Arches National Park



2003-2004 Invasive Non-Native Plant Inventory

Northern Colorado Plateau Inventorying and Monitoring Network

Final Report

April 2005

Prepared by

Steven Dewey and Kimberly Andersen

Utah State University

Cover photo:

Saltcedar (*Tamarix ramosissima*) invading Salt Wash north of Wolf Ranch. Photo by K. A. Andersen.

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Final Report

Inventory of Invasive Non-native Plants Conducted during 2003 and 2004 in portions of Arches National Park, Northern Colorado Plateau Network of the National Park Service

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INTRODUCTION

Utah State University conducted a two-year project to inventory and map invasive non-native plants for the National Park Service (NPS), Northern Colorado Plateau Network, in the summers of 2003 and 2004. The project included portions of Arches National Park (ARCH), Black Canyon of the Gunnison National Park (BLCA), Bryce Canyon National Park (BRCA), Canyonlands National Park (CANY), Capitol Reef National Park (CARE), Cedar Breaks National Monument (CEBR), Colorado National Monument (COLM), Dinosaur National Monument (DINO), Hovenweep National Monument (HOVE), Mesa Verde National Park (MEVE), Natural Bridges National Monument (NABR), and Zion National Park (ZION). This document contains the results of the portion of this inventory project that occurred within Arches National Park. Results from other Parks are documented in separate Park-specific project reports. Also, please note that this report updates and replaces the 2003 Arches National Park Inventory Annual Progress Report (Dewey et al. 2003).

BACKGROUND AND JUSTIFICATION

Numerous recent studies demonstrate that invasive non-native plant species pose one of the greatest threats to national ecosystems regionally and globally by altering native plant communities, wildlife populations, fire regimes, nutrient cycling, hydrology, and energy budgets of native ecosystems (D'Antonio and Jackson 2003, Duncan and Clark 2005, Mack et al. 2000, Sakai et al. 2001, Westbrooks 1998). A panel of scientists recently commissioned by the Council for Agricultural Science and Technology compiled an extensive list of those invasive plant species considered to be of greatest ecological and economic concern in the United States (Mullin et al. 2000). Most of those species are present in our region, and some have already invaded Parks of the Northern Colorado Plateau Network.

In a 1992 a nationwide survey of Nature Conservancy stewards, 59 percent ranked invasive plants among their top-ten conservation concerns, and 13 percent considered them the greatest challenge they faced (Randall 1995). In a similar survey of National Park superintendents regarding the conditions in their Parks, 61 percent of the 246 respondents indicated that non-native plants were a moderate or major problem (Layden and Manfredo 1994). Currently, invasive non-native plants are estimated to infest in excess of 7 million acres of National Park System lands (USDI-NPS 1996). Scientists estimate that invasive exotic plants are spreading on federal lands at a rate in excess of 4600 new acres per day, and warn that without significantly increased prevention, detection, and control efforts, the situation is certain to worsen dramatically (Asher and Harmon, 1995).

The management and control of invasive non-native species has been identified as a high priority issue within the National Park Service and is specifically, under the Government Performance and Results Act (GPRA 1993), identified as an accountable goal for all National Park units. Executive Order 13112 signed on February 3, 1999 (Clinton 1999), further identifies and strengthens the obligations of federal agencies to address the significant economic and biological threats posed by non-native species.

Additionally, the NPS has emphasized the importance of invasive species issues and their associated impacts by identifying non-native species as one of three major areas of focus under

the Natural Resource Challenge initiative (USDI-NPS 1999). The Natural Resource Challenge specifically states, "Identifying, mapping and evaluating nonnative species are critical for effective management". Similarly, the development of the Exotic Plant Management Team (EPMT) initiative has further confirmed the dedication of the NPS to the management and control of invasive plant species. However, the EPMT program has a primary funding focus on the actual treatment and control of weed infestations and has not been established as a funding source for the actual inventory and mapping of invasive weed populations. Although the Natural Resources Challenge identifies the need for obtaining "accurate data about nonnative species distributions" as critical to meeting the goal of effective and efficient management, a specific funding source to accomplish this goal was not identified.

To meet this need, in 2001, the Intermountain Region Support Office in Denver prepared a successful Natural Resource Preservation Program (NRPP) proposal (USDI-NPS 2001) to conduct invasive plant mapping in high priority areas of Parks throughout the Intermountain Region, including six Parks within the Northern Colorado Plateau Inventory and Monitoring Network (NCPN). NCPN took the lead of coordinating this project and added network funding to increase the project scope to encompass work in 12 Park units. A cooperative agreement was negotiated between NCPN and Utah State University (USU) Extension to conduct inventory work during 2003 and 2004. Arches National Park is a member of the Southeast Utah Group of Parks, which are part of the Northern Colorado Plateau Inventory and Monitoring Network as well as a member of a Prototype Park Cluster. The drafting of a plan for network vital signs monitoring is currently underway. Weed distributions, especially in riparian areas, were identified as extremely high priority needs by Arches National Park and NCPN. Riparian areas in Arches National Park were included in this project due to these needs.

OBJECTIVES

1) The overall objective of this project was to document distribution and abundance of targeted invasive non-native plant species across the range of habitats represented in areas of management concern in Arches National Park. It was anticipated that these data would provide baseline information useful in the development and implementation of effective vegetation control strategies.

2) Based on the inventory results, efforts were to be made to identify significant sources of weed introductions and vectors involved in weed spread in each area inventoried.

3) Within the scope of this project, USU was to work with regional, network and Park staff to test and refine data collection and field inventory techniques that might be used by NCPN in future invasive plant inventories.

METHODS

Utah State University supplied a 6-person crew in 2003 and 2004 to inventory designated areas within Arches National Park and other NCPN Parks. During 2003, NCPN hired additional NPS seasonal staff to augment the Utah State University crews, two of whom participated in the

ARCH inventory. Field training for all crew members was conducted by USU at the beginning of each field season. Crew qualifications are documented in Appendix A.

SELECTION OF INVENTORY AREAS AND TARGET SPECIES

Park natural resource staff and the NCPN Vegetation Ecologist worked closely with USU to provide pre-existing weed distribution information. They also provided information about weed control efforts currently underway, and the best access routes to targeted areas. All of this information was used in planning the 2003 and 2004 field inventories, and in gathering and analyzing data. NCPN and ARCH staff also helped to ensure that data were assembled and provided to the network in a useable format.

General categories of areas to be inventoried had been identified previously in the Intermountain Support Office Project Proposal and Implementation Plan (USDI-NPS 2001) based on what was considered to be the most likely invasive plant habitat, with priority given to areas of present or anticipated Park development and high visitor use. Areas of likely weed seed introduction as well as sites identified as significant known or potential weed seed sources or "vector areas" were also given priority. Areas actually inventoried in ARCH in 2003-2004 included everything in the original Implementation Plan, plus additional areas added after consultation with Ian Torrence, Vegetation Manager for the NPS Southeast Utah Group. The majority of areas inventoried in Arches National Park were associated with riparian areas.

Forty-seven species were listed in the data dictionary, representing all species targeted for inventory by the 12 Parks included in this project, plus additional species of regional or national concern. Thirteen species were identified as high-priority targets in the ARCH inventory (Table 1), and searched for systematically by all inventory crew members. Any other non-native species recognized as relatively new to ARCH and potentially invasive on wildlands in the West were documented if found.

Table 1. List of invasive plant species targeted in Arches National Park in the 2003-2004 Non-native Plant Inventory.

Invasive species	Common Name
Alhagi pseudalhagi	Camelthorn
Carduus nutans	Musk thistle
Centaurea diffusa	Diffuse knapweed
Centaurea maculosa	Spotted knapweed
Centaurea repens	Russian knapweed
Centaurea virgata v. squarrosa	Squarrose knapweed
Cirsium arvense	Canada thistle
Elaeagnus angustifolia	Russian olive
Lepidium latifolium	Perennial pepperweed
Onopordum acanthium	Scotch thistle
Sorghum halepense	Johnsongrass
Tamarix ramosissima	Saltcedar
Ulmus pumila	Siberian elm

Courthouse Wash and Salt Wash were the main focus of the inventory conducted by USU in both 2003 and 2004, and smaller drainages were inventoried by the NPS crew. Arches National Park was somewhat unique with regard to the large number of side canyons in Salt Wash and Courthouse Wash. It was known that many portions of the main washes were already heavily infested with saltcedar. However, their side canyons were included in this project hoping that most infestations of invasive plant species found therein would be small and feasible for eradication (and eventually convertible to weed-free acreages). Additional inventory areas requested by Ian Torrence were Eagle Park, Fin Canyon, Cordova Canyon, Clover Canyon, Lost Spring Canyon, Herdina Park, and Willow Spring Canyon. Crews also inventoried portions of Winter Camp Wash, Cottonwood Wash, and Mine Draw, Fish Seep Draw, and the campground due to their proximity to targeted areas and/or elevated potential for introduction of potential invasives.

Some areas of non-NPS land immediately adjacent to the Park boundary were inventoried at the encouragement of Ian Torrence. This occurred whenever crew members found infestations of high-priority weed species, such as *Centaurea repens*, extending past Park boundaries, and felt it was important to note that those infestations were contiguous beyond Arches National Park. Those areas searched outside the Park boundary include portions of Mine Draw, Cottonwood Wash, Fish Seep Draw, and Lost Spring Canyon.

DATA CATEGORIES

The data categories included in this inventory were discussed at length and agreed upon by NCPN and USU project leaders prior to initiation of the project. A complete description of the data categories, elements, and value options appears in Table 2. The GPS data dictionary developed to electronically capture data elements while in the field is presented in Appendix B. Data collection categories and definitions comply with the minimum mapping data standards established by North American Weed Management Association (NAWMA 2003) and include most of the core elements contained in the NPS Intermountain Region Weed Mapping Guidelines (Benjamin 2001, USDI-NPS 1995). Appendix C indicates the relationship of NCPN data fields to NAWMA standards and IMR Weed Mapping recommendations. A rationale is presented for any deviations from the IMR-recommended data fields.

Data elements were collected by one of several methods: automatically recorded or manually entered into GPS units in the field (GPS-entered); transcribed from field notes; obtained from previously existing GIS data sets during post-processing (GIS-derived), or added manually in office during post-processing (office). GIS-entered data included the location and size of each infestation, percent canopy cover, phenology of the weedy species, woody growth stage (if a woody species), presence of site disturbance, hydrology, dominant native species present, date, time, and any additional pertinent notes about the site. Data entered in the office during post-processing included ecological status, Park code, record numbers, detection confidence for inventory area polygons, scientific name, ITIS code, lifeform of species, county, state, and country. Additional data elements (e.g. datum, UTM zone, source of data) that pertain to the spatial data set as a whole are provided as metadata files (e.g., datum, UTM zone).

Table 2. Description of data fields used in 2003-2004 Inventory of Invasive Non-Native Plants in Arches National Park.

Data Field	Description	Options / Values	Priority	Entry
Species Name	Latin name of species	Pick-list to be provided by Park staff	Required	GPS
Species Code	IT IS		Required	Office
Additional Names	Common name of the species			Office
Date	Date species observed		Required	GPS
Observer	Name of person observing population	First initial of person's last name used in data file name	Required	GPS
Location ID	Unique identifier for species population ("Record #")		Required	GPS
Park Code	Four-letter abbreviation of Park	ARCH	Required	Office
Country	Name of country (e.g. USA)		Required	Office
State	Two-letter state abbreviation		Required	Office
County	County name		Required	Office
UTMN	UTM northing coordinate for population		Required	GPS
UTME	UTM easting coordinate for population		Required	GPS
Elevation	Elevation in meters (and feet)	Meters (or feet)	Required	GPS
Size of Infested Area	Size of population (if a point feature). Based on average diameter of weed infestation.	- 1 to few plants - 0.1 acre - 0.25 acre - 1 acre - 2.5 acres - 5 acres	Required only for points.	GPS
Gross Area		Gross estimate of land area occupied by a weed species	Required in specific situations.	GPS
Cover of infested area	Estimated percent of area infested with weed	trace (<1%) low (1 to 5%) moderate (6 to 25%) high (26 to 50%) majority (51-100%)	Required.	GPS
Distribution	Characterization of density	To be determined by PI		GPS
Phenology	Life stage of majority of population. Use most progressive life stage if population appears evenly split.	- vegetative - bud - flower - immature fruit - mature fruit - seed dispersing - dormant	Required	GPS

Table 2 continued.

Data Field	Description	Options / Values	Priority	Entry
Woody Growth	Predominant growth stage of species. Use for woody weed species only (elm, tamarisk, Russian olive, etc.) If stages are mixed, use most advanced stage. (valuable for planning control efforts)	- seedling - sapling - mature - old-growth	Optional	GPS
Lifeform	Lifeform of species.	-tree -shrub -graminoid -forb	Required	office
Ecological Status	Qualitative description of the level of infestation that identifies ability of site to recover to natural state once the weeds have been removed.	1. No weeds -The management emphasis is preventing weed encroachment. 2. New and/or small infestations - These infestations have good potential for eradication because they are small and there is a good understory of desirable plants. 3. Large scale infestation with 30% or greater understory of residual grasses and good potential productivity – Management of these sites in a way that selects for the recovery of the residual native grasses and shrubs has good potential for control but not eradication of the weeds. May be more that one noxious weed species, but the underlying biologic integrity of the unit is good. 4. Large-scale infestations with few or no (less than 30% cover) desirable grasses in the understory. Infestation often dense and/or multiple weed species. Control will require intense treatment and probably revegetation. Control may be possible but not eradication. In some areas, the infestation may have changed the character of the land so much that attempts for rehabilitation are cost prohibitive.	Required	Field and Office
Dominant Species	Species Latin name for dominant species at site (up to four species can be recorded)	Two to three dominant species need to be provided at each point (list of dominant species provided by Park). If single or few plants, use dominant species in 1/10 acre area.	Required	GPS
Buffer	Buffer needed to encompass population if GPS'ed as a line or polygon feature	Enter number in feet	Required for lines, optional for polygons	GPS

Table 2 continued.

Data Field	Description	Options / Values	Priority	Entry
Hydrology	General hydrologic setting of site. If further specificity is needed in Park, add items as subcategories to existing terms (e.g., wetland - seep).	- upland (above and away from floodplains) - riparian (along rivers or stream channels) - perennial: stream flows continuously in time. - intermittent: stream flows only at certain times of the year (typically on seasonal basis) when it receives water from springs or from melting snow. - ephemeral: stream flows only in direct response to precipitation. Ephemeral streams generally lack obligate riparian vegetation. - wetland (saturated soil for majority of growing season) - playa lakebed (poorly drained depressions)	Required	GPS
Disturbance	Evaluate disturbance at population site	1 - no disturbance apparent 2 - light to moderate disturbance 3 - site heavily disturbed	Required	GPS
Notes	Additional comments	Can include compass bearing for photos, description of non-weed features, etc.	Optional	GPS and field notes
Area ID	Unique identifier for inventory area		Required	GPS
Disturbance Comments	Comments on type and extent of disturbance noted in inventory area. If area is undisturbed, note as such.	-Agriculture/Livestock Grazing -Construction/Development -Fire -Fire Suppression -Flooding -Wind -Geothermal -Animal Disturbance (e.g. gopher mound, buffalo wallow -Irrigation/Ditches -Mining and Quarries -Oil and Gas Exploration/Production -Habitat Improvement Project -Recreation/Visitor Use -Right-of-Way -Construction/Maintenance -Utility -Construction/Maintenance -Trail/Outfitter/ORV use	Required	Field notes

FIELD PROCEDURES

Some of the terms used in this and subsequent sections of the report have been created by the authors to describe new methods and standards developed by USU for conducting invasive weed inventories on wildlands. Terms unique to this report are defined as follows:

Search Target (ST): Refers to invasive plants that are the object of a field search. ST descriptions must always include species, growth stage, and MDTS.

Minimum Detection Target Size (MDTS): 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. In this project the MDTS was set at 0.01-acre.

Effective Detection Swath Width (EDSW): The maximum width of a linear walking search pattern in which an on-the-ground searcher is confident of visually detecting at least 90 percent of all invasive plant infestations of the stated minimum target size. EDSW must be adjusted according to factors influencing target visibility, such as species, stage of growth, topography, and associated vegetative cover, in order to maintain the 90 percent minimum detection standard. Data dictionary choices for effective detection swath widths in this project were 25, 50, 100, 150, 200, 250, and 300 yards.

Patch Separation Resolution (PSR): The minimum distance between single weeds or patches of weeds that are considered to be separate infestations. Plants separated by the PSR distance or more are mapped as separate infestations. Plants separated by less than the stated PSR are usually mapped as a single infestation. The PSR for this project was 50 yards.

Detection Confidence (DC): The percentage of the total number of infestations that crew members estimate they were able to find in a searched area, based on the probability of seeing patches of the established minimum detection target size of the least visible target species in that terrain. Detection confidence is essentially meaningless without also stating the search target associated with that DC. The minimum required DC set for this project was 90 percent based on a MDTS of 0.01 acre for plants of the least visible target species in a mature or flowering stage of growth.

Between-Feature Positions (BFP): A series of location points recorded automatically by Trimble GPS units indicating the daily search routes traveled by each crew member. The distance interval for collecting BFP's in this project was set to correspond to the average effective detection swath width for each area inventoried.

The 2003 inventory in Arches National Park was conducted from June 13-23 and involved both a six-person USU crew and a two-person NPS crew. USU inventoried Salt Wash, Courthouse Wash, Winter Camp Wash, and portions of Cache Valley Wash and Eagle Park. Courthouse Wash and Salt Wash were mapped from Park boundary to Park boundary. The NPS crew inventoried mainly the side canyons branching from Salt Wash, including Lost Spring Canyon,

Clover Canyon, and Cottonwood Wash. They also searched Fin Canyon and portions of Eagle Park, and several additional side canyons branching from the main drainages of these canyons. In 2004 a six-person USU crew inventoried portions of Herdina Park and Willow Spring on May 21, and the PI and crew leader returned on August 19 to conduct quality assurance procedures and to complete the inventory (Table 3). The order in which areas were inventoried was determined by the USU crew leader. Potential invasive plant habitat within each targeted inventory area was considered prior to planning each day's travel route. Field crew members were expected to search along the planned inventory routes, spending more time in priority areas and areas of concentrated invasive plant habitat.

