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Invasive Exotic Plant Monitoring in Black Canyon of the Gunnison National Park and Curecanti National Recreation Area

2010 Field Season

Natural Resource Technical Report NPS/NCPN/NRTR—2012/576

ON THE COVER

Reed canarygrass (*Phalaris arundinacea*) along the Gunnison River in Black Canyon of the Gunnison National Park. Photo by Corey Ransom, Utah State University.

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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. Because routine monitoring for newly invading populations is an important step in successfully controlling them, 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. Routes and transects were selected for inventory and monitoring in both Black Canyon of the Gunnison National Park and Curecanti National Recreation Area. Between July 23 and August 9, 2010, a Utah State University field crew detected 21 invasive exotic plant species on 88 of 1,327 hectares searched, or about 6.6% of the total inventoried area. Of 31 targeted plant species, nine were found in the monitoring quadrats, as well as one other non-native species of concern to the area. The most abundant (in terms of hectares infested) target species mapped along monitoring routes in the parks was Canada thistle (*Cirsium arvense*), with 19.05 hectares. The second-most abundant target species, which was also the most common (i.e., most infestations), was woolly mullein (*Verbascum thapsus*), at 18.87 hectares. Yellow sweetclover (*Melilotus officinale*), not a priority species, was the most commonly encountered species in monitoring transects; it was almost exclusively recorded on transects in Curecanti NRA. Reed canarygrass (*Phalaris arundinaceae*) was the second-most commonly recorded species on transects and exclusive to the Gunnison River shoreline in Black Canyon of the Gunnison National Park.

Acronyms

BFP	Between Feature Position
BLCA	Black Canyon of the Gunnison National Park
CURE	Curecanti National Recreation Area
DC	detection confidence
EDD	effective detection distance
EDRR	early detection and rapid removal
EDSW	effective detection swath width
IEP	invasive exotic plant
MDTS	minimum detection target size
NCPN	Northern Colorado Plateau Network
NP	national park
NPS	National Park Service
NRA	national recreation area
PSR	patch separation resolution

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1 Introduction

Numerous studies have shown that invasive non-native plants are the biggest threat to biological diversity, are a threat to habitat destruction, and affect the value of many public and privately owned lands (D'Antonio et al. 2004; Vanderhoof et al. 2009). National parks, established in part to preserve native plants and animals, are seeing native plant presence decrease as the number of invasive species increases at the rate of nearly two hectares per day (Crimmins et al. 2008). National parks are at a high risk for new introductions of invasive non-native plants because of the millions of people who come each year to visit, potentially bringing with them unseen seeds on hiking boots, car tires, or camping equipment (Bella 2011; Tobin et al. 2010). Vigilance and continued monitoring is the key to finding and eradicating these new introductions.

The National Park Service Natural Resource Challenge initiative was created in 1999 with the intent to understand, measure, and improve the health of park ecosystems. Under this initiative, the importance of invasive species issues and their associated impacts was emphasized: "Identifying, mapping and evaluating nonnative species [is] critical for effective management" (NPS 1999). Early detection and rapid response (EDRR) to invasive species is the most cost effective and environmentally sound approach to managing them (Westbrooks 2004). A targeted search-and-removal effort, EDRR focuses on areas where (1) there is evidence of a certain species or (2) introductions are likely (Kaiser and Burnett 2010). Because roads and waterways provide a means of easy dispersal for invasive species (D'Antonio et al. 2004), they are important areas in which to focus EDRR efforts.

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.

In 2003–2004, Utah State University (USU) conducted an invasive species inventory project for the National Park Service. As part of this project, invasive species were mapped in Black Canyon of the Gunnison National Park (BLCA) (Dewey and Andersen 2005). In 2010, a USU field crew returned to the park to re-inventory the roads and trails and conduct inventories at Curecanti National Recreation Area (CURE). As part of the 2010 project, invasive exotic plant (IEP) monitoring routes were also established and evaluated in both BLCA and CURE. This report combines data and analysis from both the inventories and monitoring.

2 Methods

Between July 23 and August 9, 2010, a six-person crew from Utah State University inventoried designated areas and provided monitoring data from designated routes and transects in BLCA and CURE. Field methods were adapted from protocols developed by Andersen and Dewey (2007) and incorporated into the NCPN inventory and monitoring methodologies (Perkins et al. in review). Both efforts focused on areas of most likely introduction and spread, such as campgrounds, trails, roads, and waterways.

Sites inventoried and monitored included the Gunnison Route, Tomichi Route, East Portal Road, Warner Route, Red Rock Canyon, SOB Draw, Long Draw, North Rim Campground, Devil's Backbone, North River Route, Rim Trail, South Rim Road, Elk Creek Campground, Slide Draw, Crystal Creek, Hermit's Rest Trail, Curecanti Creek Trail, Neversink Trail, Dillon Pinnacles, Pine Creek Trail, Mesa Creek Trail, Sapinero Basin, Soap Creek shoreline, Coopers Ranch, Ponderosa Campground, and Blue Mesa Reservoir–shoreline, –Iola boating area, –Lake Fork Arm, and –Cebolla Arm (Figure 2-1, page 4).

The USU crew leader determined the order in which areas were inventoried. In their daily planning, the crew leader and crew considered potential invasive plant habitat within each targeted inventory area, terrain, vegetation cover, visibility of targeted invasive exotic species, and the search methods required to achieve the level of detection confidence for the established minimum target size.

All invasive species infestations were digitally mapped using global positioning system units. Each unit was equipped with GIS software and shapefiles created by the NCPN for use in recording inventoried species. Crew members also carried paper topography maps in the event that hand-mapping was necessary, as was the case in the canyon bottom. These points were later converted to a digital format.

2.1 Target invasive exotic plant list

Twenty-eight species were identified as high-priority targets in the 2010 surveys of both BLCA and CURE (Table 2-1); an additional three species were designated as high-priority for CURE. Species on the list are either already known to be present in one or both parks or are of high management concern. All crew members systematically searched for these species, which were selected by

Table 2-1. Invasive plant species targeted for inventory and monitoring in Black Canyon of the Gunnison NP and Curecanti NRA, July 23–August 9, 2010.

Scientific name (Synonym)	Common name
Targeted at both parks	
Acosta diffusa (Centaurea diffusa)	diffuse knapweed
Acosta maculosa (Centaurea stoebe)	spotted knapweed
Acroptilon repens	Russian knapweed
Arctium minus	burdock
Artemisia absinthium	absinthe
Breea arvensis (Cirsium arvense)	Canada thistle
Cardaria draba	whitetop
Carduus nutans	musk thistle
Cirsium vulgare	bull thistle
Convolvulus arvensis	field bindweed
Cynoglossum officinale	common houndstongue
Elaeagnus angustifolia	Russian olive
Euphorbia esula	leafy spurge
Hyoscyamus niger	black henbane
Iva xanthifolia	marshelder
Lepidium latifolium	broad-leaf pepperwort
Leucanthemum vulgare	ox-eye daisy
Linaria dalmatica	Dalmatian toadflax
Linaria vulgaris	butter-and-eggs
Matricaria perforata (Tripleurospermum perforatum)	scentless chamomile
Onopordum acanthium	Scotch thistle
Phalaris arundinacea	reed canarygrass
Rumex crispus	curly dock
Tamarix ramosissima	saltcedar
Ulmus pumila	Siberian elm
Verbascum thapsus	woolly mullein
Viticella orientalis (Clematis orientalis)	Oriental clematis
Targeted only on transects	
Anisantha tectorum (Bromus tectorum)	cheatgrass
Targeted only at CURE	
Hesperis matronalis	Dame's rocket
Kochia scoparia	summer cypress
Salsola australis (Salsola tragus)	Russian thistle

Editor's note: For consistency, the nomenclature used in this report is based on Hogan and others (2009a and 2009b). Where applicable, the authors' preferred nomenclature is shown here in parentheses.

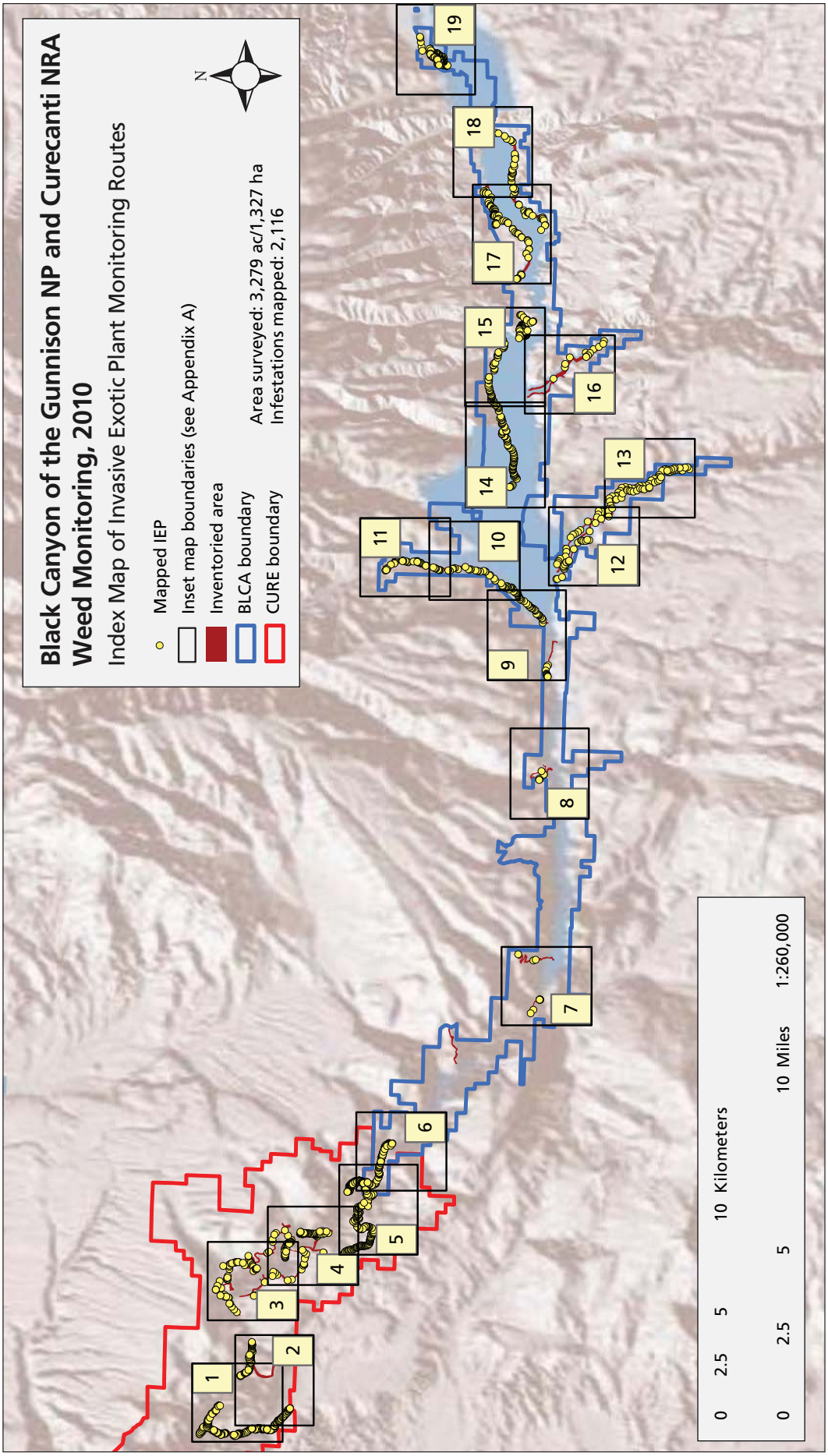

Figure 2-1. Routes inventoried for invasive exotic plants in Black Canyon of the Gunnison NP and Curecanti NRA, July 23–August 9, 2010.

park staff. Any other non-native species recognized as relatively new to BLCA or CURE and potentially invasive on wildlands in the West were documented if found. Deciding which non-target weeds to map was left to the discretion of individual crew members, based on their assessment of the potential threat and relative abundance of each species.

2.2 Monitoring routes

2.2.1 Search target

All 31 high-priority species were at a mature, recognizable growth stage during the time of this project. Search target descriptions in the GPS data always include species, growth stage, and minimum detection target size (see Section 2.2.2).

2.2.2 Minimum detection target size

The minimum detection target size (MDTS) is the smallest infestation size (single plant or patch) of the least-visible targeted invasive species that searchers are confident of detecting and identifying at a stated level of probability under actual field conditions using their stated protocols. Because it would be nearly impossible to find single plants of all targeted species within all the targeted areas within the given timeframe of the project, one goal of the project protocol was to establish an acceptable target patch size based on the project objectives. At BLCA and CURE in 2010, the MDTS was set at 40 m^2 (0.01 acre), with the assumption that any plants that might have been missed during the current inventory and monitoring effort would be discovered during the next inventory at a stage and size that would still be manageable.

2.2.3 Effective detection distance

The effective detection distance (EDD) was the maximum distance from which a searcher could consistently detect (i.e., see and recognize) the MDTS of the least-visible priority species with at least 90% detection efficiency. Crew members calibrated themselves by walking away from a targeted patch size of the least-visible species and determining the maximum distance from which they could consistently see and recognize the patch with complete confidence. The distance was measured either by pacing or using a laser rangefinder. The EDD for BLCA and CURE in 2010 was 50 m (Figure 2-2).

2.2.4 Effective detection swath width

Effective detection swath width (EDSW) is the maximum width of a linear walking search pattern in which a searcher is confident of visually detecting at least 90% of all invasive plant infestations of the MDTS. The EDSW must be adjusted according to factors influencing target visibility, including species, growth stage, topography, and associated vegetative cover, in order to maintain the 90% minimum detection standard. The effective detection swath width (EDSW) is equal to two times the EDD, because the surveyor is able to effectively detect weeds for one EDD on either side of his/her search route. Based on the terrain and targeted search areas in BLCA and CURE, the average EDSW was 100 m (Figure 2-2).

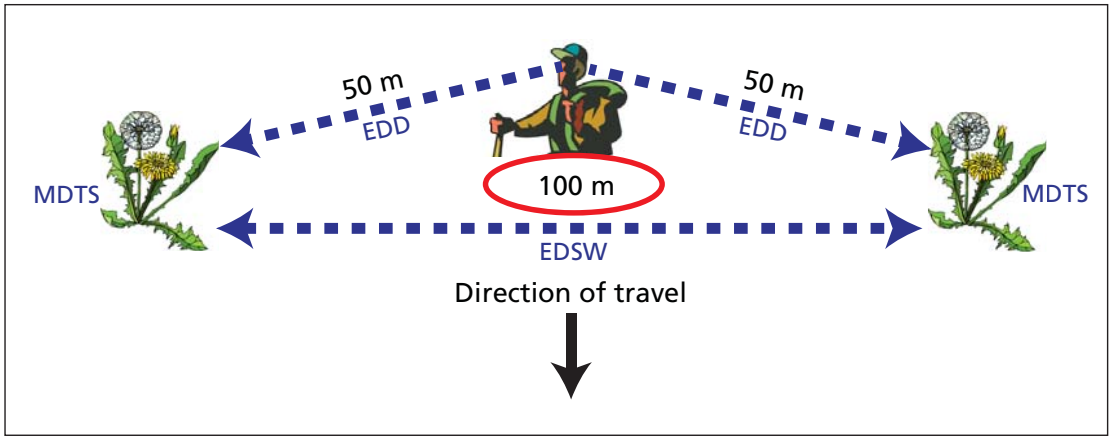

Figure 2-2. The maximum effective detection distance (EDD) at Black Canyon of the Gunnison NP and Curecanti NRA was 50 meters, making the effective detection swath width (EDSW) 100 meters.

2.2.5 Patch separation resolution

Patch separation resolution (PSR) is the minimum distance between single invasive plants of the same species or patches of invasive plants considered to be separate infestations. The PSR for this project was 50 meters. Plants separated by the PSR distance or more were mapped as separate infestations. Plants separated by less than the stated PSR were usually mapped as a single infestation unless the surveyor felt it was necessary to provide more detailed information.

2.2.6 Detection confidence

Detection confidence (DC) is the percentage of the total number of infestations that crew members estimated they were able to find in a searched area, based on the probability of seeing patches of the established MDTS of the least-visible target species in that terrain. Effective DC estimates must be accompanied by identification of the search target associated with that DC. The minimum required DC established for this project was 90%, based on an MDTS of 40 m^2 for plants of the least-visible target species in a mature or flowering growth stage.

2.2.7 Between-feature positions

Between-feature positions (BFPs) are the points automatically generated by the GPS units to record each crew member's daily search route. The distance interval used to collect BFPs in this project was set to correspond to the average EDSW for each area inventoried. A point was generated each time a crew member walked the equivalent of one EDSW, creating a tracklog of the search route for the day. Because of the narrowness of the canyon walls in BLCA, it was not always possible for the GPS units to receive signals from satellites. Thus, many of the routes in the inner canyon lack these positions.

