priority IEP species during monitoring. We recorded 1,450 priority IEP patches along 55.9 km (34.7 miles) of four monitoring routes. Canada thistle (*Breca arvensis*), musk thistle (*Carduus nutans*), woolly mullein (*Verbascum thapsus*), and Russian thistle (*Salsola spp.*) were the most widespread species. Density of invasive plants was higher along the reservoir routes than the trail routes. Along the Blue Mesa Reservoir routes, percent cover of all invasive species combined was 1.41%. The Blue Mesa Reservoir 1 and Blue Mesa Reservoir 6 routes had much higher infestations per kilometer and higher overall percent cover in 2023 than compared to 2014. Large increases were observed in Canada thistle, musk thistle, Russian thistle, and woolly mullein. The number of infestations along the Dillon Pinnacles and Pine Creek trails declined from previous sampling periods.

Acknowledgments

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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 (Maxwell et al. 2016) 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, the 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 priority IEPs in parks along key invasive pathways.

Invasive exotic plants can spread into national parks via several 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, the consequences of these plant invasions present a significant challenge to the bureau’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, reservoir shorelines, 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, animals, or both.

Specific objectives of NCPN invasive exotic plant monitoring are:

1. To detect incipient populations and new introductions of IEPs before they become established in areas of management significance and invasion pathways, and
2. To determine status and trends of selected IEP populations of management significance.

This report summarizes the 2023 field season and the start of the third monitoring rotation at Curecanti National Recreation Area (NRA).

2 Methods

We followed the invasive plant monitoring protocol developed by the NCPN (Perkins et al. 2016). The protocol emphasizes the rapid collection of IEP location and abundance data to maximize the 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).

After park and NCPN staff reviewed the list of priority invasive plants (see Section 2.1), we established a series of co-located monitoring routes and quadrats along all roads, shorelines, major drainages, and trails in the park. The quadrats, which are sampled quantitatively, 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, maximizing our opportunities for detecting IEPs in the park.

The monitoring routes sampled in 2023 were previously sampled in 2014 (Perkins 2015, Perkins and Wight 2016) and 2010–2011 (Perkins 2012, 2013).

2.1 Developing a park priority invasive exotic plant list

Prior to beginning monitoring in 2015, staff from the NCPN, Black Canyon of the Gunnison National Park, and Curecanti NRA reviewed the park's list of priority IEPs (Table 1), which was created in 2010. The original list of target IEPs was developed by reviewing past park literature and state and county weed lists, as well as consulting with park staff and county weed managers. The priority IEP list includes existing IEPs and potential IEPs of high management concern. Because these methods were designed to be rapid, field crews were trained to develop a focused search image on the priority IEPs, rather than looking for every possible invasive plant species. Eradicating these priority species, or containing them within a park, is still thought to be possible.

Table 1. Priority invasive plant list, Curecanti NRA, 2010–2023.

Scientific Name	Common Name
<i>Acosta diffusa</i>	diffuse knapweed
<i>Acosta maculosa</i>	spotted knapweed
<i>Acroptilon repens</i>	Russian knapweed
<i>Arctium minus</i>	burdock
<i>Artemisia absinthium</i>	absinth wormwood
<i>Bassia sieversiana</i>	kochia
<i>Breea arvensis</i>	Canada thistle

^A 2010 and 2023 only

^B Changed *Cardaria draba* to *Cardaria sp.* in 2023

Table 1 (continued). Priority invasive plant list, Curecanti NRA, 2010–2023.

Scientific Name	Common Name
<i>Cardaria sp.</i> ^B	hoary cress
<i>Cardaria latifolia</i>	perennial pepperweed
<i>Carduus nutans</i>	musk thistle
<i>Cirsium vulgare</i>	bull thistle
<i>Cyclachaena xanthifolia</i>	marsh elder
<i>Convolvulus arvensis</i> ^A	field bindweed
<i>Cynoglossum officinale</i>	common hound's-tongue
<i>Elaeagnus angustifolia</i>	Russian olive
<i>Hesperis matronalis</i>	Dame's rocket
<i>Hyoscyamus niger</i>	black henbane
<i>Leucanthemum vulgare</i>	ox-eye daisy
<i>Linaria genistifolia</i>	Dalmatian toadflax
<i>Linaria vulgaris</i>	yellow toadflax
<i>Matricaria perforata</i>	scentless chamomile
<i>Onopordum acanthium</i>	Scotch thistle
<i>Phalaroides arundinacea</i>	reed-canarygrass
<i>Potentilla recta</i>	sulfur cinquefoil
<i>Rubus armeniacus</i>	Himalayan blackberry
<i>Rumex crispus</i> ^A	curly dock
<i>Salsola sp.</i>	Russian thistle
<i>Tamarix spp.</i>	tamarisk
<i>Tithymalus esula</i>	leafy spurge
<i>Ulmus pumila</i>	Siberian elm
<i>Verbascum thapsus</i>	woolly mullein
<i>Viticella orientalis</i> ^A	Chinese clematis

^A 2010 and 2023 only

^B Changed *Cardaria draba* to *Cardaria sp.* in 2023

Prior to the start of monitoring in 2023, NCPN and park staff reviewed the list of priority IEPs (Table 1) that was developed in 2015. Park staff requested that field bindweed (*Convolvulus arvensis*) and curly dock (*Rumex crispus*), which were both on the 2010–2011 target list and were removed from the 2014 list, be added to the 2023 target list.

2.2 Monitoring routes

While observers strive to observe and map all priority IEP patches along monitoring routes, some priority IEP species, especially those with low numbers and small stature, will inevitably be overlooked. To account for these non-detections, the NCPN has developed a minimum detection target size (MDTS), effective detection distance (EDD), and effective detection swath width (EDSW)

that are based on the observability of the least-visible priority IEP species. Therefore, these areas and distances should be considered conservative estimates of an observer's ability to detect IEP patches, as most (and potentially, all) IEP patches mapped during monitoring are composed of more easily visible species. As a result, many mapped patches of priority IEP species are observed partially or completely beyond these values.

2.2.1 Minimum detection target size

The minimum detection target size (MDTS) represents the patch size 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 priority IEPs. Use of the MDTS is necessary because field technicians are not expected to find every single plant of every priority IEP species during route surveys. Although searching for single mature plants of some priority IEP species, such as tamarisk (*Tamarix* sp.), is possible due to their large size, single plants of other priority IEP 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 priority IEP species with at least 90% detection efficiency (Figure 1). Crew members are trained to quantify EDD by walking away from the least-visible priority IEP species (or, if this species is not present, plants of similar stature) of a MDTS (i.e., 40 m²) and determining the maximum distance from which they could consistently see and recognize this patch with complete confidence.

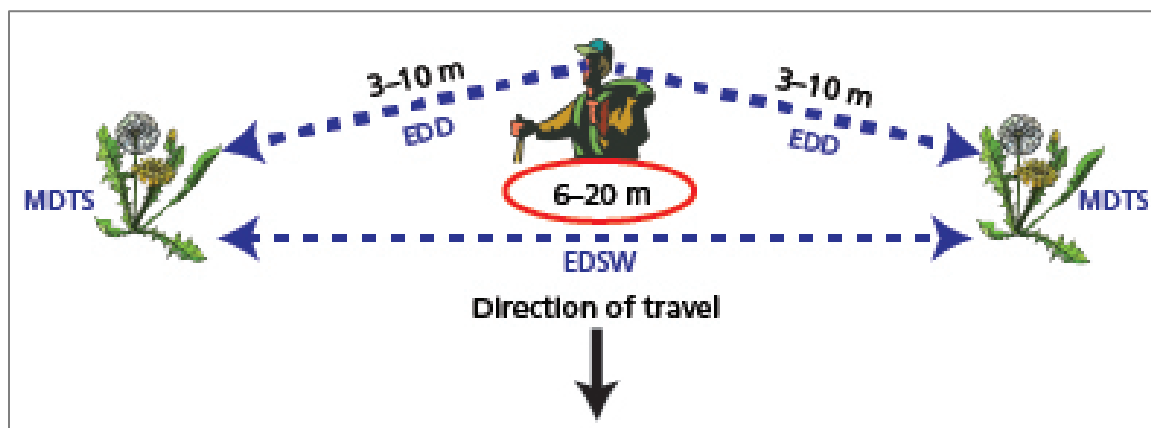


Figure 1. The maximum Effective Detection Distance (EDD) at Curecanti National Recreation Area ranged from 3–10 meters in 2023, making the Effective Detection Swath Width (EDSW) 6–20 meters.
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The size of the EDD is quantified in the field by crew members at the start of each monitoring route and adjusted as necessary, depending on surrounding vegetation and terrain. In 2023, the EDD for Curecanti NRA was between 3 and 10 meters.