When arriving at a site, crews would discuss what they determined to be the best method for searching that area to achieve the required level of detection confidence for the established minimum target size. Consideration of terrain, vegetation cover, expected visibility of target weed species, and crew size were all factored into setting effective detection swath widths and other mapping techniques and standards used for each site. Areas such as Eagle Park and Herdina Park were open and visibility was generally good, so systematic coverage of the area was done using the EDSW method. When inventorying areas wider than a single swath width, multiple parallel passes of a lone crew member (or multiple crew members walking parallel transects or contours) were searched as contiguous or slightly overlapping strips to avoid coverage gaps. Most areas in Courthouse Wash and Salt Wash were narrow in width and vegetation cover was heavy. In such situations crews searched in parallel passes up and/or down the length of each wash, penetrating as far as possible into even the thickest vegetation areas. Daily inventory routes of each crew member were recorded and mapped using the BFP tracking function of the GeoExplorer GPS units. BFP tracking distance setting was adjusted as needed to correspond to the EDSW distance.

Field searches were conducted at as fine of a scale as required to be confident that 90 to 100 percent of all invasive plant infestations 0.01 acre or larger within each inventory area were detected. Search swath widths were adjusted as needed based on variations in terrain, walking speed, associated vegetation, and target species. In heavy cover and/or for difficult-to-see species this required slowly walking swath widths as narrow as 25 yards. In very open terrain and/or for highly visible species such as saltcedar, some effective swath widths were 100 yards or greater. Inventorying steep terrain using the standard search swath method was not always possible; in which case crew members used binoculars to visually scan the open but inaccessible hillsides for suspected target species. Binoculars were also used to search flats and wash bottoms for suspected weeds in any openings surrounded by impenetrable woody vegetation. This method was employed mostly in portions of Salt Wash when crews could not access the interior or large dense stands of *Tamarix ramosissima*, but could view the area from hillside or canyon wall vantage points.

Each inventoried area within Arches National Park was assigned a detection confidence value based on the crew's estimated ability to see infestations of 0.01 acre in size of the least visible target species, taking into account terrain, vegetation cover, and the size and growth stage of the targeted plant species. Detection confidence was broken into three categories: Low (1 to 50 %), Medium (51 to 89 %), and High (90 to 100%).

Table 3: Invasive plant inventory areas, inventory dates, crew members, and acres inventoried in 2003-2004 in Arches National Park.

Area Number	Area Description	Dates Inventoried	Crew Members	Acres Inventoried	Corresponding Inset Map Names and Letter Codes *
1	Lower Courthouse Wash (to south Park boundary)	Jun 13, 2003	MB, JS, RR**	234	Matrimony Spring - H
2	Middle Courthouse Wash	Jun 14, 2003	MB, JS, RR	179	The Organ - I
3	Middle Salt Wash	Jun 13, 2003	KA, EL	332	Salt Wash - B Winter Camp Wash - C
4	Eagle Park	Jun 20, 2003	KA, MB, HR, JS, EL, RR, LZ	920	Eagle Park - M
5	Upper Courthouse Wash (to northwest Park boundary)	Jun 14, 16, 18, 23, 2003	KA, MB, JS, EL, RR	1853	Courthouse Wash - K Courthouse Towers - J
6	Lower Salt Wash (to Colorado River)	Jun 16, 2003	KA, EL	201	Salt Spring - A
7	Winter Camp Wash	Jun 23, 2003	KA, RR	185	Winter Camp Wash - C
8	Upper Salt Wash and associated side canyons (Cordova Canyon, Cottonwood Wash, Fish Seep Draw, Mine Draw, Lost Spring Canyon)	Jun 14, 16-19, 22-23, 2003	KA, MB, HR, JS, EL, RR, LZ	2757	Winter Camp Wash - C Lost Spring Canyon - D Cordova Canyon - E
9	Fin Canyon	Jun 21, 2003	HR, LZ	240	Fin Canyon - G
10	Upper Clover Canyon and Campground	Jun 23, 2003	SD, JS, EL	541	Clover Canyon - F
11	Herdina Park, Willow Spring,	May 21, 2004	BA, MB, HH, RR	381	Herdina Park - L
12	West fork of Willow Spring	Aug 19, 2004	KA, SD	343	Herdina Park - L
	TOTAL			8,166	

[Year **2003**: 7442 acres (5909 USU, 1533 NPS), 119.3 acres/ person / 10-hr day. Year **2004**: 724 acres, 185.6 acres / person / 10-hr day]

* Indicates key to mapped areas presented later in Figure 3.
** Crew abbreviations: BA = Bridget Atkin, KA = Kim Andersen, MB = Melanie Ballard, SD = Steve Dewey, HH = Hillary Hudson, EL = Eric Lamalfa, RR = Ruth Richards, JS = Janna Simonsen, LZ = Liz Ballenger, HR = Heather Rickleff

As inventory units were traversed, locations of all target species were documented by the USU crew using Trimble GeoExplorer 3 global positioning system (GPS) units and GeoExplorer XM GPS units with 2- to 5-meter accuracy. Crews also recorded the location and documented the identity of any other non-target species they encountered if that species has a known history of invasiveness in other regions in the West. However, not all non-native species that were found were mapped. For example, species such as *Bromus tectorum*, *Salsola kali* and *Melilotus officinali*s were present in most areas but were ignored at the request of Ian Torrence due to their already known widespread distribution and abundance in the Park.

GPS configuration settings used in this project are listed in Appendix D. Additional equipment used by crew members included laser rangefinders, compasses, binoculars, topographic maps, calculators, and radios. Appendix E contains a photograph and complete list of equipment used in this study. Field locations were recorded by GPS as UTM coordinates, and were later differentially corrected in the production of final digital products. The crews recorded invasive plant occurrence data on hard-copy (USGS 7.5-minute topographical maps) in any situation where GPS satellite reception was not possible (such as in narrow side canyons) or in cases of GPS equipment malfunction. All data from field maps were converted to digital format.

Invasive plant infestations 1 acre or less in size were typically recorded as point features. Crew members were given the option to record infestations between 1 and 5 acres in size as points, polygons (actual areas or gross-areas), or line features, depending on which feature they felt would best represent the situation. However, essentially all infestations within this size range were recorded as point features in Arches National Park. The few polygon and line features within these small size categories that were recorded were later converted in the office to point features in order to facilitate viewing on GIS-generated maps.

Crews mapped extensive weed infestations (greater than 5 acres in size) by collecting GPS "generic points" in the field at key locations along the boundary of the infestation, and then using those points later to digitize the infestation polygon on the computer in the office. Generic points were deleted after such polygons were drawn, and are not included in the final report. This type of mapping was used exclusively for large infestations of *Tamarix ramosissima* found in inventory areas of Arches National Park.

The size of each infestation recorded as a point feature was estimated visually (using a laser rangefinder) and placed in the size category most closely matched to its actual area: 1) 1 to few plants (0.001 acre), 2) 0.01 acre, 3) 0.1 acre, 4) 0.25 acre, 5) 0.5 acre, 6) 1.0 acre, 7) 2.5 acres, or 8) 5 acres. Canopy cover of each infestation was estimated visually and placed in a category of either: 1) trace = less than 1 percent, 2) low = 1 to 5 percent, 3) moderate = 6 to 25 percent, 4) high = 26 to 50 percent or 6) majority = 51 to 100 percent. As a general rule, clustered plants with individuals separated by less than 50 yards were considered a single infestation and were mapped as a single feature (point, line, or polygon). Plants or groups of plants separated by more than 50 yards were mapped as separate infestations. (Refer to definition of PSR.)

In deciding on the dominant vegetation cover, crews identified the two most prevalent or most dominant native species in the region in which the weedy infestation was found growing. The full list was not a part of the data dictionary due to its size, but a paper copy (Appendix F) was

carried and referred to by each crew member while working in the field. The vegetation list was compiled by Tamara Naumann, botanist at Dinosaur National Monument, for an inventory conducted by USU in 2002-2003, and it was decided to use the same list for this project. Native species were coded with a 2-digit number and these codes were entered into the data dictionary. The list was not a complete list and crews had the option to add additional native species if they encountered them in the field.

POINTS OF INTEREST

The locations of some non-weed points of interest were recorded by field crews. These points include springs, seeps, Park boundaries, and sites of possible archeological interest. Points of interest were collected at the discretion of individual crew members. The information collected was delivered to NCPN, but not included within this report.

GENERAL PHOTOGRAPHS

Representative photos are included in this report showing some of the species and habitats inventoried, as well as a sampling of photographs of field crews doing inventory work. Photographs were taken of each new weed species found in the Park. Close-up photographs were intended to serve as a type of voucher specimen for weed species encountered, and landscape photos of weeds are expected to assist in relocating small isolated infestations for future control. The location of each weed infestation documentation photo was recorded as a GPS "photo point". In the case of landscape photographs of a weed and/or its surrounding habitat, the UTM coordinates represent the location of the photographer, and the direction that the camera was facing is noted as a compass bearing (magnetic north reference). The locations of photos taken to show general types of terrain and habitat, or crew activities usually were not documented with GPS points. Photographs were taken with 35-mm slide film and later digitized. Pertinent photographs are included with this report (see Appendix G). Digital copies of all photographs were submitted to NCPN as part of the final deliverables.

VOUCHER SPECIMENS

Specimens were to be collected to document new or otherwise unique occurrences of invasive species encountered within Arches National Park. No plant voucher specimens were collected in 2004. Two voucher specimens of *Centaurea repens* were collected in 2003. The voucher specimens collected in 2003 were processed for deposit in herbaria at USU and Arches National Park. The specimen deposited at USU is considered "on loan" from NPS and documented in a loan agreement. Both specimens were curated and managed following NPS service-wide protocols. The specimens collected as part of this project are affixed with labels containing information on species, collector, collection date, collection site, and NPS record number. Specimen data also is provided in electronic format.

FIELD DATA PROCESSING

At the end of each day, field crews marked and dated all inventoried areas on USGS 7.5' topographic maps to assist in determining project progress and thoroughness of coverage. The

GPS between-feature positions recorded each day were used for reference when marking the topographic maps. Each crew member kept a daily log of where they searched, what species they encountered, disturbances noted, thoroughness of coverage, and any additional information that they felt might be of importance to the project. Data were downloaded from GPS units onto a laptop computer each day using Pathfinder Office GIS software. Edits (such as eliminating any duplicate features) were made to the data, and any additional information (such as infestations drawn by hand on field maps or other data not recorded with a GPS unit) were added at this time. Four sub-folders were created within the main project folder on the computer hard drive. These were for: 1) unedited raw GPS rover files, 2) edited GPS rover files, 3) differentially corrected edited GPS rover files, and 4) GIS shapefiles created from the differentially corrected rover files (for export and use in ArcView). Separate disks were used for raw and edited rover files.

Raw data consisted of rover files transferred directly from GPS units to the computer, and stored without any editing or modification. They were named using a 6-digit code (month-day-hour) preceded by a single letter (corresponding to the first letter in the crew member's last name), and ending in ".ssf." For example, "A051913.ssf" would be the file name for raw GPS data collected by Kim Andersen beginning in the thirteenth hour (24-hr local time) on May 19.

Edited data files were created from raw files that were viewed in Pathfinder Office and checked for accuracy. Features were added or deleted in the process of editing to eliminate any duplicate reporting (two crew members finding the same infestation), and to add locations drawn on field maps (as when satellite signals could not be obtained). Any locations added in the editing process were noted as "hand mapped" in the notes section and are denoted as "Non-GPS" under the differential correction section. Notes were sometimes expanded during the editing process to include more detailed information about the surrounding habitat. Gross area features also were added during this process. File names were changed after editing to avoid confusion with the raw files. Edited files were named as a 3-letter month and 2-digit day abbreviation, followed by a dash and the first letter of the crew member's last name. If a crew member collected more than one file for that day, a number would follow the crew identification letter. For example, the edited version of the second file of GPS data collected by Kim Andersen on May 19 would be May19-A2.ssf.

The data from edited GPS rover files were then differentially corrected. Features that were added or deleted in the editing process were not differentially corrected; nor were points for which corresponding base station data were not available. Generally, the closest base station to the inventory area was used. However, if use of a slightly more distant base station resulted in a higher percentage of successfully corrected points, it was used in preference to a closer station. Corrected files retained the same name as their edited counterparts, but used the file extension "cor" rather than "ssf". Example: May19-A2.cor

Shapefiles were created from exported data by exporting the differentially corrected files from Pathfinder Office into ArcView. The shapefiles were created from the various categories in the data dictionary such as point-weed shapefile, line-weed shapefile, area-weed shapefile, photo-point shapefile, and between-feature point shapefile. Three kinds of files were created from each ".cor" file. These are ".shp", ".shx", and ".dbf." Example: pt-weed.shp, pt-weed.shx, pt-weed.dbf

POST-SEASON DATA PROCESSING

At the end of the field season, the project crew leader again reviewed the data in Pathfinder Office software to ensure 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 inventory areas were complete. Data were then exported from Pathfinder Office as shapefiles. Exported files were compiled into specific shapefiles 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, and the shape of the data collected. For example, points of weeds data collected in 2003 are compiled into one shapefile labeled as 03pt-weed.shp. Between-feature points from 2004 are labeled 04psnpnt.shp. Shapefiles were then imported into ArcView GIS 3.3 for map-making and data analysis. When shapefiles were imported into ArcView, additional data fields were added to comply with the task agreement. These fields include scientific name, ITIS code, life form of the species, county, state, country, and Park code. Individual record numbers, including the four-letter Park code, were assigned to each weed infestation location entry. It was decided to enter this information after the field season to minimize the amount of time spent collecting non data in the field and maximize the acres inventoried. The data were checked again for any duplication of entries. Any gaps in the sequence of record numbers are due primarily to elimination of duplicated entries.

Polygons of areas inventoried within the various drainages of the Park were created in ArcView 3.3 using the between-feature positions that tracked each crew member's daily route. Individual areas represent the units used in planning and executing inventories. Each inventory unit is identified by a unique area number, and is described using names of associated canyons or other geographical features. Information provided for each inventory area includes area size (acres), dates of the inventory, the persons involved, Park code, county, state, and country. In addition, each area was assigned a detection confidence level indicating the crew's estimated ability to detect 0.01-acre patches of targeted weed species based on the vegetation types and the terrain. Each area also was given an ecological status rating which is a qualitative estimate of the ability of a site to recover to a natural state once the weeds have been removed. The levels of ecological status are defined in Table 2. The crew leader assigned this number based on crew field notes and/or personal on-site inspections of the areas.

The shapefiles were used to create maps using ArcView software. Large-scale maps were created to show the total area inventoried during the 2003-2004 project and the location of smaller-scale (1:24,000) inset maps used to present weed distribution information. Each small-scale inset map is identified by a letter, as well as the name of prominent feature found on that section of map. The distribution maps also illustrate weed-free areas within inventoried units and may help managers prioritize areas for weed prevention efforts. Queries and summations of the weed acreages were conducted in ArcView and are included in the Results and Discussion portion of this report.

Individual maps were exported and saved as .jpeg files. Any data tables were exported and saved as Microsoft Excel spreadsheets. Metadata was compiled for the final 2003-2004 dataset by Utah State University using ArcGIS ArcCatalog software. The metadata was provided to the Northern Colorado Plateau Network in an electronic format as part of the final project

deliverables. All shapefiles, spreadsheets, raw, edited, and differentially corrected data files as well as digital photographs were also provided to NCPN as part of the final deliverables. Voucher specimens collected were sent to Arches National Park.

QUALITY ASSURANCE

Numerous measures were taken to ensure the quality of data collected by weed mapping crews. Quality assurance began by hiring only highly qualified individuals. In addition to in-person interviews, a written exam was administered to each applicant to evaluate their skills in weed recognition, taxonomic terminology, map reading and orienteering, GPS/GIS terms and applications, math, wilderness survival, and first aid. Crew members completed an intensive 1- to 2-week pre-season training course consisting of classroom presentations and field exercises to familiarize them with all inventory procedures and policies, and to improve all skills related to the job. Each crew member was provided with a copy of the training manual.

During the first few weeks of the field season, and periodically thereafter, the Crew Supervisor (CS) and/or the Principal Investigator (PI) worked individually with each crew member to ensure that all skills had been mastered and that procedures were consistent among all crew members. The CS reviewed the crew's downloaded data and project log entries at the end of each day. Any gaps in search patterns that were significantly wider than the effective detection swath width were identified, revisited, and inventoried.

Periodically during the field season, the CS and/or PI conducted inservice training in the form of weed I.D. quizzes or demonstrations, reviewing targeted and other invasive weed species at various stages of growth. Each time any new weed species was found, the identity was verified by the CS and/or PI. Throughout both seasons the PI and CS conducted random field inspections of areas already inventoried by individual crew members. Data collected by the PL and CS were compared with data collected by individual crew members to evaluate detection thoroughness and data accuracy (species, location, size, canopy cover, stage of growth, associated vegetation, etc.). At the end of the season both the CS and PI reviewed the data again.

New field methods and standards such as effective detection swath widths, minimum detection target size, patch size resolution, MDTS-based between-feature position settings, and detection confidence guidelines (all described previously) that were developed for this project each contributed significantly to the overall quality and repeatability of the data, particularly with regard to collection of weed distribution and abundance data.

RESULTS and DISCUSSION

Field crews inventoried 8,166 acres in Arches National Park during the summers of 2003 and 2004 (Table 3), an amount representing approximately 11 % of the entire 76,519-acre Park. An average of 119.3 acres was inventoried per person per 10-hr day in 2003, and 185.6 acres per person were inventoried per 10-hr day in 2004.

The sum of all infestations of invasive plants mapped in this project was nearly 748 acres (Table 4), and represented 9.2 % of the total area inventoried. Of the 13 initial targeted species, crews found only *Centaurea repens*, *Elaeagnus angustifolia*, *Onopordum acanthium*, and *Tamarix ramosissima* in the Park. *Tamarix ramosissima*, which was especially abundant throughout much of Salt Wash and Courthouse Wash, comprised more than 85% of the total invasive acreage recorded. *Centaurea repens* and *Elaeagnus angustifolia* together made up 14% of the infested acres. The remaining infestations (1%) consisted of seven non-native species, at least some of which are potentially invasive and which we feel should be targeted for immediate eradication. The non-target weedy species mapped in this project were: *Amaranthus albus*, *Convolvulus arvensis*, *Halogeton glomeratus*, *Rumex crispus*, *Sisymbrium altissimum*, *Sonchus oleraceus* and *Tribulus terrestris*. 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. Because not all crew members may have chosen to map each of the non-target weeds listed in Table 4, the acreage values and corresponding distribution maps for these species should be considered to represent less than complete inventories.