2.2.8 Data collection methods

Crew members walked along designated routes and shorelines, visually scanning for targeted plants within the EDSW. When a target species was encountered, its location was recorded with a GPS unit. Because the Gunnison River could not be crossed in the canyon bottom of BLCA, the crew used binoculars to visually scan the opposite bank for suspected target species. Invasive exotic plants observed across the river were mapped using the offset feature of the GPS units. If several species were present at a location, then a separate point was created for each species to ensure its visibility on a map.

The scale of field searches varied according to the crew's ability to confidently detect 90–100% of all IEP infestations of 40 m^2 or larger within the EDSW of each inventory area. The EDSW was adjusted as needed based on variations in terrain, walking speed, associated vegetation, and target species. Invasive plant infestations of 4,046 m^2 (1 acre) or less in size were recorded as point features. For each invasive species location, the following information was recorded: (1) species name, (2) infestation size class (see below), (3) canopy cover (see below), (4) whether the plant was pulled, (5) growth stage of the plant, (6) evidence of prior treatment, (7) evidence of disturbance, (8) surveyor, (9) patch separation resolution, and (10) additional notes.

The size of each infestation recorded as a point feature was visually estimated with a laser rangefinder and placed in the size category that most closely matched its area. Infestation size classes were as follows:

1. 1–few plants ($\leq 2 \times 2$ m),
2. few plants–40 m^2 (0.01 acre),
3. 40–400 m^2 (0.01–0.1 acre),
4. 400–1,000 m^2 (0.1–0.25 acre),
5. 1,000–2,000 m^2 (0.25–0.5 acre).

Canopy cover of each infestation was visually estimated as the amount of ground covered by the invasive plant and placed in its corresponding category:

1. Trace (<1%),
2. Low (1–5%),
3. Moderate (6–25%),
4. High (26–50%),
5. Majority (51–100%).

Extensive weed infestations, or those greater than 20,234 m^2 (5 acres) in size, were usually mapped either as "actual" or gross" area

polygons (see NAWMA [2002] for definitions and Dewey and Andersen [2005] for methods). A large infestation of reed canarygrass (*Phalaris arundinacea)*, found in BLCA, was the only area mapped using this method. Because the GPS units generally did not receive signals at the bottom of Black Canyon, where reed canarygrass occurred in patches of less than 400 m^2 (0.1 acre), those infestations were mapped as points or hand-drawn polygons digitized on the screen.

2.2.9 Field data processing

Daily inventory routes were recorded and mapped by the tracking feature of the GPS units. They were also highlighted on paper maps. Each crew member kept a daily log of the areas searched, species encountered, thoroughness of coverage, and any additional information thought to be important.

Data were downloaded daily from the GPS units onto a laptop computer. Edits (such as eliminating duplicate features or adding locations drawn on field maps) were made to the data, and any additional information (data not recorded with a GPS unit) were added at this time. Notes were also sometimes expanded during the editing process to include more detailed information about the surrounding habitat. Gross area features were also added during this process. Any gaps in the sequence of record numbers are due primarily to elimination of duplicated entries.

2.2.10 Post-season data processing

At the end of the field season, the project crew leader again reviewed the data to ensure that all were present and complete. Data files were compared to entries in the field notebooks, and maps served to ensure that all species were included in the data set and that inventory areas were complete.

Shapefiles were created for each type of data collected. The shapefiles created for this project were named according to the year of the data, the type of file, the shape of the data collected, and the location where the data were collected. For example, weed data points collected in 2010 were compiled into one shapefile labeled as 2010pt_weed_usu_BLCU.shp. Shapefiles were then imported into ArcGIS for map-making and data analysis.

2.3 Monitoring transects

2.3.1 Transect establishment

Monitoring transects were established every 500 m along each route (Figure 2-3). Some transects were missed due to inaccessibility of terrain. At each transect, three 1-m^2 quadrats were sampled. When four consecutive transects were found to be weed-free, the crew began to sample transects every 1,000 m. If invasive plants were subsequently found, the crew resumed sampling transects every 500 m. Methods for sampling monitoring quadrats were based on protocols by Stohlgren and others (2005).

2.3.2 Quadrat establishment

Quadrats were placed at 0.5, 5, and 10 m from the monitoring route. On single-track trails, transects were established perpendicular from the route on alternating sides. On roads and along water sources, transects were established on only one side of the road or water souce. When there was less than 10 m between the route and an obstacle (e.g., lake, river, cliff), quadrats were spaced equidistant apart, at the discretion of the crew member. This was sometimes the case at the bottom of the canyon in BLCA.

2.3.3 Data collection methods

In each monitoring quadrat, crew members recorded species on the IEP priority list, as well as any other known non-native plants. Presence and absence data for species on the target list is reliable. However, identification of species not on the target list was subject to the knowledge of the surveyor. The presence of these species is considered reliable but absence of non-target species may be unreliable along some routes. Exceptions include cheatgrass (*Anisantha tectorum*), which was not included in the route inventory, although it is prevalent in both BLCA and CURE, but was noted only in the monitoring quadrats.

Percent cover was estimated only on plants found inside quadrats. For each quadrat, percent cover for each species present was recorded using the following classes: 0, <1, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 20, 30, 40, 50, 60, 70, 80, 90, and 100%. Cover was also recorded for dominant microhabitat characteristics (i.e.,

dead wood, dung, fungus, lichen, litter/duff, live root/bole, mineral soil/sediment, moss, cryptogram, road, rock, standing water/flooded, stream, trash/junk) using the same cover classes as for the plants.

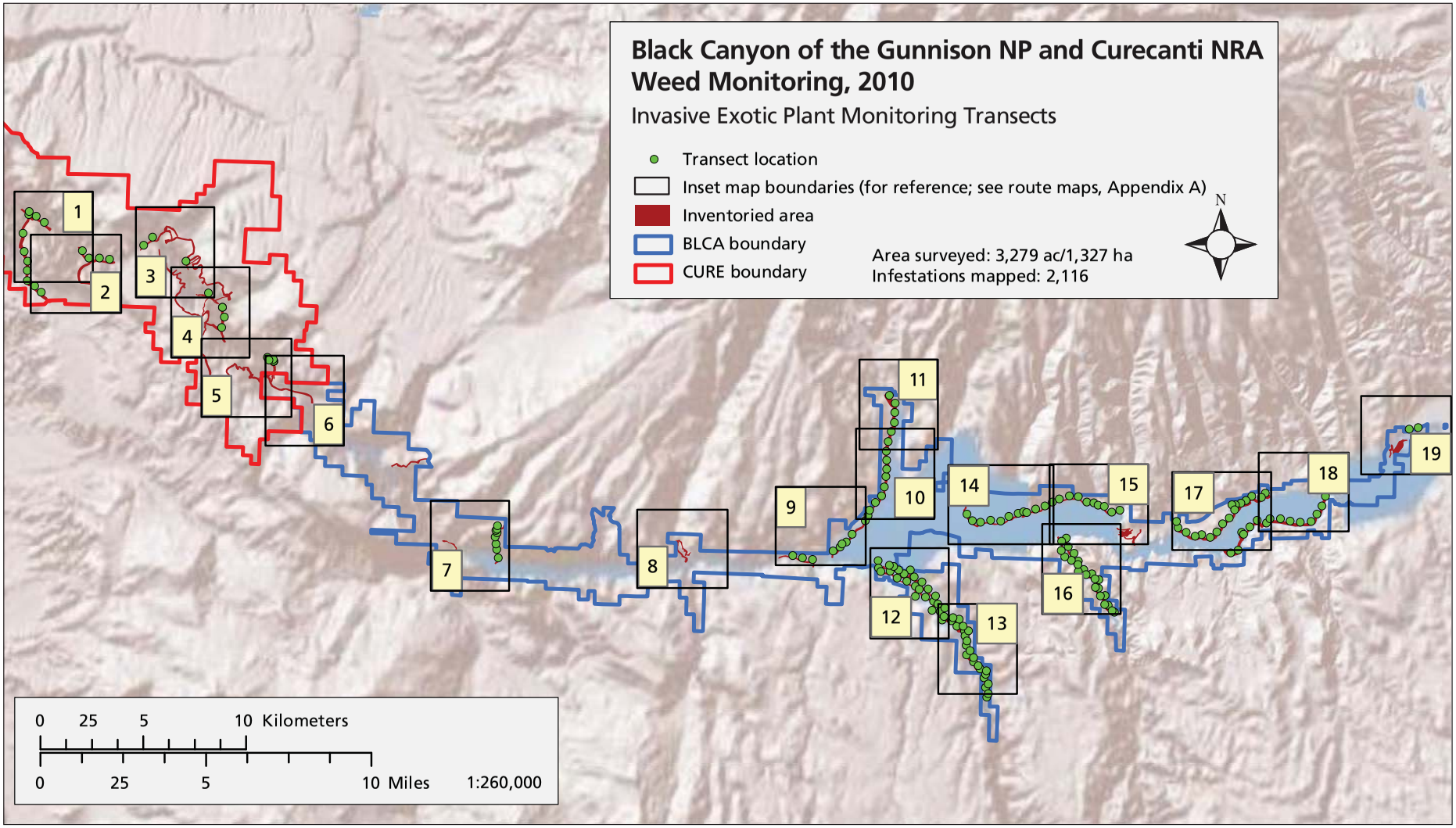

Figure 2-3. Location of monitoring transects in Black Canyon of the Gunnison NP and Curecanti NRA, July 23–August 9, 2010.

3 Results

A total of 1,326.9 hectares of roads, trails, and shoreline were mapped in BLCA and CURE in 2010. Because many of the invasive exotic plant populations found were very small, and to facilitate ease of viewing, infestations were drawn on maps as single, non-buffered points to indicate location of infestation and species, regardless of infestation size or canopy cover (Appendix A).

3.1 Target invasive exotic plant list

A total of 2,116 individual infestations of 21 species were found to be infesting 87.88 hectares (or about 6.6% of the total inventoried area) at BLCA and CURE in 2010 (Table 3-1, Appendix A). Of the 28 IEP species targeted for both parks, 18 were present on the monitoring routes. On transects, seven of the 28 IEP species targeted for both parks were found (Table 3-1). Of the three additional species searched for in CURE, all were found

Table 3-1. Invasive exotic plants detected at Black Canyon of the Gunnison NP and Curecanti NRA, July 23–August 9, 2010.

Species	Common name	Method detected		Hectares infested			
		Routes	Transects	BLCA	CURE	Total	% of total
Targeted at both parks							
Acosta diffusa[1]	diffuse knapweed	X		0	0.02	0.02	0.0%
Acosta maculosa[1]	spotted knapweed	X		0	0.0002	0.0002	0.0%
Acroptilon repens	Russian knapweed	X	X	0.19	0.40	0.59	0.7%
Anisantha tectorum[1,2]	cheatgrass	n/a	X				
Arctium minus	burdock	X		0.48	0.09	0.57	0.6%
Breea arvensis[1]	Canada thistle	X	X	1.92	17.13	19.05	21.7%
Carduus nutans	musk thistle	X		2.06	1.85	3.91	4.4%
Cirsium vulgare	bull thistle	X		0.01	0.18	0.19	0.2%
Convolvulus arvensis	field bindweed	X	X	1.92	0.56	2.48	2.8%
Cynoglossum officinale	common houndstongue	X		0	0.02	0.02	0.0%
Lepidium latifolium	broad-leaf pepperwort	X		0	0.02	0.02	0.0%
Leucanthemum vulgare	ox-eye daisy	X		0	0.36	0.36	0.4%
Linaria vulgaris	butter-and-eggs	X		0.002	3.68	3.682	4.2%
Matricaria perforata[1]	scentless chamomile	X	X	0	1.15	1.15	1.3%
Phalaris arundinacea	reed canarygrass	X	X	13.99	2.79	16.78	19.1%
Tamarix ramosissima	saltcedar	X		0.002	0.0002	0.0022	0.0%
Ulmus pumila	Siberian elm	X		0.0002	0.03	0.027	0.0%
Verbascum thapsus	woolly mullein	X	X	2.00	16.87	18.87	21.5%
Viticella orientalis[1]	Oriental clematis	X		0	0.02	0.02	0.0%
Targeted at CURE only							
Hesperis matronalis[3]	Dame's rocket	X		0.01	0	0.01	0.0%
Kochia scoparia[3]	summer cypress	X	X	1.83	8.22	10.05	11.4%
Salsola australis[1,3]	Russian thistle	X	X	0.31	9.77	10.08	11.5%
Total				**24.725**	**63.1574**	**87.882**	
Total hectares inventoried				**477.51**	**849.43**	**1,327**	
Percent infested				**5.17**	**7.44**	**6.6**	
Non-target, recorded only on transects							
Melilotus officinale[2]	yellow sweetclover		X				

[1]See Table 2-1 for alternative nomenclature.

[2]Only recorded when present in quadrats. Although present, species was not mapped along routes.

[3]Species not consistently mapped in BLCA.

on monitoring routes and two were found on transects (Table 3-1). (While crew members also documented Dame's rocket [*Hesperis matronalis*], summer cypress [*Kochia scoparia*], and Russian thistle [*Salsola australis*] in BLCA, this should not be considered a complete inventory of these species for that particular park.)

The most abundant target species mapped in the parks was Canada thistle (*Breea arvensis*), infesting 19.05 hectares, or about 21.7% of total infested acres. The second-most abundant target species, which was also the most common (i.e., most infestations) IEP, was woolly mullein (*Verbascum thapsus*), infesting 18.87 hectares, or about 21.5% of total infested acres. Appendix B depicts the targeted species found along each monitoring route as well as the number of infestations recorded per size class.

3.2 Monitoring routes

3.2.1 Black Canyon of the Gunnison National Park

The USU crew inventoried all major access routes into the inner canyon of BLCA (Appendix A, Figures A-1 through A-4). Of the targeted list of 28 species, 123 were found in BLCA along the Gunnison River, inner canyon routes, and Red Rock Canyon (Table 3-2). Reed canarygrass, woolly mullein, and musk thistle (*Carduus nutans*) were the most common species found during the search. Reed canarygrass was found almost anywhere there was water; it was almost continuous in areas inventoried along the Gunnison River as well as the creek in Red Rock Canyon. Patches formed monocultures and were densely covered, reflecting the rhizomatous root system of this species.

Patches of woolly mullein and musk thistle were sparser and less dense than reed canarygrass in overall canopy cover. While both species were found along the inner canyon routes, musk thistle was especially prevalent in small patches along the East Portal Road and Red Rock Canyon (see Appendix B). In general, the inner canyon routes were only moderately infested with target IEPs, aside from reed canarygrass. East Portal Road and Red Rock Canyon tended to have higher concentrations of the other targeted IEPs than the inner canyon routes, possibly because they receive higher levels of use and are to easier to access than the inner canyon routes (Table 3-2).

3.2.2 Black Canyon/Curecanti corridor

Woolly mullein, musk thistle, and Canada thistle were the most commonly detected IEPs along the Devils Backbone and East Portal Road routes (Figures 3-5 and 3-6) that included portions of both parks.

3.2.3 Curecanti National Recreation Area

Areas inventoried in CURE included much of the shoreline along Blue Mesa Reservoir, hiking trails that access overlooks, and the Gunnison River (Figures 3-7 through 3-19). Of the targeted list of 31 species, 19 were found in CURE (Table 3-2). Canada thistle, woolly mullein, Russian thistle (*Salsola australis*), and summer cypress (*Kochia scoparia*) were the most common species detected in 2010. While the species were spread across all areas searched, the campgrounds and Coopers Ranch area, which play host to a large degree of concentrated recreational activity, contained disproportionate numbers of IEP infestations (Appendix B). Pine Creek Trail, the Dillon Pinnacles shoreline, and the Lake Fork Arm of Blue Mesa Reservoir also contained a high proportion of IEP populations relative to the other inventory routes in CURE. At Lake Fork Arm, infestations were almost exclusively woolly mullein. Many of the trails inventoried in CURE contained few invasive infestations relative to the shoreline of Blue Mesa Reservoir.

3.3 Monitoring transects

A total of 567 quadrats were sampled on 190 transects in 2010 (see Appendix C), providing almost complete coverage of the trails and roads within BLCA and many miles of shoreline along Blue Mesa Reservoir and the Gunnison River in CURE. Of total transects and quadrats sampled, 50 transects (26%) and 87 quadrats (15%) were infested with 10 different IEPs (Table 3-3, Appendix C). Of the 28 IEPs searched for in quadrats that were a priority for both parks, seven were found: woolly mullein, Canada thistle, scentless chamomile (*Matricaria perforata*), field

bindweed (*Convolvulus arvensis*), cheatgrass, Russian knapweed (*Acroptilon repens*), and reed canarygrass (Table 3-3). Summer cypress and Russian thistle, priority species for CURE only, were also found in quadrats. While not listed as a priority species for either park, yellow sweetclover (*Melilotus officinale*) was also documented. Information on percent cover is provided in Appendix C.

Yellow sweetclover was the most common species found, present in 10% of transects (Table 3-3). It was primarily recorded in CURE, as was woolly mullein, which was the third-most common species found in transects. Reed canarygrass was the second-most common species detected in transects, representing 8% of transects sampled, although it was found exclusively in transects sampled in BLCA.