2.2.3 Effective detection swath width

Effective detection swath width (EDSW) is defined as the maximum width of a linear search swath (band transect) in which a walking observer is confident of visually detecting 90% of all priority species of the MDTs (Figure 1). The effective detection swath width (EDSW) is equal to two times the EDD, because the surveyor can effectively detect priority IEPs for one EDD on either side of the search route. The EDSW ranged from 6 to 20 meters at Curecanti NRA in 2023.

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 priority 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

Observers walked down the center of the route (see Figure 2), searching for priority IEPs by visually scanning (side to side) all the land within the EDSW. If the terrain was uneven or steep, and the observers had to glance frequently at the ground to ensure safe foot placement, then searchers stopped approximately every 6–20 meters (the length of one EDSW) and visually scanned the area in all directions. As monitoring routes were traversed, locations of all priority species were documented using GPS units with at least 5-meter accuracy. Only species designated as priority were consistently recorded on monitoring routes. Survey crew members were allowed to record additional IEP species if they were noteworthy.

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 of $\leq 2 \times 2$ 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).

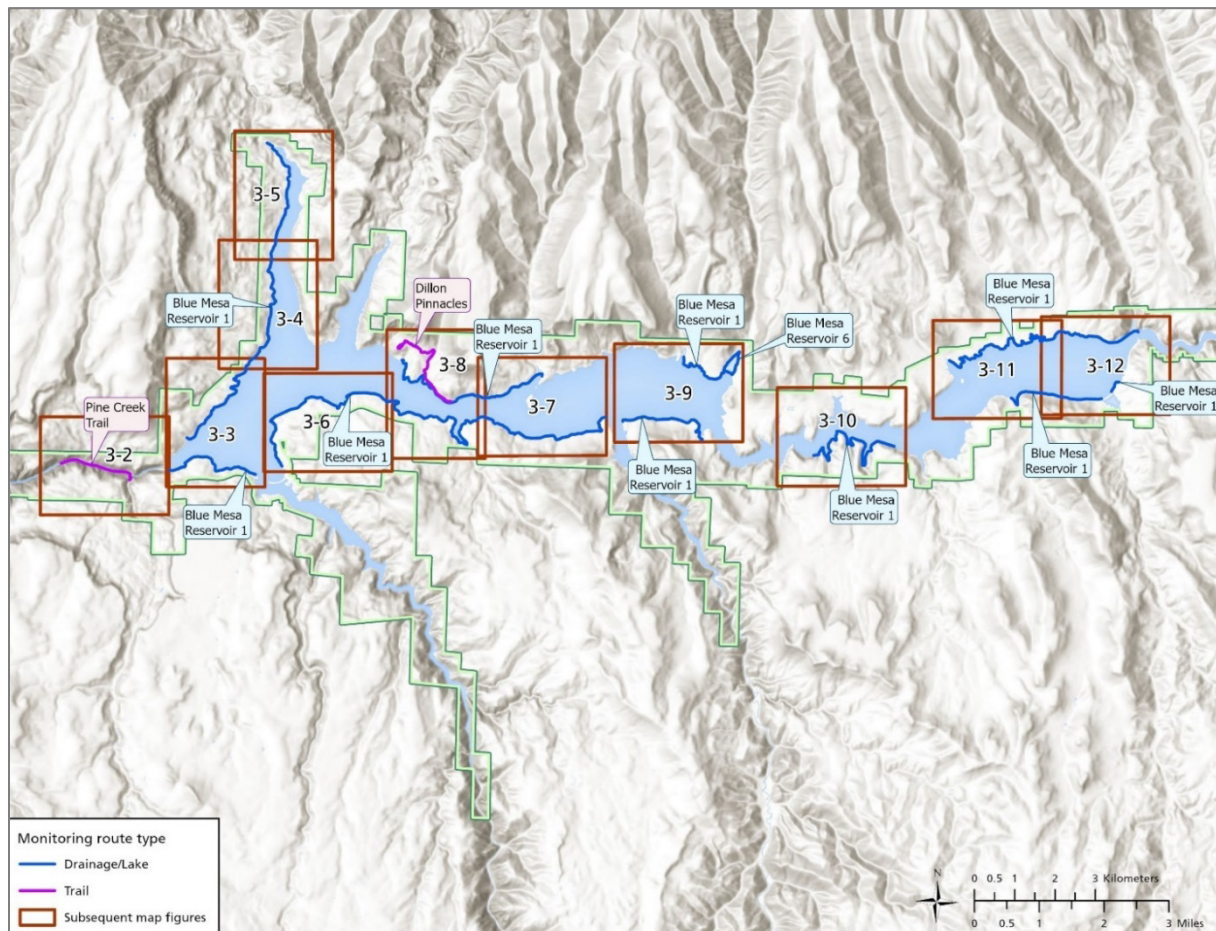


Figure 2. Overview of invasive exotic plant monitoring routes surveyed at Curecanti National Recreation Area, June 21–27, 2023.

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We recorded cover class by estimating the amount, or percentage, of ground covered by the vertical projection of plant matter in the 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., seedling, sapling, mature tree, old growth), evidence of prior treatment, and evidence of disturbances (e.g., recent fire, flood, small mammal disturbance).

2.3 Monitoring transects and quadrats

The ability to map priority IEPs along routes is inherently subjective due to differences in observer experience and attention to detail. Furthermore, the broad cover classes used in mapping are insufficient to accurately represent the percent cover of an IEP along monitoring routes. To improve consistency in detecting and quantifying IEPs among observers, we supplemented IEP mapping with additional observations along transects. Transects were established every 500 meters along monitoring routes. Transects extended perpendicularly from the edge of a route being walked and on alternating sides of routes consisting of narrow riparian areas, small roads, or trails.

Along each transect, we established up to three 1-m² sampling frames (i.e., quadrats) to quantify vegetation cover and soil surface features. Quadrats were centered at 0.5, 5, and 10 meters along the right side of the transect line as the technician walked from the monitoring route. In some cases, quadrats could not be placed at 5 and 10 meters due to safety concerns. When necessary, observers leveled the sampling frame by propping up quadrat corners.

In the monitoring quadrats, we recorded all priority IEP species as well as cheatgrass (*Anisantha tectorum*) and yellow sweet-clover (*Melilotus officinalis*). Plants recorded as present in quadrats include both plants rooted within quadrats as well as plants rooted outside of, but leaning over, the quadrat frame. 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.

3 Results

3.1 Priority invasive exotic plant list

In 2023, field crews searched monitoring routes for 32 species identified as high priority at Curecanti NRA (see Table 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 for the areas searched, but presence and absence data for other species may be less reliable. We detected 18 priority IEP and 2 non-priority IEP species along 55.9 kilometers (34.7 miles) of monitoring routes and 114 transects in 2023 (Table 2, see Figure 3).

Table 2. Invasive exotic plants detected at Curecanti National Recreation Area, June 21–27, 2023.

Scientific Name	Common Name	Method Detected	Park Priority
<i>Acroptilon repens</i>	Russian knapweed	Routes	Yes
<i>Ansiantha tectorum</i>	Cheatgrass	Transects	No
<i>Artemisia absinthium</i>	absinth wormwood	Routes	Yes
<i>Bassia sieversiana</i>	summer-cypress	Routes, Transects	Yes
<i>Breea arvensis</i>	Canada thistle	Routes, Transects	Yes
<i>Cardaria latifolia</i>	broad leaf pepperwort	Routes	Yes
<i>Cardaria sp.</i>	whitetop	Routes, Transects	Yes
<i>Carduus nuttans</i>	musk thistle	Routes, Transects	Yes
<i>Cirsium vulgare</i>	bull thistle	Routes	Yes
<i>Convolvulus arvensis</i>	field bindweed	Routes	Yes
<i>Leucanthemum vulgare</i>	oxeye daisy	Routes, Transects	Yes
<i>Matricaria perforata</i>	scentless chamomile	Routes	Yes
<i>Melilotus officinalis</i>	yellow sweet clover	Transects	No
<i>Phalaroides arundinacea</i>	reed-canarygrass	Routes	Yes
<i>Potentilla recta</i>	sulfur cinquefoil	Routes	Yes
<i>Rumex crispus</i>	curly dock	Routes, Transects	Yes
<i>Salsola sp.</i>	Russian thistle	Routes, Transects	Yes
<i>Tamarix spp.</i>	tamarisk	Routes	Yes
<i>Ulmus pumila</i>	Siberian elm	Routes	Yes
<i>Verbascum thapsus</i>	woolly mullein	Routes, Transects	Yes