Table 4: Acres infested by invasive plant species within inventory areas of Arches National Park and adjacent lands in 2003-2004.

Species	2003	2004	Total Acres (Inside Park)	Total Acres (Outside Park)	Total
Amaranthus albus	0.010	---	0.010	---	0.010
Centaurea repens	71.931	---	70.811	1.12	71.931
Convolvulus arvensis	0.010	---	---	0.010	0.010
Elaeagnus angustifolia	34.645	---	34.595	0.050	34.645
Halogeton glomeratus	15.010	---	14.760	0.250	15.01
Onopordum acanthium	---	0.001	0.001	---	0.001
Rumex crispus	1.300	---	1.300	---	1.300
Sisymbrium altissimum	0.010	---	0.010	---	0.010
Sonchus oleraceus	0.280	---	0.280	---	0.280
Tamarix ramosissima	624.758	0.008	608.947	15.819	624.766
Tribulus terrestris	---	0.011	0.011	---	0.011
Totals	**747.954**	**0.020**	**730.725**	**17.249**	**747.974**

The location and size of areas inventoried in 2003 and 2004 are represented in Figure 1. Lands inventoried in 2003 are shown in orange and those inventoried in 2004 are in red. Figure 2 shows the same acreage divided into the 12 individual areas referred to for planning and reporting purposes. The area number, drainage description, and acreage of each inventory area are listed in the legend. Each area is also color-coded for ease in identification. Figure 3 serves

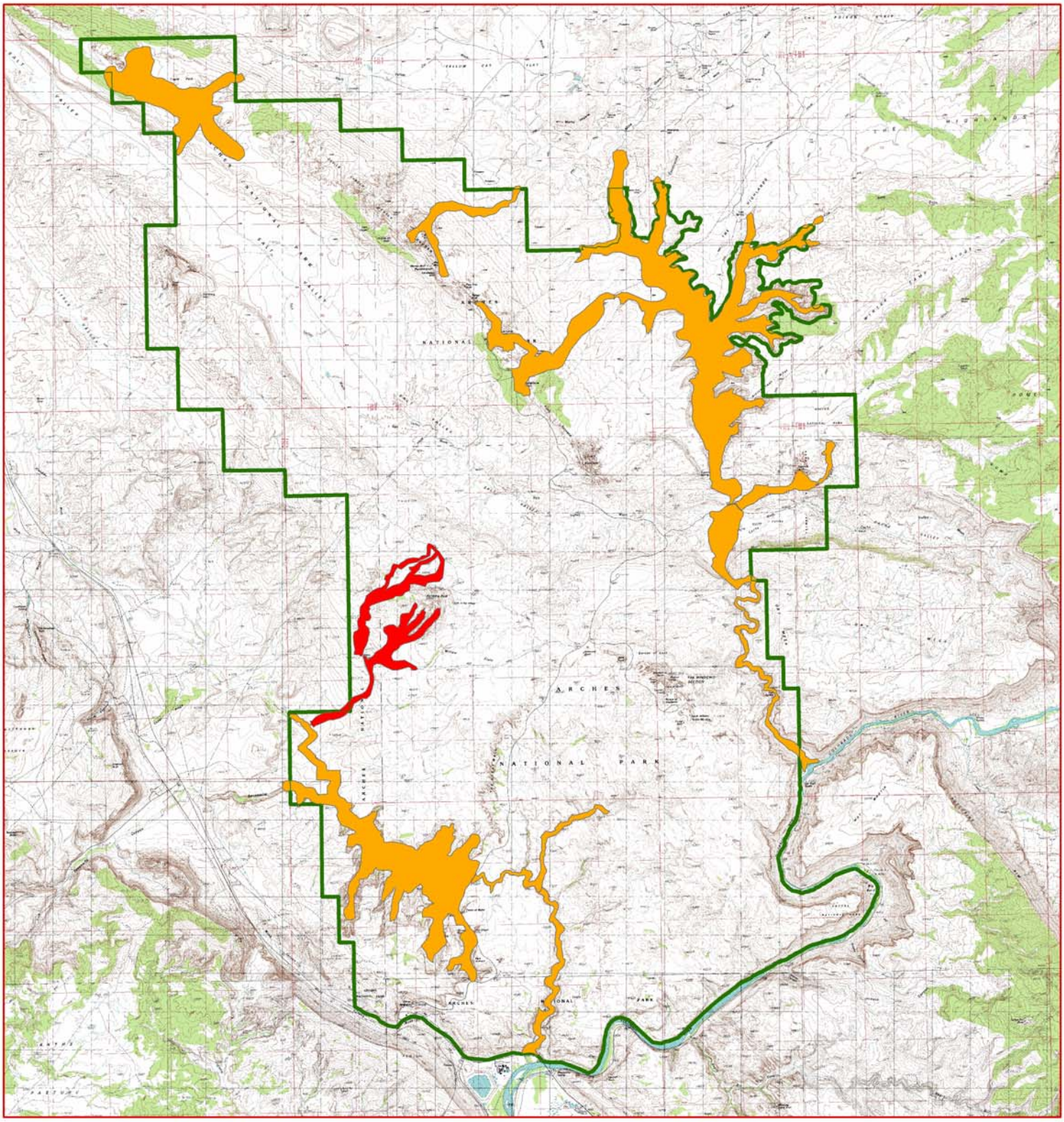
as an orientation or reference map for the smaller 1:24,000 scale weed-distribution inset maps contained in Appendices H and I. Inset maps are distinguished by letters A - M, plus the name of a distinct geographic feature found within its boundaries. The corresponding inventory area numbers from Figure 2 are included in the legend in parentheses behind each inset map name. Thirteen inset map units are required to cover all 12 of the inventory areas, and large inventory areas may span over several inset maps. For example, different sections of Upper Courthouse Wash (Inventory Area 5) appear on Courthouse Wash and Courthouse Towers inset maps (J, K).

Appendix H contains maps showing the distribution and relative abundance of all mapped weeds (no species distinction) within the boundaries of inventoried areas. Appendix I contains maps of individual species occurrences within all inventoried portions of Arches National Park. Following is a discussion of specific species occurrences and weed-free areas within each of the inventory areas.

Salt Wash and associated drainages [Cordova Canyon, Cottonwood Wash, Mine Draw, Lost Spring Canyon, Fish Seep Draw] (Area Numbers 3,6,8; Inset Maps A, B, C, D, E)
Salt Wash is a major drainage which includes several large branches. The most abundant woody species found in the main wash were *Tamarix ramosissima* and native willows. Several stands of cottonwoods as well as native forbs were also found along the main wash. A few small marshes were also scattered along Salt Wash and several wildlife species were observed in those areas including fish, ducks, herons, deer, and various amphibians. Several sections of the wash between the northern Park boundary and Wolfe Ranch were very thick with both weedy and native vegetation. Many times the brush was well over ten feet tall and formed a very dense canopy. The crew covered as much of the inner wash as was possible. When unable to penetrate the brush, crews walked the canyon rims and visually searched down into the wash with binoculars. It is possible that some lower-growing species were missed in dense brush areas of Salt Wash.

Tamarix ramosissima (saltcedar), *Centaurea repens* (Russian knapweed), and *Elaeagnus angustifolia* (Russian olive) were the only targeted species found in Salt Wash and its associated side canyons. *Tamarix* was found continuously in Salt Wash between the northern Park boundary and the Colorado River and crews recorded 529 acres of it in the main drainage as well as in Cottonwood Wash, Mine Draw, Lost Spring Canyon, Cordova Canyon, and Fish Seep Draw. The majority of the Tamarix found were large mature trees approximately 10-20 feet tall. Due to widespread occurrence and dense stands of *Tamarix* in the main wash, it was sometimes mapped as polygons created from boundary points taken along edges. Crews also noted *Tamarix* to be in some seeps in the alcoves along Salt Wash. It did not appear that any *Tamarix* had been controlled in Salt Wash prior to the inventory. Due to its widespread distribution within Salt Wash, the immediate management goal should be to prevent further spread and to reduce current infestations, while preventing spread into non-infested areas. *Centaurea repens* was found most abundantly in the mouths of Mine Draw and Cordova Canyon. These two canyons appear to serve as a seed source for infestations found downstream in Salt Wash. It is likely *Centaurea repens* will spread into Cottonwood Wash and Lost Spring Canyon if not controlled very soon. It also was found at the junction of Salt Wash and the Colorado River, and has great potential for spread downstream along this river as well. It was evident that *Centaurea repens* control efforts were already underway in Cordova Canyon, and it is our recommendation that this work should

Figure 1. Total area inventoried for non-native invasive plant species in Arches National Park during 2003 and 2004



Areas Inventoried - 2003 (7442 acres)

Areas Inventoried - 2004 (724 acres)

Park Boundary

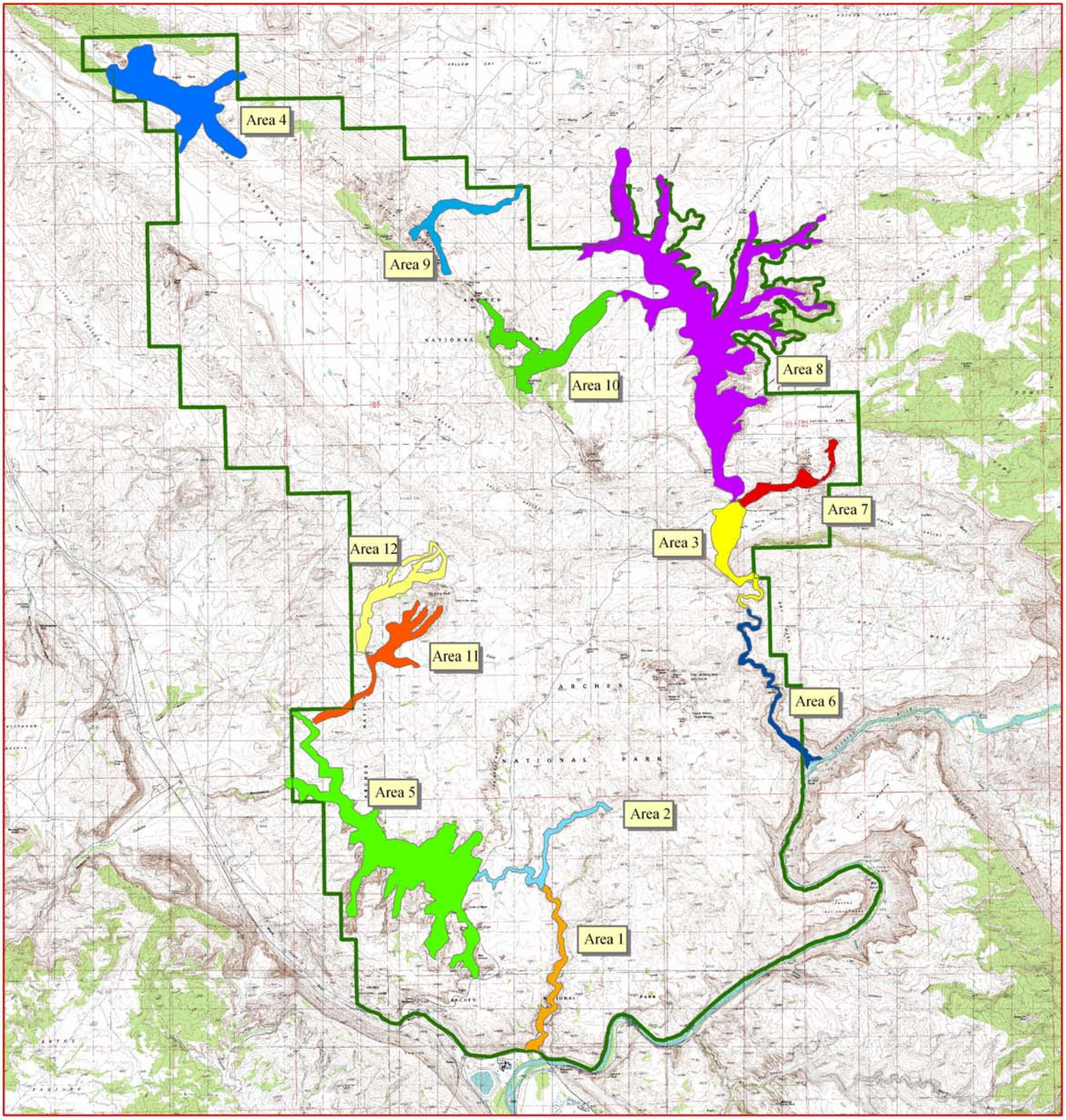
0 1 2 3 4 Miles

1:140,000 Scale

N

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Arches National Park
2003 - 2004 Invasive Non-native Plant Inventory
Northern Colorado Plateau Network

Figure 2. Identification number and acreage of individual areas inventoried for non-native invasive plant species in Arches National Park during 2003 and 2004.



Areas Inventoried (2003)

- Area 1 - Lower Courthouse Wash (234 acres)
- Area 2 - Middle Courthouse Wash (179 acres)
- Area 3 - Middle Salt Wash (332 acres)
- Area 4 Eagle Park (920 acres)
- Area 5 - Upper Courthouse Wash (1853 acres)
- Area 6 - Lower Salt Wash (201 acres)
- Area 7 - Winter Camp Wash (185 acres)
- Area 8 - Upper Salt Wash, side cyns (2757 acres)
- Area 9 - Fin Canyon (240 acres)
- Area 10 - Campground, Upper Clover Canyon (541 acres)

Areas Inventoried (2004)

- Area 11 - Herdina Park (381 acres)
- Area 12 - W. fork Willow Spring (343 acres)
- Park Boundary

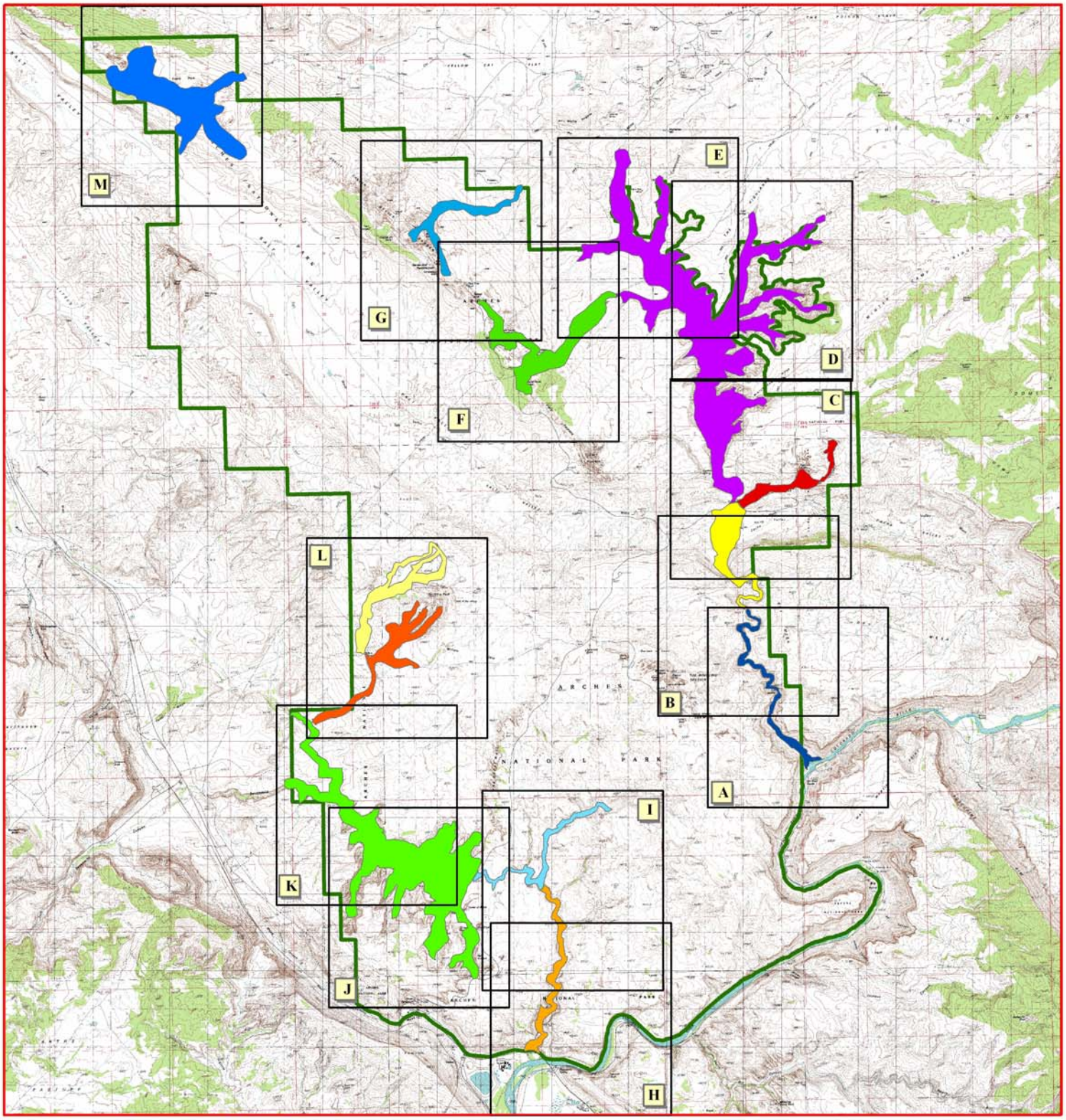
0 1 2 3 4 Miles

1:140,000 Scale

N

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Figure 3. Insets indicating the location, letter code, and name of the thirteen 1:24,000 scale maps used in Appendix tables to show weed distribution within individual inventoried areas.



Inset A - Salt Spring (Area 6)
Inset B - Salt Wash (Area 3)
Inset C - Winter Camp Wash (Areas 3, 7, 8)
Inset D - Lost Spring Canyon (Area 8)
Inset E - Cordova Canyon (Areas 9, 10)
Inset F - Clover Canyon (Area 10)
Inset G - Fin Canyon (Area 9)

Inset H - Matrimony Spring (Area 1)
Inset I - The Organ (Areas 1, 2)
Inset J - Courthouse Towers (Area 2)
Inset K - Courthouse Wash (Area 2)
Inset L - Herdina Park (Areas 11, 12)
Inset M - Eagle Park (Aera 4)

Park Boundary

0 1 2 3 4 Miles

1:140,000 Scale

N

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be continued aggressively. *Elaeagnus angustifolia* was only found sporadically in Salt Wash and control efforts were also evident on this species.

