INVENTORY OF
INVASIVE NON-NATIVE TARGET PLANTS
IN PORTIONS OF ARCHES NATIONAL PARK

FIELDWORK COMPLETED
AUGUST 8 – OCTOBER 12, 2006

Upper edge of Colorado River riparian zone along boundary of Arches National Park, across river from mouth of Jackass Canyon.

Text and field mapping by Mary Moran
Biological Technician, National Park Service, Southeast Utah Group

Maps produced by Aneth Wight
GIS Specialist, I&M Northern Colorado Plateau Network

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Inventory of Invasive Non-native Target Plants in Portions of Arches National Park: Fieldwork Completed August 8 – October 12, 2006

Mary Moran and Aneth Wight, April 2007

Executive Summary

This report describes mapping of target non-native invasive plants in Arches National Park by Mary Moran and SCA Julia Sonn in 2006. This work was supplemental to the extensive 2003-2004 field mapping of Steven Dewey, Kimberly Andersen and crew of Utah State University. A 2005 report, complete with extensive maps, describes their work. Both mapping efforts were funded by the National Park Service Northern Colorado Plateau Inventory and Monitoring Network.

Moran attended a one-week training by Steven Dewey and Kim Andersen. The training focused primarily on methods of efficiently describing a variety of sizes and shapes of weed patches of numerous species, using a Garmin GPS unit and accessory gear. Methods and variations unique to Moran's 2006 field mapping are described here. Areas were chosen within the park that were not surveyed in the 2003-2004 effort, yet are likely locations to find weeds. Riparian areas and drainages mapped in this effort include Freshwater Canyon and its largest tributary, which both drain into Salt Wash, two small washes draining from the La Sal Mountain Overlook parking area to Courthouse Wash, three larger sidecanyons of Courthouse Wash, and most of the Colorado River riparian zone bounding Arches National Park. In addition, all of the shoulders of the paved roads in the park were carefully mapped, as were all pullouts and parking areas, several short trails, and most of the valley containing the residences and Visitor Center.

Results are presented by area or zone in both text and map form. The text includes distribution notes for primary target species, methods particular to certain locations, information on plants eradicated during the mapping effort, lists and notes on some of the non-target non-native plants seen but not mapped, detection confidence levels and swath widths. Maps show both the weeds mapped and the scope of the areas examined during mapping. Weeds were pulled, dug or cut when individuals were scarce enough that the removal effort did not substantially slow the mapping effort, and these weeds are indicated with a slash through them on the maps.

A first-year goathead (aka puncturevine: *Tribulus terrestris*) eradication effort was implemented. Approximately 35 to 50 percent of the goathead individuals were removed from the Visitor Center- Entrance area, and all found individuals were removed from the first few miles of the park road into the park. Dominant target weed species along the river corridor were tamarisk (aka, saltcedar: *Tamarix chinensis*), Russian olive (*Elaeagnus angustifolia*), and Russian knapweed (*Centaurea repens*). Goatheads and Russian thistle (*Salibe tragus*) were most dense in the Visitor Center-Entrance Area, while dominants in other areas were not as obvious or as prevalent. Several species not previously documented in the park were mapped, including perennial pepperweed (*Lepidium latifolium*), burdock (*Arctium minus*), and woolly mullein (*Verbascum*

thapsus) along the Colorado River, one individual of yellow bluestem (*Bothriochloa ischaemum*) along the park road, dried up ripgut brome (*Bromus diandrus*) in a sidecanyon of Courthouse Wash, and a few species that have sprouted in the new Arches Visitor Center landscaped area.

Recommendations presented for prioritizing invasive non-native plant control include a shift in thinking for controlling tamarisk as tamarisk beetles (*Diorhabda elongata*) introduced on nearby private lands spread into the parks, preventing new invasives or stopping them before they spread or enter park boundaries, inventorying and removing weeds along the roadsides and parking areas annually or at least biannually, finalizing a new vegetation management plan, utilizing and integrating all weed mapping and weed treatment records, and completing the mapping of target invasives along the Colorado River during the summer, when they area easiest to detect.

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INTRODUCTION

This report describes mapping of target non-native invasive plants in Arches National Park in late summer and fall of 2006. This work was supplemental to the extensive 2003-2004 field mapping of Steven Dewey, Kimberly Andersen and crew of Utah State University. A 2005 report, complete with extensive maps, describes their work (Dewey and Andersen, 2005). Both mapping efforts were under the direction of the National Park Service Northern Colorado Plateau Inventory and Monitoring Network.

METHODS

In June 2006, I attended an I&M-sponsored one-week training for Inventory and Mapping of Invasive Wildland Weeds, taught by Utah State University's Steven Dewey with assistance from Kim Andersen. I followed their methods while mapping in Arches National Park. These methods are well-documented in their report for Arches and in their training manual (Dewey and Anderson, 2006), so I will not repeat the details in this report. I used the 2006 version of the I&M Invasives data dictionary, installed in a Garmin GeoExplorer 3 GPS unit. I collected plants when I was uncertain of their identification and nativity, and usually identified them within a day or two in the office. I entered notes in a field notebook for each day of mapping, and downloaded data every day or two after returning from the field. I reviewed the downloaded data within a few days, cleaning up data, and making corrections and clarifications as needed. I probably was not quite as diligent in setting swath widths while mapping as suggested in the training; I sometimes did not re-set them for days. Swath widths give an indication of the maximum transect width that could be examined with at least 90 percent detection of a .01 acre patch of target weeds, in a particular setting and with particular invasives in mind. I include notes on my estimated swath widths in the results section.

Determining which non-natives are target weeds is a difficult proposition. For the most part, I followed the list generated for Arches by the Utah State crew, with a few exceptions. Generally I did not map halogeten (*Halogeten glomeratus*), because from my observations in the park and in Canyonlands National Park during the wet spring of 2005 halogeten seeds are widespread and eradicating the species is unlikely to become a management priority. However, I did map halogeten in a couple areas where I saw very little of it. I often did not map cheatgrass (*Bromus tectorum*) or Russian thistle (*Salibe tragus*), because they were so plentiful that they would have taken too much of the mapping effort, and because their eradication is low on the priority list for invasives management. Further, there are currently initial efforts underway to map cheatgrass using satellite imagery. I did map and eradicate Russian thistle on the shoulders of the Arches paved spur road to the Windows area, however, because it was relatively uncommon there, and pulling every plant was feasible.

In choosing areas to map during this limited project, I focused on areas not mapped in the initial rather extensive mapping effort by Utah State University in the 2003 and 2004 field seasons (Dewey and Anderson, 2005). With that in mind, I looked at perennial and intermittent drainages, as well as roads and trails, all of which together are the most likely

places for non-native invasives to be introduced. The only truly perennial stream in Arches is the Colorado River, which forms the southeastern boundary of the park. While difficult logistically, I did map more than half of its right bank along the Arches boundary. Most intermittent and semi-perennial streams in the park were mapped in the 2003-2004 effort, but I mapped two small washes draining from the La Sal Mountain Overlook parking area to Courthouse Wash, three larger sidecanyons of Courthouse Wash, and Freshwater Canyon and its largest tributary, which both drain into Salt Wash. The Utah State crews mapped just a few invasives on the Arches road shoulders in 2003 and 2004 as they happened to notice them while focusing on other areas. I mapped all of the road shoulders, pullouts and parking areas along the paved roads within Arches. I also mapped several short popular trails, including those at Balanced Rock, Park Avenue, Delicate Arch Viewpoint, all of those from the main Windows parking area (including the primitive loop), and the trail to Landscape Arch (including the side trails to Pine Tree and Tunnel Arches). In the headquarters area of Arches, I mapped all of the road shoulders; including visitor center, office, and maintenance yard service roads, and residence area roads and driveways, as well as the main entrance road from the highway. I also mapped the areas and yards surrounding the residences and maintenance yard, including the Bloody Mary Wash area for 100 meters downstream of the maintenance yard. In the landscaped area around the new Visitor Center, I made a list of non-native exotic plants, and mapped a few target species.