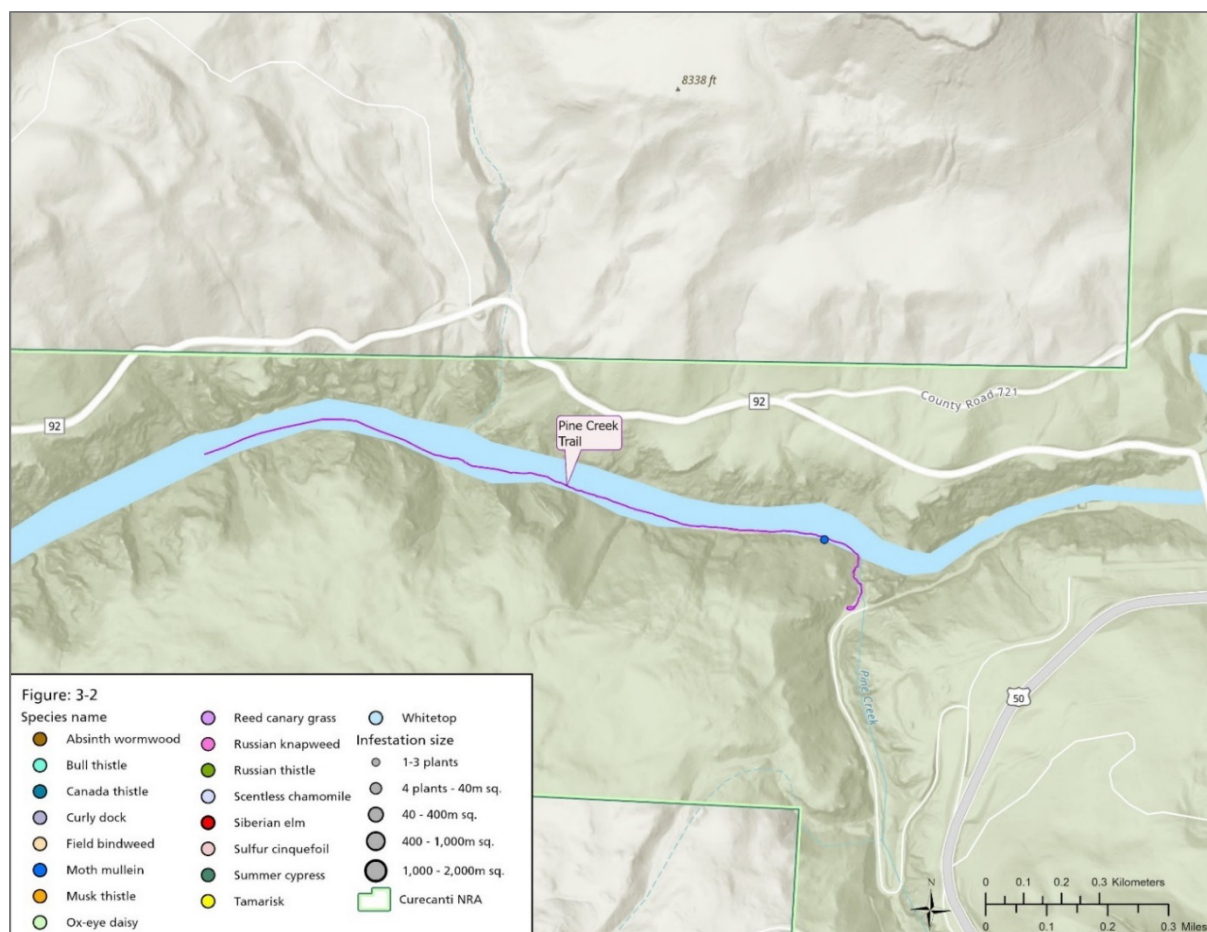


Figure 3. Invasive plants detected on monitoring routes and quadrats in the vicinity of the Pine Creek Trail, Curecanti NRA, June 21–27, 2023.

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3.2 Monitoring routes

A total of 1,450 patches of 18 different priority species were detected along the monitoring routes (Tables 3 and 4; Figures 2–13; NCPN 2025a). Density of invasive plants was higher along the reservoir routes than the trail routes (Table 3). Canada thistle (*Breea arvensis*), musk thistle (*Carduus nutans*), woolly mullein (*Verbascum thapsus*), and Russian thistle (*Salsola* spp.) were the most widespread species (Table 4). These four species represented 79.6% of all patches detected.

Table 3. Monitoring routes surveyed, route type, length, number of IEP infestations, and number of infestations/km, Curecanti NRA, June 21–27, 2023.

Route	Type of Route	Length (m)	Area (ha)	# of Infestations	Infestations/km
Blue Mesa 1	Reservoir	49,250.2	47.1	1,409	28.6
Blue Mesa 6	Reservoir	1,476.2	1.0	40	27.1
Reservoir Total	–	50,726.4	48.1	1,449	28.6
Dillon Pinnacles	Trail	3,133.4	3.1	0	0.0
Pine Creek	Trail	2,024.4	1.2	1	0.5
Trail Total	–	5,157.8	4.3	1	0.2

Table 4. Species observed and infestation size class detected along all monitoring routes, Curecanti NRA, June 21–27, 2023.

Species	Total Infestations	1 to Few Plants	Few Plants < 40 m²	40–400 m²	400–1000 m²	>1000 m²
<i>Acroptilon repens</i>	19	0	10	7	2	0
<i>Artemisia absinthium</i>	1	0	1	0	0	0
<i>Bassia sieversiana</i>	60	1	19	24	14	2
<i>Breea arvensis</i>	409	3	63	284	59	0
<i>Cardaria latifolia</i>	1	0	0	1	0	0
<i>Cardaria spp.</i>	25	3	14	8	0	0
<i>Carduus nutans</i>	359	30	71	229	29	0
<i>Cirsium vulgare</i>	10	7	1	1	1	0
<i>Convolvulus arvensis</i>	10	1	3	6	0	0
<i>Leucanthemum vulgare</i>	32	3	11	14	4	0
<i>Matricaria perforata</i>	17	4	9	4	0	0
<i>Phalaris arundinacea</i>	36	4	9	22	1	0
<i>Potentilla recta</i>	14	3	9	2	0	0
<i>Rumex crispus</i>	67	31	24	10	2	0
<i>Salsola sp.</i>	131	1	40	78	10	2
<i>Tamarix sp.</i>	1	1	0	0	0	0
<i>Ulmus pumila</i>	3	1	2	0	0	0
<i>Verbascum thapsus</i>	255	29	60	140	26	0
Priority Species	1,450	122	346	830	148	4