Little recent disturbance was noted in Salt Wash. Some disturbance was seen along field edges where cattle had been grazing at one time. These sites often contained *Salsola kali, Bromus tectorum, Erodium cicutarium*. However, these species were not mapped at this time. *Halogeton glomeratus, Rumex crispus,* and *Sonchus oleraceus* were mapped in Salt Wash but were not targeted species of concern at Arches National Park. *Melilotus officinalis* was also seen throughout much of Salt Wash but only occasionally in places such as Lost Spring Canyon.

Courthouse Wash (Area Numbers 1,2, 5; Inset Maps I, H, J, K)

Courthouse Wash is also a large drainage consisting of several side canyons. It has large stands of native willows and smaller stands of cottonwoods along the main wash. This wash tended to be more open and had large meadows of sagebrush and greasewood on either side of the stream bed. Of the targeted species, only *Tamarix ramosissima* and *Elaeagnus angustifolia* were found in Courthouse Wash. *Elaeagnus angustifolia* occurred primarily in the main wash, with very few found in side canyons. *Tamarix ramosissima* was abundant in much of the main Courthouse Wash, with a few small infestations and single plants found scattered in several of the inventoried side canyons. *Halogeton glomeratus* was also found and mapped, although it was not a targeted species, and the confidence level for detecting all infestations of this species is considered below 90 percent as it was not searched for as intensively. Species not mapped but noted included *Salsola kali, Bromus tectorum, Tragopogon dubius, Erodium cicutarium,* and *Chenopodium berlandieri.* A trail running through the lower portion of Courthouse Wash was the only obvious non-natural disturbance noted in the drainage.

Eagle Park (Area Number 4; Inset Map M)

Both the USU and the NPS crew spent a day inventorying Eagle Park. Eagle Park was very open and visibility was generally very good. Approximately two-thirds of Eagle Park was inventoried but no targeted species were detected. Some disturbance from livestock was evident, although it did not appear to be recent activity. Weedy species not targeted but noted in Eagle Park include *Bromus tectorum, Salsola kali,* and *Chenopodium berlandieri*. Future efforts to finish the inventory of this area may not be worthwhile due to the absence of targeted species noted so far, the remoteness of the site, and the lack of significant disturbance.

Fin Canyon (Area Number 9; Inset Map G)

The NPS crew inventoried Fin Canyon, which appeared to be a very undisturbed area. Scattered *Tamarix* plants were found throughout the lower canyon, and one *Sisymbrium altissimum* plant was found and pulled.

Winter Camp Wash (Area Number 7; Inset Map C)

Winter Camp Wash was searched from near its mouth at Wolfe Ranch until the crew reached several impassable pouroffs some miles up-drainage. The lower wash is heavily infested with *Tamarix ramosissima* and continues heavy until the canyon narrows to a thin slot. However, the canyon widens again and *Tamarix* can be found scattered throughout the remainder of the area inventoried above that point. Several patches had been controlled, and several cut stump treatments were found by the inventory crew approximately below the Delicate Arch overlook.

Some of the *Tamarix* plants at these controlled sites have resprouted since the time of the treatment.

Herdina Park and Willow Spring (Area Numbers 11, 12; Inset Maps L, K)
Herdina Park and Willow Spring were not inventoried until 2004. This area is a fairly remote site not likely to have heavy visitor use. The terrain was generally open and visibility very good for much of the area inventoried. Only *Tamarix ramosissima* was found, and only in small patches along the dry stream beds. Willow Spring is an area of concern as it is occupied by a large willow population which will most likely be replaced by *Tamarix* if the current population in that location is allowed to spread. Some *Melilotus officinalis, Salsola kali,* and *Erodium cicutarium* were noted in the Herdina Park area.

Although roads were not officially searched during this project, crews did find a single senesced plant of *Onopordum acanthium* on the road shoulder above the visitor center. *Tribulus terrestris* was also found at the nearby pullout. It is highly likely that other new invasive weed species could be found along the road corridors. The crews also recorded any targeted species found at or just outside the Park boundaries due to their potential to spread into the Park. These species include 0.01 acres of *Convolvulus arvensis* (field bindweed), 1.12 acres of *Centaurea repens,* 0.50 acres of *Elaeagnus angustifolia,* 0.25 acres of *Halogeton glomeratus,* and 15.57 acres of *Tamarix ramosissima.*

Inventory areas were generally open and visibility was good, thus it is unlikely that any 0.01-acre or larger patches of targeted *Tamarix ramosissima* or *Elaeagnus angustifolia* were missed. As discussed earlier, it is possible that some targeted species such as *Centaurea repens* were missed in Salt Wash if growing under the heavy canopies of thick stands if *Tamarix* and/or willow. However, crews were still confident of finding at least 90 percent of all 0.01-acre or larger patches of Russian knapweed in most inventoried areas. The single *Onopordum acanthium* and small patches of *Tribulus terrestris* found should be considered new invaders to the Park and prioritized for immediate eradication. All other targeted species that were mapped were quite widely distributed and Park weed crews were aware of most locations. The immediate management strategy for these species should be to contain (prevent further spread) and reduce (acreage and/or density) existing infestations, with emphasis on preventing their spread into presently non-infested areas.

The ecological status of each area was assigned by the project crew leader based on her impression of the site's ability to recover once the weeds have been removed. The majority of Salt Wash was assigned a level 4 due to widespread infestations of *Tamarix ramosissima* and presence of *Centaurea repens*. However, most side canyons and even some portions of the main wash still have good potential for control. Level 3 was assigned to Courthouse Wash, portions of Salt Wash, Winter Camp Wash, and Clover Canyon. Level 2 was assigned to Fin Canyon and Herdina Park because of the small size of the infestations present and the high potential for their eradication. Eagle Park was assigned a Level 1 because no targeted species were found. However, it is noted several other non-native weedy species were seen and have the potential to crowd out the native plants in that area.

CONCLUSIONS / RECOMMENDATIONS

The primary objective of this project was to document the distribution and relative abundance of targeted invasive non-native plant species across the range of habitats and areas of management concern in Arches National Park. It is anticipated that the information obtained from this inventory will be useful in the Park's ongoing efforts to improve strategic planning and to increase the efficiency and effectiveness of all field operations associated with invasive plant management.

It is acknowledged that Arches National Park is already implementing many effective weed control strategies and practices, for which they are to be commended. Several sites of smaller infestations of *Centaurea repens, Elaeagnus angustifolia*, and *Tamarix ramosissima* mapped in 2003 had signs of previous control treatments, and the Park land manager was aware of many of the current infestations at the time of our inventories. Data gathered in 2003 by USU and NPS mapping crews was also used in planning a large scale control project during March of 2004 when fourteen National Park Exotic Plant Management Teams (EPMTs) were deployed to Arches National Park to concentrate on reducing *Tamarix* and *Elaeagnus angustifolia* in Courthouse Wash.

If it does not already exist, the Park is urged to develop a comprehensive written management plan for invasive plant species in Arches National Park, similar to the plan currently being finalized by Utah State University for Dinosaur National Monument. If there currently is a written plan in place, the Park is encouraged to review and improve it on a regular basis. An excellent reference that will aid the Park in crafting specific control methods is the "Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas" developed by The Nature Conservancy (Tu et al. 2001).

Regularly scheduled weed inventories of all Park lands should be an ongoing part of a weed management plan aimed at early detection. Inspections of all high-visitation areas should be performed at least annually, whereas inventories of the most remote sites or habitats least suitable for weed establishment or spread might need to be performed only once every 5 to 10 years. A rotating schedule should be developed by Arches National Park to inventory a portion of their land each year, so that within a set number of years all of the Park could be inspected. The key is to schedule inventories often enough to detect all new weed infestations before they exceed a size considered feasible for eradication. Early detection of invasive weeds through regular searches and mapping is just as essential to successful weed management as the early detection of wildfires is to effective fire management.

Tied to an ongoing inventory effort, the Park should consider establishing permanent monitoring sites to evaluate the impact and spread of weeds, as well as evaluate the effectiveness of its weed management approaches. Long-term studies provide valuable insight into the effectiveness of current management techniques and quantify whether management goals have been accomplished. Monitoring standards and protocols exist in the federal agencies and provide guidelines as to selecting appropriate sites and proper techniques for gathering information. Several excellent publications on monitoring methods and standards are currently available for

reference (Coulloudon et al. 1999, Elzinga et al. 1998, Kuchler et al.1988, Silsbee et al. 1991, USDI-USGS 1994, Winward 2000).

If it has not already occurred, Arches National Park is encouraged to become an active member of a local Cooperative Weed Management Area. Weed management goals can be achieved more effectively when managed in cooperation with partner organizations also trying to achieve the same goals. The following excerpt taken from the National Park Service's own 2002 publication "Inventory and Monitoring for Invasive Plants Guidelines" further emphasizes the importance of this concept, particularly as it relates to invasive weed inventories:

> "Although the Park's primary responsibility is to itself and to upholding the mission for which is was established, Parks have a role and responsibility in promoting and supporting collaborative information exchange among local weed and natural resource management professionals. It is in the self-interest of the Park (in fulfilling its mission) and the agency (as a cooperating federal land management agency) to do more than simply share data passively or opportunistically. To the extent a Park can place the distribution and abundance of its invasive plants in the context of a larger landscape, the Park's efforts to identify management objectives and allocate resources efficiently will be improved as the scale of that landscape grows in size."

Dinosaur National Monument is currently a member of a Cooperative Weed Management Area. Other Parks interested in more information and advice should contact Tamara Naumann, Park botanist at DINO.

Species prioritization is an important part of strategic weed management planning, especially when limited budgets don't allow all weed problems to be addressed equally. As a general rule when weed abundance exceeds weed control resources, the least abundant species should be given highest priority, with the ultimate objective being eradication whenever possible. Species that are somewhat more abundant but still highly manageable should be controlled as aggressively as possible, with containment being the initial goal, and followed by a significant reduction in acreage. Populations of invasive or otherwise undesirable non-native species presently beyond the hope of containment or reduction in acreage should not be ignored, but should not be the object of significant expense until all higher-priority situations have been adequately addressed. Relatively inexpensive methods such as policy and procedural changes aimed at preventing or minimizing further spread (protecting non-infested areas), release of biological control agents, or use of cultural methods are generally recommended for weed species in this category.

Applying that strategy to Arches National Park would mean that species such as *Onopordum acanthium* and *Tribulus terrestris* should be given the highest control priority of the species mapped, and should be targeted for prompt Park-wide eradication. *Centaurea repens* and *Elaeagnus angustifolia* would likely fit into the second priority category of "contain and reduce " in some portions of the Park, but also could be candidates for eradication in other areas. For example, *Elaeagnus angustifolia* was prevalent in Courthouse Wash and probably beyond feasibility of eradication, at least in the near term. But it was relatively rare in Salt Wash and could be eliminated quite easily from that drainage. *Centaurea repens* is not a new species

within the Park, but presents a unique situation. Although 72 acres are infested by this weed, all of the known infestations are contained within Salt Wash and its associated canyons. No *Centaurea repens* was found in Courthouse Wash, Fin Canyon, Clover Canyon, Herdina Park, or the Eagle Park area. If effective prevention, early detection, and rapid response strategies are implemented now, managers should be able to keep all of these and other portions of the Park free from the impacts of this species. It might be possible to eradicate *Centaurea repens* from the lower portion of Salt Wash, as only 6 small infestations were found below Wolf Ranch. However, abundant infestations in upper Salt Wash, both inside and outside of the Park, will serve as a continual source of potential reinfestation into lower Salt Wash.

As is true throughout much of the southwest, *Tamarix ramosissima* was the most abundant and most well-established invasive species found in Arches National Park. Although *T. ramosissima* infests much of Salt Wash and Courthouse Wash, native vegetation is still abundant throughout most portions of these drainages. Thick patches of willows and several large cottonwoods are scattered throughout, and many of the side canyons contain little or no weedy species. However, it is likely that populations of willows, cottonwoods, and other native species will eventually be reduced significantly or even lost if control strategies are not put in place in the near future to stop the spread and reduce the impact of *Tamarix*. We would place Tamarix ramosissima in the second priority category, recommending containment of existing infestations, complemented by effective prevention, early detection, and rapid response (eradication) strategies on the non-infested and lightly infested portions of the Park. Plants that we would place in the third management category (lowest priority) include *Bromus tectorum, Melilotus officinalis,* and *Salsola kali* which were widespread throughout the Park and too abundant for meaningful mapping.

The second objective of this project was to identify potential sources of weed introductions and significant vectors involved in weed spread in the Park. Humans are the most likely vectors for new introductions of invasive plant species into Arches National Park and other Parks of the Northern Colorado Plateau Network, and areas of highest human visitation are also the areas where new invaders might be expected to appear first. As an example, the patches of *Tribulus terrestris* and *Onopordum acanthium* found in 2004 were at a scenic pullout less than a mile from the visitor center. Millions of visitors come from all over the world to enjoy the unique beauty of this region, and each person potentially brings with them errant seeds of an exotic invasive plant lodged in the tread of a tire or hidden in the dried mud of a hiking boot. The ever-increasing number of visitors, combined with the distant and diverse geographical areas from which they come, all combine to make National Parks highly and uniquely vulnerable to exotic plant invasions. Frequent inspection of high-visitation sites within each Park is essential to the "early detection and rapid response" strategy of invasive plant management. Roadways, parking areas, visitor centers, picnic sites, campgrounds, view points, boat ramps, trails, and all other high-visitation sites should be searched regularly (at least yearly) at a time when new plants would be visible. Park visitors should be informed of the potential damage caused by invasive plants, and ways they can help minimize the chances of it occurring. This might be done in the form of written information distributed at the Park's main entrance gate, through displays or a video program at the Visitor Center, and evening fireside presentations to visitors made by Park personnel.

Routine Park operations represent another significant source of potential weed invasions. Road maintenance, fire fighting, and even weed control operations can result in the unintentional introduction or spread of invasive weeds within Parks. Specific procedures should be developed and implemented to minimize the spread of weed seeds by Park employees and/or the creation of unprotected disturbed sites that can be ideal for weed establishment. An excellent example of effective weed prevention methods can be seen in protocols developed for the recent multi-crew EPMT deployment exercise conducted at Arches National Park (USDI-NPS 2004) (Appendix J). Additional weed prevention protocols have been developed by the Forest Service (USDA-Forest Service 2001).

Natural vectors such as wind, water, and wildlife do play a role in weed seed dissemination within the National Parks, and cannot be overlooked. However, they probably play a much less significant role overall, compared to human-related vectors. Control of isolated new weed infestations at the heads of otherwise non-infested drainages could prevent rapid spread associated with flowing streams or flash flood events. Traditional annual migration routes of deer, elk, bighorn sheep, or other large animals should be considered a high-probability area for weed seed transport and introduction.

All NCPN Parks that were inventoried in 2003 and 2004 are in the enviable situation of still having the majority of their lands free of invasive weeds. In Arches National Park 90.8 percent of the acres inventoried were free of all mapped species. And, because areas selected for this inventory were generally considered the sites most likely to be infested, it can be assumed that those ARCH lands that were not inventoried have an even higher proportion of weed-free acres. Furthermore, 100 percent of all inventoried lands were completely free of 26 targeted species of great concern to the region (Appendix K).

An important new trend in weed management is the concept of identifying areas that are currently free of one or more species of invasive plants, and officially designating them as “Weed Prevention Areas”(WPA). Land units designated as WPA's are given a higher priority for prevention efforts, early detection, and rapid control (eradication) of any new invaders. In our opinion, all areas within Arches National Park that are currently "clean" should be identified as WPAs, and Park management should take all appropriate measures to keep invasives from spreading into them. Protecting and preserving lands in this weed-free condition is much more cost-effective than restoring extensive areas already badly infested by invasives, and therefore should be the highest weed management priority for the Northern Colorado Plateau Network. Programs based on prevention, early detection, and rapid response to control all new invaders on presently weed-free lands will be needed to accomplish this objective.

The WPA concept is an excellent way to emphasize the fact that the majority of NPS lands are still clean and healthy with respect to the threat of invasive plants. The total number of acres in WPA's within a Park could help to justify increased budgets for prevention practices. Increasing the number of weed-free acres in a Park should be recognized as a highly significant accomplishment, and Park managers should be encouraged to make the necessary efforts to convert lightly infested lands to WPA's as quickly as possible (by aggressively controlling and eradicating those few plants keeping these areas from being declared "weed free"). WPA's also

present an opportunity for Parks to help the general public feel more involved as visitors see more clearly the focus of the preventive measures they are being asked to adopt.

The final objective of this project was to test and refine data collection and field inventory techniques that might be used by NCPN in future invasive plant inventories. In their effort to meet that objective, USU provided a two-week intensive training in inventory techniques to the NPS crew leaders involved in this project in May of 2003 as well as a week-long field training exercise held in Zion National Park for all NPS crew members involved. USU also provided training in weed mapping techniques at several state weed conferences as well as at the regional Western Society of Weed Science Weed Management Short Course held in Montana annually. An overview of the USU weed mapping program was also presented to over 60 EPMT personnel from around the country during a week-long field training exercise held in Arches National Park in 2004. Several recent publications describing USU weed mapping strategies, standards, and field techniques are listed in the References Cited section of this report. (Andersen et al. 2003, Andersen and Dewey 2005, Ballard et al. 2003, Dewey and Andersen 2004a, Dewey and Andersen 2004b, Dewey and Andersen 2005a; Dewey and Andersen 2005b, Dewey and Andersen 2005c).

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Appendix Tables and Figures

Appendix A. Crew Qualifications and Project Quality Assurance for 2003-2004 Invasive Non-native Plant Inventory in Arches National Park.