For the most part, we pulled non-natives when we found just one or a few plants, but didn't eradicate them when it would have significantly interrupted my mapping. I mapped any plants pulled, but indicated that they were pulled in the notes section of the mapping entry, so that the location could be checked for resprouts or new seedlings later. In addition, we initiated a first-year effort toward eventual eradication of puncturevine (aka, goatheads: *Tribulus terrestris*) along the park road shoulders and in the entrance area of Arches.

Because the river surveys require different logistical methods than any of the areas in Arches surveyed by the Utah State crew, I describe the method I used here. I surveyed the generally broad river floodplain in the mile stretch above the Moab boat ramp on foot, with methods similar to other Arches areas except that the vegetation was so thick that the swath width and detection confidence level were both lower than in other areas. On the upstream stretches of river surveyed, Julia Sonn and I used inflatable kayaks to access the river riparian zone. We examined the riverbank, which was predominantly densely vegetated and steep, from the kayaks, and landed at accessible spots to climb up the bank and survey from the top side of the dense riparian vegetation strip, making frequent forays into the dense areas. Usually I would walk in one direction while Julia walked in the other; she would alert me to patches that needed to be mapped, using a radio for communication. At each river landing we would take note of where our downstream exploration ended and from our next landing we would walk to that point going upstream, so that no area was missed. We ran out of time for the intensive searches from the top of the riparian zone on two days. We still searched for target weeds from the river in these stretches, with one of us searching the riverbank and the other floating farther out in the river and visually searching farther up in the riparian zone, particularly looking for

mature Russian olive trees. These stretches, with a less complete survey, are noted on the map.

I was assisted in the field most days by Student Conservation Association intern Julia Sonn. I trained her in the field, and though she did not have a separate GPS unit, she gained an observant eye for weeds. She sometimes explored different areas near me and directed me to weeds found, and was particularly helpful while driving slowly down the Arches roads, as each of us examined one shoulder of the road. She cheerfully put more time into the goathead eradication effort than any other individual, and endured the muddiest takeout from the river that I've ever experienced.

Aneth Wight and Gery Wakefield gave essential and helpful assistance in the office with maps and GIS technology. Aneth created all the maps accompanying the report.

Joe Castello and Dwayne Coleman, experienced NPS seasonal weed technicians, spent one day with us on the goathead eradication effort, and the senior high school class from the Pioneer School in Fort Collins, Colorado, volunteered a few hours toward the effort.

RESULTS

Most of the results of this mapping project are contained within the maps and accompanying data dictionary entry, including notes, for each map point. However, I present additional information below, primarily from my field notes, divided into the four types of areas, or zones, mapped within Arches. The zonal information includes distribution notes for primary target species, methods particular to certain locations, information on plants eradicated during the mapping effort, lists and notes on some of the non-target non-native plants seen but not mapped, detection confidence levels and swath widths. The confidence level is based on my estimation of the detected percentage of 0.01 acre patches of the least visible primary target plant. Swath width is my estimated transect width in which at least 90 percent of this same size patch can be detected in a particular terrain.

Notes on the first-year goathead eradication effort are included in both the Roads and Park Entrance sections. Early 2007 treatment of Russian olive and tamarisk by the Lake Mead Weed Team is noted in the section called Three Tributaries from the North into Lower Courthouse Wash.

Drainages within Arches National Park

The detection confidence is high for all of the following areas, meaning that I am confident that we found more than 90 percent of patches at least .01 acre in size of all the target species, including the least visible expected target species.

Freshwater Canyon and associated tributary

Both of these tributaries had water, sometimes flowing and commonly in pools, when we surveyed them on August 24, 2006. The abundance of riparian vegetation here indicates

that surface water or shallow groundwater is perennial in much of these two canyons. We observed red-spotted toads in both canyons and bullfrogs in one large, perennial pool below the confluence of these two canyons, just above the confluence with Salt Wash.

Tamarisk (aka, saltcedar: *Tamarix chinensis*) was the most common target invasive species in these canyons, though the lower parts of both canyons were tamarisk-free. There was scattered evidence of dead treated individuals in the lower 1.6 km of Freshwater Canyon above its confluence with the tributary, and we found and cut down one sapling in this stretch. But mature tamarisk were scattered through the upper half of each canyon. A clump of large, mature Siberian elm (*Ulmus pumila*) trees were present in the lower part of the tributary canyon.

Non-native species seen but not mapped include cheatgrass (*Bromus tectorum*), which was scattered on the canyon slopes and dense in some places in the canyon bottom, and sowthistle (Sonchus sp.), which was scattered but most plentiful near the head of each canyon. The EDSW (Effective Detection Swath Width) was set at 250 yards in the GPS unit, but was probably usually more than 300 yards, as visibility was good and the canyon walls were generally visible.

Cocklebur (*Xanthium strumarium*), a species considered native but spread from the Eastern U.S., and generally considered undesirable, was very common in Freshwater Canyon. Not realizing its nativity at that time, we pulled most of the individuals in Freshwater Canyon, taking out most of the immature seedheads, but did not pull them in the tributary canyon.

La Sal Mountain Overlook Tributaries of Courthouse Wash

Surveyed on August 23, 2006, as I trained Julia Sonn to assist in mapping, the only target invasive we detected in these dry broad and rocky tributary washes was one goathead (aka puncturevine: *Tribulus terrestris*) found on the edge of the La Sal Mountain Overlook parking area. We pulled and removed it. The non-native non-target species we observed include Russian thistle (*Salibe tragus*) scattered through the area, and a few tumble pigweed (*Amaranthus albus*) around the parking area, as well as one Amaranth individual in the eastern drainage. This area is broad and open, and the detection confidence level was high.

Three Tributaries from the North into Lower Courthouse Wash

There are four main tributary canyons into Courthouse Wash downstream of the main park road. One of these, the second downstream from the road, was mapped by the Utah State crew in 2003. We mapped the other three canyons, on August 28 and September 5, 2006. These canyons have abundant riparian vegetation and had some surface water pools during our visit. We saw red-spotted toads in the third and fourth sidecanyons down from the park road. The canyons are relatively narrow, and the detection confidence level was high.

We found no tamarisk or Russian olive (*Elaeagnus angustifolia*) in the first sidecanyon down from the park road, except for one Russian olive sapling, which I pulled. We saw

evidence of three treated tamarisk, which I did not map because they were completely dead with no resprouts. The other two sidecanyons had numerous Russian olives and tamarisk, especially concentrated in the middle section of the third sidecanyon and the lower section of the fourth sidecanyon. These were treated by the Lake Mead Weed Team in early 2007. I found and mapped a few western salsify (*Tragopogon dubius*) and sowthistle (*Sonchus sp*.) in the three canyons.

I also mapped an area in the first sidecanyon with dried plants that were the first documented ripgut brome (*Bromus diandrus*) in Arches National Park. The identification was confirmed by Walt Fertig. This is a very invasive plant.

The non-native non-target species we observed but did not map include cheatgrass, Russian thistle and white and yellow sweetclover (*Melilotus alba* and *M. officinalis*). All were scattered throughout the canyons; the cheatgrass was thick on some benches above the canyon bottoms, and Russian thistle was thick in patches.

Colorado River Riparian Zone along the Park Boundary

The Colorado River bounds Arches National Park for approximately eleven river miles along the park's southeast border, from its confluence with Salt Wash to highway 191 at the Moab bridge. I mapped 7.5 miles of the riparian zone along this boundary (only on the right bank of the river), from Big Bend to the Moab boat ramp just upstream of the bridge. Two sections within this, totaling approximately 1.7 river miles, were incompletely mapped, as described in the methods section. I mapped the 1.1 mile stretch upstream of the boat ramp by walking from the boat ramp, on August 8 and 10, 2006. I mapped the remainder of this stretch, with Julia Sonn, using inflatable kayaks, on Sept. 19, Sept. 27, and Oct.12, 2006.