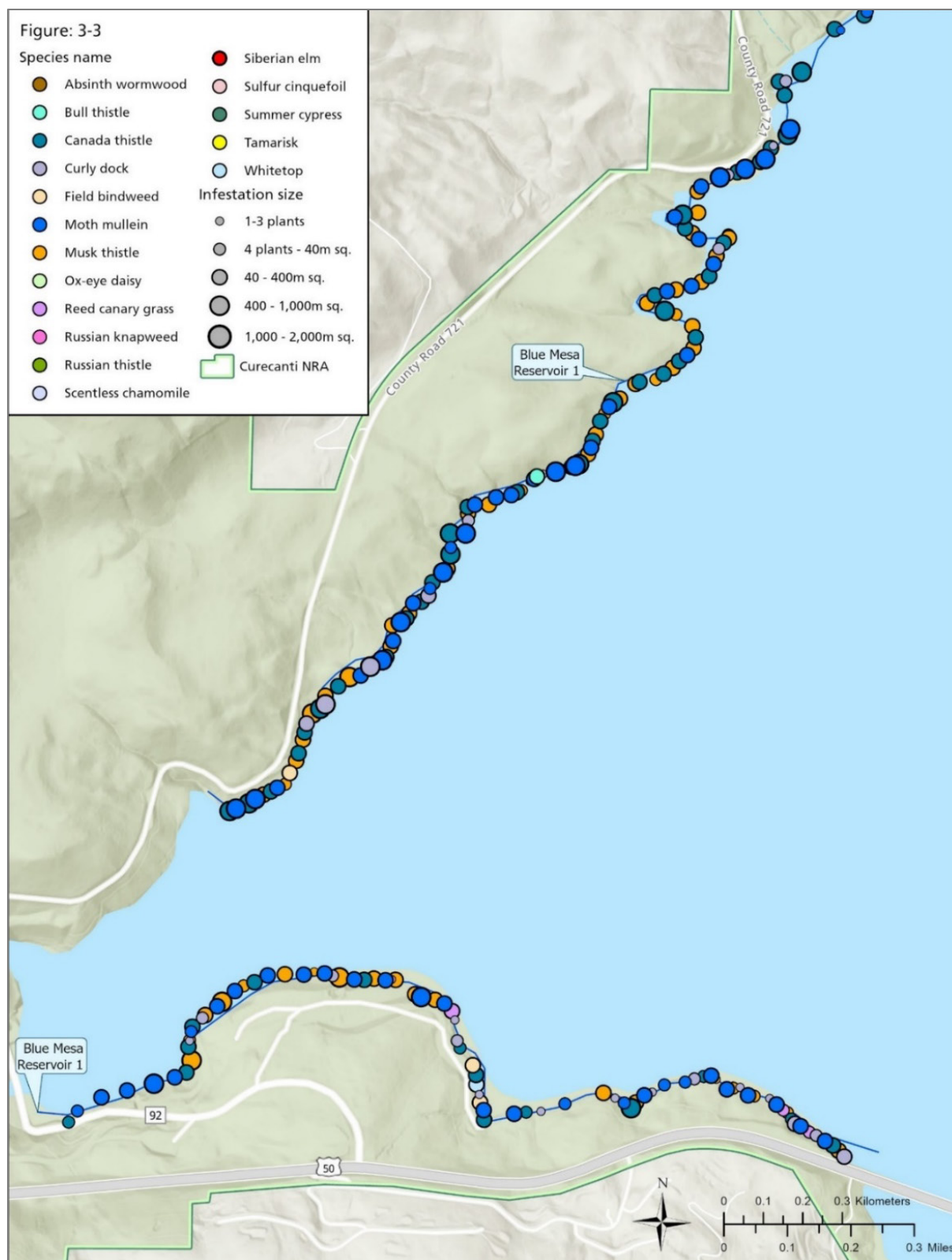


Figure 4. Invasive plants detected on monitoring routes and quadrats along the western portion of Blue Mesa Reservoir, Curecanti NRA, June 21–27, 2023.

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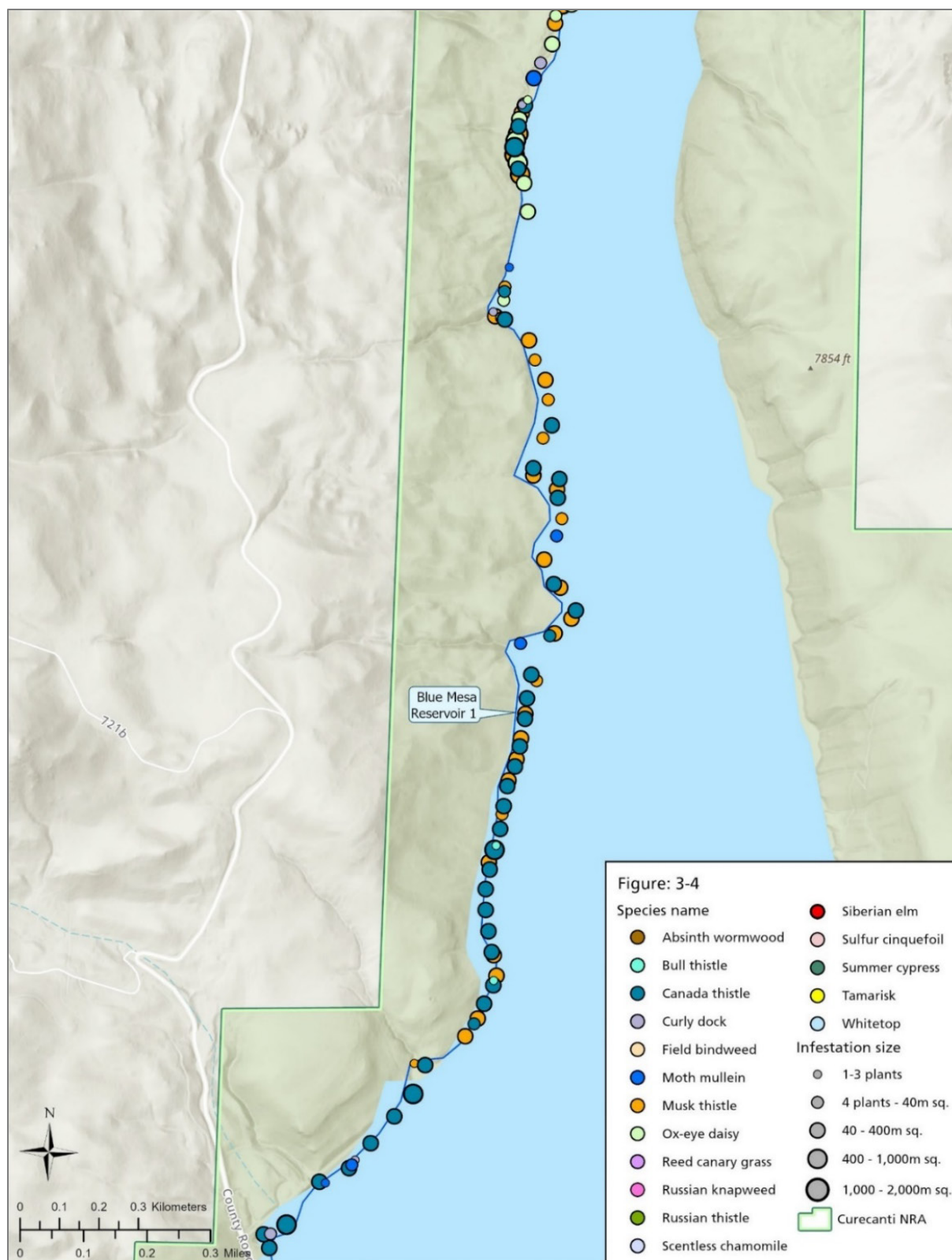


Figure 5. Invasive plants detected on monitoring routes and quadrats along the southwestern portion of the Soap Creek section of Blue Mesa Reservoir, Curecanti NRA, June 21–27, 2023.

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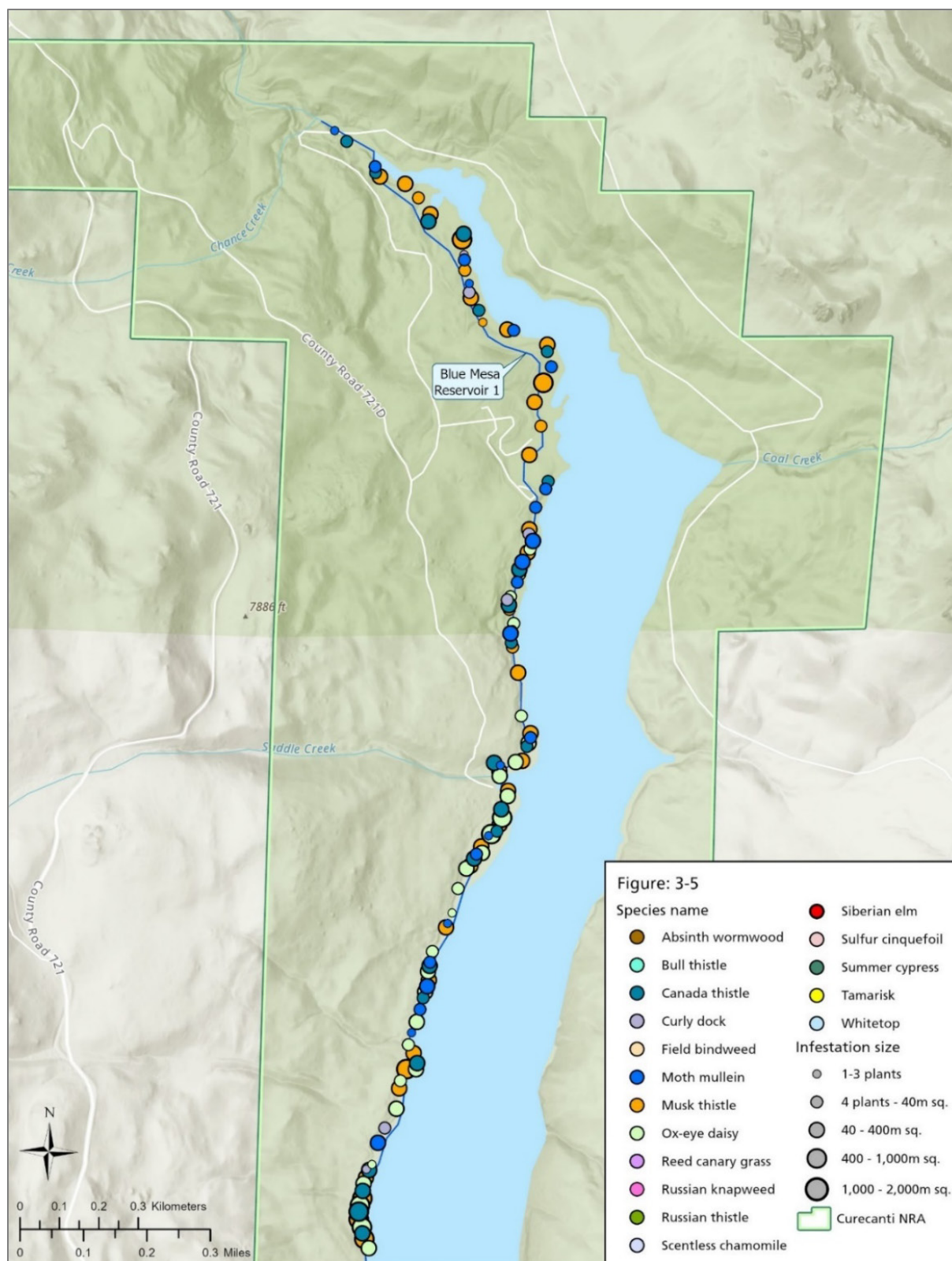