The Utah State University wildland weed mapping team has considerable experience conducting the type of survey required in this NPS project. Previous weed surveys conducted by USU include:

1997	Mt. Naomi Wilderness Area, Cache County, UT
1998	Wellsville Mountains Wilderness Area, Cache and Box Elder Counties, UT
1999	Franklin Basin Recreation Area, USFS Logan Ranger District, Cache County UT
2000	Rich County Public Lands (BLM, USFS), UT
2001	Hardware Ranch WMA, UDWR, Cache County, UT
2001	Bud Phelps WMA, UDWR, Cache County, UT
2002	Hawkins Fire, USFS, Bannock County, ID
2002	Canyon Fire, USFS, Franklin County, ID
2002	Cherry Creek Fire, USFS, Bannock County, ID
2002	West Fork Fire, BLM, Bannock County, ID
2002	Dinosaur National Monument, Green River District, UT

Kim Andersen (crew leader) and Melanie Ballard (assistant crew leader) have considerable experience working on the USU crew in past years. Kim has a Bachelor of Science degree in Fisheries and Wildlife from the College of Natural Resources and is currently working towards a Master's Degree in Weed Science. Melanie has a Bachelor of Science degree in Plant Science. Kim began work on the USU crew in 1999, and has been crew leader since 2000. Melanie started on the crew in 2002. Both Kim and Melanie have additional experience with invasive weed GPS mapping projects in National Parks (Grand Teton and Yellowstone). Ruth Richards has a Bachelor of Science degree in Crop Science and is currently working towards a Master's Degree in Weed Science. She has worked on the crew in 2003 and 2004. Janna Simonsen has worked as a biological technician for the Wasatch-Cache National Forest since 1999 conducting vegetation analyses and range monitoring studies using GPS/GIS technologies. Janna has a BS degree from USU in Environmental Studies. Hillary Hudson has a Bachelor's degree and has worked on an Exotic Plant Management Team in California from 2003 to 2004. She has also worked as a national park ranger in the Maze District of Canyonlands National Park. Eric Lamalfa is a student at USU in the Plant Science department. Liz Ballenger has a Bachelor's degree in Biology from the College of Wooster and a Master's Degree in Ecology from the University of Michigan. Heather Rickleff has a Bachelor's degree in Outdoor Recreation and Resource Management from Indiana University.

All USU weed survey crew members were required to pass a written exam in weed identification and mapping skills before being hired. Each also had passed an upper-division university course in weed identification, biology, and management, and/or has extensive practical experience in wildland plant identification. Once hired, USU and NPS crew members also attended a 3-week classroom and outdoor training course in late April and early May in wildland weed mapping

techniques taught by Dr. Dewey at Logan and Zion National Park during 2003. A similar training course was offered to the USU crew in 2004. Crew members were provided with weed identification field guide book, taxonomic keys, and pressed reference specimens of all targeted weeds. During the course of the summers USU crew members were quizzed periodically with fresh plant specimens provided by the crew leader and/or Dr. Dewey. Dr. Dewey also spent several days in the parks working with individual crew members under field conditions. To further authenticate findings, Dr. Dewey and/or the crew leader re-visited representative areas in each park that had been previously mapped by the USU crew, using the most recent crew-generated weed infestation maps to compare them against their own field observations.

Appendix B. Standard GPS Data Dictionary used in the 2003-2004 Invasive Non-native Plant Inventory in Arches National Park.

NPS-2004
Inventory of invasive weeds in NCPN

pt-weed Point Feature, Label 1 = Species Code 1 = IT IS code Code 2 = Plant Code

Species	Menu, Required, Normal	
Asparagus sp.	[42782]	[ASPAR]
Bells of Ireland	[32569]	[MOLA]
Bindweed, field	[30705]	[COAR4]
Blackberry, Himalayan	[24852]	[RUDI2]
Brome, downy	[40524]	[BRTE]
Brome, smooth	[40502]	[BRIN2]
Burdock	[36546]	[ARMI2]
Camelthorn	[508549]	[ALMA12]
Chamomile	[36330]	[ANTHE]
Cress, hoary	[23072]	[CADR]
Dock, curly	[20937]	[RUCR]
Elm, Siberian	[19057]	[ULPU]
Halogeton	[20692]	[HAGL]
Hemlock, poison	[29473]	[COMA2]
Henbane, black	[21454]	[HYNI]
Houndstongue	[31890]	[CYOF]
Horehound	[32561]	[MAVU]
Johnsongrass	[42111]	[SOHA]
Knapweed, diffuse	[36958]	[CEDI3]
Knapweed, Russian	[510530]	[CERE6]
Knapweed, spotted	[36964]	[CEMA]
Knapweed, Squarrose	[533280]	[CETR8]
Lambsquarter	[20592]	[CHAL7]
Loosestrife, purple	[27079]	[LYSA2]
Marshelder	[36041]	[IVA]
Mullein, common	[33394]	[VETH]
Mustard, Sahara	[23064]	[BRTO]
Olive, Russian	[27770]	[ELAN]
Orchardgrass	[193446]	[DAGL]
Pepperweed, perennial	[503379]	[LELA2]
Puncturevine	[29057]	[TRTE]
Reed, giant	[41450]	[ARDO4]
Saltcedar	[22310]	[TARA]
Salsify, western	[38564]	[TRDU]
Spurge, leafy	[28064]	[EUES]
Starthistle, yellow	[36972]	[CESO3]
Thistle, bull	[36428]	[CIVU]
Thistle, Canada	[36335]	[CIAR4]
Thistle, musk	[35787]	[CANU4]
Thistle, Russian	[20655]	[SAKA]
Thistle, Scotch	[38140]	[ONAC]
Timothy grass	[41062]	[PHPR3]
Toadflax, Dalmatian	[33219]	[LIDA]
Toadflax, yellow	[33216]	[LIVU2]
Tree of Heaven	[28827]	[AIAL]
Wheatgrass, crested	[40371]	[AGCR]
Woad, dyer's	[23151]	[ISTI]

OTHER	[XXXX] [XXXX]
% Cover Trace: < 1 % Low: 1 to 5 % Mod: 6 to 25 % High: 26 to 50 % Majority: 51 to 100 %	Menu, Required, Normal, weed canopy within infested area
Size 0.01 acres 0.1 acres 0.25 acres 0.5 acres 1.0 acres 2.5 acres 5.0 acres	Menu, Required, Normal, based on average perimeter diameter
Phenology Vegetative Bud Flower Fruit-immature Fruit-mature Seed dispersing Dormant/senesced	Menu, Required, Normal, weed growth stage
Woody Growth Seedling Sapling Mature Dormant/senesced	Menu, Normal, Normal, growth stage of woody species
Dominant Native Spp.	Text, Maximum Length = 30, 2-digit codes, 2 species, order of prevalence Normal, Normal
Disturbance None Low-Mod (default) High	Menu, Normal, Normal
Hydrology Upland (default) Rip-perennial Rip-intermittent Rip-ephemeral Wetland Playa-lakebed	Menu, Normal, Normal, site hydrology
Notes	Text, Maximum Length = 30 Normal, Normal
Date	Date, Auto generate Create, Month-Day-Year Format Normal, Normal

Time	Time, Auto generate Create, 24 Hour Format Normal, Normal
Ln-weed	Line Feature, Label 1 = Time
Species	Menu, Required, Normal

******See species list under pt-weed.

Line Width (ft)	Numeric, Decimal Places = 0, average width of linear area Minimum = 5, Maximum = 500, Default Value = 20 Required, Normal
Notes	Text, Maximum Length = 50 Normal, Normal
Time	Time, Auto generate Create, 24 Hour Format Normal, Normal
Date	Date, Auto generate Create, Month-Day-Year Format Normal, Normal
Ar-weed	Area Feature, Label 1 = Time GPS-generated polygon
Species	Menu, Required, Normal

******See species list under pt-weed.

Notes	Text, Maximum Length = 50 Normal, Normal
Time	Time, Auto generate Create, 24 Hour Format Normal, Normal
Date	Date, Auto generate Create, Month-Day-Year Format Normal, Normal
Gross-weed	Point Feature, Label 1 = Time, Office-generated polygon
Species	Menu, Required, Normal

******See species list under pt-weed.

Infested (% of Area Infested)	Numeric, Decimal Places = 0, (% of gross area actually infested) Minimum = 1, Maximum = 100, Default Value = 1 Required, Normal
% Cover (IA only) Trace: < 1 % Low: 1 to 5 % Mod: 6 to 25 % High: 26 to 50 % Majority: 51 to 100 %	Menu, Required, Normal, % weed cover in typical infestations
Area ID (# on map)	Numeric, Decimal Places = 0, From infestation ID # noted on field map Minimum = 1, Maximum = 100, Default Value = 1

	Required, Normal
Notes	Text, Maximum Length = 50 Normal, Normal
Date	Date, Auto generate Create, Month-Day-Year Format Normal, Normal
Time	Time, Auto generate Create, 24 Hour Format Normal, Normal
Point	Point Feature, Label 1 = Notes
Notes	Text, Maximum Length = 50 Normal, Normal
Line	Line Feature, Label 1 = Notes
Notes	Text, Maximum Length = 50 Normal, Normal
Area	Area Feature, Label 1 = Notes Text, Maximum Length = 50 Normal, Normal
Photo	Point Feature, Label 1 = Notes, Label 2 = Bearing (MN)
Species	Menu, Required, Normal

******See species list under pt-weed.

Bearing (MN)	Numeric, Decimal Places = 0 Minimum = 0, Maximum = 360, Default Value = 0 Normal, Normal
Notes	Text, Maximum Length = 50 Normal, Normal
Date	Date, Auto generate Create, Month-Day-Year Format Normal, Normal
Time	Time, Auto generate Create, 24 Hour Format Normal, Normal
Voucher	Point Feature, Label 1 = Notes
Species	Menu, Required, Normal

******See species list under pt-weed.

Notes	Text, Maximum Length = 50 Normal, Normal

Appendix C. Relationship of NCPN Project Data Elements to IMR and NAWMA Weed Mapping Standards used in 2003-2004 Invasive Non-native Plant Inventory in Arches National Park.

Relationship of NCPN Weed Mapping Project Database Elements to proposed IMR Weed Mapping Data Elements and NAWMA Standards. Column labeled 'NCPN Data Element Status' indicates whether or not data element were included in NCPN Weed Mapping Database. If data element was included (=YES) an indication is made whether or not the data was field collected or compiled in an office setting.

CATEGORY	*DATA ELEMENTS*	NPS Intermountain Region	NAWMA	NCPN Data Element Status	NCPN Data Source	Comments
AGENCY METADATA	1. Collection Date (yyyymmdd)	Required	Required	YES	Field	
	2. Source of Data (contact of individual who manages data)	Required	Required	YES	Office	Included in metadata only
	3. Scale of Data Source	Required (recommend 1:24000)	Required (recommend 1:24000)	YES	Office	Included in metadata only
	4. Datum of Original Data (N_{27}/N_{83})	Required	N/A	YES	Office	Included in metadata only
	5. Surveyor Name	Optional	Optional	YES	Field	
	6. Site ID (Name or Number)	Optional	Optional	YES	Field	
	7. Quality Control Assessment (Yes/No)	Optional	N/A	(yes)	Office	This will be done but not entered as a data field.
	8. Methodology Used For Inventory (casual observation/formal survey/remote)	Optional	Optional	YES	Office	Included in metadata only
INVASIVE SPECIES INFORMATION	1. Plant Scientific Name (Genus/species) a. Intraspecific Name b. Authority for Name	Required a. Optional b. Optional (Recommend Kartez)	Required a. Optional b. Required (Kartez)	YES	Field	Scientific Name only
	2. ITIS Code (allows for link to NPSpecies)	Required	N/A	YES	Office	ITIS code will allow linkage to authority, common name, state status etc.
	3. Common Name	Optional	Optional	YES	Office	
	4. Plant Code (Based on USDA "PLANTS" web Database)	Optional	Optional	NO		ITIS is cross-walked with PLANTS database.
	5. Species Status a. State listed noxious weed b. Species of concern to park	Optional	Optional	NO		
	6. Species On Priority List For Park (Yes/No)	Optional	Optional	NO		

LOCATION DATA (For Survey Unit and Each Weed Population	1. Country (USA/Canada/Mexico)	*Required*	Required	YES	Office	
	2. State (2-Letter Code)	Required	Required	YES	Office	
	3. County	Required	Required	YES	Office	
	4. Site Location (Lat/Long/ UTM/legal)	Required (UTM preferred)	Required	YES	Field	
	5. USGS 7.5 Quad Name	Optional	Optional	NO		This is readily available in GIS
	6. USGS 7.5 Quad Number	Optional	Optional	NO		This is readily available in GIS
	7. Hydrologic Unit Code (HUC#) for watershed	Required for aquatic invasives only	Required for aquatic invasives only	NO		This is readily available in GIS
	8. NPS LOCATION DATA a. Park Unit (4-letter code) b. Park Subunit c. Network Name d. Region e. Weed Management Area f. Other	a. Required b. Optional c. Required d. Required e. Optional f. Optional	N/A	a. YES b. NO c. YES d. NO e. NO f. NO	Office Office	
CHANGES IN SPECIES POPULATION OVER TIME	1. Infested Area a. Unit of Measure (Acre or Hectare)	Required a. Required	Required a. Required	YES	Field	
	2. Gross Area a. Unit of Measure (Acre or Hectare)	Optional a. Optional	Optional a. Optional	YES	Field	
	3. Canopy Cover (% Aerial) A. Type of Measurement (actual/estimated/mid-pt of cover class)	Required a. Required	Required a. not used	YES	Field	
	4. Distribution (light/moderate/heavy) (density)	Optional	N/A	YES	Field	Note: USU will experiment with defining a useful density characterization here – possibly by species
	5. Phenology (Vegetative/ flower/seed/senesced)	Optional	N/A	YES	Field	
	6. Distance to Water (horizontal & vertical	Optional	N/A	NO		
	7. Management Actions Taken (Manual/Chemical/BioControl/Domestic Livestock) a. Date of Action b. % of Population treated (1-25)(/26-50)(51-75)(76-100)	Optional a. Optional b. Optional	N/A	NO		
	8. Site Undergoing Active or Inactive Management	Optional	N/A	NO		

SITE ENVIRONMENTAL INFORMATION	ABIOTIC DATA	1. Elevation (Avg, max/min) - Unit of Measure (feet/meters)	Optional (highly recommended)	N/A	YES	Field	Also available in GIS
		2. Aspect	Optional (highly recommended)	N/A	NO		Can be derived in GIS
		3. Percent Slope - Actual or estimated	Optional (highly recommended)	N/A	NO		Can be derived in GIS
		4. Slope Position (top 1/3, mid 1/3, low, 1/3, toe)	Optional (highly recommended)	N/A	NO		Not a helpful data field – too variable, also can be derived in GIS
		5. Soil Type	Optional (highly recommended)	N/A	NO		Field crews not knowledgeable about soils. Can be derived from soil maps.
		6. Landform	Optional (highly recommended)	N/A	NO		We tried this last year, too much variation & difficult to interpret. Data quality not sufficient.
		7. Geologic Substrate	Optional (highly recommended)	N/A	NO		Can be derived in GIS from geologic maps.
		8. Climate (Develop Link to Separate Table with Avg. Temp & Precip.)	Optional (highly recommended)	N/A	NO		Tabular and spatial climate data are available for GIS analysis.
	BIOTIC DATA	1. Life Form (Grass/Forb/Shrub/Tree)	Required	N/A	YES	Office	
		2. Ecological Status	Required	N/A	YES	Field and Office	
		3. Values At Risk	Required	N/A	NO		Relationship of weed occurrences to resource values can be derived through GIS analysis as needed.
		4. Vegetation Classification	Optional (highly recommended)	N/A	NO		Vegetation classifications not available yet for NCPN parks
		5. Dominant Associated Species	Optional (highly recommended)	N/A	YES	Field	
		6. Cover Type	Optional (highly recommended)	N/A	NO		Standard cover type classifications not yet being applied in NCPN parks.
		7. Habitat Type	Optional (highly recommended)	N/A	NO		Not applicable to NCPN parks.
		8. Seral Stage	Optional (highly recommended)	N/A	NO		These relationships not described for NCPN parks.
		9. Disturbances *(See Below)	Optional (highly recommended)	N/A	(yes)	Field and office	Describe for broader survey areas, but only generally at polygon or point level

Appendix D. GPS Settings using in 2003-2004 Invasive Non-native Plant Inventory in Arches National Park

System / Setup

Configurations

Data

Log between features:	Distance, 500 ft, (Set at surveyor's discretion)
Log PPRT data:	No
Log velocities:	No
Antenna height	4 ft
Allow GPS update	Yes
Warning distance:	Never
Filename prefix:	R

GPS

(Advanced mode window)	
PDOP mask:	6.0 (Can be higher in areas where satellite reception is difficult, GPS will take best PDOP if set at a higher number)
SNR mask:	4.0
Elevation mask	15 deg
Minimum satellites	4
2D altitude	N/A

Real Time

Mode	Best available
Velocity filter	Off
RTCM age limit	50 s
Station ID	Any

Coordinates

System	UTM
Zone	12 North
Datum	NAD 1927 (Western U.S.)
Altitude reference	MSL
Geoid:	DMA 10x10 (Global)
Coordinate units	Meters
Altitude units	Feet

Units

Distance	Feet
Area	Acres
Velocity	Miles/Hour
Angle	Degrees
North reference	True
Declination	Auto

Formats

Language	English
Offset	Horz/Vert
Degrees	DD-MM-SS-ss
Date	YYYY/MM/DD
Time	12 Hour

Time Zone	-06.00 (daylight savings, Mtn Zone)
Coordinate order	North/East
COMMS	
Data transfer	Support module (must change to "Serial clip" when using clip)
RTCM input	Off
NMEA output	Off
Port settings	
Input baud rate	N/A
Output baud rate	N/A
Data bits	N/A
Stop bits	N/A
Parity	N/A
Other	
Beep volume	On
NMEA output interval	5s
NMEA messages	
GGA	Yes
VTG	Yes

Data Dictionaries

(Select NCPN-04)

Feature Settings

(Do not adjust. Interval and minimum positions are set in office upon creation of dictionary)

About

(Nothing to set here)

Reset (Do not adjust. It will reset everything to factory defaults)

Appendix E. Photograph and list of equipment used in 2003-2004 Invasive Non-native Plant Inventory in Arches National Park.