Table 3-2. Total infestations and infestation size class by species, Black Canyon of the Gunnison NP and Curecanti NRA, July 23–August 9, 2010.

Scientific name	Common name	Total infestations	% of total	Infestation size class Number of infestations 1	2	3	4	5
Black Canyon of the Gunnison NP								
Phalaris arundinacea	reed canarygrass	299	41.2%	4	37	142	83	30
Verbascum thapsus	woolly mullein	127	17.5%	46	45	31	5	0
Carduus nutans	musk thistle	83	11.4%	33	25	17	5	3
Breea arvensis[1]	Canada thistle	60	8.3%	12	17	30	1	0
Arctium minus	burdock	53	7.3%	26	15	10	1	1
Convolvulus arvensis	field bindweed	48	6.6%	0	19	18	9	2
Hesperis matronalis[2]	Dame's rocket	15	2.1%	12	3	0	0	0
Cirsium vulgare	bull thistle	14	1.9%	7	2	0	1	4
Kochia scoparia[2]	summer cypress	14	1.9%	0	0	1	2	11
Salsola australis[1,2]	Russian thistle	7	1.0%	1	1	1	4	0
Acroptilon repens	Russian knapweed	3	0.4%	0	0	2	1	0
Tamarix ramosissima	saltcedar	2	0.3%	1	1	0	0	0
Linaria vulgaris	butter-and-eggs	1	0.1%	0	1	0	0	0
BLCA total		**726**	**34.3%**	**142**	**166**	**252**	**112**	**51**
Black Canyon of the Gunnison NP/Curecanti NRA corridor								
Verbascum thapsus	woolly mullein	175	42.9%	22	89	63	1	0
Carduus nutans	musk thistle	102	25.0%	25	41	34	2	0
Breea arvensis[1]	Canada thistle	69	16.9%	4	21	41	3	0
Convolvulus arvensis	field bindweed	36	8.8%	0	14	21	1	0
Phalaris arundinacea	reed canarygrass	12	2.9%	0	0	5	1	6
Acroptilon repens	Russian knapweed	5	1.2%	0	4	0	1	0
Cirsium vulgare	bull thistle	4	1.0%	2	2	0	0	0
Ulmus pumila	Siberian elm	4	1.0%	1	2	1	0	0
Lepidium latifolium	broad-leaf pepperwort	1	0.2%	0	0	1	0	0
Corridor total		**408**	**19.3%**	**54**	**173**	**166**	**9**	**6**
Curecanti NRA								
Breea arvensis[1]	Canada thistle	257	26.2%	9	37	87	45	79
Verbascum thapsus	woolly mullein	174	17.7%	18	16	30	22	88
Salsola australis[1]	Russian thistle	144	14.7%	9	5	56	44	30
Kochia scoparia	summer cypress	128	13.0%	1	2	47	58	20
Carduus nutans	musk thistle	76	7.7%	19	19	27	6	5
Linaria vulgaris	butter-and-eggs	54	5.5%	2	9	17	8	18
Phalaris arundinacea	reed canarygrass	48	4.9%	0	4	31	7	6
Matricaria perforata[1]	scentless chamomile	40	4.1%	14	5	13	5	3
Cirsium vulgare	bull thistle	23	2.3%	12	7	3	1	0
Convolvulus arvensis	field bindweed	13	1.3%	0	3	7	1	2
Leucanthemum vulgare	ox-eye daisy	11	1.1%	0	4	3	4	0
Acroptilon repens	Russian knapweed	4	0.4%	0	0	0	2	2
Arctium minus	burdock	3	0.3%	0	1	1	1	0
Viticella orientalis[1]	Oriental clematis	2	0.2%	0	1	1	0	0
Acosta diffusa[1]	diffuse knapweed	1	0.1%	0	0	1	0	0

Table 3-2. Total infestations and infestation size class by species, Black Canyon of the Gunnison NP and Curecanti NRA, July 23–August 9, 2010, cont.

Scientific name	Common name	Total infestations	% of total	Infestation size class Number of infestations 1	2	3	4	5
Cynoglossum officinale	common houndstongue	1	0.1%	0	0	1	0	0
Lepidium latifolium	broad-leaf pepperwort	1	0.1%	0	1	0	0	0
Acosta maculosa[1]	spotted knapweed	1	0.1%	1	0	0	0	0
Tamarix ramosissima	saltcedar	1	0.1%	1	0	0	0	0
CURE total		**982**	**46.4%**	**86**	**114**	**325**	**204**	**253**

[1]See Table 2-1 for alternative nomenclature.

[2]These species were found in BLCA but were not priority species for that park.

Table 3-3. Number of infestations and mean percent cover of invasive species found on transects in Black Canyon of the Gunnison NP and Curecanti NRA, July 23–August 9, 2010.

Scientific name	Common name	Transects Total	% of infested (50)	% of total (190)	Quadrats Total	% of infested (87)	% of total (567)
Melilotus officinale[1]	yellow sweetclover	19	38.00%	10.00%	31	35.63%	5.47%
Phalaris arundinaceae	reed canarygrass	15	30.00%	7.89%	24	27.59%	4.23%
Verbascum thapsus	woolly mullein	12	24.00%	6.32%	13	14.94%	2.29%
Cirsium arvesnse	Canada thistle	10	20.00%	5.26%	12	13.79%	2.12%
Kochia scoparia[2]	summer cypress	2	4.00%	1.05%	2	2.30%	0.35%
Acroptilon repens	Russian knapweed	1	2.00%	0.53%	1	1.15%	0.18%
Anisantha tectorum[3]	cheatgrass	1	2.00%	0.53%	1	1.15%	0.18%
Convolvulus arvensis	field bindweed	1	2.00%	0.53%	1	1.15%	0.18%
Matricaria perforata[3]	scentless chamomile	1	2.00%	0.53%	1	1.15%	0.18%
Salsola australis[2,3]	Russian thistle	1	2.00%	0.53%	1	1.15%	0.18%

Only transects found to contain non-native species are shown.

[1]Not a priority species

[2]Searched for only in CURE

[3]See Table 2-1 for alternative nomenclature.

4 Discussion

4.1 Target invasive exotic plant list

All routes of Black Canyon of the Gunnison National Park that were inventoried in 2003 and 2004 were re-inventoried in 2010. Between 2004 and 2010, there was an increase in burdock (*Arctium minus*), Russian knapweed, Canada thistle, bull thistle (*Cirsium vulgare*), Russian thistle, and woolly mullein. In some cases, the increase in infested acreage was, at least in part, due to the increase in numbers of hectares inventoried.

Three species that were targeted in both 2004 and 2010 were found only in 2010: common houndstongue (*Cynoglossum officinale*), broad-leaf pepperwort (*Lepidium latifolium*), and scentless chamomile. Oriental clematis (*Clematis orientalis*), ox-eye daisy, and Dame's rocket were not on the 2004 target list. Of those six species, common houndstongue, broad-leaf pepperwort, and Oriental clematis (with infestations of 0.02 hectares each; see Table 4-1), are candidates for early detection and rapid response, defined as species with fewer than 10 recorded infestations totaling an area of less than 0.405 hectares (1 acre).

Many species decreased in total hectares infested from 2004 to 2010, including Siberian elm (*Ulmus pumila*), saltcedar (*Tamarix ramosissima*), marshelder (*Iva xanthifolia*, not found in 2010), field bindweed, spotted knapweed (*Centaurea stoebe*), diffuse knapweed (*Centaurea diffusa*), and musk thistle. It is hoped that the decrease in acreage of these species is a direct result of control efforts by BLCA. The parks are to be commended for their management efforts and their success in reducing the size and number of these infestations if this is the case.

Cheatgrass was mapped in 2003 but dropped from the effort in 2004 due to its recognized abundance in most of the inventory sites. Likewise, it was not included in route monitoring in 2010 (but was recorded in the monitoring quadrats).

4.2 Management implications

Park staff is encouraged to continue its efforts to reduce IEP infestation within the two parks. As a general rule, the species found in the smallest numbers of hectares infested should receive highest priority for treatment. The management objective for these species is eradication. Species that are more abundant but still considered manageable would receive second priority, with the goal of containing the perimeter of each infestation and then reducing the overall hectares infested over time. Widespread species presently found in numerous locations or in high numbers should receive lowest priority if the total species abundance exceeds the resources available for control. The focus of widespread species control is containment until higher-priority species have been adequately addressed.

Based on the 2010 results for this project, species for consideration of highest priority (marked for eradication) might include spotted knapweed, saltcedar, Dame's rocket, diffuse knapweed, common houndstongue, broad-leaf pepperwort, Oriental clematis, Siberian elm, and Russian knapweed (Table 4-1). Although Russian knapweed infests a total hectarage larger than would typically be considered for priority management, we have included it as a first priority species due to its recognized invasiveness and ability to quickly form monocultures (Benz et al. 1999). Species for consideration of second-highest priority (marked for containment and reduction) might include bull thistle, ox-eye daisy, burdock, scentless chamomile, field bindweed, butter-and-eggs (*Linaria vulgaris*), and musk thistle. More widespread species of lower priority (marked for containment) might include summer cypress, Russian thistle, reed canarygrass, woolly mullein, and Canada thistle.

4.3 Future monitoring efforts

Both BLCA and CURE are encouraged to continue scheduled IEP monitoring of all their managed lands, in support of early detection and rapid response efforts. Inspection of high-visitation areas (such as trails, routes, roads, campgrounds, and other developed used areas) should be performed annually, as these areas serve as the most likely sites of new introductions. Continued follow-up with sampling of monitoring quadrats will allow park staff to quantify and document the long-term effects of the species distributions already present.

Table 4-1. Recommendations for prioritizing IEP control efforts.

Species	Common name	Hectares infested		
		BLCA	CURE	Total
First priority				
Centaurea stoebe	spotted knapweed	0	0.0002	0.0002
Tamarix ramosissima	saltcedar	0.002	0.0002	0.0022
Hesperis matronalis	Dame's rocket	0.01	0	0.01
Centaurea diffusa	diffuse knapweed	0	0.02	0.02
Cynoglossum officinale	common houndstongue	0	0.02	0.02
Lepidium latifolium	broad-leaf pepperwort	0	0.02	0.02
Clematis orientalis	Oriental clematis	0	0.02	0.02
Ulmus pumila	Siberian elm	0.0002	0.03	0.027
Acroptilon repens	Russian knapweed	0.19	0.40	0.59
Second priority				
Cirsium vulgare	bull thistle	0.01	0.18	0.19
Leucanthemum vulgare	ox-eye daisy	0	0.36	0.36
Arctium minus	burdock	0.48	0.09	0.57
Tripleurospermum perforatum	scentless chamomile	0	1.15	1.15
Convolvulus arvensis	field bindweed	1.92	0.56	2.48
Linaria vulgaris	butter-and-eggs	0.002	3.68	3.682
Carduus nutans	musk thistle	2.06	1.85	3.91
Third priority				
Kochia scoparia	summer cypress	1.83	8.22	10.05
Salsola tragus	Russian thistle	0.31	9.77	10.08
Phalaris arundinacea	reed canaraygrass	13.99	2.79	16.78
Verbascum thapsus	woolly mullein	2.00	16.87	18.87
Cirsium arvense	Canada thistle	1.92	17.13	19.05

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Appendix A. Invasive Species Maps

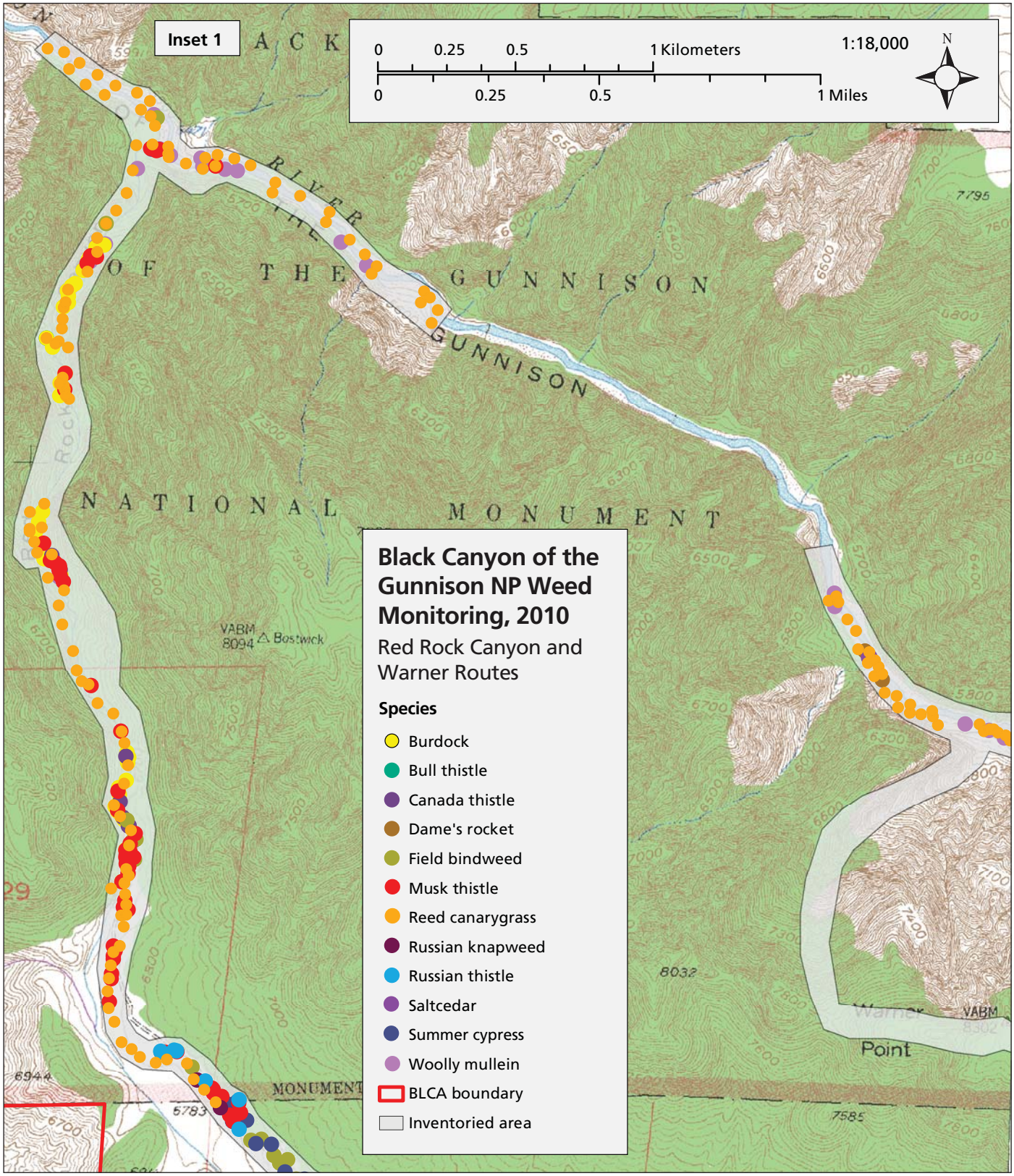

Figure A-1. Invasive plants detected on the Red Rock Canyon and Warner Routes and the Gunnison River access in BLCA, July 23–August 9, 2010.