Figure 6. Invasive plants detected on monitoring routes and quadrats along the northern portion of Soap Creek section of Blue Mesa Reservoir, Curecanti NRA, June 21–27, 2023.

NPS / ANETH WIGHT

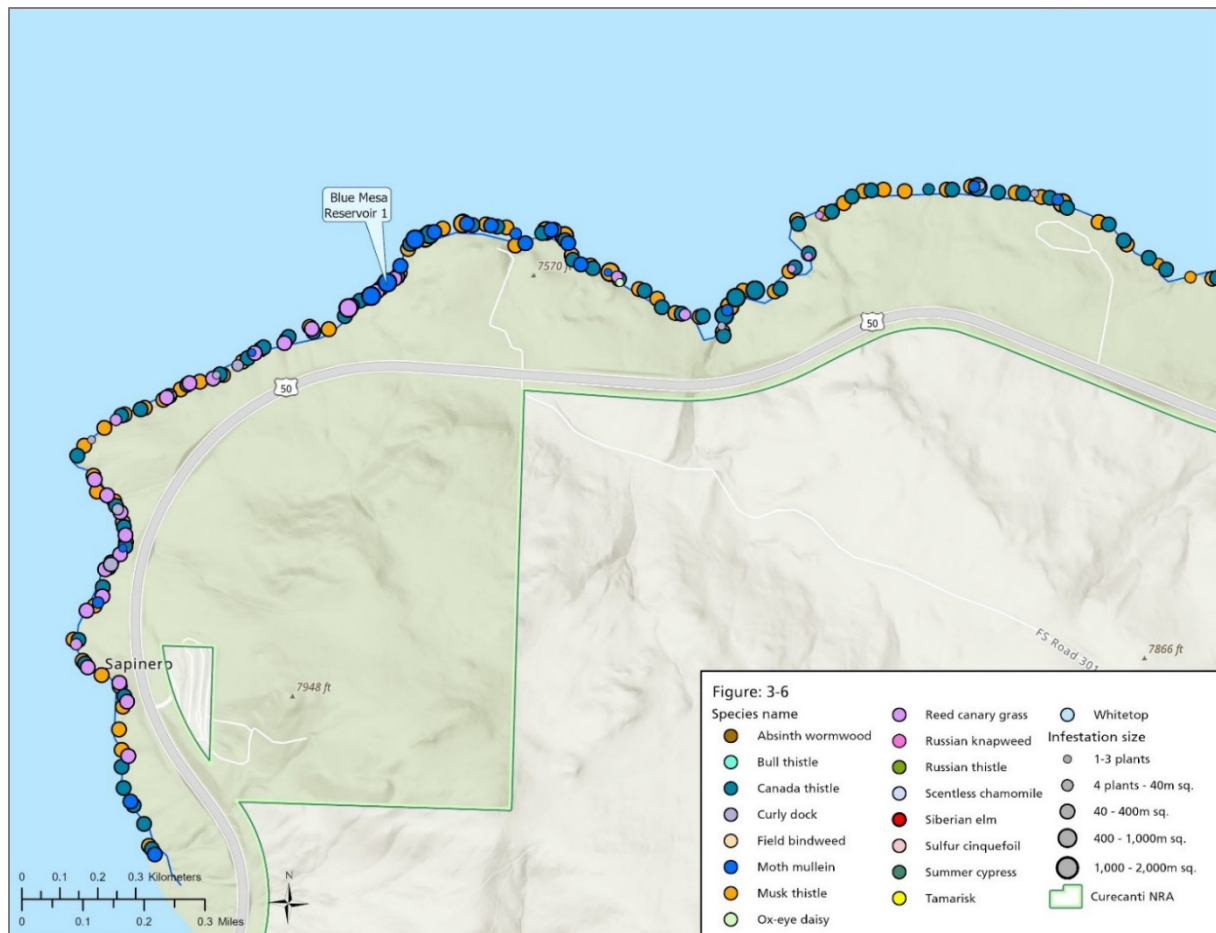


Figure 7. Invasive plants detected on monitoring routes and quadrats in the vicinity of Sapinero, Curecanti NRA, June 21–27, 2023.

NPS / ANETH WIGHT



Figure 8. Invasive plants detected on monitoring routes and quadrats in the vicinity of Dillon Pinnacles Trail, Curecanti NRA, June 21–27, 2023.

NPS / ANETH WIGHT



Figure 9. Invasive plants detected on monitoring routes and quadrats in the vicinity of Red Pond, Curecanti NRA, June 21–27, 2023.