Equipment



- Trimble Geo3 Explorer GPS units
- Laser Range Finder
- Binoculars
- Clinometer
- Compass
- Calculator
- 2-way Radios
- Cellular Phone
- Field notebook
- Field Sheets
- Uinta Basin Flora and other plant taxonomic keys
- Plant dissection kits
- Hand lens
- Collection bags
- Topographic maps
- Geology maps
- 35-mm camera and slide film
- Surveyor marking ribbon

Appendix F. Dominant Vegetation Types Key used in 2003-2004 Invasive Non-native Plant Inventory, Arches National Park

Key Code	Common Name	Scientific Name	Class Type
10	Rocky Mountain maple	Acer glabrum	T
11	boxelder	Acer negundo	T
12	Utah juniper, white cedar, bone-seed juniper	Juniperus osteosperma	T
13	Rocky Mountain juniper, R. Mtn. red cedar	Juniperus scopulorum	T
14	piñon, piñon pine, pinyon pine	Pinus edulis	T
15	ponderosa pine, Western yellow pine	Pinus ponderosa	T
16	Douglas fir	Pseudotsuga menziesii	T
17	narrow-leaf cottonwood, alamo sauco	Populus angustifolia	T
18	Fremont cottonwood, alamo	Populus fremontii	T
19	hackberry, net-leaf hackberry	Celtis reticulata	T
20	Gambel Oak	Quercus gembelii	T
21	Singleaf ash	Fraxinus anomala	T
22	*Add up to #29*		T
30	Basin big sagebrush, chamiso hediondo	Artemisia tridentata	S
31	spreading rabbitbrush	Chrysothamnus linifolius	S
32	rubber or gray rabbitbrush, chamiso blanco	Chrysothamnus nauseosus	S
33	gray horsebrush	Tetradymia canescens	S
34	mountain alder, thin-leaf alder	Alnus incana	S
35	red birch, river birch, water birch	Betula occidentalis	S
36	mountain snowberry	Symphoricarpos oreophilus	S
37	four-wing saltbush, chamiso	Atriplex canescens	S
38	hopsage, spiny hopsage, applebush	Grayia spinosa	S
39	greasewood, black greasewood	Sarcobatus vermiculatus	S
40	red osier dogwood	Cornus stolonifera	S
41	Torrey ephedra, Mormon tea, popotillo	Ephedra torreyana	S
42	green ephedra, Mormon tea, cañutillo	Ephedra viridis	S
43	serviceberry, Saskatoon serviceberry	Amelanchier alnifolia	S
44	Utah serviceberry	Amelanchier utahensis	S
45	dwarf or little-leaf mountain mahogany	Cercocarpus intricatus	S
46	curl-leaf mountain mahogany	Cercocarpus ledifolius	S
47	true or birch-leaf mountain mahogany	Cercocarpus montanus	S
48	chokecherry, capulin	Prunus virginiana	S
49	bitterbrush, antelope bitterbrush	Purshia tridentata	S
50	wild rose, Woods rose	Rosa woodsii	S
51	Salix sp.?	Willow	S
52	tamarisk, tamarix, salt cedar	Tamarix ramosissima	S
53	Mazanita sp.	Arctostaphylos sp	S
54	Three-leaf sumac	Rhus trilobata	S
55	Seep-willows	Baccharis sp	S
56	Apache plume	Fallugia paradoxa	S
57	Cliffrose	Cowania stansburiana	S
58	Shrub oaks	Quercus sp.	S
59	*Add up to #59*		S
60	Bigelow sagebrush	Artemisia bigelovii	DS
61	black sagebrush	Artemisia nova	DS
62	rough brickellbush	Brickellia microphylla	DS
63	mountain low rabbitbrush, green rabbitbrush	Chrysothamnus viscidiflorus	DS
64	broom snakeweed, matchbrush	Gutierrezia sarothrae	DS
65	hairy goldenaster	Heterotheca villosa	DS
66	mountain peppergrass	Lepidium montanum	DS
67	shadscale	Atriplex confertifolia	DS
68	mat saltbush, mat atriplex	Atriplex corrugata	DS
69	winterfat, white sage, winter sage	Ceratoides lanata	DS
70	*Add up to #79*		DS
80	prairie sage, Louisiana sage, estafiate	Artemisia ludoviciana	H

Appendix F. Dominant Vegetation Types Key used in 2003-2004 Invasive Non-native Plant Inventory, Arches National Park

Key Code	Common Name	Scientific Name	Class Type
81	arrow-leaf balsamroot	Balsamorhiza sagittata	H
82	Russian thistle, tumbleweed, tumbling thistle	Salsola iberica	H
83	bluebunch wheatgrass	Agropyron spicatum	H
84	slender wheatgrass	Agropyron trachycaulum	H
85	cheatgrass, downy chess, cheat	Bromus tectorum	H
86	Idaho fescue	Festuca idahoensis	H
87	Indian ricegrass, ricegrass	Oryzopsis hymenoides	H
88	needle-and-thread grass	Stipa comata	H
89	Wyoming big sagebrush	Artemisia tridentata var. wyomingensis	S
90	Mountain big sagebrush	Artemisia tridentata var. vaseyana	S
91	Common reed	Phragmites australis	H
92	Horsetail	Equisetum laevigatum	H
93	Cattail	Typha latifolia	H
99	Other		
99	Needlegrass (accidentally used in COLM for short time)	Stipa comata	H

Appendix G. Project Photographs of Weed Species Detected, Inventoried Landscapes, and Crew working in Arches National Park during the 2003-2004 Invasive Non-native Plant Inventory.

Weeds Detected

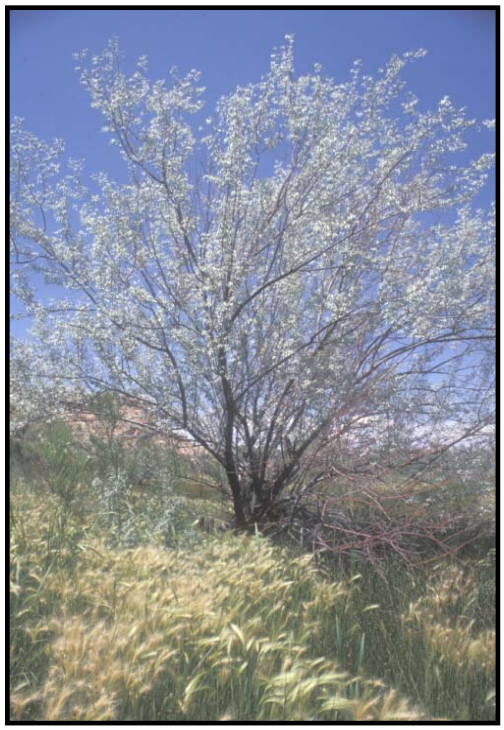


Photo 1. *Elaeagnus angustifolia* in Salt Wash. (ARCH PR-10), 2003.



Photo 2. *Elaeagnus angustifolia* surrounded by *Hordeum jubatum* in Salt Wash. (ARCH PR-10), 2003.



Photo 3. *Halogeton glomeratus* in alkali salt flat. (ARCH PR-9), 2003.



Photo 4. *Halogeton glomeratus* on alkali soils along Salt Wash. (ARCH PR-9), 2003.

Weeds Detected



Photo 5. *Tamarix ramosissima* in flower in Salt Wash. (ARCH PR-1), 2003.



Photo 6. One of many mature *Tamarix ramosissima* along Salt Wash. (ARCH PR-2), 2003.

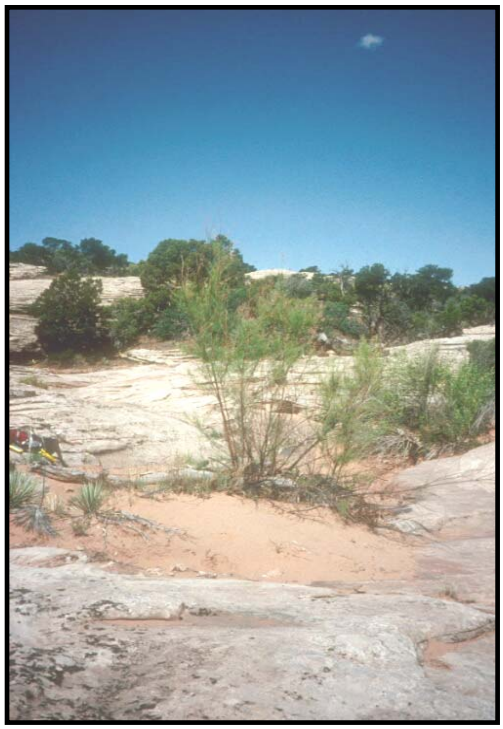


Photo 7. *Tamarix ramosissima* sapling along Fin Canyon. (ARCH PR-29), 2003.



Photo 8. *Tamarix ramosissima* in a side canyon east of Lost Spring Canyon. (ARCH PR-20), 2003.

Weeds Detected



Photo 9. *Tamarix ramosissima* in Herdina Park, (R40F05, No photo point), 2004.



Photo 10. *Tamarix ramosissima* in draw to Willow Spring, (ARCH PR-45b), 2004.

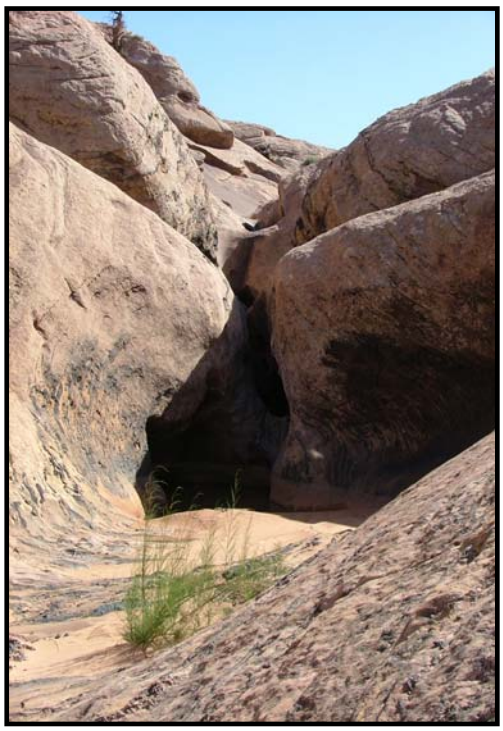


Photo 11. *Tamarix ramosissima* in draw to Willow Spring, (ARCH PR-45), 2004.

Weeds Detected



Photo 12. *Centaurea repens* in flower. (ARCH PR-3), 2003.



Photo 13. *Centaurea repens* growing at base of *Tamarix ramosissima* in Salt Wash. (ARCH PR-3), 2003.



Photo 14. *Centaurea repens* in flower. (ARCH PR-6), 2003.



Photo 15. *Centaurea repens* growing along the flower of Salt Wash. (ARCH PR-6), 2003.

Weeds Detected



Photo 16. Dense patch of *Centaurea repens* growing along Salt Wash. (ARCH PR-15), 2003.



Photo 17. *Hordeum jubatum* growing underneath *Tamarix ramosissima* in Salt Wash. (ARCH PR-8), 2003.



Photo 18. *Hordeum jubatum* and *Tamarix ramosissima* in the bottom of Salt Wash. (ARCH PR-8), 2003.



Photo 19. *Hordeum jubatum* and *Tamarix ramosissima* along Salt Wash. (ARCH PR-4), 2003.

Weeds Detected



Photo 20. *Xanthimum strumarium* found in side canyon east of Lost Spring Canyon. (ARCH PR-21), 2003.



Photo 21. *Sonchus oleraceus*, 2003. **



Photo 22. *Convolvulus arvensis*, 2003. **



Photo 23. *Rumex crispus*, 2003. **

** Photos not taken in Arches National Park, but representative of plants found and mapped.

Weeds Detected



Photo 24. *Amaranthus albus*, 2003. **



Photo 25. Sisymbrium altissimum, 2003**. ****

** Photos not taken in Arches National Park, but representative of plants found and mapped.

Arches Landscapes



Photo 26. Looking southeast at Eagle Park. (ARHC PR-16), 2003.



Photo 27. View SSE of Eagle Park, 2003.



Photo 28. Side canyon east of Eagle Park. (ARCH PR-27), 2003.



Photo 29. Looking south down Salt Wash. (ARCH PR-17), 2003.

Arches Landscapes



Photo 30. Looking upstream and north at Salt Wash and Cache Valley Wash. (ARCH PR-17), 2003.



Photo 31. A thick stand of *Tamarix ramosissima* lines the bottom of Salt Wash looking north. (ARHC PR-7), 2003.



Photo 32. Looking north, *Tamarix ramosissima* and *Hordeum jubatum* line the bottom of Salt Wash., 2003.



Photo 33. View of greasewood in Salt Wash, 2003.

Arches Landscapes



Photo 34. Greasewood covers the dry benches above Salt Wash. (ARCH PR-5), 2003.



Photo 35. Coyote skull found on dry bench above Salt Wash, 2003.



Photo 36. Looking up Lost Spring Canyon. (ARCH PR-23), 2003.



Photo 37. Side canyon east of Lost Spring Canyon. (ARCH PR-22), 2003.

Arches Landscapes



Photo 38. Looking up the left fork of Fish Seep Draw. (ARCH PR-34), 2003.

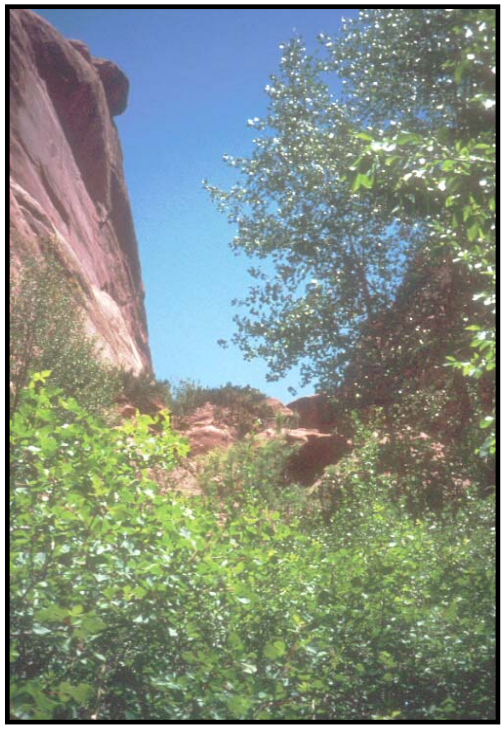


Photo 39. Right fork of Fish Seep Draw looking downstream. (ARCH PR-36), 2003.

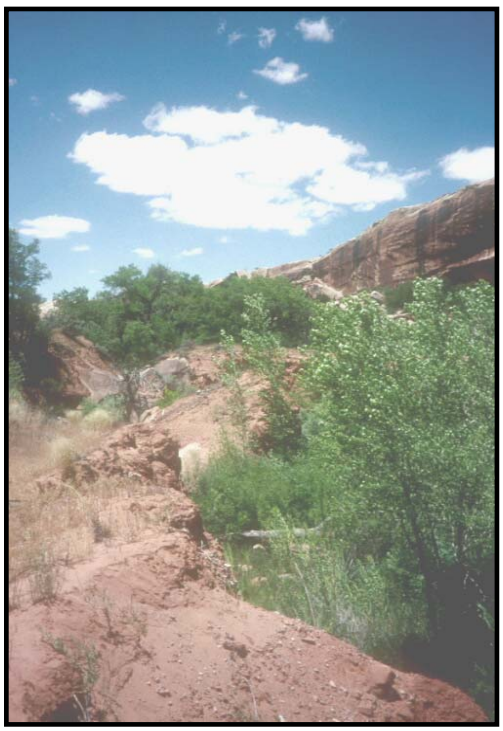


Photo 40. Clover Canyon looking west. (ARCH PR-32), 2003.



Photo 41. Fin Canyon. (ARCH PR-37), 2003.

Arches Landscapes



Photo 42. Fin Canyon survey area. (ARCH PR-30), 2003.



Photo 43. View of Courthouse Wash with the Tower of Babel in the background, 2003.



Photo 44. Looking northwest up Courthouse Wash, where the wash crosses the main road, 2003.



Photo 45. Looking southeast at the benches of Courthouse Wash. (ARCH PR-13), 2003.

Arches Landscapes



Photo 46. View of side canyon in Courthouse Wash. (ARCH PR-13), 2003.



Photo 47. Western park boundary in Sevenmile Canyon, 2003.



Photo 48. View of Courthouse Wash looking south. (ARCH PR-12), 2003.



Photo 49. Large alcove in Seven Mile Canyon. (ARCH PR-11), 2003.

Arches Landscapes

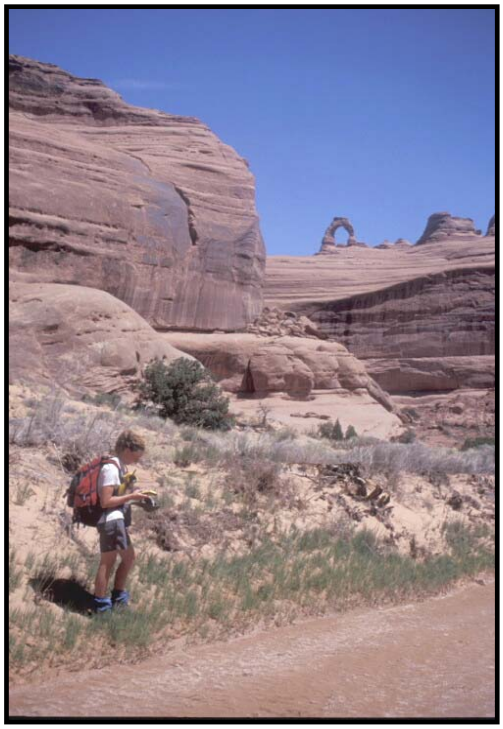


Photo 50. Kim Andersen mapping *Tamarix ramosissima* in Winter Camp Wash, 2003.

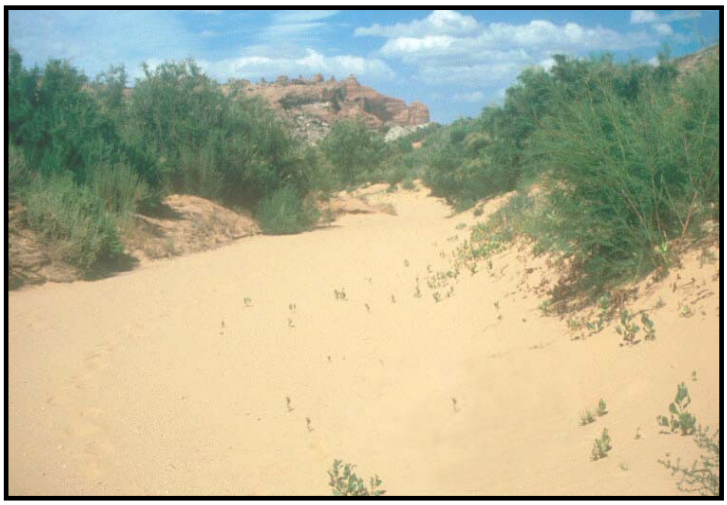


Photo 51. View of Winter Camp Wash lined with *Tamarix ramosissima*, 2003.