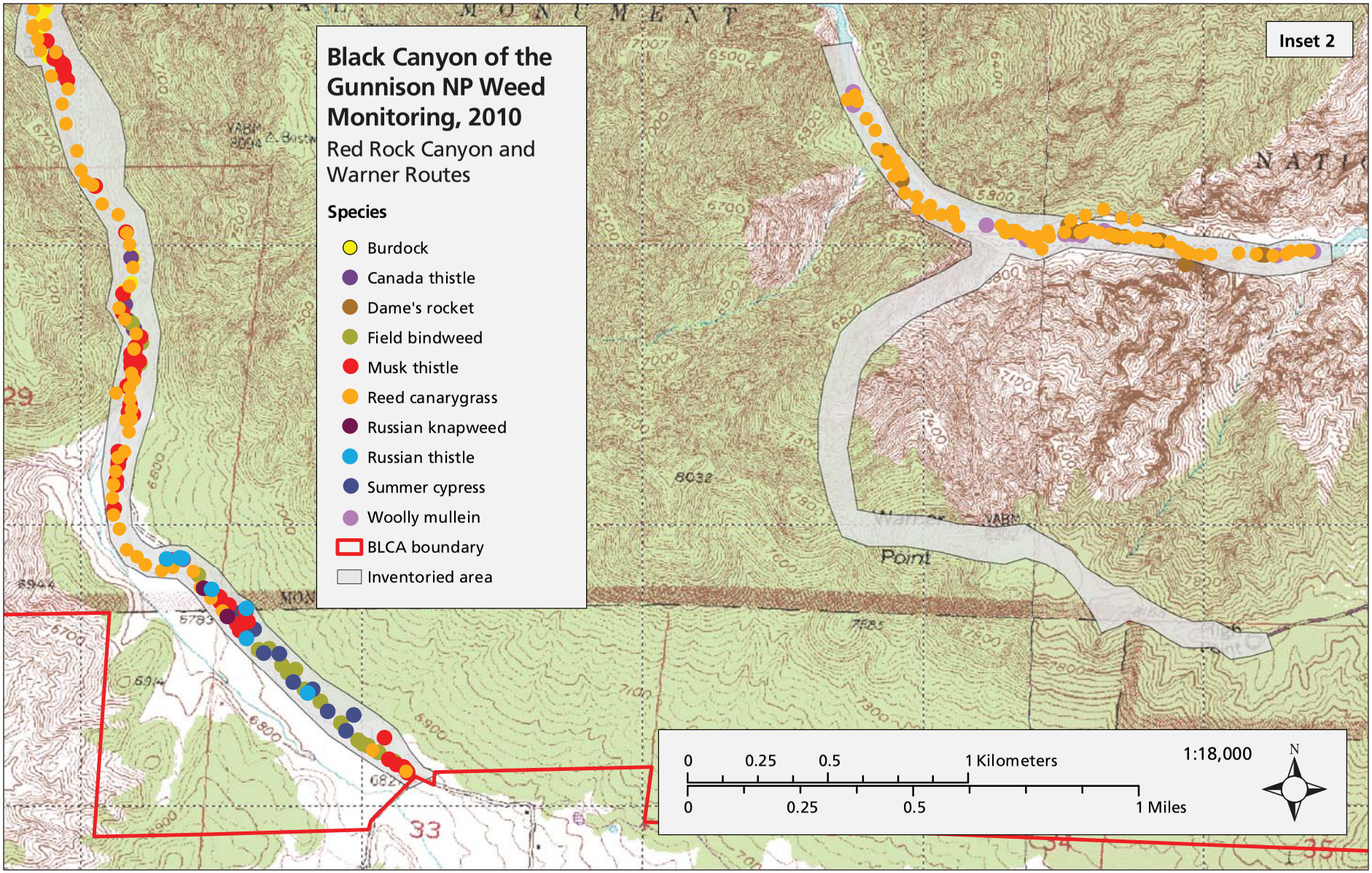

Figure A-2. Invasive plants detected on the Red Rock Canyon and Warner Routes and the Gunnison River access in BLCA, July 23–August 9, 2010.

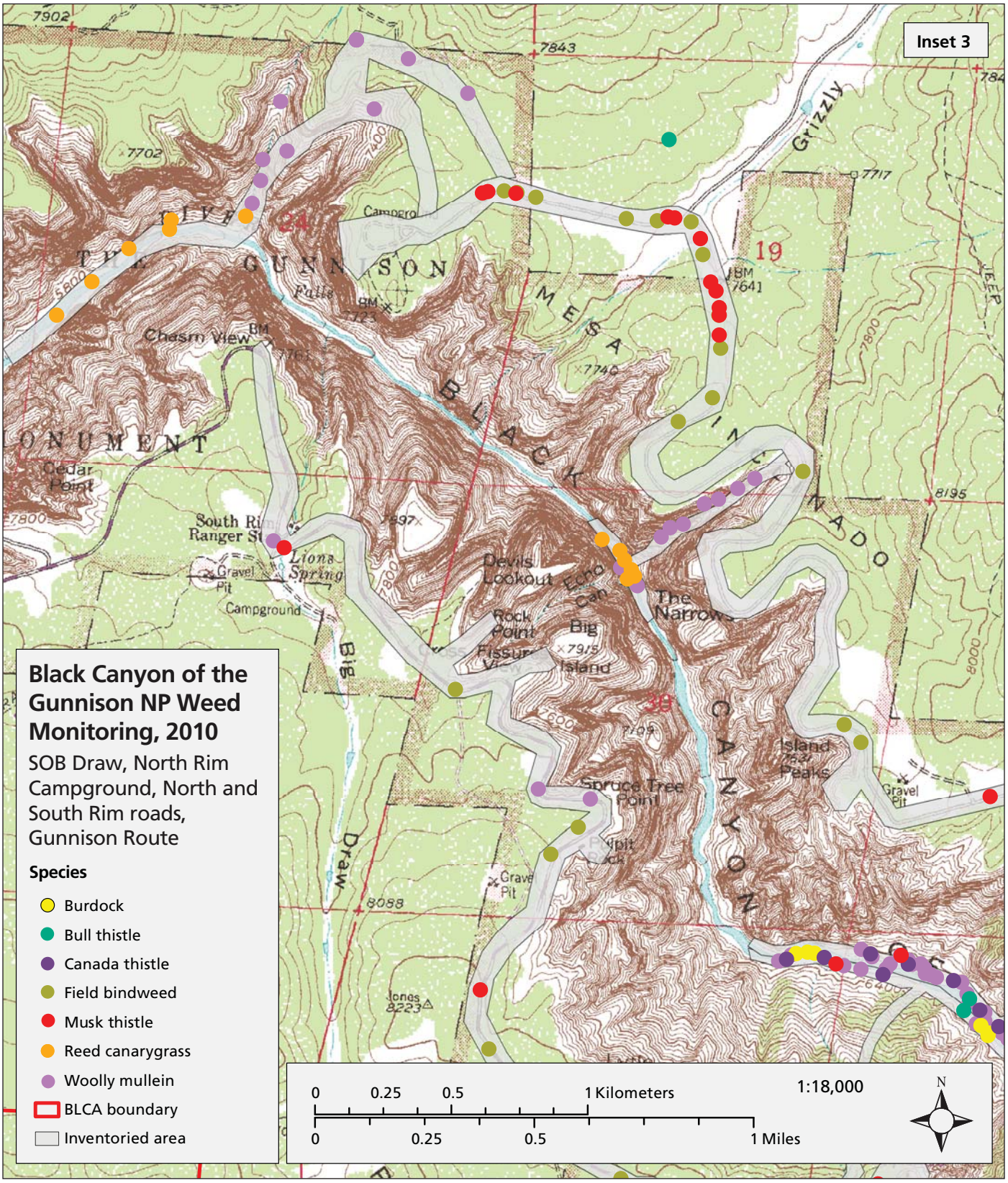

Figure A-3. Invasive plants detected on SOB Draw, North Rim Campground, North and South Rim roads, and the Gunnison route and Gunnison River access in BLCA, July 23–August 9, 2010.

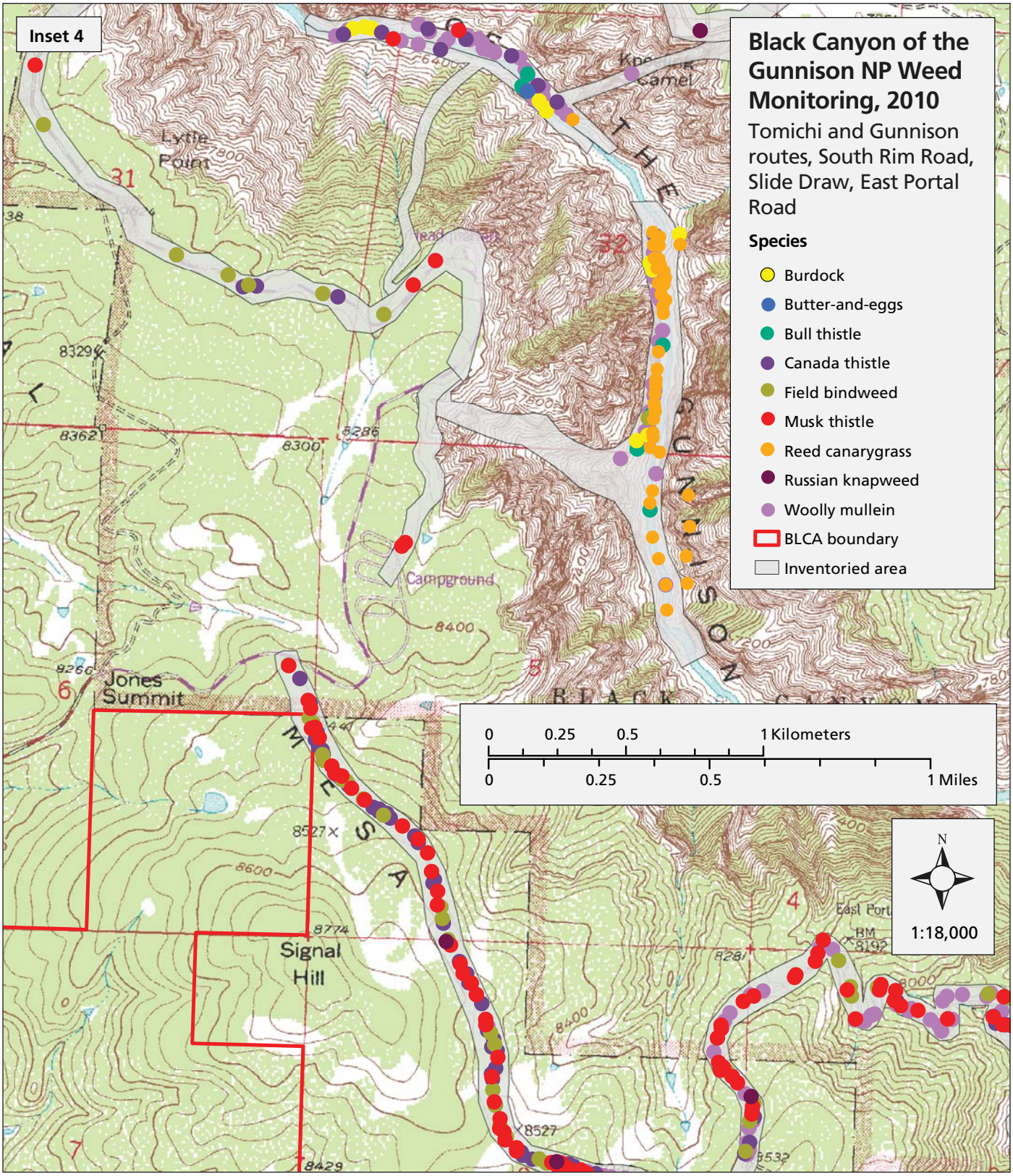

Figure A-4. Invasive plants detected on the Tomichi and Gunnison routes, South Rim Road, Slide Draw, East Portal Road, and the Gunnison River access in BLCA, July 23–August 9, 2010.

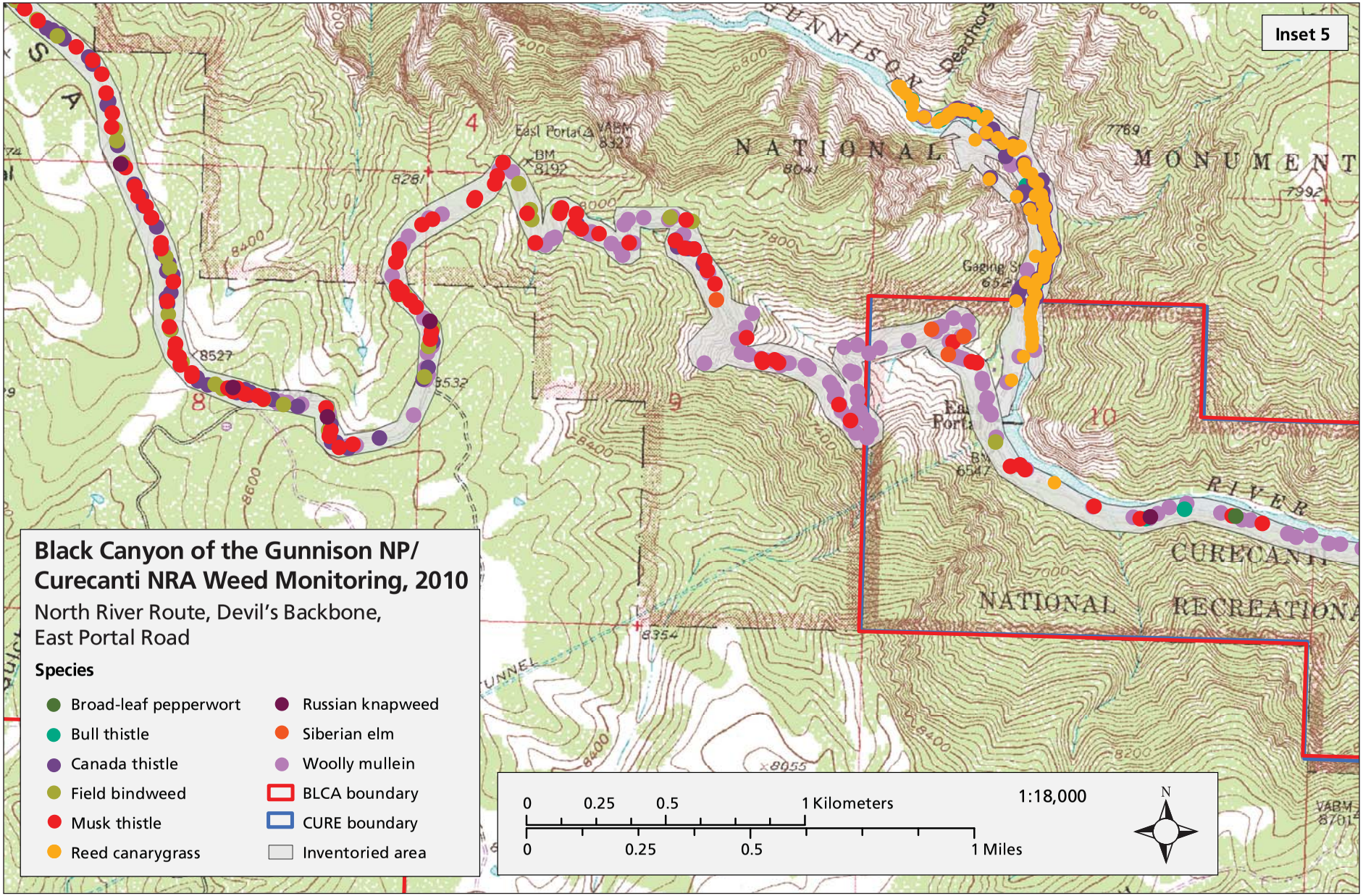

Figure A-5. Invasive plants detected on the North River Route, Devil's Backbone, and East Portal Road in BLCA and CURE, July 23–August 9, 2010.

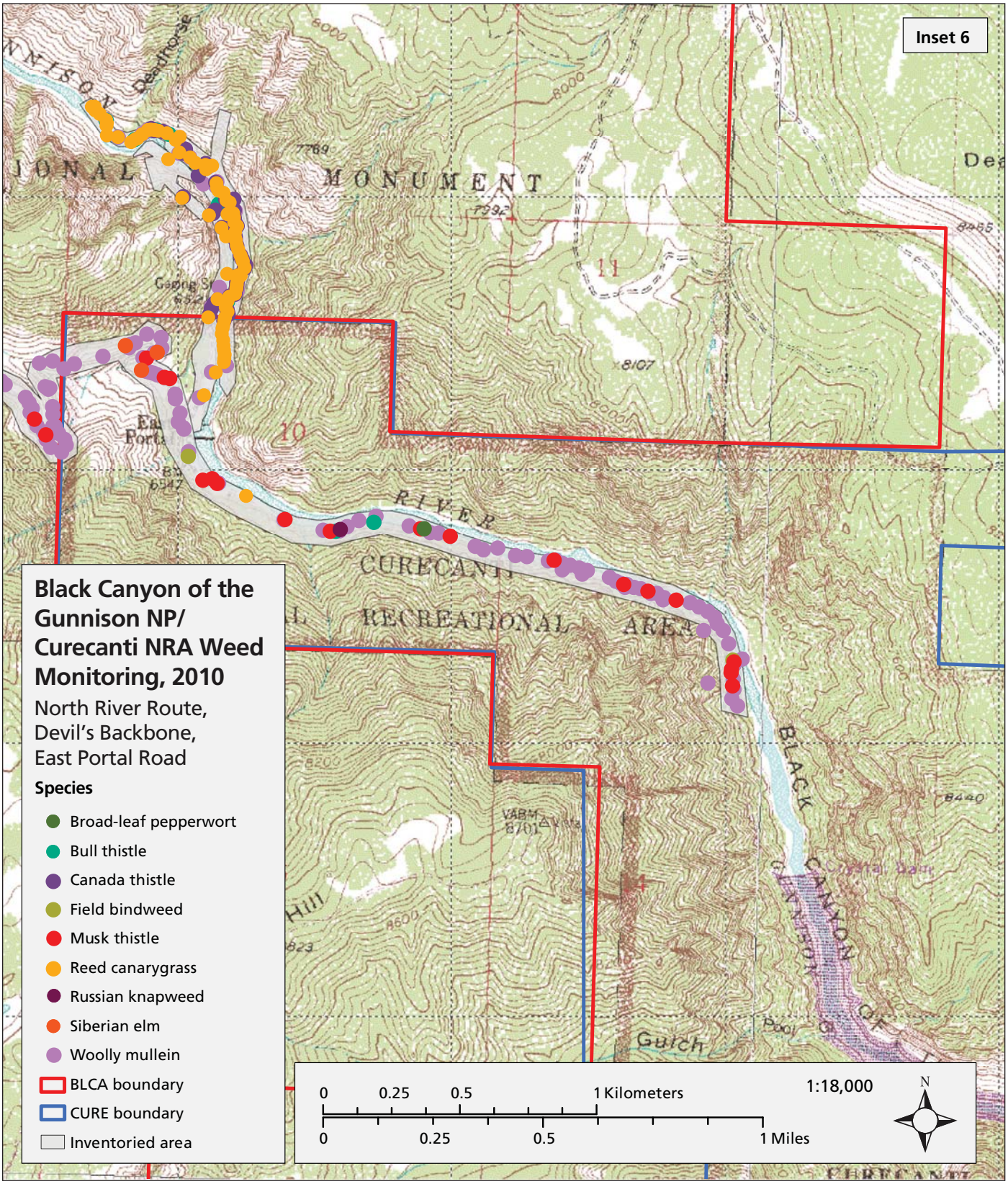

Figure A-6. Invasive plants detected on the North River Route, Devil's Backbone, and East Portal Road in BLCA and CURE, July 23–August 9, 2010.