NPS / ANETH WIGHT

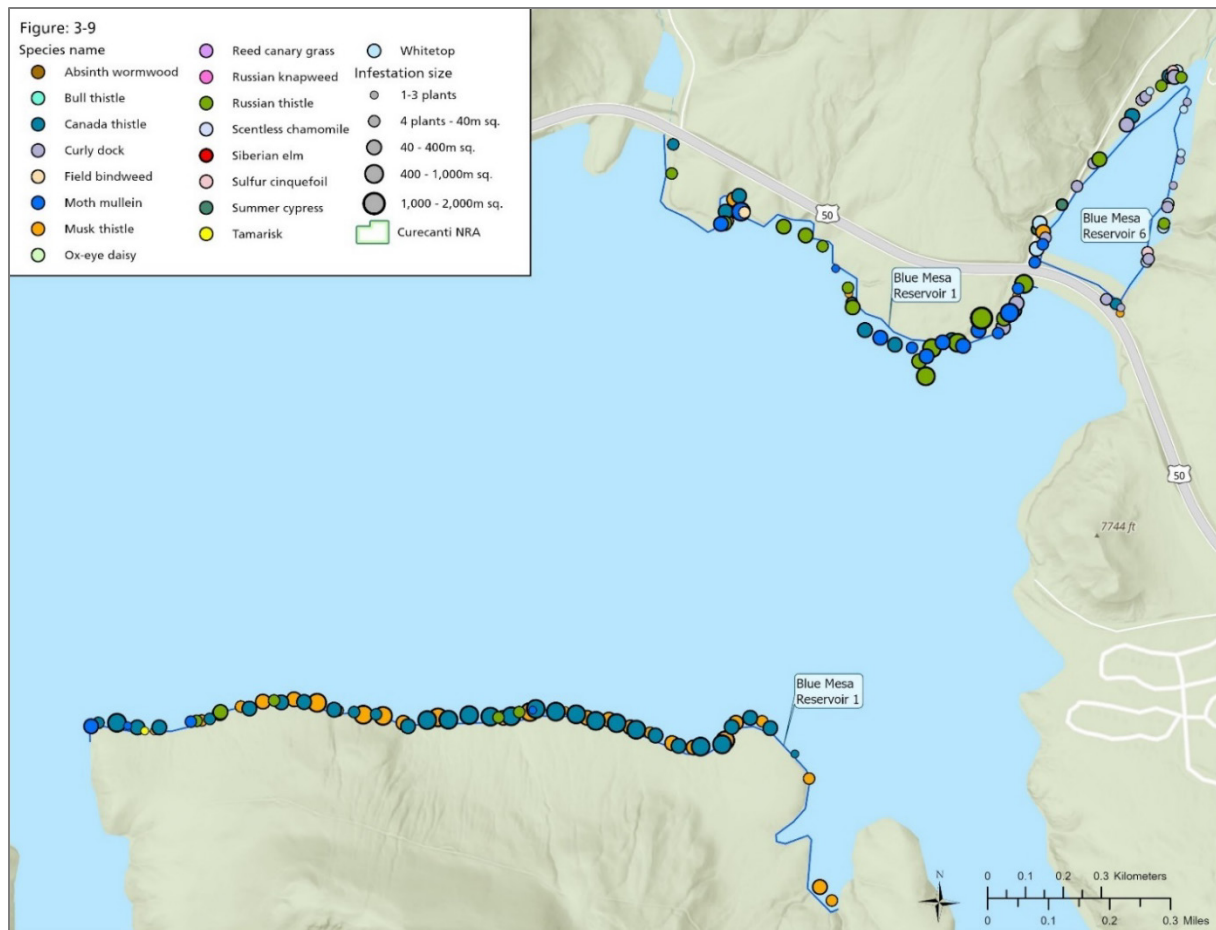


Figure 10. Invasive plants detected on monitoring routes and quadrats in the vicinity of the Elk Creek Visitor Center, Curecanti NRA, June 21–27, 2023.

NPS / ANETH WIGHT

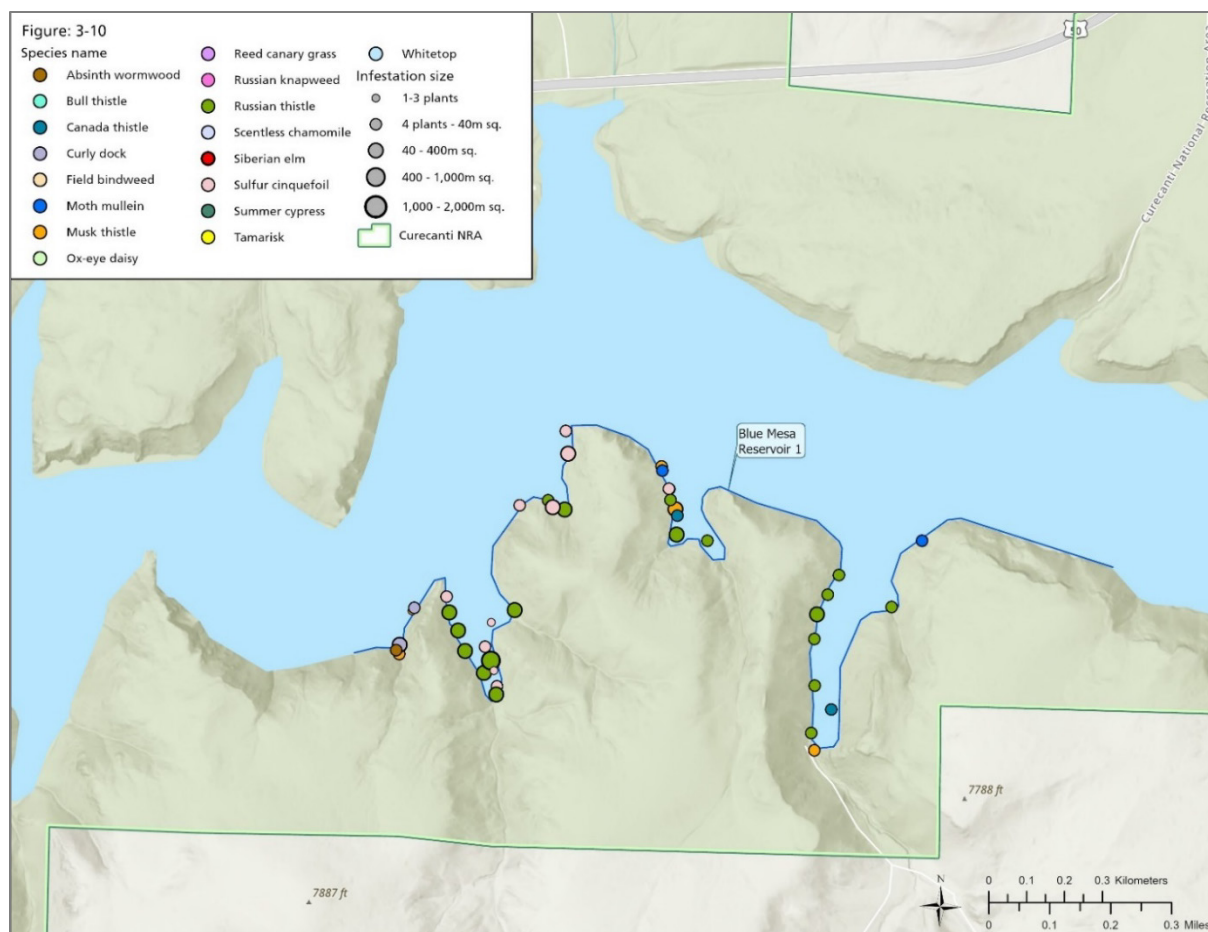


Figure 11. Invasive plants detected on monitoring routes and quadrats in the vicinity of the Dry Creek Picnic Area, Curecanti NRA, June 21–27, 2023.

NPS / ANETH WIGHT

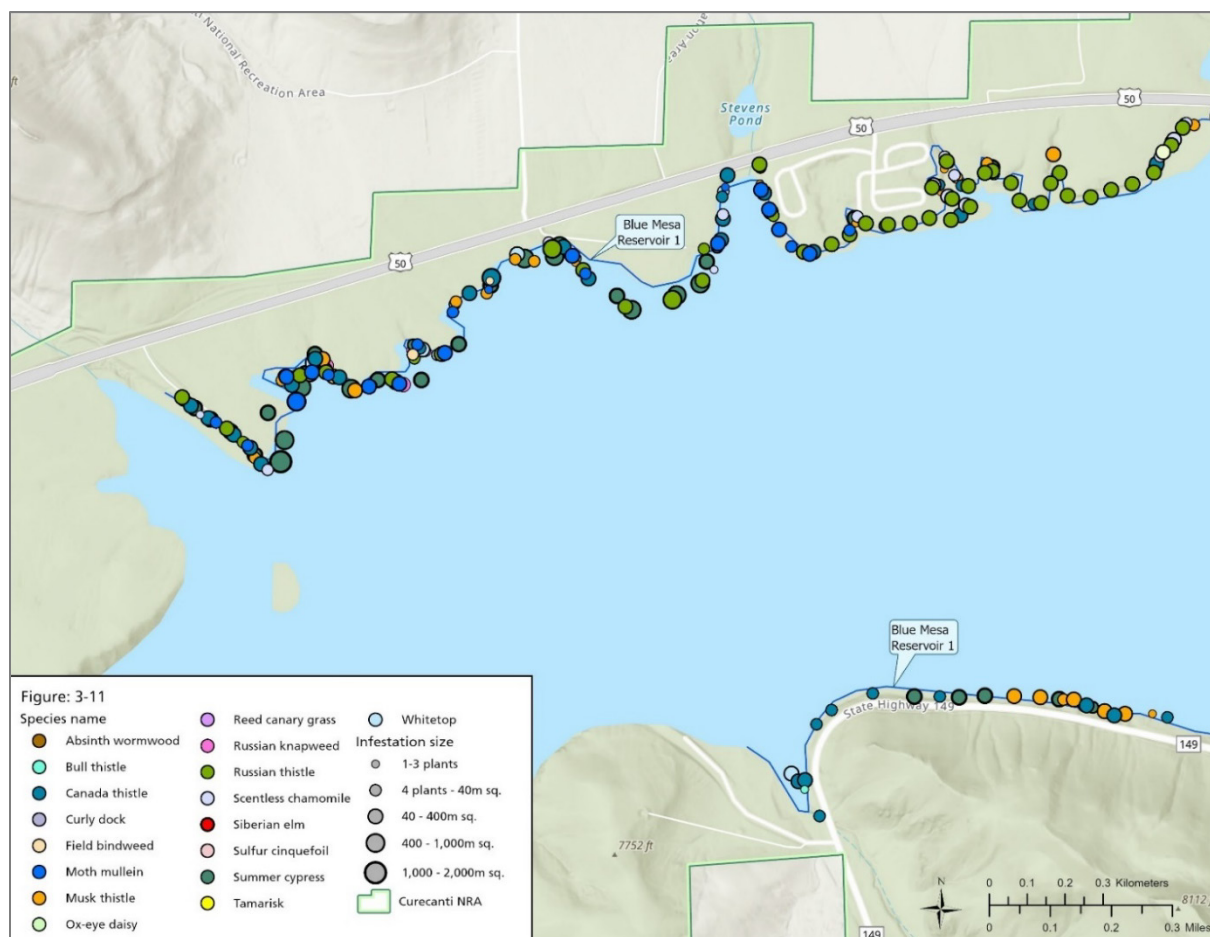


Figure 12. Invasive plants detected on monitoring routes and quadrats in the vicinity of Stevens Pond, Curecanti NRA, June 21–27, 2023.