Arches Landscapes



Photo 52. Kim Andersen inventorying in Herdina Park, 2004.



Photo 53. Kim Andersen below large cottonwood in Herdina Park, 2004.



Photo 54. Looking toward Willow Spring (ARCH PR- 46), 2004.

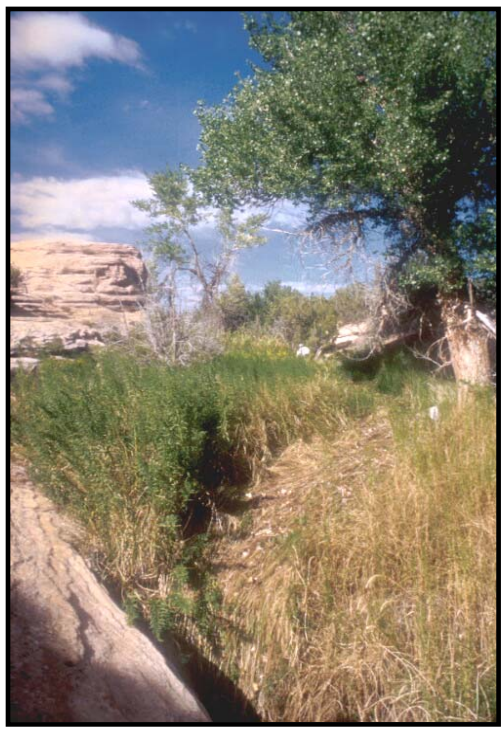


Photo 55. Willow Spring (ARCH PR-41), 2004.

Crew



Photo 56. Liz Ballenger taking field notes in Eagle Park. (ARCH PR-24), 2003.



Photo 57. Heather Rickleff surveying for weeds in side canyon of Eagle Park. (ARCH PR-26), 200..



Photo 58. Melanie Ballard, Janna Simonsen, and Ruth Richards checking their GPS configurations before surveying Courthouse Wash, 2003.



Photo 59. USU crew heading into Courthouse Wash, 2003.

Crew



Photo 60. Janna Simonsen mapping *Centaurea repens* in Salt Wash, 2003.



Photo 61. Janna Simonsen searching in greasewood on the bench above Salt Wash, 2003.

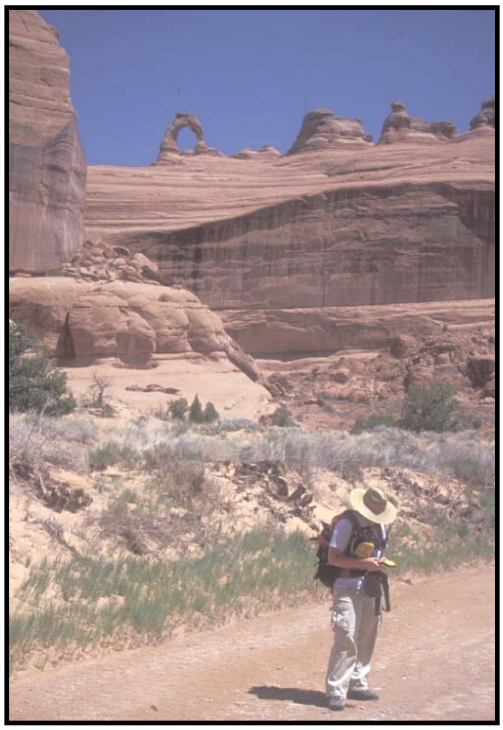


Photo 62. Ruth Richards mapping *Tamarix ramosissima* in Winter Camp Wash, 2003.



Photo 63. Eric Lamalfa in Courthouse Wash, 2003.

Crew

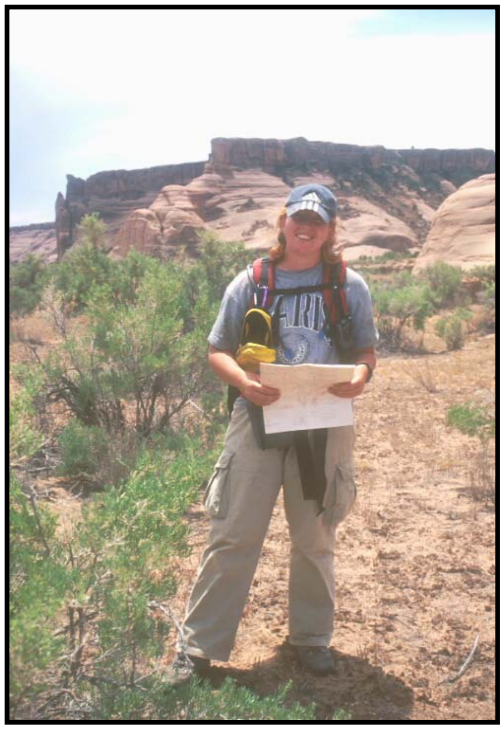


Photo 64. Ruth Richards checking her location in Salt Wash, 2003.

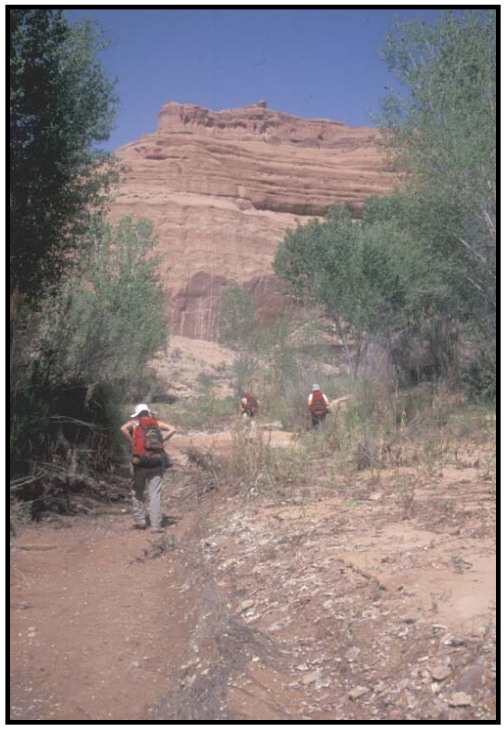


Photo 65. USU crew heading down Courthouse Wash, 2003.



Photo 66. Kim Andersen climbing up a slot in Winter Camp Wash, 2003.

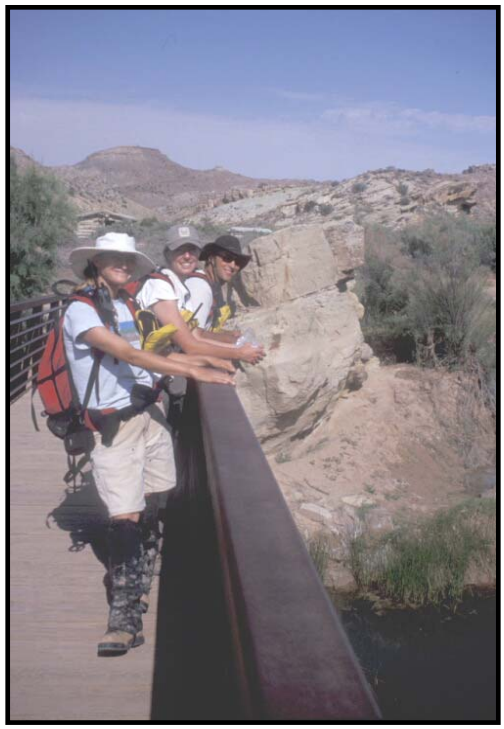
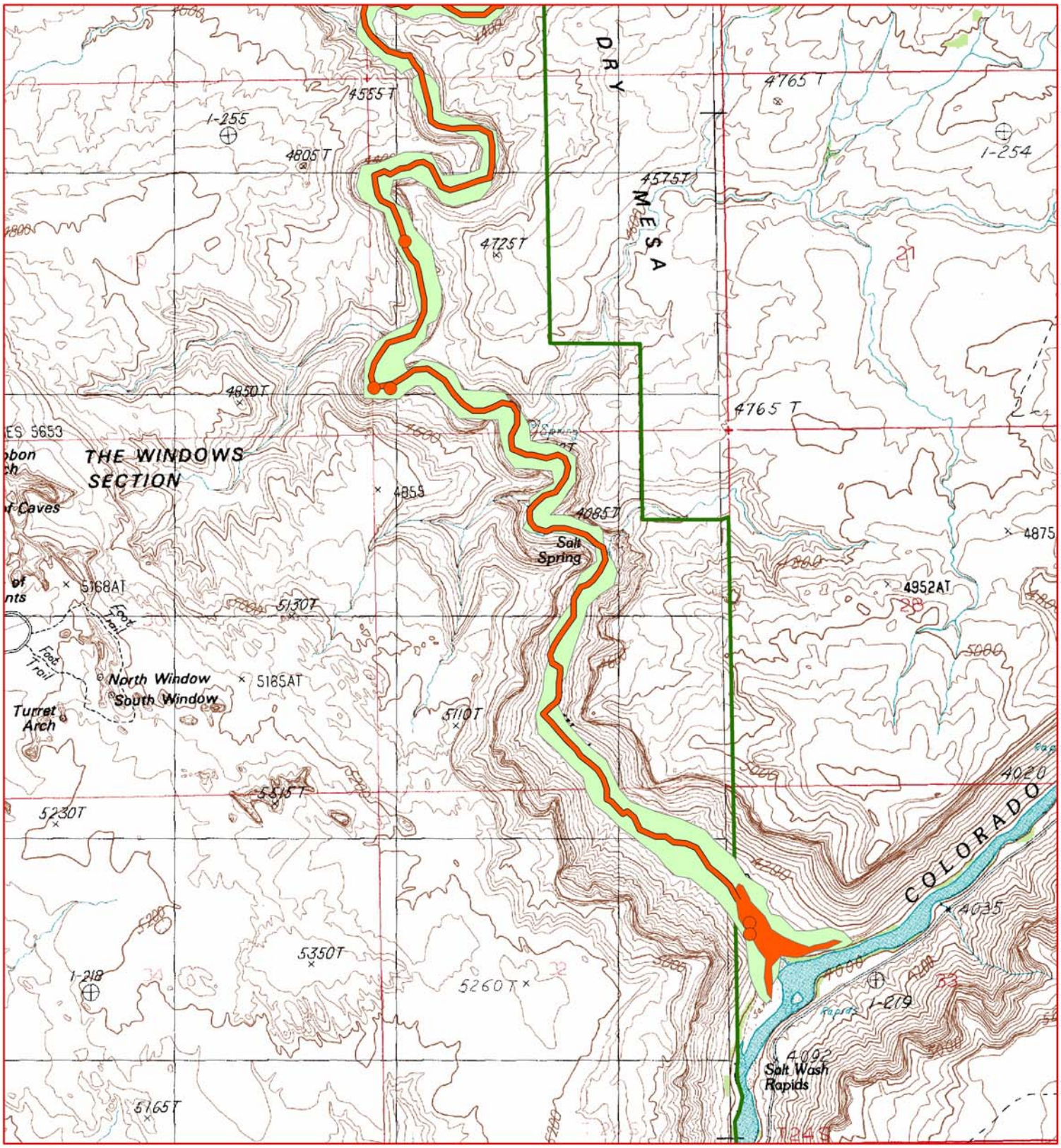


Photo 67. The crew at the bridge over Salt Wash near Wolfe Ranch, 2003.

H-1. Overall Weed Distribution in Inventoried Areas - Salt Spring (Inset A)



Weed Points
Line Weeds
Weed Areas
Area Inventoried
Park Boundary

0 2,000 4,000 Feet

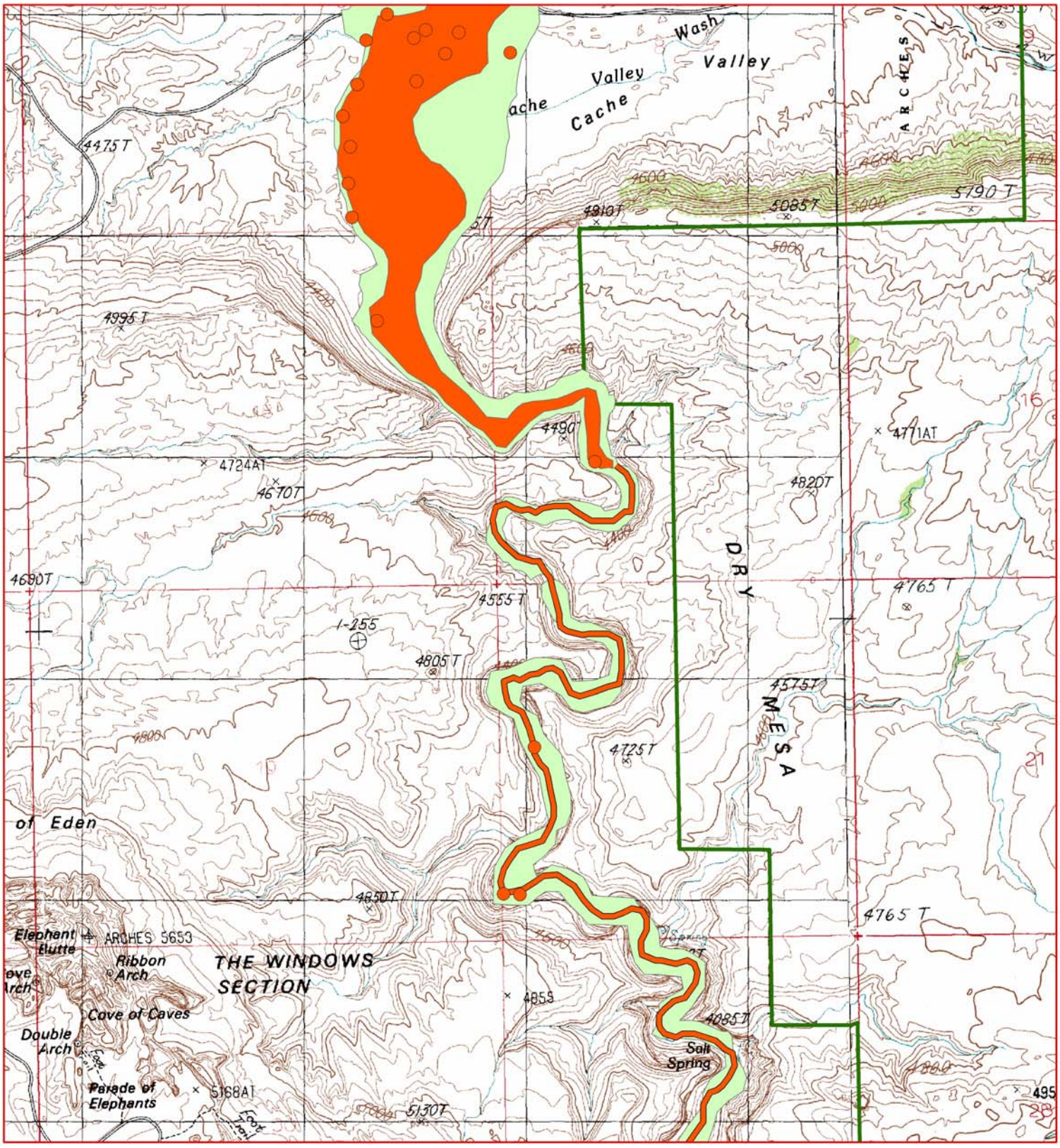
1:24,000 Scale

N

H-1

Inset A
Utah State University
Arches National Park
2003 - 2004 Invasive Non-native Plant Inventory
Northern Colorado Plateau Network

H-2. Overall Weed Distribution in Inventoried Areas - Salt Wash (Inset B)



Weed Points
Line Weeds
Weed Areas
Area Inventoried
Park Boundary

0 2,000 4,000 Feet

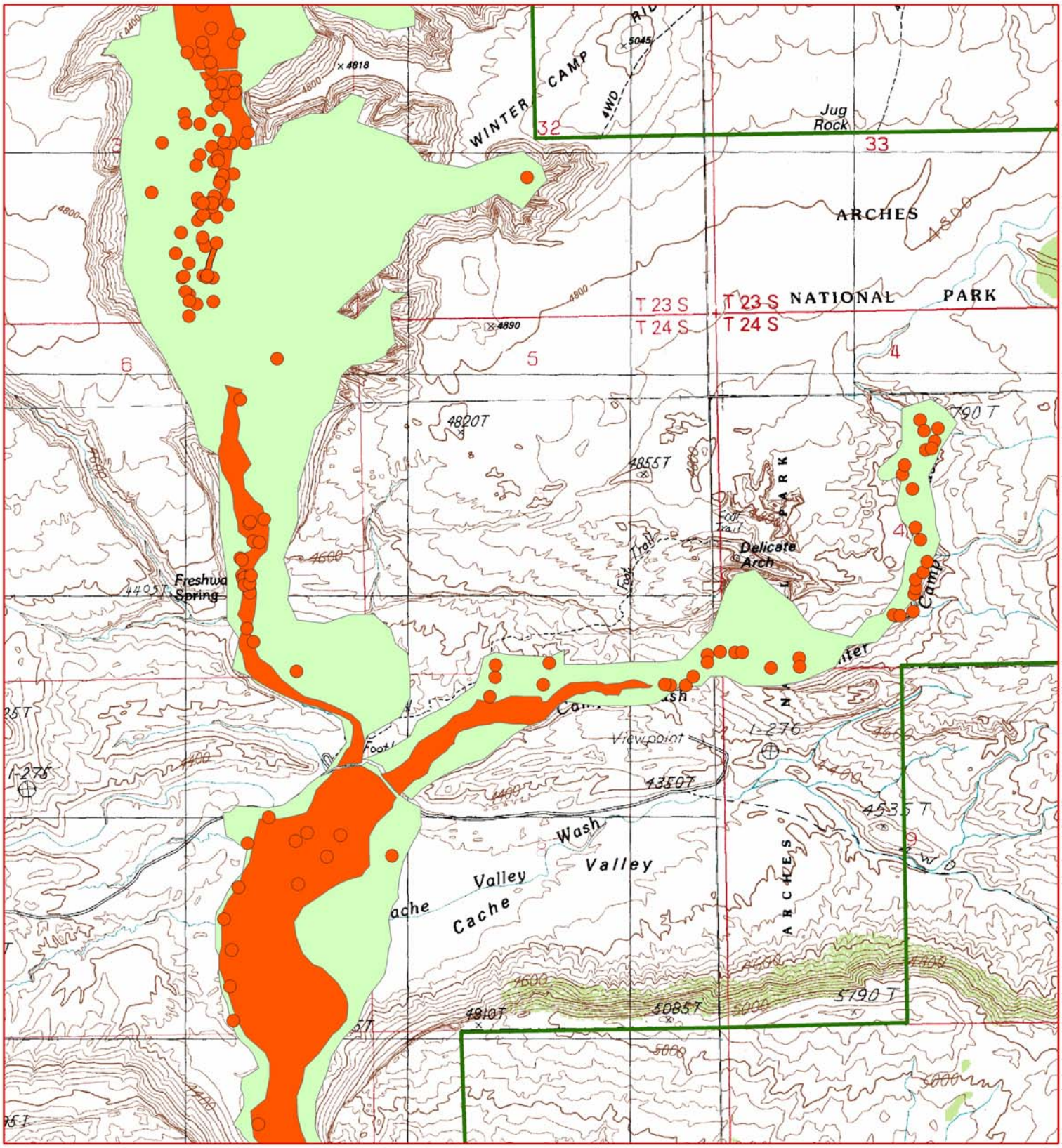
1:24,000 Scale

N

H-2

Inset B
Utah State University
Arches National Park
2003 - 2004 Invasive Non-native Plant Inventory
Northern Colorado Plateau Network