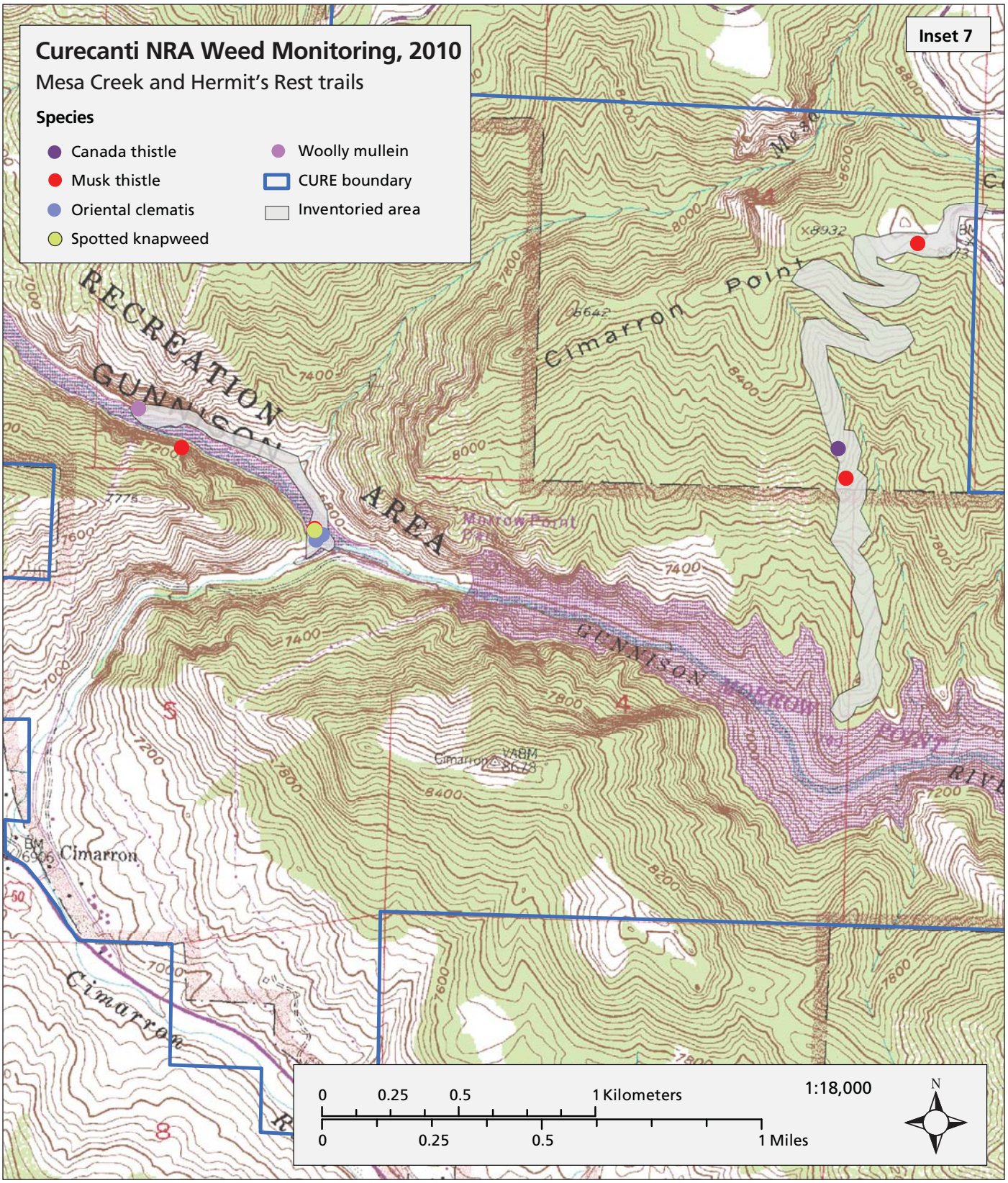

Figure A-7. Invasive plants detected on the Mesa Creek and Hermit's Rest trails in CURE, July 23–August 9, 2010.

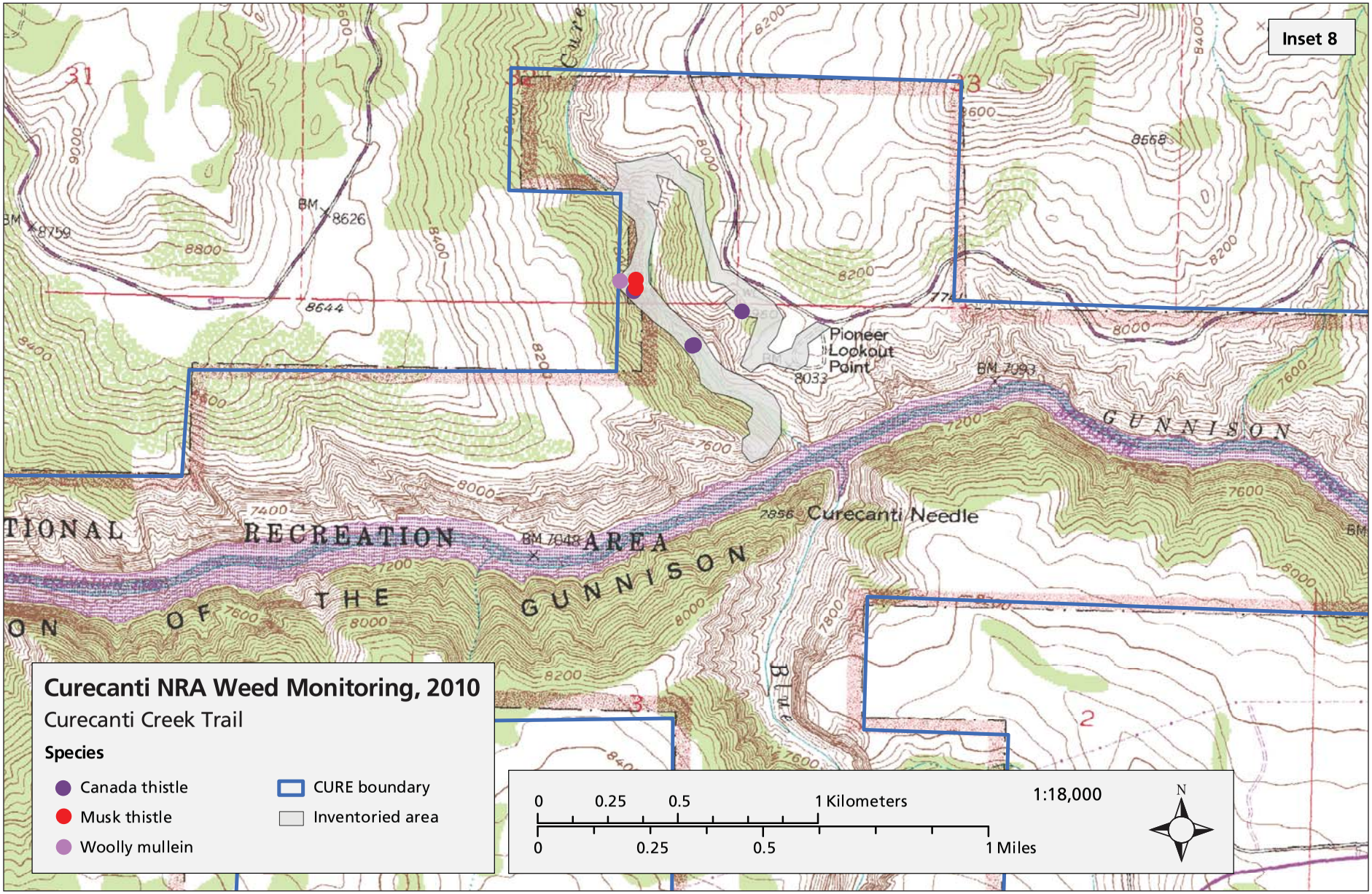

Figure A-8. Invasive plants detected on the Curecanti Creek Trail in CURE, July 23–August 9, 2010.

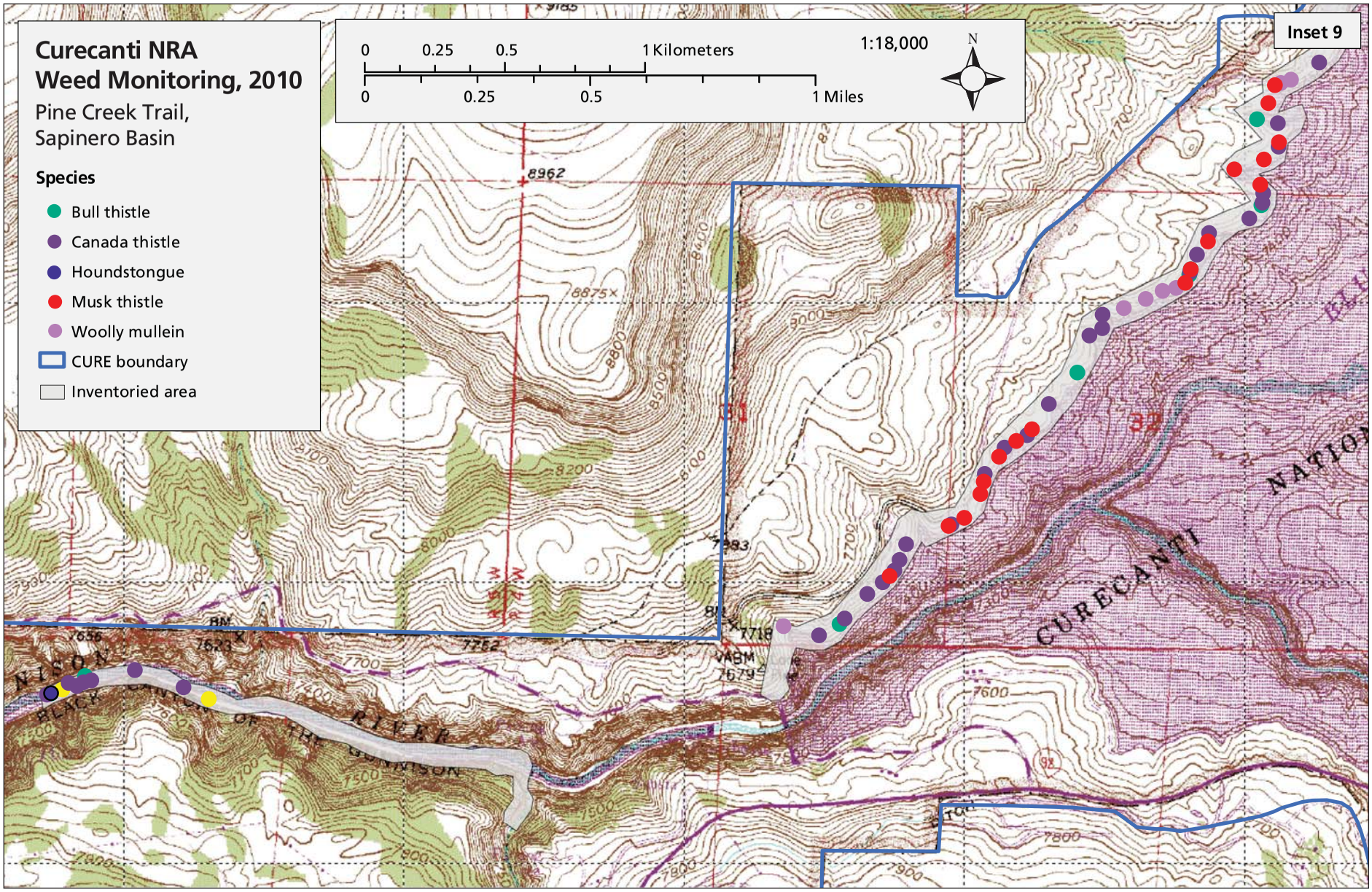

Figure A-9. Invasive plants detected on the Pine Creek Trail and Sapinero Basin routes in CURE, July 23–August 9, 2010.

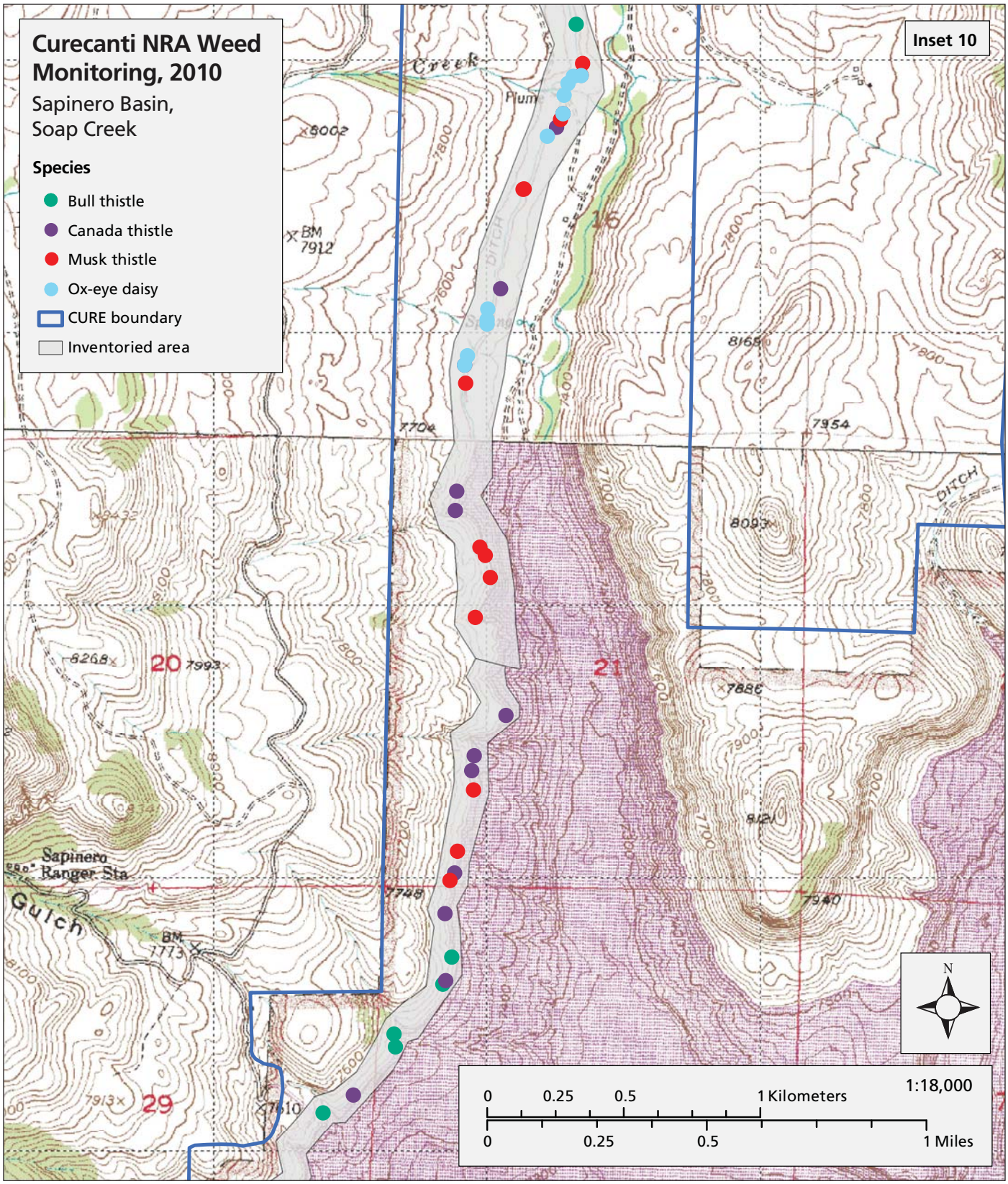

Figure A-10. Invasive plants detected on the Sapinero Basin and Soap Creek routes in CURE, July 23–August 9, 2010.