NPS / ANETH WIGHT

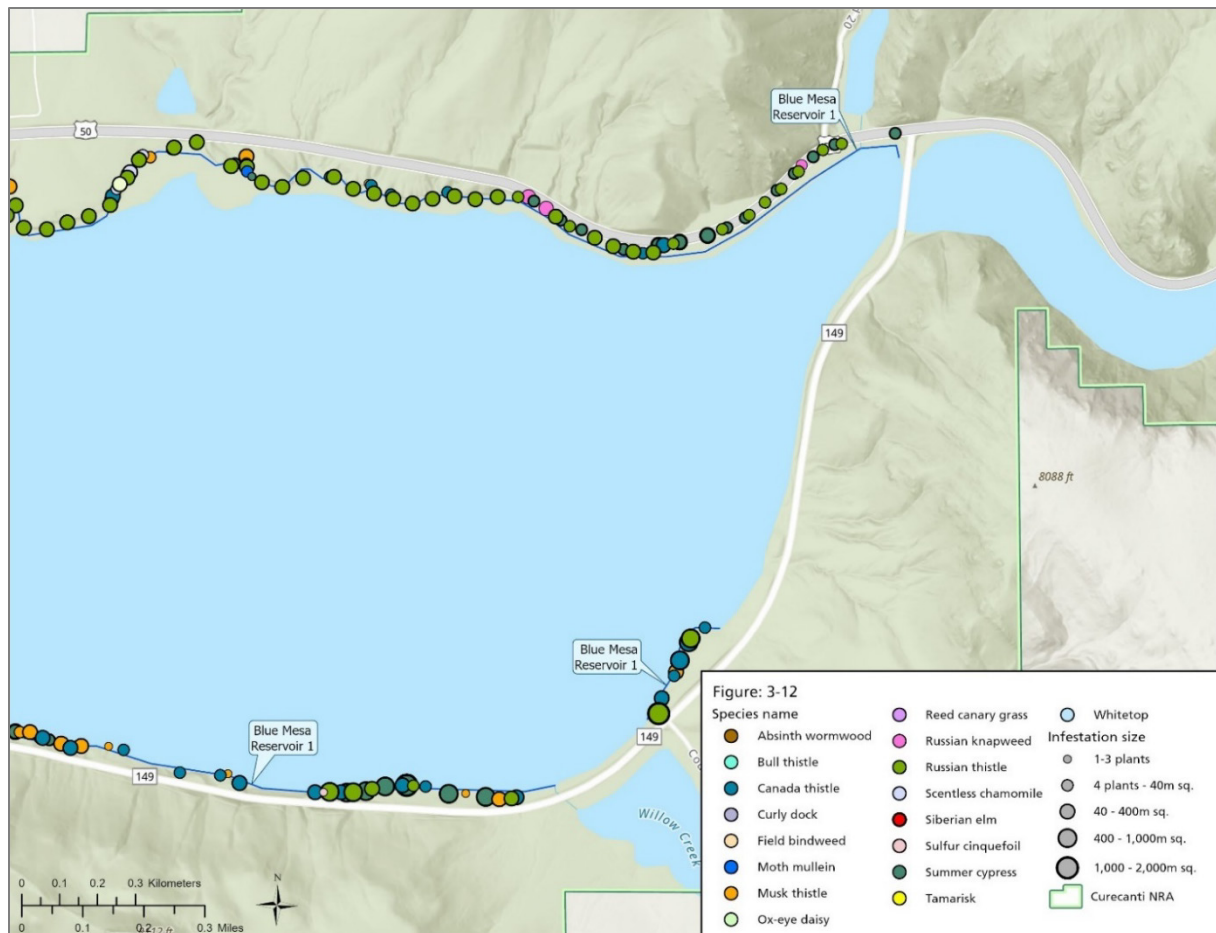


Figure 13. Invasive plants detected on monitoring routes and quadrats in the vicinity of Willow Creek, Curecanti NRA, June 21–27, 2023.

NPS / ANETH WIGHT

3.3 Monitoring transects

A total of 10 species (eight priority IEPs, cheatgrass, and yellow sweet-clover) were detected in quadrats along the 114 transects sampled in 2023 (NCPN 2025b). These species were found on 44% of transects around Blue Mesa Reservoir, with an average of 0.76 IEP species detected per plot (Table 5). Including all quadrats and transects (i.e., including those where no IEPs were observed), the species with the highest percent cover were yellow sweet-clover (0.46%), Canada thistle (0.25%), and musk thistle (0.24%). The percent cover of all invasive species combined was 1.41%. There were no invasive plants detected in seven and four transects along the Dillon Pinnacles and Pine Creek Trail, respectively.

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 Curecanti NRA, June 21–27, 2023.

Species	Detected / Total	Percent Cover (SE)
<i>Anisantha tectorum</i>	9/103	0.10 (0.07)
<i>Bassia sieversiana</i>	6/103	0.18 (0.10)
<i>Breea arvensis</i>	17/103	0.25 (0.09)
<i>Cardaria sp.</i>	3/103	0.02 (0.01)
<i>Carduus nutans</i>	7/103	0.25 (0.13)
<i>Leucanthemum vulgare</i>	2/103	0.02 (0.02)
<i>Melilotus officinalis</i>	19/103	0.46 (0.18)
<i>Rumex crispus</i>	2/103	0.07 (0.06)
<i>Salsola sp.</i>	11/103	0.04 (0.02)
<i>Verbascum thapsus</i>	6/103	0.06 (0.03)
All Invasive Species	47/103	1.46 (0.25)

3.4 Results comparison: 2010–2011, 2014, and 2023

Blue Mesa 1 was sampled in all 3 sampling periods, but only about 35% of the route was sampled in 2023, making only broad general comparisons worthwhile. For the portion of the route that was sampled in 2023, there were more than twice as many infestations/kilometer when compared to 2014, which had increased from 2010–2011 (Table 6). In the earlier two time periods, the entire route was completed. Large increases were seen in Canada thistle, musk thistle, Russian thistle, and woolly mullein.

Blue Mesa 6, Dillon Pinnacles Trail, and Pine Creek Trail were sampled comparably across all three sample periods. Blue Mesa 6 followed a similar pattern as Blue Mesa 1 with large increases in the number of infestations/km in 2023 when compared to 2014, which was driven by increases in whitetop (*Cardaria sp.*) and Russian thistle. The number of infestations along the Dillon Pinnacles and Pine Creek trails declined from previous sampling periods (Table 6).

There were only enough transects to make comparisons across all invasive species in the Blue Mesa area. Percent cover increased in 2023 ($1.46\% \pm 0.25$ SE) when compared to 2014 ($0.64\% \pm 0.15$ SE) (Perkins and Wight 2016) but was lower than percent cover in 2010–2011 ($1.98\% \pm 0.33$ SE) (Perkins 2013).

Table 6. Monitoring routes surveyed by year, species, length, number of priority IEP infestations, and number of infestations/km, Curecanti NRA. Note that total numbers do not match numbers in Table 4 because *Convolvulus arvensis* and *Rumex crispus* were removed from totals since they were not a priority species in all sampling periods.