The detection confidence level along the river was lower than in other areas, probably between 80 and 90 percent detection (for patches at least .01 acre in size). There are two reasons for the lower detection level. First, the riparian zone is wide in places, and can be thick to the point of being impenetrable. Second, the mapping was done too late in the season for easiest detection of both Russian knapweed (*Centaurea repens*) and perennial pepperweed (*Lepidium latifolium*), the two primary smaller target weeds found here. Both were mostly beyond blooming and much less visible than they would have been a month earlier in the season. The EDSW (Effective Detection Swath Width) was generally quite low as would be expected in the thick riparian zones along the Colorado River, but it varied tremendously. I did not change this feature on the GPS unit to reflect this variation, but we did penetrate into thickly vegetated parts of the riparian zone as much as was reasonable with our time constraints.

Tamarisk is common along this stretch of the river. I mapped this species as patches in the lower section above the boat ramp. A large part of this area was leased to Grand County decades ago, and there was visual evidence of the county's tamarisk treatment, using a brush-hog to churn up the mature trees, followed up by painting stumps with herbicide. In addition, many of the remaining mature trees were yellowish-brown. Upon

inspection, I found numerous *Diorhaba elongata* beetles. These beetles have been introduced on several private parcels of land in Grand County over the last couple years, with the intention of killing tamarisk or at least reducing its growth. I assume that the beetles I found came from private property on the riverbank just downstream of highway 191, owned by Canyonlands by Night, where beetles were released in 2005.

Along the river upstream, in the area mapped from kayaks, I chose to map the tamarisk as a series of line segments. Along much of this stretch of river the riparian zone is dominated by native species, primarily coyote willow (aka sandbar willow: *Salix exigua*), but mature tamarisk are scattered as individuals and thick clumps throughout, and we found tamarisk saplings and/or seedlings even in the short stretches with no mature trees. My method was to observe the width of the riparian zone and relative abundance of tamarisk throughout the day as I was mapping, taking field notes or marking a map when these factors changed. After downloading the day's data in the office, I added the tamarisk line segments, estimating various widths as well as percent cover.

Russian olives (*Elaeagnus angustifolia*) are relatively rare on this stretch of the river on the Arches side. They are more common on the other riverbank. On the Arches side, there is one large tree on the riverbank 100 meters upstream of the Moab boat ramp, and several trees in a short stretch approximately 1200 to 1500 meters upstream of the ramp. But we saw no Russian olives between this group and the Big Bend area, over six miles upstream.

We found Russian knapweed (*Centaurea repens*) scattered along the entire right bank of river that I mapped, from Big Bend to the Moab boat ramp. It was more abundant from Big Bend to Negro Bill Canyon than it was farther downstream. Most of the patches were located along the uphill edge of the riparian zone; less commonly, we found them in the middle thickest part of the zone. We never found them at river's edge. We probably missed a few patches in the two incompletely mapped river stretches. Because the plant was mostly beyond blooming when we were there, we may have missed a few patches even in the area mapped. July or August would be the ideal time to map this species. Most of the patches mapped fell into the 0.01 acre size category, though several fell into the 0.1 acre size class. Cover densities varied, but were generally around 50 percent.

I found a few patches of perennial pepperweed (*Lepidium latifolium*) in two stretches along the right riverbank, from Big Bend to Drinks Canyon, and in the kilometer above the Moab boat ramp. For both of the reasons noted for Russian knapweed, we may have missed a few patches. Additionally, perennial pepperweed can be difficult to distinguish from the *Lepidium allyssoides – Lepidium moabense* complex, which was abundant along the riverbank.

Several Siberian elms (*Ulmus pumila*) and mulberries (*Morus sp*.) are scattered in the 1.25 kilometers above the Moab boat ramp. We found and pulled an additional mulberry sapling 0.6 km below the mouth of Negro Bill Canyon. We found and pulled one lone puncturevine (*Tribulus terrestris*) plant adjacent to the Moab boat ramp. A lone patch of burdock (*Arctium minus*), consisting of approximately twenty plants, is located 1.2 km

below the mouth of Negro Bill Canyon. I pulled a lone large basal rosette of woolly mullein (*Verbascum thapsus*), found across the river from Big Bend.

A lone, large catalpa tree (*Catalpa bignonioides*) is located on the right bank 1.6 kilometers below the mouth of Negro Bill Canyon. This inaccessible tree is on the upper edge of a thick riparian zone. Because the tree showed no signs of regeneration, I suggest leaving it in place.

I mapped one to a few patches of several other non-native species along the right riverbank, including lambsquarter (*Chenopodium album*), yellow salsify (*Tragopogon dubius*), tumble pigweed (*Amaranthus albus*), common plantain (*Plantago major*), curly dock (*Rumex crispus*). These are not target species; I mapped them in a few places, but not in other places.

Non-native species that I saw but did not map along the right riverbank include Russian thistle (*Salsola tragus*, thickest near the boat ramp in the area where tamarisk have been treated by the county), cheatgrass (*Bromus tectorum*, scattered throughout area and thick in places), stork's-bill (*Erodium cicutarium*, fairly abundant autumn seedlings), field bindweed (*Convolvulus arvensis*, mostly in 1 km upstream of boat ramp), sow-thistle (*Sonchus sp*.), and sweet-clover (*Melilotus sp*.).

Road Shoulders, Parking Areas, Pullouts and Short Trails from the Paved Arches Roads (excluding Entrance Area)

We mapped all of the road shoulders, pullouts and parking areas along paved roads in Arches National Park, as well as a number of short trails and the maintenance boneyard near Balanced Rock. Generally Julia and I mapped the road shoulders starting near dawn, when traffic was lowest. We mapped trails later in the day. Dates of this road and trail mapping were September 6, 14, 21 and 26, and October 2.

The detection confidence is high (greater than 90 percent) for all of the following areas. The Effective Detection Swath Width along the road shoulders was usually more limited by the speed of our driving than by a lack of view, but I adjusted our slow driving speed so that Julia and I could always examine the road shoulders and at least a short distance beyond them into the older native vegetation. The EDSW was generally at least 200 feet along the short trails we mapped.

The dominant target species found and mapped in this zone was goathead (aka puncturevine: *Tribulus terrestris*). It was very common on the road shoulders and edges of parking lots and pullouts from the switchbacks near the park entrance to the Courthouse Towers area, becoming scattered more widely from Courthouse Towers to the Petrified Dunes Interpretive pullout. We also found single or just a few plants in the Balanced Rock area, including around the parking lot, along the Balanced Rock trail, on the dirt piles in the nearby maintenance yard, and on the paved road shoulder 1.4 km southwest of Balanced Rock. We found one plant on the edge of the Wolfe Ranch parking area.

Julia Sonn with a large goathead pulled from the road shoulder. Photo by Mary Moran.

We pulled all, or at least 95 percent, of the goatheads mapped in this zone. This effort included pulling isolated individuals as we mapped, a full-day effort of four of us in the densest area around the Moab Fault Overlook to the Park Avenue parking area, and several few-hour efforts by Julia Sonn to finish up. Our method was to pull and collect the plants, depositing them into buckets and then trash cans to be removed from the park. Though relatively late in the season, most of the seedheads were still clinging to the plants, with few falling off. Starting around October 11 the seedheads began falling off more frequently, but we attempted to collect most of them.

I mapped and cut down a lone Siberian elm sapling on the Windows road shoulder. We mapped and dug up a small field bindweed plant (*Convolvulus arvensis*) on the edge of the parking lot at the Devil's Garden trailhead. I found and pulled one individual of a non-native grass never before documented in Arches National Park, *Bothriochloa ischaemum*, along the road shoulder between Courthouse Towers and Courthouse Wash.

We mapped and pulled Russian thistle along the spur road to the Windows, as we did not find many in this area, just a few each along the road shoulder, the trail edges and the edges of the Windows parking lot. I saw but did not map Russian thistle in other areas within this zone, because it was common and is not the highest priority for weed eradication. I noted some dense stands along the roads closer to the park entrance, and in some parts of the large parking lot island at the Devil's Garden trailhead.

Other non-native species noted but not mapped include cheatgrass (*Bromus tectorum*, common) and stork's-bill (*Erodium cicutarium*, relatively rare, in September anyway).