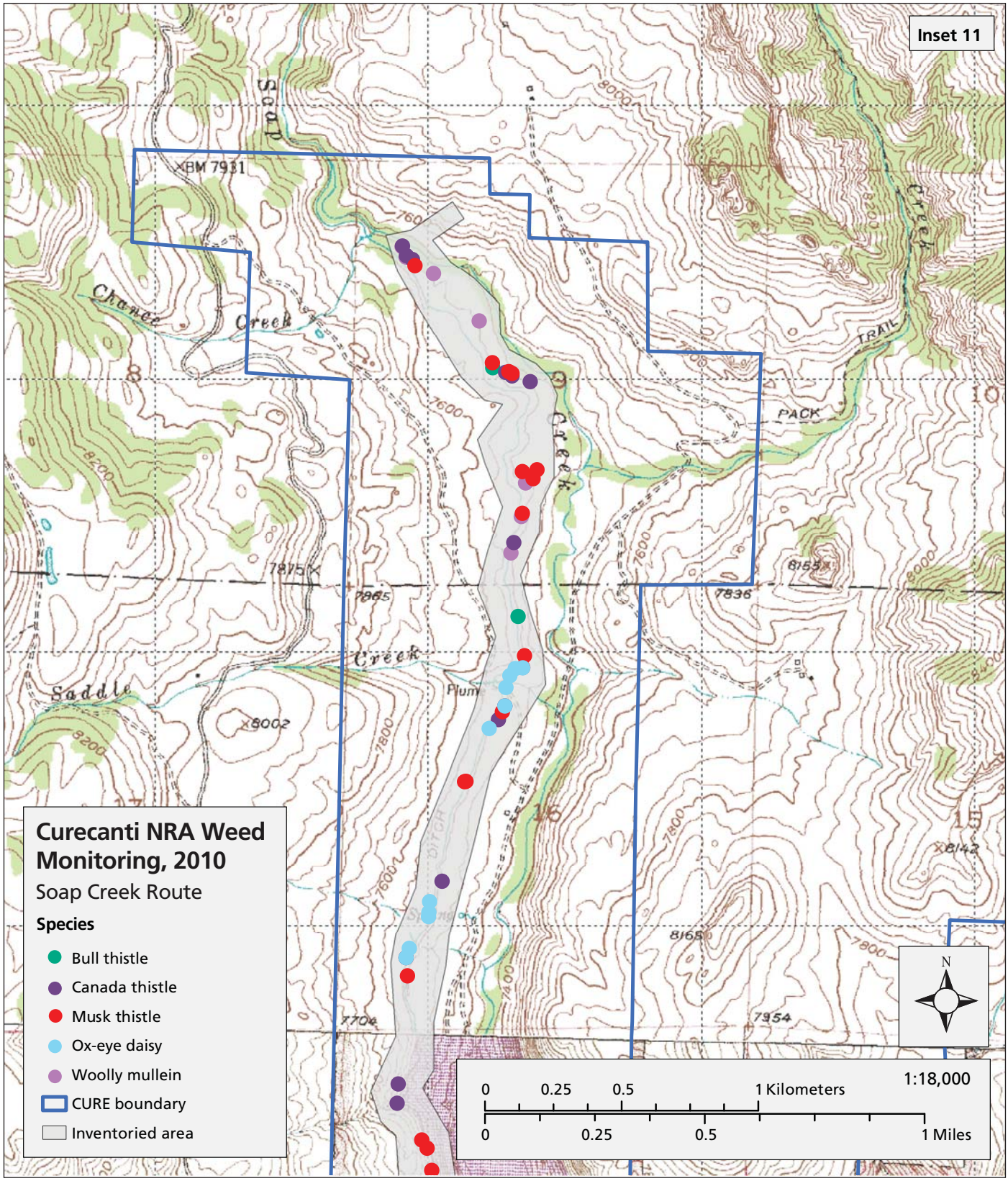

Figure A-11. Invasive plants detected on the Soap Creek route in CURE, July 23–August 9, 2010.

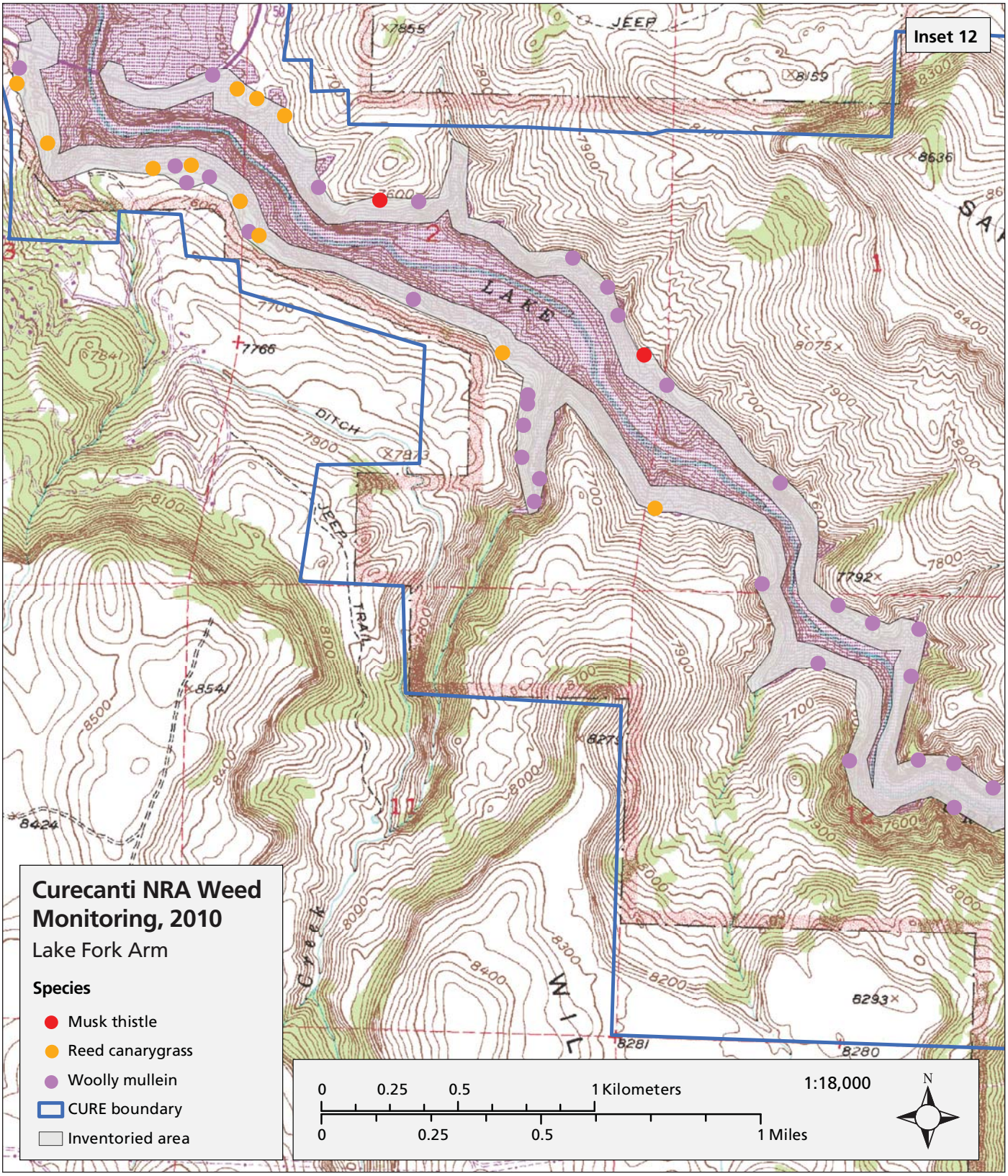

Figure A-12. Invasive plants detected on the Lake Fork Arm on Blue Mesa Reservoir in CURE, July 23–August 9, 2010.

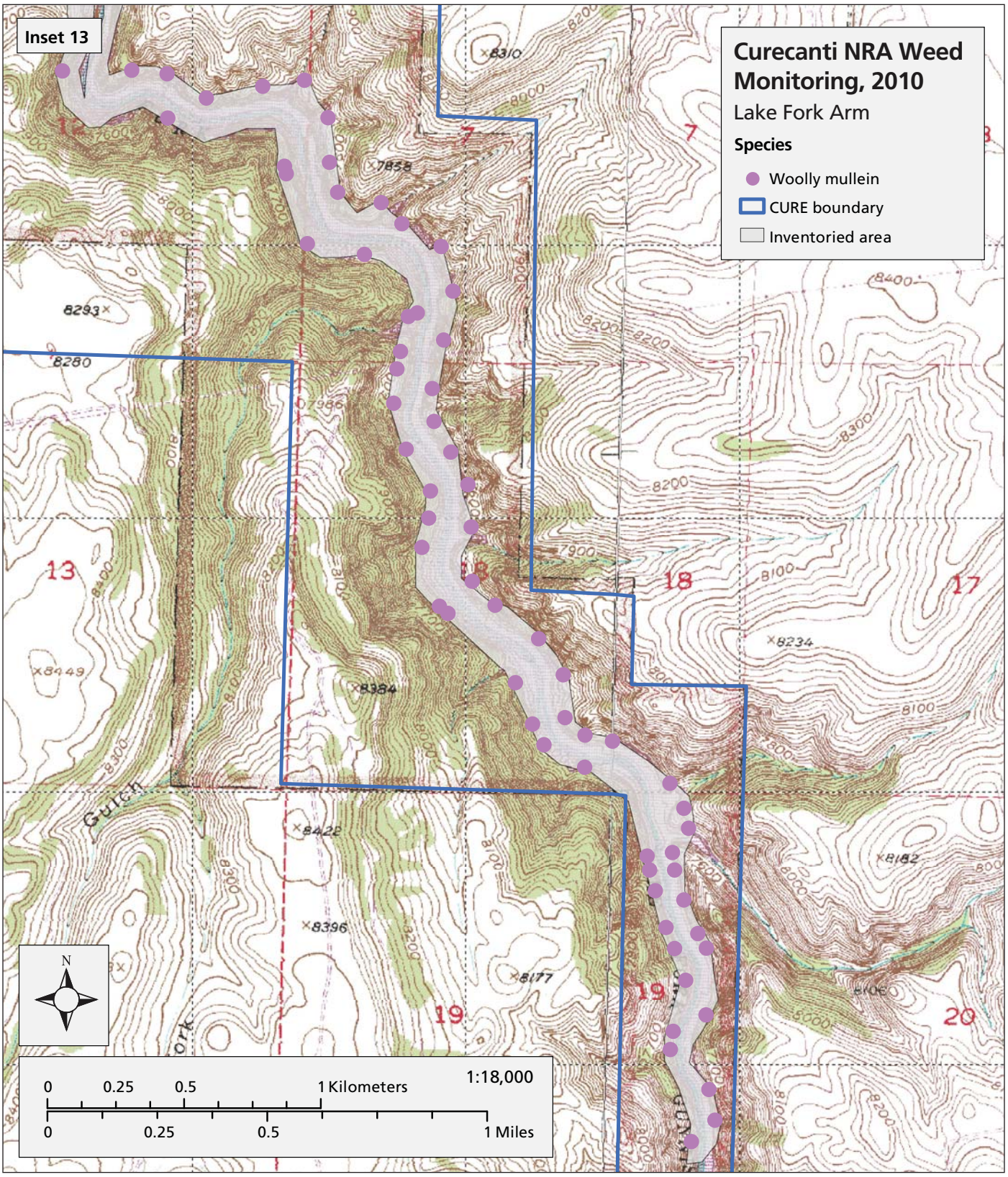

Figure A-13. Invasive plants detected on the Lake Fork Arm on Blue Mesa Reservoir in CURE, July 23–August 9, 2010.

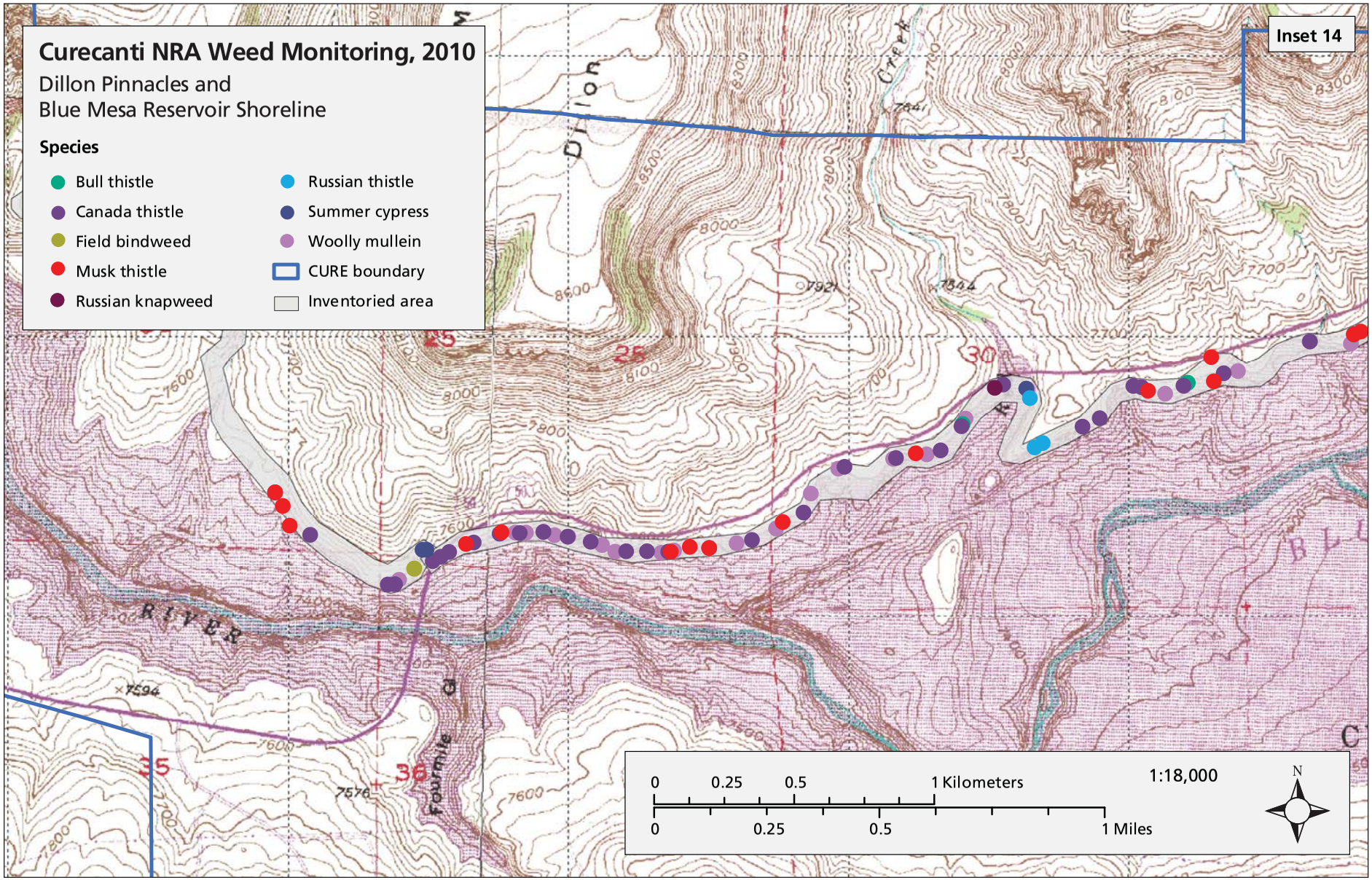

Figure A-14. Invasive plants detected on the Dillon Pinnacles and Blue Mesa Reservoir Shoreline routes in CURE, July 23–August 9, 2010.