Route	Year	Species	Length (m)	# of Infestations	Infestations/km
Blue Mesa 1	2023	All	49,250.20	1,332	27.0
Blue Mesa 1	2014	All	131,978.90	1,722	13.1
Blue Mesa 1	2010–11	All	142,575.40	1,144	8.0
Blue Mesa 1	2023	<i>Acroptilon repens</i>	49,250.20	19	0.4
Blue Mesa 1	2014	<i>Acroptilon repens</i>	131,978.90	0	0.0
Blue Mesa 1	2010–11	<i>Acroptilon repens</i>	142,575.40	6	<0.1
Blue Mesa 1	2023	<i>Bassia sieversiana</i>	49,250.20	58	1.2
Blue Mesa 1	2014	<i>Bassia sieversiana</i>	131,978.90	50	0.4
Blue Mesa 1	2010–11	<i>Bassia sieversiana</i>	142,575.40	61	0.4
Blue Mesa 1	2023	<i>Breea arvensis</i>	49,250.20	405	8.2
Blue Mesa 1	2014	<i>Breea arvensis</i>	131,978.90	470	3.6
Blue Mesa 1	2010–11	<i>Breea arvensis</i>	142,575.40	337	2.4
Blue Mesa 1	2023	<i>Cardaria latifolia</i>	49,250.20	1	<0.1
Blue Mesa 1	2014	<i>Cardaria latifolia</i>	131,978.90	62	0.5
Blue Mesa 1	2010–11	<i>Cardaria latifolia</i>	142,575.40	4	<0.1
Blue Mesa 1	2023	<i>Carduus nutans</i>	49,250.20	356	7.2
Blue Mesa 1	2014	<i>Carduus nutans</i>	131,978.90	265	2.0
Blue Mesa 1	2010–11	<i>Carduus nutans</i>	142,575.40	230	1.6
Blue Mesa 1	2023	<i>Cirsium vulgare</i>	49,250.20	10	0.2
Blue Mesa 1	2014	<i>Cirsium vulgare</i>	131,978.90	49	0.4
Blue Mesa 1	2010–11	<i>Cirsium vulgare</i>	142,575.40	38	0.3
Blue Mesa 1	2023	<i>Luecanthemum vulgare</i>	49,250.20	32	0.6
Blue Mesa 1	2023	<i>Luecanthemum vulgare</i>	131,978.90	16	0.1

Table 6 (continued). Monitoring routes surveyed by year, species, length, number of priority IEP infestations, and number of infestations/km, Curecanti NRA. Note that total numbers do not match numbers in Table 4 because *Convolvulus arvensis* and *Rumex crispus* were removed from totals since they were not a priority species in all sampling periods.

Route	Year	Species	Length (m)	# of Infestations	Infestations/km
Blue Mesa 1	2010–11	<i>Luecanthemum vulgare</i>	142,575.40	16	0.1
Blue Mesa 1	2023	<i>Matricaria perforata</i>	49,250.20	17	0.3
Blue Mesa 1	2014	<i>Matricaria perforata</i>	131,978.90	72	0.5
Blue Mesa 1	2010–11	<i>Matricaria perforata</i>	142,575.40	44	0.3
Blue Mesa 1	2023	<i>Phalaroides arundinacea</i>	49,250.20	36	0.7
Blue Mesa 1	2014	<i>Phalaroides arundinacea</i>	131,978.90	78	0.6
Blue Mesa 1	2010–11	<i>Phalaroides arundinacea</i>	142,575.40	13	0.1
Blue Mesa 1	2023	<i>Rumex crispus</i>	49,250.20	53	1.1
Blue Mesa 1	2010–11	<i>Rumex crispus</i>	142,575.40	0	0.0
Blue Mesa 1	2023	<i>Salsola sp.</i>	49,250.20	126	2.6
Blue Mesa 1	2014	<i>Salsola sp.</i>	131,978.90	188	1.4
Blue Mesa 1	2010–11	<i>Salsola sp.</i>	142,575.40	98	0.7
Blue Mesa 1	2023	<i>Verbascum thapsis</i>	49,250.20	252	5.1
Blue Mesa 1	2014	<i>Verbascum thapsis</i>	131,978.90	455	3.4
Blue Mesa 1	2010–11	<i>Verbascum thapsis</i>	142,575.40	284	2.0
Blue Mesa 6	2023	All	1,476.20	40	27.1
Blue Mesa 6	2014	All	1,475.50	3	2.0
Blue Mesa 6	2011	All	1,473.40	4	2.7
Blue Mesa 6	2023	<i>Cardaria sp.</i>	1,476.20	9	6.1
Blue Mesa 6	2014	<i>Cardaria sp.</i>	1,475.50	0	0.0
Blue Mesa 6	2011	<i>Cardaria sp.</i>	1,473.40	0	0.0
Blue Mesa 6	2023	<i>Rumex crispus</i>	1,476.20	14	9.5
Blue Mesa 6	2014	<i>Rumex crispus</i>	1,475.50	0	0.0

Table 6 (continued). Monitoring routes surveyed by year, species, length, number of priority IEP infestations, and number of infestations/km, Curecanti NRA. Note that total numbers do not match numbers in Table 4 because *Convolvulus arvensis* and *Rumex crispus* were removed from totals since they were not a priority species in all sampling periods.

Route	Year	Species	Length (m)	# of Infestations	Infestations/km
Blue Mesa 6	2011	<i>Rumex crispus</i>	1,473.40	0	0.0
Blue Mesa 6	2023	<i>Salsola sp.</i>	1,476.20	4	2.7
Blue Mesa 6	2014	<i>Salsola sp.</i>	1,475.50	0	0.0
Blue Mesa 6	2011	<i>Salsola sp.</i>	1,473.40	0	0.0
Dillon Pinnacles	2023	All	3,133.40	0	0.0
Dillon Pinnacles	2014	All	3,125.80	19	6.1
Dillon Pinnacles	2010	All	3,133.40	10	3.2
Pine Creek	2023	All	2,024.40	1	0.5
Pine Creek	2014	All	1,383.80	2	1.4
Pine Creek	2010	All	2,011.00	12	6.0

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 priority IEP species should be reliable for the area surveyed. We added curly dock and field bindweed back to the priority IEP list in 2023, and cheatgrass was added to the list of species to record in transects. NCPN does not have any recommendations to add to the priority IEP list for future years. However, park managers should consider whether the most common IEPs—particularly Canada thistle, musk thistle, woolly mullein, and Russian thistle—are truly of management interest. As evidenced by the relatively small proportion (35%) of Blue Mesa Reservoir monitored in 2023, keeping these abundant species on the priority IEP list will limit the ability of future observers to cover more ground and potentially detect infestations of other priority IEPs that are less extensive and, as a result, likely more controllable.

4.2 Possibilities for management control

In 2023, priority IEPs were very widespread along the shores of Blue Mesa Reservoir, and control is not likely possible for many of these species without regular inundation of the reservoir. No infestations were found on the Dillon Pinnacles Trail, and only one infestation of woolly mullein was found on the Pine Creek Trail. This suggests that these routes should be prioritized for future IEP monitoring and control so that IEPs will not invade or expand.

It should be noted that estimates of percent cover in this report (see Table 5) are limited to the routes surveyed. Actual percent cover of IEPs across the entire park cannot be inferred with these methods. Because we have chosen to monitor along areas most likely to be invaded by a broad suite of IEPs, it is plausible that the percent cover for most IEP species is lower in the interior of the park than along the monitoring routes.

4.3 Comparison of sample periods

Curecanti NRA was monitored for IEPs in 2010–2011, 2014, and 2023. Because observer judgment varies, mapping is subjective. For example, one observer may identify two small patches separated by 45 meters (the patch separation rule is 50 m, but exact measurements are not made in the field) as two patches, while another observer may identify them as one large patch. Therefore, although general comparisons and species with major differences between the survey periods are useful (if somewhat problematic) and likely represent biological differences, smaller changes may not reflect biologically important differences.

Along the Pine Creek Trail and Dillon Pinnacles Trail, the number of infestations has declined since 2014.

The decreases seen on these two trails contrast with large increases along the shores of Blue Mesa Reservoir at Curecanti NRA, where the park has not been able to complete substantial control work. Notably, around the time monitoring took place in 2023, the reservoir reached an elevation above 7,510 feet for the first time since 2019. The recent decline in water elevation at the reservoir over the

preceding four years has likely resulted in expansion of invasive plants around the reservoir. In fact, we noted many infestations that were inundated (Figures 14 and 15) at the time of sampling. It is possible the recent rise in lake elevation has aided park managers by drowning IEP populations following this monitoring effort.



Figure 14. Oxeye daisy (*Leucanthemum vulgare*) infestations that were inundated by the 2023 runoff.
NPS / AMY WASHUTA



Figure 15. Musk thistle (*Carduus nutans*) infestations that were inundated by the 2023 runoff.
NPS / AMY WASHUTA

4.4 Future monitoring efforts

Priority IEPs at Curecanti NRA 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 of most species. For many species, sampling any time from May through September is not expected to drastically alter the chances of detecting invasive species larger than the MDTS. Extra-area surveys will also be considered for inventories at the park's request.

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