Park Entrance Area

On October 4 and 10, I mapped target weeds in the Arches National Park entrance area, including 100-200 foot-wide swaths centered on the main entrance road, the service road that parallels the entrance road, and connecting short roads. I mapped narrower swaths centered on driveways and parking lots for the Visitor Center, rock house, I&M office building, all residences, and maintenance compound. I walked the front and back yards of all residences, the maintenance compound interior and exterior, and the entire new Visitor Center landscaped area, as well as a roughly 125 meter swath from the maintenance compound southeast and downstream to Bloody Mary Wash.

The detection confidence level was high (greater than 90 percent) for the areas covered. The EDSW (Effective Detection Swath Width) was usually at least 200 feet, and sometimes more, as the area is fairly open and vegetation is generally not very tall.

The most abundant target invasive was goathead (aka puncturevine: *Tribulus terrestris*). It was found in abundance throughout this zone. Roughly one-third to one-half of the individuals mapped were pulled and removed from the park during and following the mapping, through the combined efforts of me, Julia Sonn, and the high school seniors and their teachers from the Pioneer School of Fort Collins. Several Arches staff members had begun the effort by pulling goatheads for the last several years.

Though I chose not to map halogeten (*Halogeten glomeratus*) in most of the park, I did map and pull it in this zone because I saw only one individual.

Most of the nonnative species mapped in the entrance area zone were associated with either residential plantings or with the landscaping project at the new Arches Visitor Center.

Mature Siberian elm trees (*Ulmus pumila*) are in many residential yards and both older office building yards, including approximately thirty trees around the rock house. There are also several Siberian elm saplings, especially around residence #4. There is a mulberry tree (*Morus sp*.) in the yard of the apartment building. I mapped purslane (*Portulaca oleracea*) around the rock house, and across the service road from it, but then saw more of it in the zone that I did not map. The I&M office building has plantain (*Plantago major*) in its front lawn and field bindweed (*Convolvulus arvensis*) growing in two places at the base of its walls.

The landscaping project around the new Arches Visitor Center, still a work in progress, has introduced numerous non-native species, some of which are invasive target species. Some of the non-native species have never before been documented in the park. A few of the species were actually mistaken plantings substituted by the landscaper for requested species; most of these individuals have been removed. But most of the non-native species in the landscaped area are associated with soils that were brought in that contained numerous and diverse, primarily riparian, seeds. Many of these, both native and non-native, are thriving after being on drip irrigation since July of 2005, despite heroic weed-pulling efforts by Arches staff members, primarily those from the Interpretive Division,

with help from some volunteer groups. The drip irrigation was intended for establishment of planted xeric native species; the intention is that at some future date the irrigation will be turned off. Rather than map all of the individuals in the landscaped area, I mapped and pulled a few key species, and made a species list of all the non-natives in the landscaped area as of October 4, 2006. Julia Sonn and I mapped and pulled the few goatheads and tamarisk not yet pulled by the staff. We removed the seedhead-laden goatheads to a park dumpster. I mapped and pulled at least some of the *Setaria glauca* and *Chloris virgata*.

The following is a list of non-native species observed in the Visitor Center landscaped area, compiled from visits on November 10, 2005, May 3, 2006, and October 4, 2006:
Tamarisk (*Tamarix chinensis*)
Russian olive (*Elaeagnus angustifolia*)
Goathead (aka puncturevine: *Tribulus terrestris*)
Russian thistle (*Salibe tragus*)
Broadleaf plantain (*Plantago major*)
Globemallow (*Spharalcea sp*.; one exotic was planted along with the natives planted.)
Tree of heaven (*Ailanthus altissima*)
Purslane (*Portulaca oleracea*)
Stork's-bill (*Erodium cicutarium*)
Southernwood (*Artemesia abrotanum*; planted by landscaper. Most removed in 2005-06, but nine plants seen in Oct. 2006, one of these in the back part of the pet area)
Yellow bristlegrass (*Setaria glauca*)
Lambsquarter (*Chenopodium album*)
Amaranth (*Amaranthus blitoides* and/or *Amaranthus albus*)
Halogeten (*Halogeten glomeratus*)
Common sow-thistle (*Sonchus oleraceus*)
Sweet-clover (*Melilotus sp*.)
Feather finger grass (*Chloris virgata*)
Flower-of-an-hour (*Hibiscus trionum*)
Long-leaf ground-cherry (*Physalis longifolia*)
Field bindweed (*Convolvulus arvensis*)
Morning-glory (*Ipomoea purpurea*)

There were a few non-target non-native plants that we saw in the entrance area zone but did not map. Russian thistle (*Salsola tragus*) was common, particularly in roughly the same areas as the mapped goatheads (*Tribulus terrestris*), usually with a cover of 25-50 percent. But in most of the septic area between the entrance road and the service road the plants were huge, with a 90-100 percent cover. Additionally, Russian thistle extended up the dirt two-track road to the water tank, where goatheads were only visible near the bottom of that road. Cheatgrass (*Bromus tectorum*) was common in both brown, dried-up form and as new green sprouts following September and early October rains. One or two amaranth (*Amaranthus spp.*) species were scattered in the area, and the purslane (*Portulaca oleracea*) mapped near the rock house was seen but not mapped in several other locations. Stork's-bill (*Erodium cicutarium*) was plentiful as seedlings.

RECOMMENDATIONS

Below are recommendations for prioritizing invasive non-native plant control.

1) One of these is a shift in thinking about controlling tamarisk, as tamarisk beetles (*Diorhabda elongata*) introduced on nearby private lands spread into Arches and Canyonlands National Parks. These beetles have been introduced at numerous localities throughout the western United States (except Arizona and most of New Mexico), and have had varying success in maintaining their populations enough to impact dense tamarisk stands. But the beetles released on private lands near Arches and Canyonlands National Parks have been one of the two most successful test cases, and are spreading remarkably quickly. The shift in thinking may place less emphasis on treating dense stands of tamarisk, since the beetles are spreading quickly, and more emphasis on planning effective treatments of the remaining dead tamarisk stands. Will the fire danger be significantly greater, and if so, in what areas does this create a significant threat? Should tamarisk still be chain-sawed and treated where they are in close proximity to large cottonwood stands, for example? Will the stands of some of the invading herbaceous non-natives, including perennial pepperweed and Russian knapweed increase quickly in size because of increased light to the understory, and should more emphasis be placed on treating these species?

2) Preventing new invasives or stopping them before they spread or enter park boundaries should always be a priority in invasives management. The mapping reported here brought a couple instances of this to light. A small patch of dried ripgut brome (*Bromus diandrus*) was discovered in a sidecanyon of Courthouse Wash. I have notified Craig Hauke, SEUG Natural Resource Specialist in charge of treating invasive weeds, and he intends to aggressively pursue treatment, beginning in spring 2007, with repeat visits over the next years until it is eradicated. Goathead (aka puncturevine: *Tribulus terrestris*) has fully invaded the valley surrounding the Visitor Center and residence areas in Arches. It had also become common on the roadsides for a few miles into the park, along and above the switchbacks. We removed at least 95 percent of the latter group and roughly 33 to 50 percent of the individuals in the Visitor Center area during September and October of 2006. However, more work needs to go toward removing the coming year's crop of plants around the Visitor Center. And because goathead seeds may be viable for five to seven years, the roadsides and Visitor Center area should be monitored every year for the next seven years. Limited personnel will make this task difficult to achieve, but creative scheduling of SEUG and Arches personnel, SCA interns, volunteers and volunteer groups should assure accomplishment each year. Monitoring for most new weeds is most successful around late May, but goatheads sprout later, and must be monitored and removed mid-summer through early October.