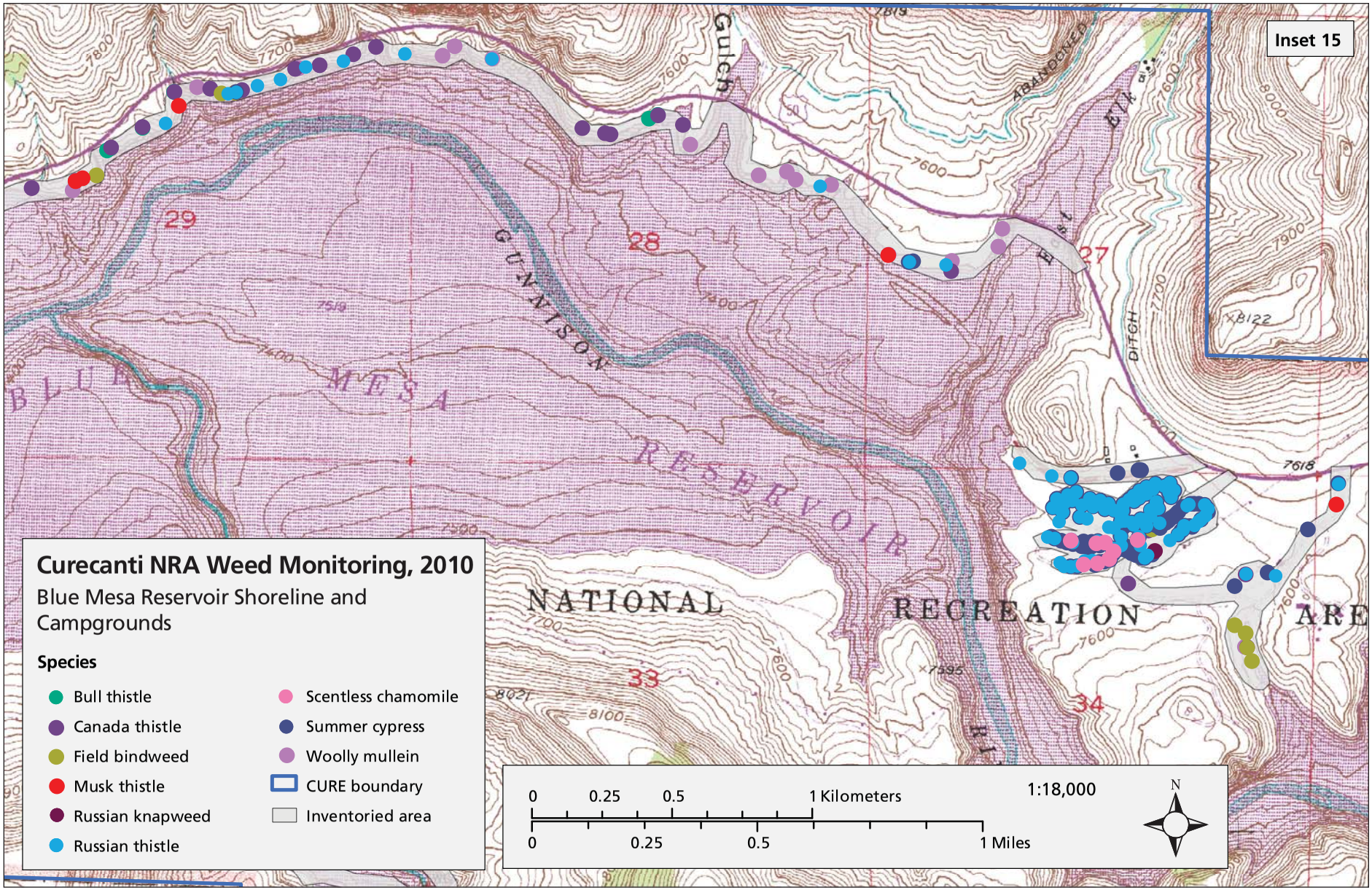

Figure A-15. Invasive plants detected on the Blue Mesa Reservoir Shoreline route and in campgrounds in CURE, July 23–August 9, 2010.

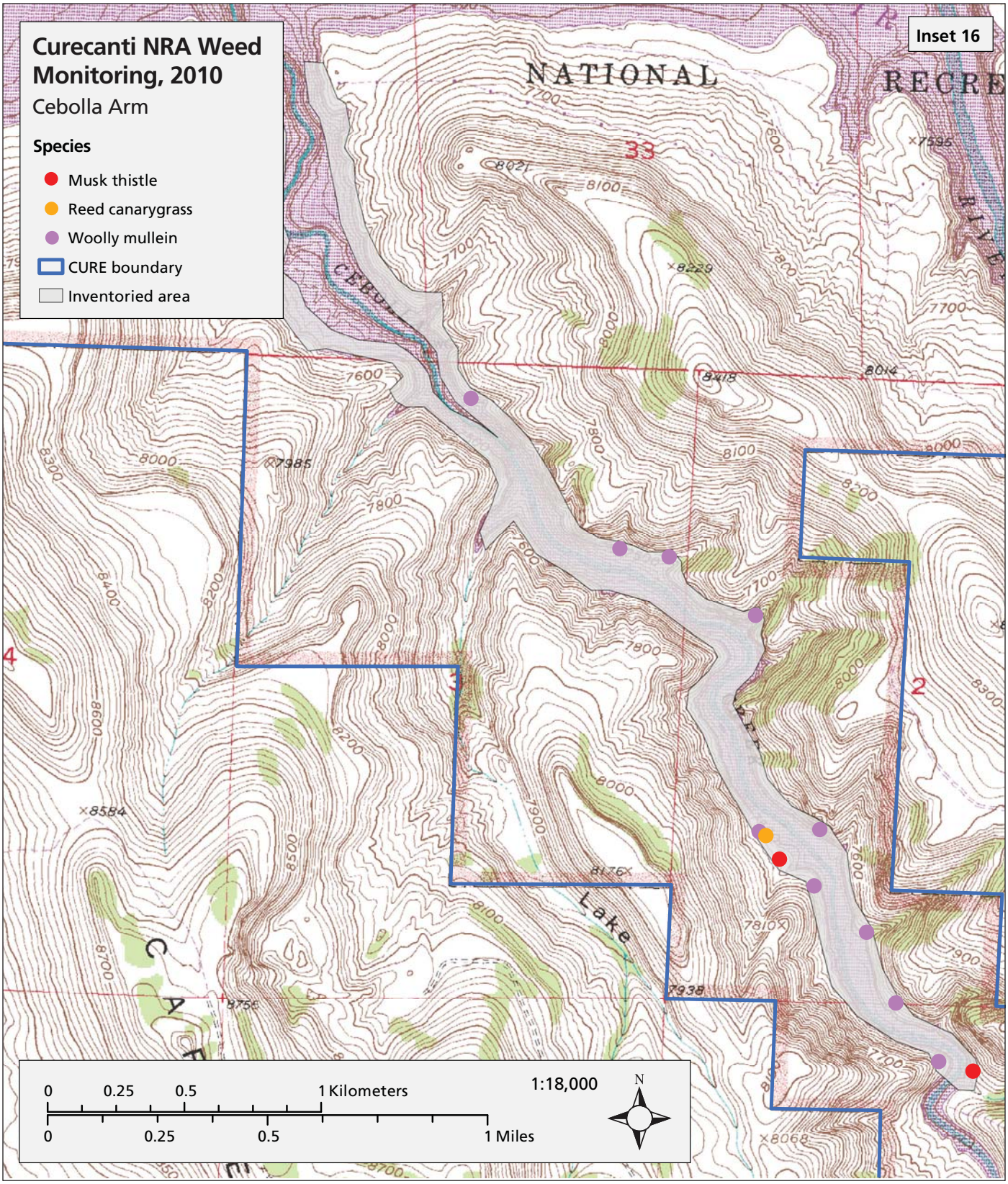

Figure A-16. Invasive plants detected on the Cebolla Arm of Blue Mesa Reservoir in CURE, July 23–August 9, 2010.

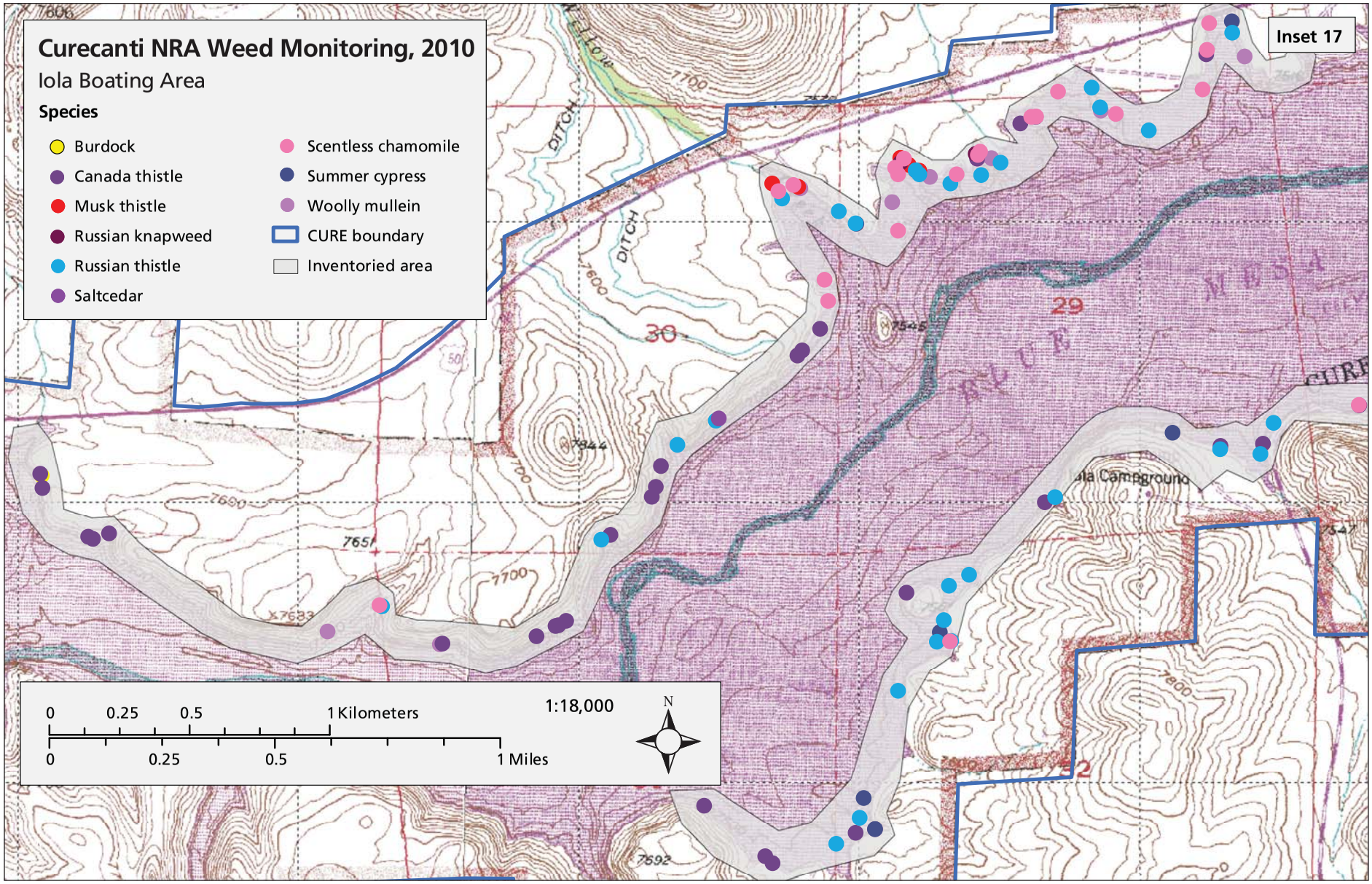

Figure A-17. Invasive plants detected on the Blue Mesa Reservoir Shoreline and near Iola Boating Area in CURE, July 23–August 9, 2010.

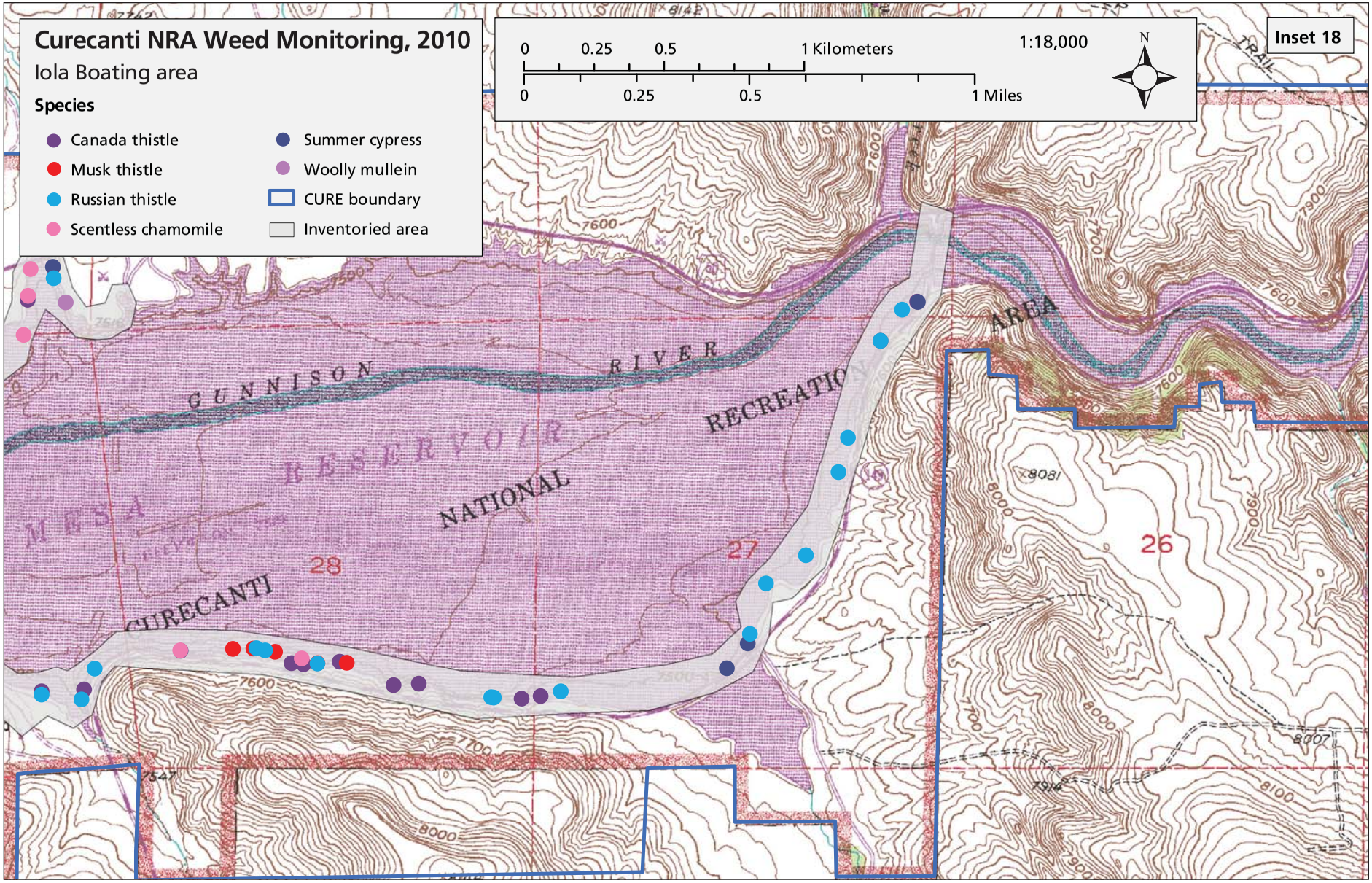

Figure A-18. Invasive plants detected on the Blue Mesa Reservoir Shoreline near Iola Boating area in CURE, July 23–August 9, 2010.

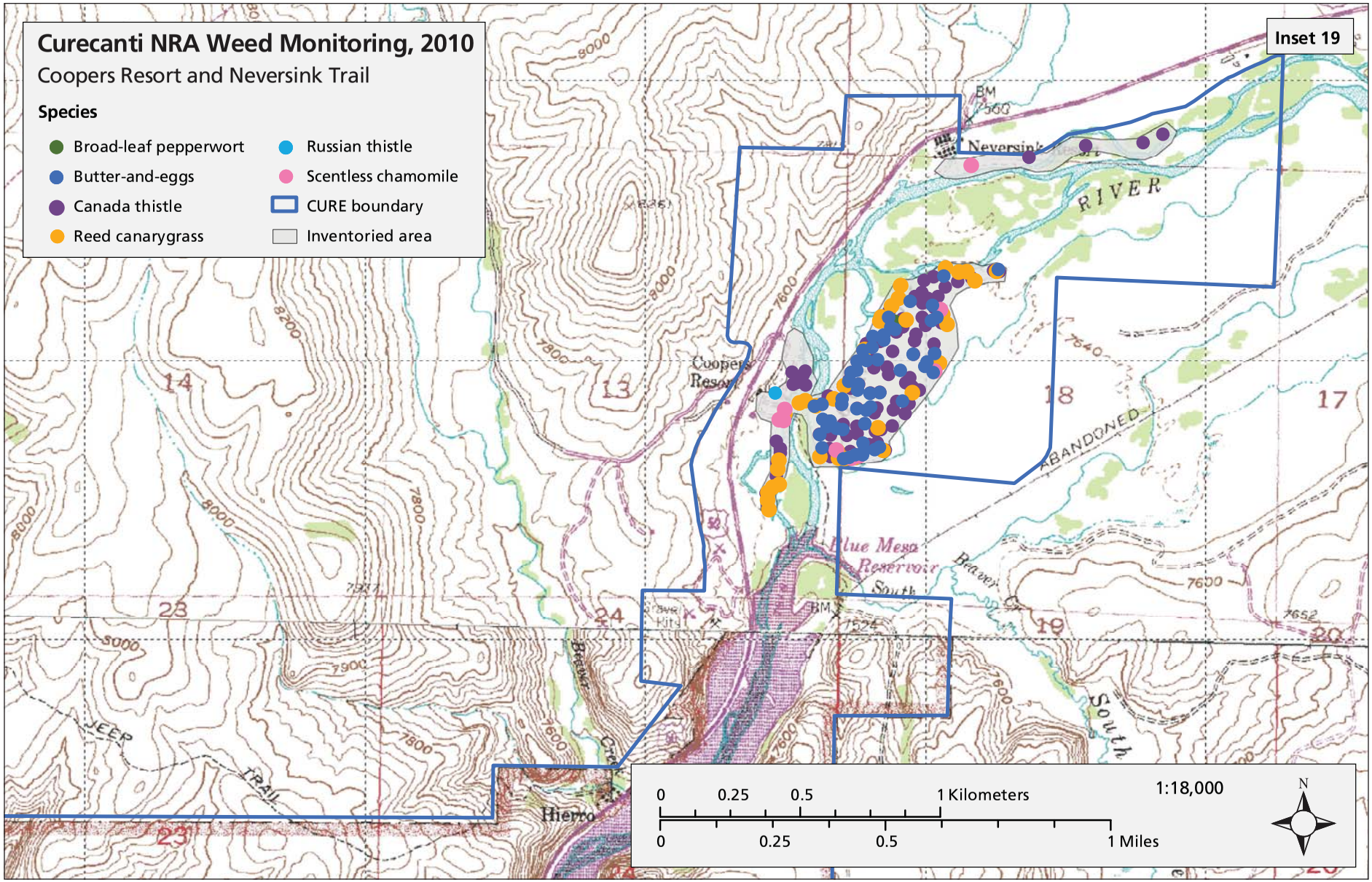

Figure A-19. Invasive plants detected on the Coopers Ranch route and Neversink Trail in CURE, July 23–August 9, 2010.

Appendix B. Species observed and size of infestations detected along monitoring routes in Black Canyon of the Gunnison NP and Curecanti NRA on July 23–August 9, 2010.

Species	Total infestations	Percent cover (mean)	Infestation size class Number of infestations				
			1	2	3	4	5
Tomichi Route							
Bull thistle	4	6.1	3	1	0	0	0
Burdock	5	12.0	3	2	0	0	0
Canada thistle	1	3.0	0	1	0	0	0
Field bindweed	1	15.5	0	0	1	0	0
Reed canarygrass	41	48.6	0	9	27	5	0
Woolly mullein	19	8.9	12	5	2	0	0
Total	71		18	18	30	5	0
Gunnison Route							
Bull thistle	1	3.0	1	0	0	0	0
Burdock	6	2.2	2	4	0	0	0
Butter-and-eggs	1	75.7	0	1	0	0	0
Canada thistle	2	9.3	1	1	0	0	0
Musk thistle	1	3.0	0	1	0	0	0
Reed canarygrass	1*	3.0	0	0	0	0	0
Woolly mullein	5	15.5	3	2	0	0	0
Total	17		7	9	0	0	0
Warner Route							
Dames rocket	15	4.0	12	3	0	0	0
Reed canarygrass	62	40.8	1	10	40	7	4
Saltcedar	2	15.5	1	1	0	0	0
Woolly mullein	14	19.3	8	6	0	0	0
Total	93		22	20	40	7	4
Long Draw							
Reed canarygrass	6	21.3	3	2	1	0	0
Woolly mullein	9	13.6	3	5	0	1	0
Total	15		6	7	1	1	0
Slide Draw							
Bull thistle	1	0.5	1	0	0	0	0
Canada thistle	6	8.4	4	0	2	0	0
Musk thistle	1	0.5	1	0	0	0	0
Reed canarygrass	3*	63.0	0	1	0	0	0
Woolly mullein	20	3.3	8	6	5	1	0
Total	31		14	7	7	1	0
Rim Trail							
Musk thistle	2	38.0	1	0	0	0	1
Total	2		1	0	0	0	1

Appendix B. Species observed and size of infestations detected along monitoring routes in Black Canyon of the Gunnison NP and Curecanti NRA on July 23–August 9, 2010, cont.

Species	Total infestations	Percent cover (mean)	Infestation size class Number of infestations 1	2	3	4	5
North River Route							
Bull thistle	6	57.2	0	1	0	1	4
Canada thistle	36	18.1	2	7	27	0	0
Reed canarygrass	66	37.2	0	5	59	2	0
Woolly mullein	23	16.0	2	4	16	1	0
Total	131		4	17	102	4	4
Devils Backbone							
Bull thistle	2	38.0	2	0	0	0	0
Canada thistle	8	6.1	0	4	4	0	0
Reed canarygrass	11	16.6	0	0	4	1	6
Woolly mullein	6	5.9	3	2	1	0	0
Total	27		5	6	9	1	6
East Portal Road							
Broad-leaf pepperwort	1	3.0	0	0	1	0	0
Bull thistle	2	3.0	0	2	0	0	0
Canada thistle	61	16.7	4	17	37	3	0
Field bindweed	36	24.9	0	14	21	1	0
Musk thistle	102	10.4	25	41	34	2	0
Reed canarygrass	1	15.5	0	0	1	0	0
Russian knapweed	5	41.5	0	4	0	1	0
Siberian elm	4	48.0	1	2	1	0	0
Woolly mullein	169	23.6	19	87	62	1	0
Total	381		49	167	157	8	0
SOB Draw							
Reed canarygrass	6	32.2	0	5	0	1	0
Woolly mullein	11	10.3	2	6	2	1	0
Total	17		2	11	2	2	0
North Rim Road and Campground							
Bull thistle	1	15.5	1	0	0	0	0
Canada thistle	1	38.0	0	1	0	0	0
Field bindweed	15	38.5	0	6	9	0	0
Musk thistle	14	23.5	7	5	2	0	0
Russian knapweed	1	38.0	0	0	1	0	0
Total	32		8	12	12	0	0
South Rim Road							
Canada thistle	3	7.2	1	2	0	0	0
Field bindweed	9	3.0	0	9	0	0	0
Musk thistle	4	3.0	0	4	0	0	0
Woolly mullein	3	3.0	0	3	0	0	0
Total	19		1	18	0	0	0

Appendix B. Species observed and size of infestations detected along monitoring routes in Black Canyon of the Gunnison NP and Curecanti NRA on July 23–August 9, 2010, cont.

Species	Total infestations	Percent cover (mean)	Infestation size class Number of infestations 1	2	3	4	5
Red Rock Canyon							
Bull thistle	1		1	0	0	0	0
Burdock	42		21	9	10	1	1
Canada thistle	11		4	5	1	1	0
Field bindweed	23		0	4	8	9	2
Musk thistle	61		24	15	15	5	2
Reed canarygrass	114		0	5	15	68	26
Russian knapweed	2		0	0	1	1	0
Russian thistle	7		1	1	1	4	0
Summer cypress	14		0	0	1	2	11
Woolly mullein	23		8	8	6	1	0
Total	298		59	47	58	92	42
Mesa Creek Trail							
Canada thistle	1	3.0	1	0	0	0	0
Diffuse knapweed	1	15.5	0	0	1	0	0
Musk thistle	2	3.0	1	1	0	0	0
Oriental clematis	2	15.5	0	1	1	0	0
Spotted knapweed	1	15.5	1	0	0	0	0
Woolly mullein	2	3.0	1	0	1	0	0
Total	9		4	2	3	0	0
Hermit's Rest Trail							
Canada thistle	1	15.5	0	0	1	0	0
Musk thistle	2	1.75	0	0	2	0	0
Total	3		0	0	3	0	0
Curecanti Creek Trail							
Canada thistle	4	18.00	0	1	2	1	0
Musk thistle	2	9.25	1	1	0	0	0
Woolly mullein	1	3.00	0	0	1	0	0
Total	7		1	2	3	1	0
Pine Creek							
Bull thistle	2	9.25	2	0	0	0	0
Burdock	2	9.25	0	0	1	1	0
Canada thistle	7	6.57	2	2	2	1	0
Houndstongue	1	15.5	0	0	1	0	0
Total	12		4	2	4	2	0
Sapinero Basin							
Bull thistle	11	19.59	3	6	2	0	0
Canada thistle	31	11.47	1	11	19	0	0
Musk thistle	20	21.38	2	7	11	0	0
Woolly mullein	7	22.29	0	5	2	0	0
Total	69		6	29	34	0	0

Appendix B. Species observed and size of infestations detected along monitoring routes in Black Canyon of the Gunnison NP and Curecanti NRA on July 23–August 9, 2010, cont.

Species	Total infestations	Percent cover (mean)	Infestation size class Number of infestations 1	2	3	4	5
Soap Creek							
Bull thistle	2	45.5	1	1	0	0	0
Canada thistle	13	24.15	0	5	6	1	1
Musk thistle	18	21.61	3	6	8	1	0
Oxeye daisy	11	22.77	0	4	3	4	0
Scentless chamomile	1	0.5	0	0	1	0	0
Woolly mullein	7	28.02	3	1	2	1	0
Total	52		7	17	20	7	1
Dillon Pinnacles							
Canada thistle	4	15.5	0	2	2	0	0
Field bindweed	2	26.8	0	0	2	0	0
Musk thistle	3	15.5	2	1	0	0	0
Summer cypress	1	15.5	0	0	0	1	0
Woolly mullein	3	23.0	1	1	1	0	0
Total	13		3	4	5	1	0
Blue Mesa Reservoir Shoreline–Lake Fork Arm							
Musk thistle	2	56.8	2	0	0	0	0
Reed canarygrass	11	30.0	0	0	7	2	2
Woolly mullein	93	12.0	9	6	17	4	57
Total	106		11	6	24	6	59
Blue Mesa Reservoir Shoreline–Cebolla Arm							
Musk thistle	2	19.3	1	0	1	0	0
Reed canarygrass	1	38.0	0	0	0	1	0
Woolly mullein	10	4.5	0	3	1	6	0
Total	13		1	3	2	7	0
Blue Mesa Reservoir Iola Boating Area							
Canada thistle	18	28.8	1	5	9	3	0
Musk thistle	5	17.0	1	0	3	0	1
Russian thistle	25	16.6	3	1	5	10	6
Scentless chamomile	3	38.8	1	2	0	0	0
Summer cypress	8	6.8	0	0	2	4	2
Total	59		6	8	19	17	9
Blue Mesa Reservoir Shoreline							
Burdock	1	38.0	0	1	0	0	0
Bull thistle	8	37.0	6	0	1	1	0
Canada thistle	67	2.4	4	7	10	20	26
Field bindweed	4	23.6	0	0	1	1	2
Musk thistle	19	17.9	5	3	2	5	4
Russian knapweed	3	23.0	0	0	0	1	2
Russian thistle	31	7.7	3	1	7	11	9
Scentless chamomile	19	23.8	12	0	2	2	3
Saltcedar	1	38	1	0	0	0	0
Summer cypress	6	8.8	0	2	2	1	1
Woolly mullein	49	3.3	3	0	4	11	31
Total	208		34	14	29	53	78

Appendix B. Species observed and size of infestations detected along monitoring routes in Black Canyon of the Gunnison NP and Curecanti NRA on July 23–August 9, 2010, cont.

Species	Total infestations	Percent cover (mean)	Infestation size class Number of infestations 1	2	3	4	5
Coopers Ranch							
Broad-leaf pepperwort	1	75.5	0	1	0	0	0
Butter-and-eggs	54	24.7	2	9	17	8	18
Canada thistle	101	20.5	0	0	32	17	52
Reed canarygrass	36	31.9	0	4	24	4	4
Russian thistle	1	75.5	1	0	0	0	0
Scentless chamomile	8	13.3	0	2	5	1	0
Total	201		3	16	78	30	74
Elk Creek Campground							
Canada thistle	6	34.7	0	2	2	2	0
Field bindweed	7	27.3	0	3	4	0	0
Musk thistle	1	75.5	1	0	0	0	0
Russian knapweed	1	0.5	0	0	0	1	0
Russian thistle	87	5.0	2	3	44	23	15
Scentless chamomile	8	32.7	1	1	4	2	0
Summer cypress	113	17.4	1	0	43	52	17
Woolly mullein	2	45.5	1	0	1	0	0
Total	225		6	9	98	80	32
Neversink Trail							
Canada thistle	4	15.5	0	2	2	0	0
Scentless chamomile	1	15.5	0	0	1	0	0
Total	5		0	2	3	0	0

*Polygons mapped in addition to points for these species.

Infestation size classes: 1 = 1–few plants (used for single plants or very small patches ($\leq$ 2 x 2 m); 2 = few plants–40 m^2 (0.01 acre); 3 = 40–400 m^2 (0.01–0.1 acre); 4 = 400–1,000 m^2 (0.1–0.25 acre); 5 = 1,000–2,000 m^2 (0.25–0.5 acre).

Appendix C. Non-native plant species found in monitoring quadrats by transect, Black Canyon of the Gunnison NP and Curecanti NRA, July 23–August 9, 2010.

Transect	Species	Percent cover (mean)			
		Q1 @ 0.5m	Q2 @ 5m	Q3 @ 10m	Overall
Gunnison Route					
KE1	reed canarygrass	50	0	0	16.67
KE2	reed canarygrass	10	0	0	3.33
KE3	reed canarygrass	2	0	0	0.67
Red Rock Canyon					
C2072810#2	reed canarygrass	100	5	0	35
C3072810#3	Russian knapweed	20	0	0	6.67
F1072810RedRock	reed canarygrass	10	0	0	3.33
S2072810RedRock	reed canarygrass	40	0	0	13.33
S3072810RedRock	reed canarygrass	0	70	100	56.67
SOB Draw					
S1072910SOB	reed canarygrass	0	0	75	25
Slide Draw					
BLCA0809201001	cheatgrass	0	0	1	0.33
	woolly mullein	0	0	1	0.33
Tomichi Route					
19CF07232010	Canada thistle	0	0	1	0.33
	reed canarygrass	20	20	7	15.67
	woolly mullein	0	0	2	0.67
22CF07232010	reed canarygrass	0	40	5	15
6CF07232010	reed canarygrass	4	10	5	6.33
C072310#1	reed canarygrass	20	10	0	10
Warner Route					
C072610#1	reed canarygrass	30	0	0	10
C072610#2	reed canarygrass	10	6	0	5.33
Devil's Backbone					
S1073010DevilsRidge	reed canarygrass	0	0	50	16.67
	yellow sweetclover	0	1	0	0.33
Blue Mesa Reservoir–Lake Fork Arm					
F18 LakeFork08062010	woolly mullein	0	0	5	1.67
F20LakeFork08062010	woolly mullein	2	0	0	0.67
S10080610Shoreline	woolly mullein	0	50	0	16.67
Iola Boating–Blue Mesa					
F12RES08052010	Canada thistle	5	10	10	8.33
F13RES08052010	Canada thistle	0	0	5	1.67
Pine Creek Trail					
F5PINE0802010	yellow sweetclover	10	0	0	3.33

Appendix C. Non-native plant species found in monitoring quadrats by transect, Black Canyon of the Gunnison NP and Curecanti NRA, July 23–August 9, 2010, cont.

Transect	Species	Percent cover (mean)			
		Q1 @ 0.5m	Q2 @ 5m	Q3 @ 10m	Overall
Sapinero Basin/Soap Arm					
F11RES08032010	Canada thistle	2	0	0	0.67
	yellow sweetclover	0	5	60	21.67
F1RES08032010	yellow sweetclover	0	5	0	1.67
F3RES08032010	Canada thistle	0	20	0	6.67
F4RES08032010	Canada thistle	0	5	0	1.67
	yellow sweetclover	0	20	0	6.67
F5RES08032010	Canada thistle	5	0	0	1.67
F6RES08032010	yellow sweetclover	0	30	0	10
F7RES08032010	yellow sweetclover	10	20	5	11.67
F8RES08032010	woolly mullein	0	5	30	11.67
Blue Mesa Reservoir shoreline					
S1080310Shoreline	yellow sweetclover	0	50	10	20
S11080310Shoreline	field bindweed	60	0	0	20
	yellow sweetclover	0	60	0	20
S14080310Shoreline	yellow sweetclover	0	10	2	4
S15080310Shoreline	yellow sweetclover	10	100	0	36.67
S16080310Shoreline	yellow sweetclover	0	10	2	4
S17080310Shoreline	yellow sweetclover	0	10	0	3.33
S18080310Shoreline	yellow sweetclover	0	2	2	1.33
S2080310Shoreline	Canada thistle	0	10	0	3.33
	woolly mullein	0	0	2	0.67
S4080310Shoreline	woolly mullein	0	2	0	0.67
S8080310Shoreline	Canada thistle	0	0	15	5
	woolly mullein	0	0	2	0.67
	yellow sweetclover	0	100	25	41.67
S9080310Shoreline	Canada thistle	20	0	0	6.67
S6080410Shoreline	Russian thistle	10	0	0	3.33
	summer cypress	40	0	0	13.33
	woolly mullein	2	0	0	0.67
S8080410Shoreline	scentless chamomile	5	0	0	1.67
S1080410Shoreline	woolly mullein	0	0	10	3.33
	yellow sweetclover	0	10	5	5
S2080410Shoreline	yellow sweetclover	0	0	60	20
S4080510Shoreline	yellow sweetclover	0	20	80	33.33
S5080510Shoreline	yellow sweetclover	0	60	2	20.67
S7080510Shoreline	summer cypress	0	10	0	3.33
Soap Creek					
F1RES08052010	woolly mullein	0	3	0	1

Only transects containing non-native species are shown.

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