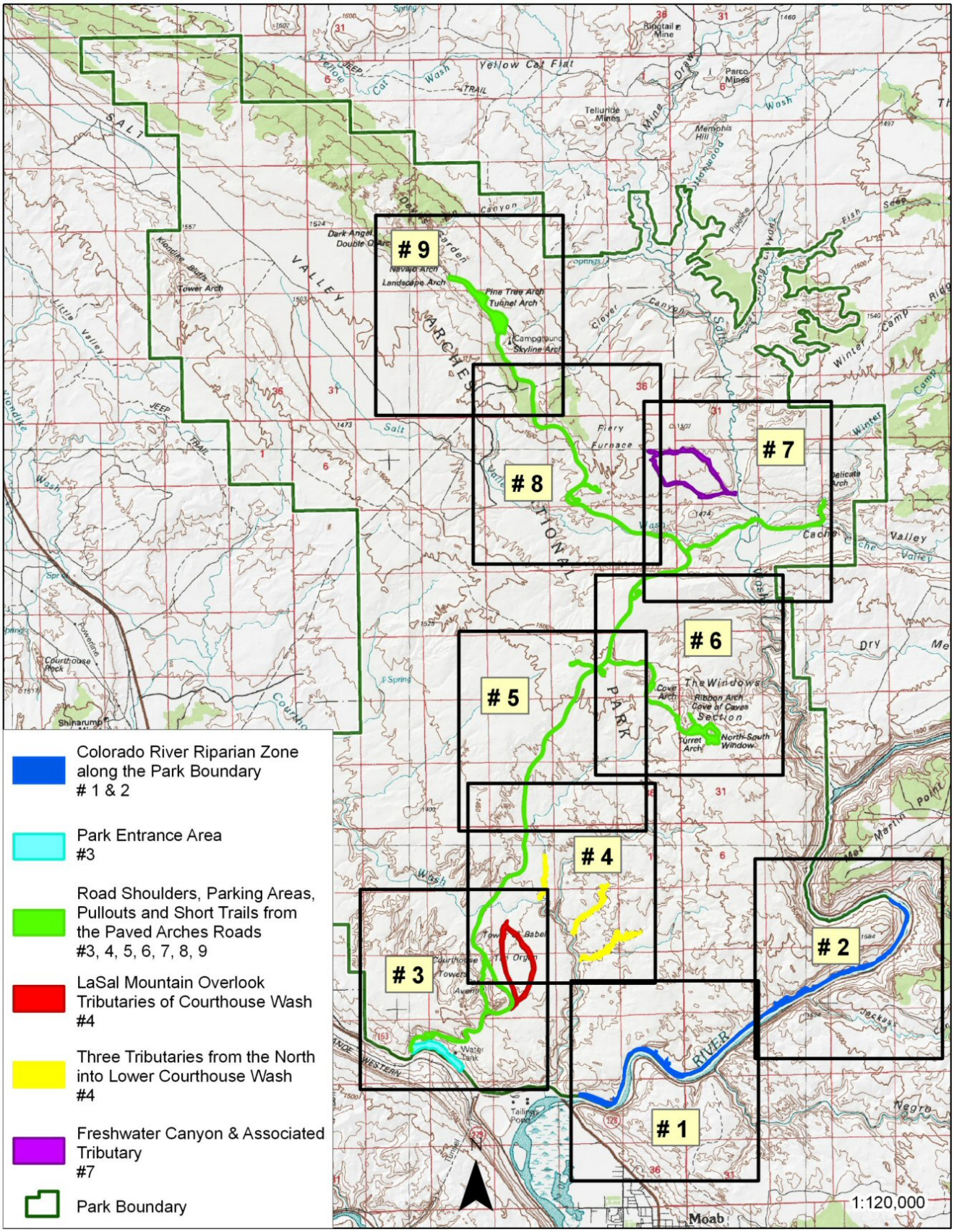
3) Further, it seems prudent to inventory and pull weeds along the roadsides and parking areas annually or at least biannually to remove new non-natives before they spread. The monitoring must be done either walking or driving at a low speed in order to see all of the plants. It cannot be done casually as rangers perform other duties, though information from rangers that do notice invasives is always useful. During our

mapping we found just one or two individual goatheads at each of five scattered areas in the park. These probably spread from the infested areas around the Visitor Center or along the first few miles of roadside. We also dug up a lone bindweed (*Convolvulus arvensis*) at the edge of the Devil's Garden trailhead parking area. The only other place in the park known to have bindweed is the Visitor Center area. We cut down a Siberian elm on the roadside in the Windows area. The locations of these treatments have been mapped and should be made available to rangers and volunteers who can check these areas regularly.

4) A vegetation management plan for the Southeast Utah Group is being written, and is essential for prioritizing invasive weed control. Utah State University weed maps generated in the 2003-2005 field seasons, and supplemented by the 2006 effort of this report, contain a wealth of information and should be extensively utilized for planning priorities.

5) Documentation of all weed treatments within the parks should be fully integrated with weed mapping efforts, past and present. Annual reports should be written that include all documented past treatments and recommendations for the future. Each report should also provide a prioritized list of areas in need of future treatment.

6) Mapping of target invasives in the Colorado River riparian zone along the boundary of Arches National Park should be completed. The areas needing completion are from Salt Wash to Big Bend, as well as areas described in the report that were incompletely mapped due to time constraints. The best time to detect the primary river understory invasives is while they are in bloom, probably May through July.


Colorado River Riparian Zone along the Park Boundary # 1 & 2
Park Entrance Area #3
Road Shoulders, Parking Areas, Pullouts and Short Trails from the Paved Arches Roads #3, 4, 5, 6, 7, 8, 9
LaSal Mountain Overlook Tributaries of Courthouse Wash #4
Three Tributaries from the North into Lower Courthouse Wash #4
Freshwater Canyon & Associated Tributary #7
Park Boundary
1
2
3
4
5
6
7
8
9
Moab
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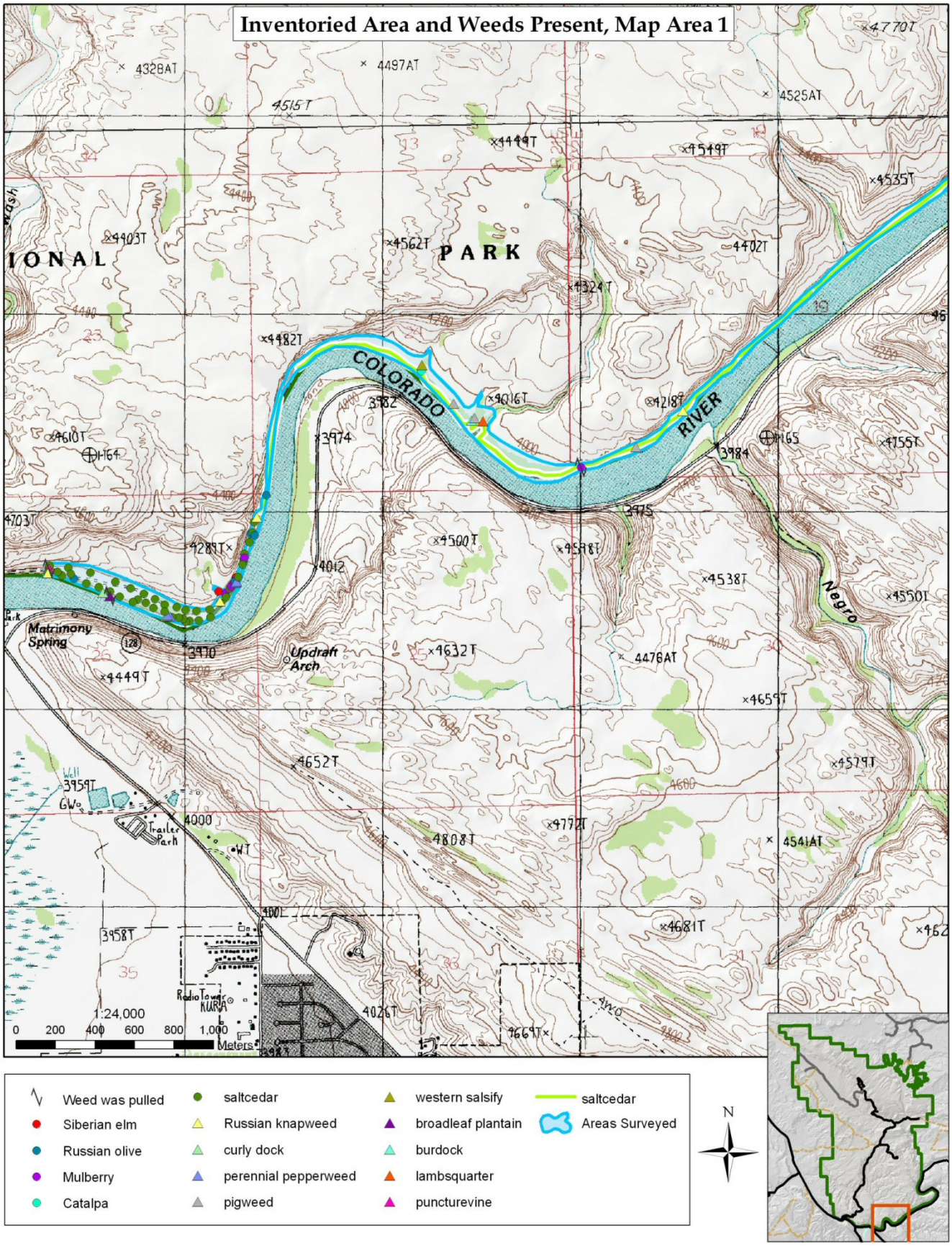
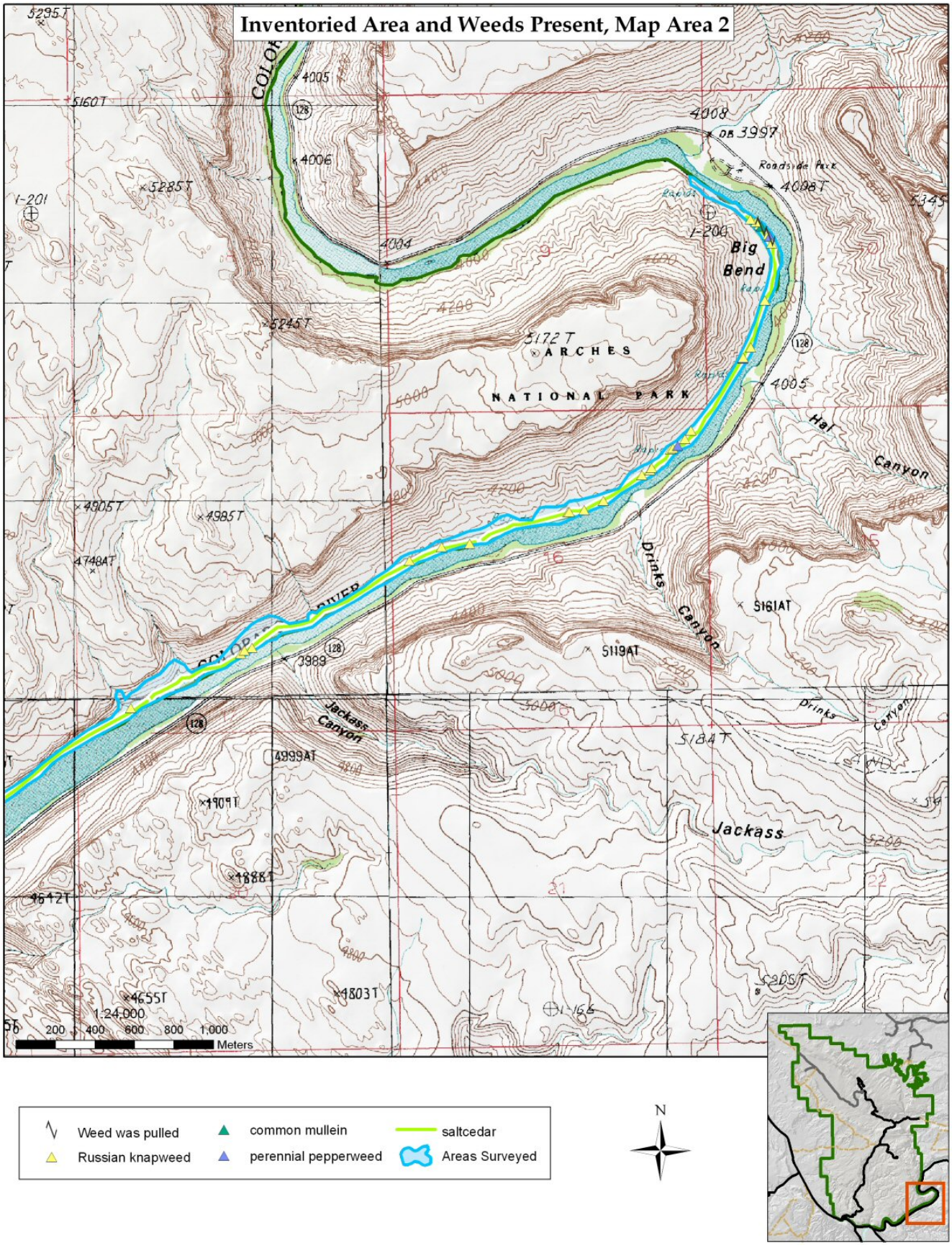
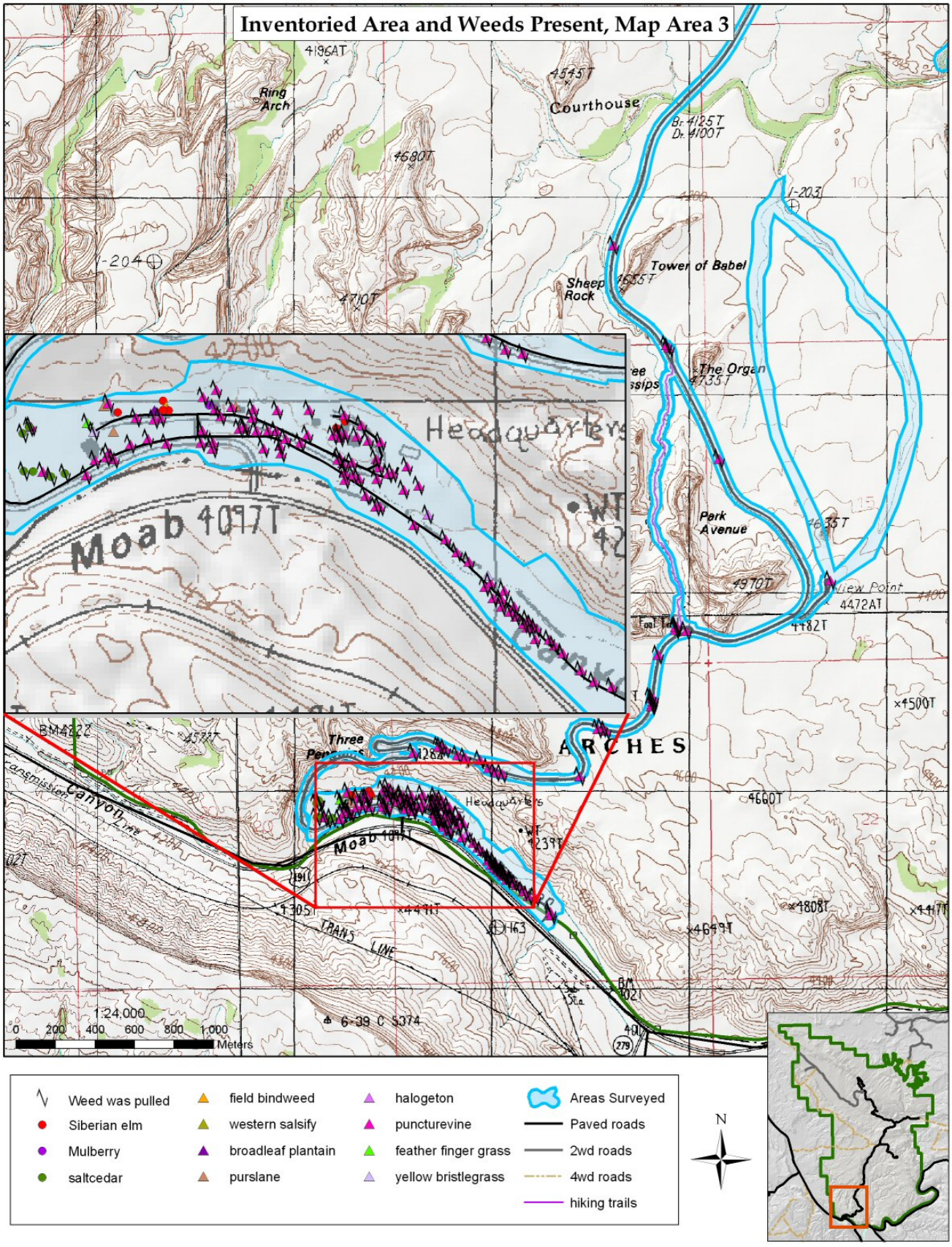
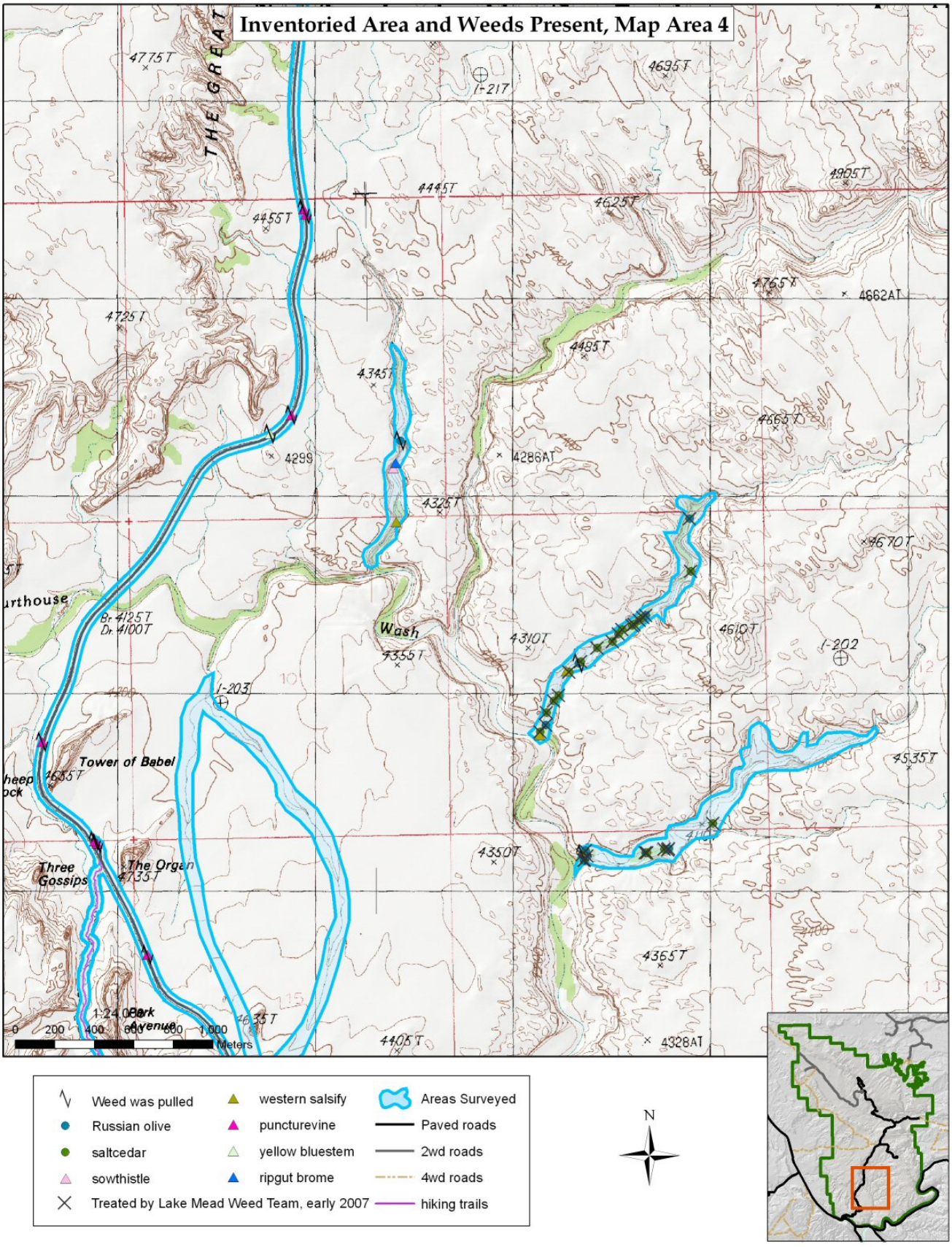
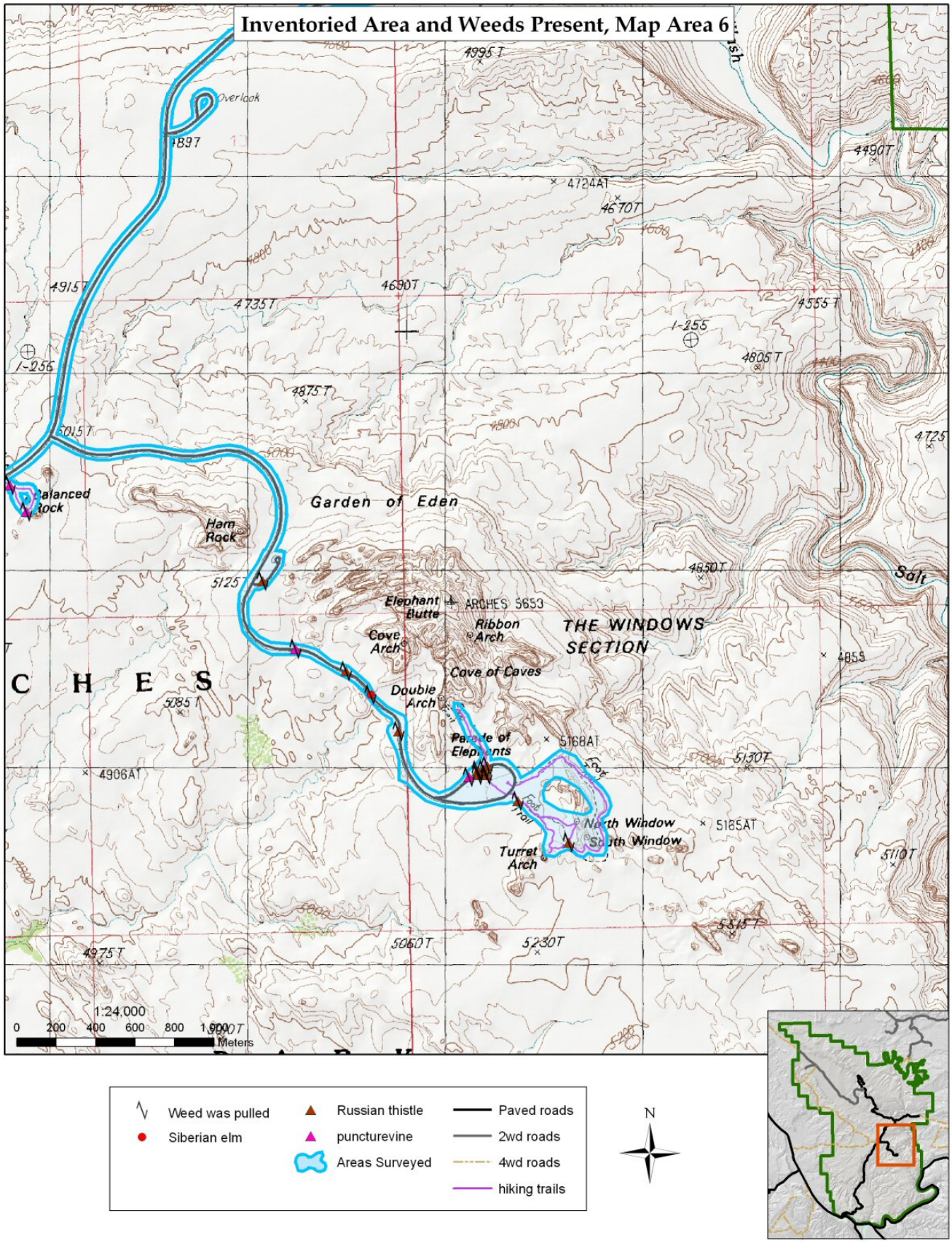

Inventoried Area and Weeds Present, Map Area 1
PARK
COLORADO
RIVER
Negro
Matrimony Spring
Updraft Arch
Trailer Park
Radio Tower KURA
1:24,000
0 200 400 600 800 1,000
Meters
Weed was pulled
Siberian elm
Russian olive
Mulberry
Catalpa
saltcedar
Russian knapweed
curly dock
perennial pepperweed
pigweed
western salsify
broadleaf plantain
burdock
lambsquarter
puncturevine
saltcedar
Areas Surveyed
N


Inventoried Area and Weeds Present, Map Area 2
ARCHES
NATIONAL PARK
Big Bend
Hal Canyon
Drinks Canyon
Jackass Canyon
Jackass
Roadside Park
I-200
I-201
1:24,000
200 400 600 800 1,000
Meters
Weed was pulled
Russian knapweed
common mullein
perennial pepperweed
saltcedar
Areas Surveyed
N

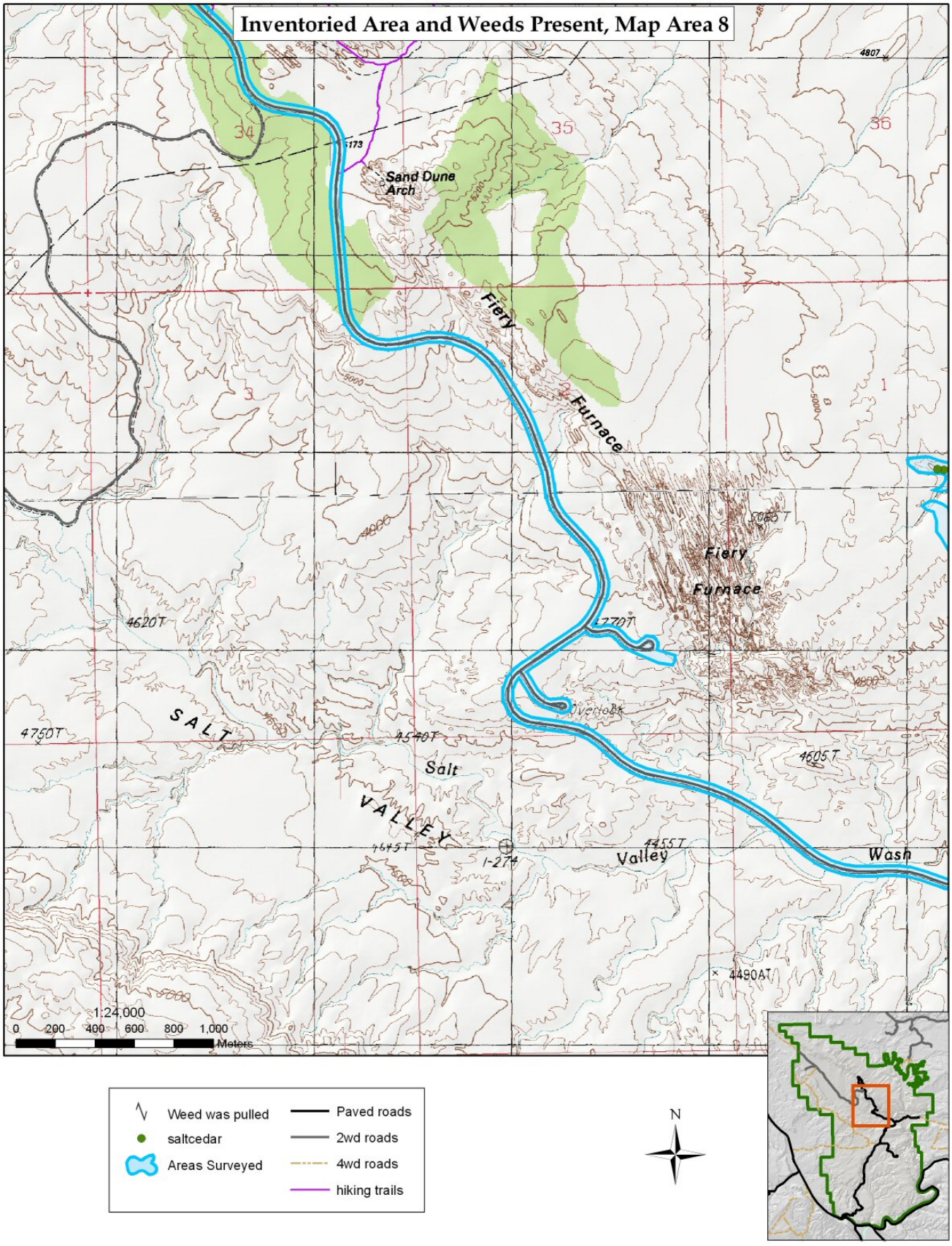

Inventoried Area and Weeds Present, Map Area 3
Ring Arch
Courthouse
Tower of Babel
Sheep Rock
The Organ
Park Avenue
Headquarters
Moab 4097T
ARCHES
Canyon Trans Line
TRANS LINE
1:24,000
0 200 400 600 800 1,000 Meters
Weed was pulled
Siberian elm
Mulberry
saltcedar
field bindweed
western salsify
broadleaf plantain
purslane
halogeton
puncturevine
feather finger grass
yellow bristlegrass
Areas Surveyed
Paved roads
2wd roads
4wd roads
hiking trails
N


Inventoried Area and Weeds Present, Map Area 4
THE GREAT
Wash
Tower of Babel
Three Gossips
The Organ
Park Avenue
I-217
I-203
I-202
4299
4286AT
4328AT
0 200 400 600 800 1,000 Meters
Weed was pulled
Russian olive
saltcedar
sowthistle
Treated by Lake Mead Weed Team, early 2007
western salsify
puncturevine
yellow bluestem
ripgut brome
Areas Surveyed
Paved roads
2wd roads
4wd roads
hiking trails
N


Inventoried Area and Weeds Present, Map Area 5
Willow
Flats
4WD
4WD
Balanced Rock
ARCHES
NATIONAL
THE GREAT WALL
Natural Arch
1:24,000
0 200 400 600 800 1,000
Meters
Weed was pulled
puncturevine
Areas Surveyed
Paved roads
2wd roads
4wd roads
hiking trails
N


Inventoried Area and Weeds Present, Map Area 6
Overlook
Balanced Rock
Ham Rock
Garden of Eden
Elephant Butte
ARCHES 5653
Ribbon Arch
Cove Arch
THE WINDOWS SECTION
Cove of Caves
Double Arch
Parade of Elephants
North Window
South Window
Turret Arch
Salt
I-255
I-256
C H E S
1:24,000
0 200 400 600 800 1,000
Meters
Weed was pulled
Siberian elm
Russian thistle
puncturevine
Areas Surveyed
Paved roads
2wd roads
4wd roads
hiking trails
N


Inventoried Area and Weeds Present, Map Area 7
T 23 S
T 24 S
Freshwater Spring
Salt Wash
Footbridge
Winter Camp Wash
Viewpoint
Cache Valley
Cache Valley Wash
Overlook
1:24,000
0 200 400 600 800 1,000
Meters
Weed was pulled
Siberian elm
saltcedar
puncturevine
Areas Surveyed
Paved roads
2wd roads
4wd roads
hiking trails
N


Inventoried Area and Weeds Present, Map Area 8
Sand Dune Arch
Fiery Furnace
Salt Valley
Wash
I-274
1:24,000
0 200 400 600 800 1,000
Meters
Weed was pulled
saltcedar
Areas Surveyed
Paved roads
2wd roads
4wd roads
hiking trails
N


Inventoried Area and Weeds Present, Map Area 9
Natural Arch
Natural Arch
Black Arch
Double O Arch
GARDEN
Wall Arch
Navajo Arch
Partition Arch
Landscape Arch
Pine Tree Arch
Tunnel Arch
ARCHES
NATIONAL PARK
Devils Garden Campground
Skyline Arch
Broken Arch
Sand Dune Arch
Prospect
Canyon
Fin
1:24,000
0 200 400 600 800 1,000
Meters
Weed was pulled
field bindweed
Areas Surveyed
Paved roads
2wd roads
4wd roads
hiking trails
N

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