H-3. Overall Weed Distribution in Inventoried Areas - Winter Camp Wash (Inset C)



Weed Points
Line Weeds
Weed Areas
Area Inventoried
Park Boundary

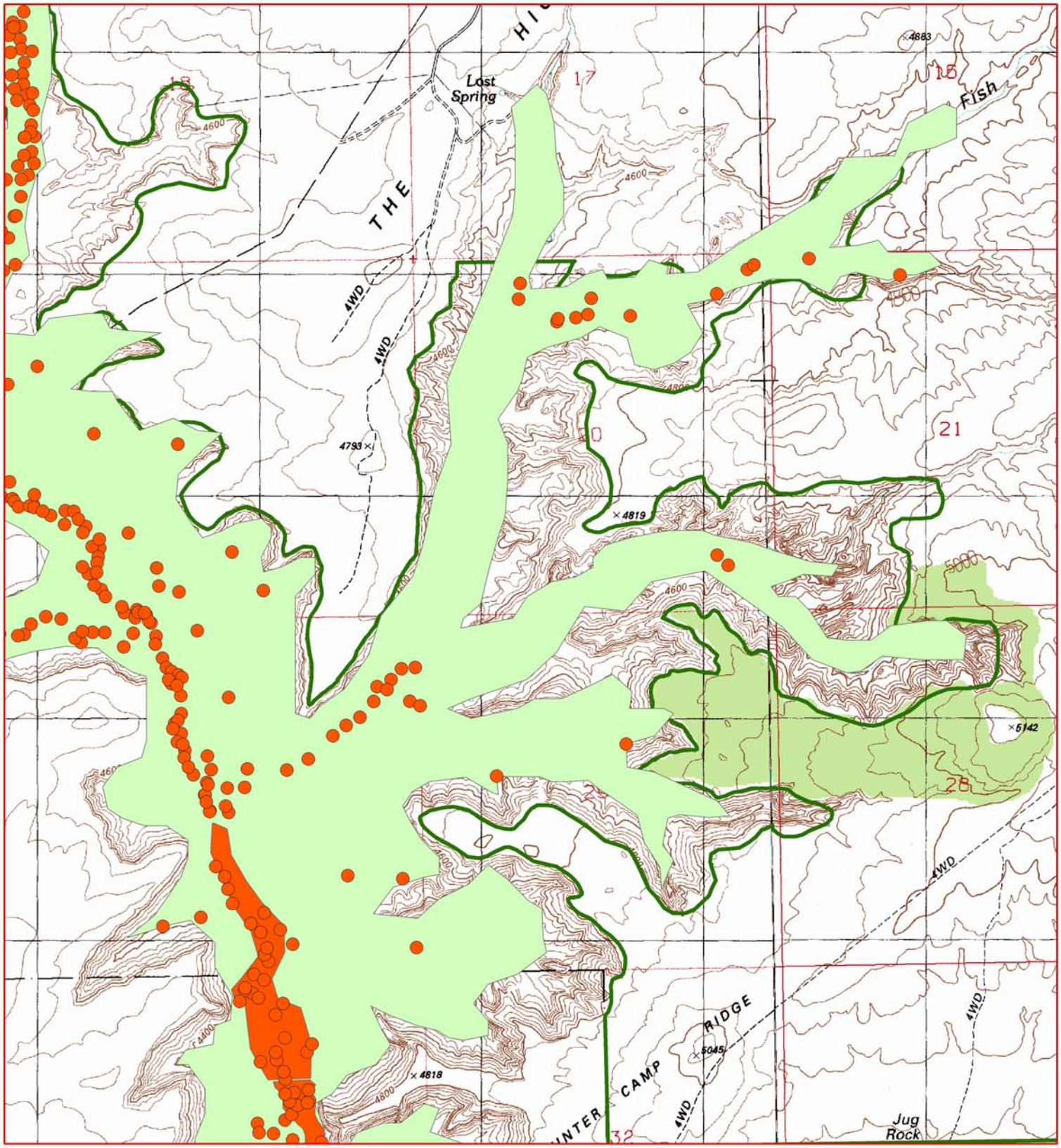
0 2,000 4,000 Feet

1:24,000 Scale

N

Inset C
Utah State University
Arches National Park
2003 - 2004 Invasive Non-native Plant Inventory
Northern Colorado Plateau Network

H-4. Overall Weed Distribution in Inventoried Areas - Lost Spring Canyon (Inset D)



Weed Points
Line Weeds
Weed Areas
Area Inventoried
Park Boundary

0 2,000 4,000 Feet

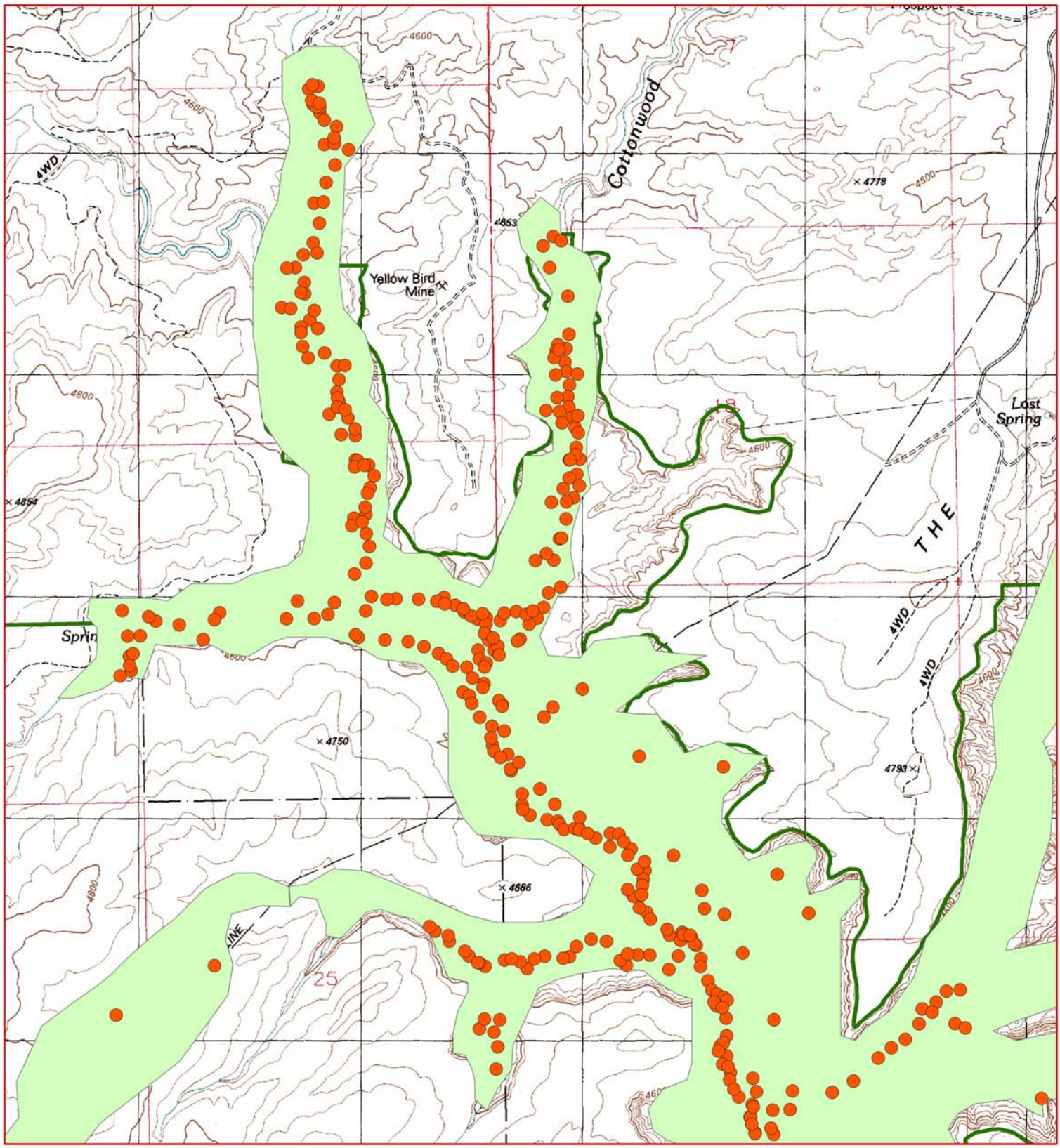
1:24,000 Scale

N

H-4

Inset D
Utah State University
Arches National Park
2003 - 2004 Invasive Non-native Plant Inventory
Northern Colorado Plateau Network

H-5. Overall Weed Distribution in Inventoried Areas - Cordova Canyon (Inset E)



Weed Points

Area Inventoried

Park Boundary

0 2,000 4,000 Feet

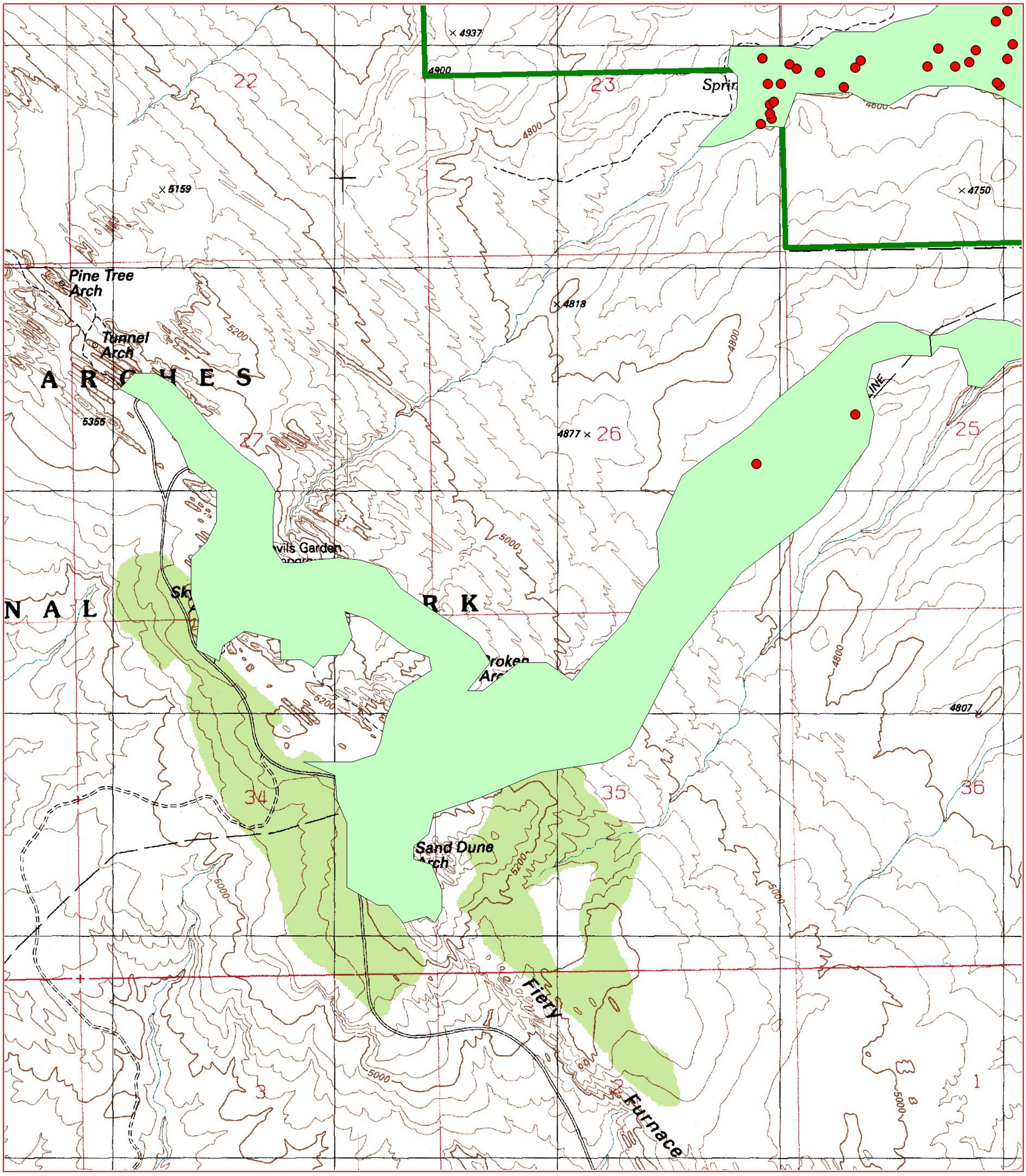
1:24,000 Scale

N

H-5

Inset E
Utah State University
Arches National Park
2003 - 2004 Invasive Non-native Plant Inventory
Northern Colorado Plateau Network

H-6. Overall Weed Distribution in Inventoried Areas - Clover Canyon (Inset F)



Weed Points

Area Inventoried

Park Boundary

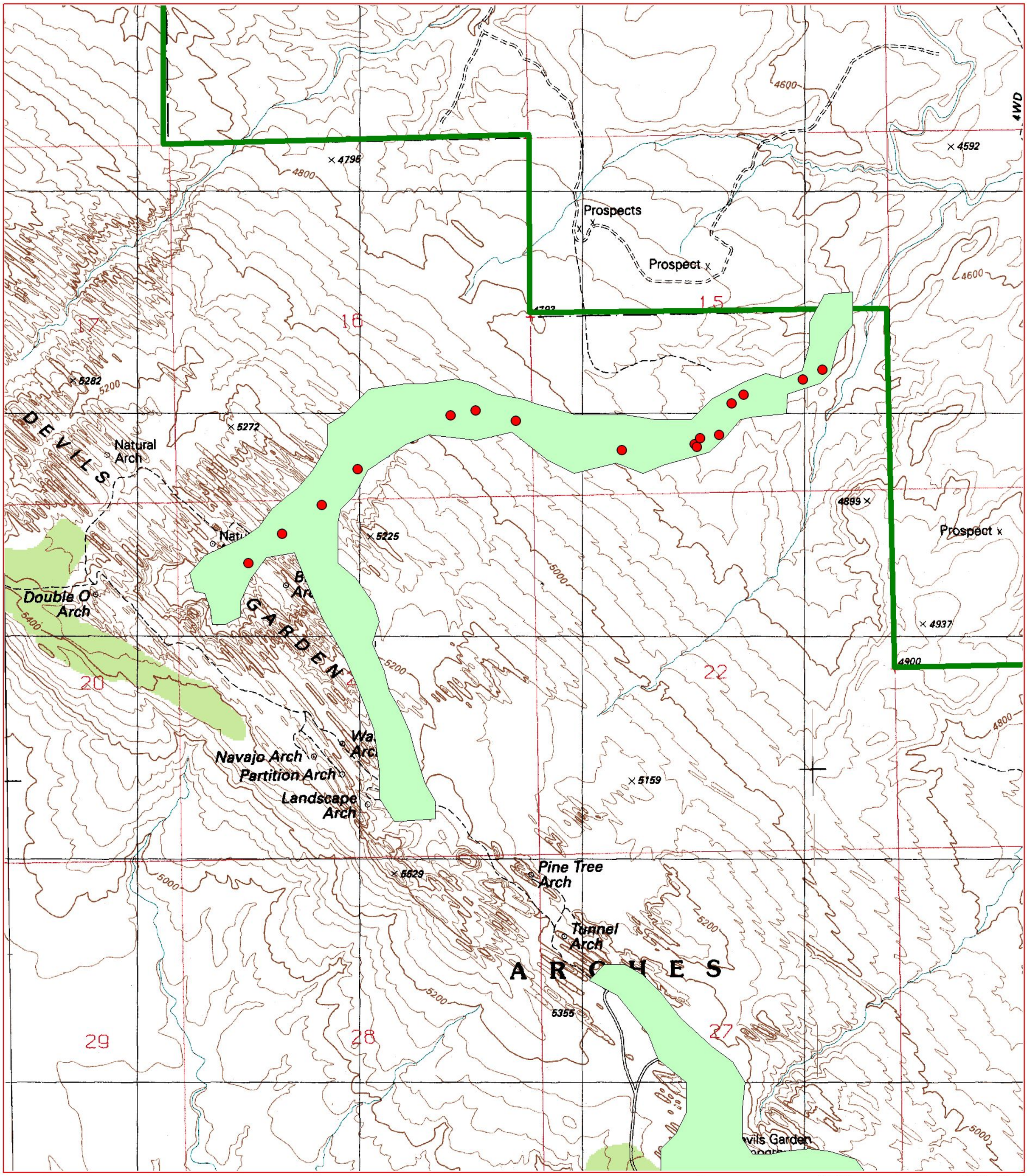
1:24,000 Scale

N

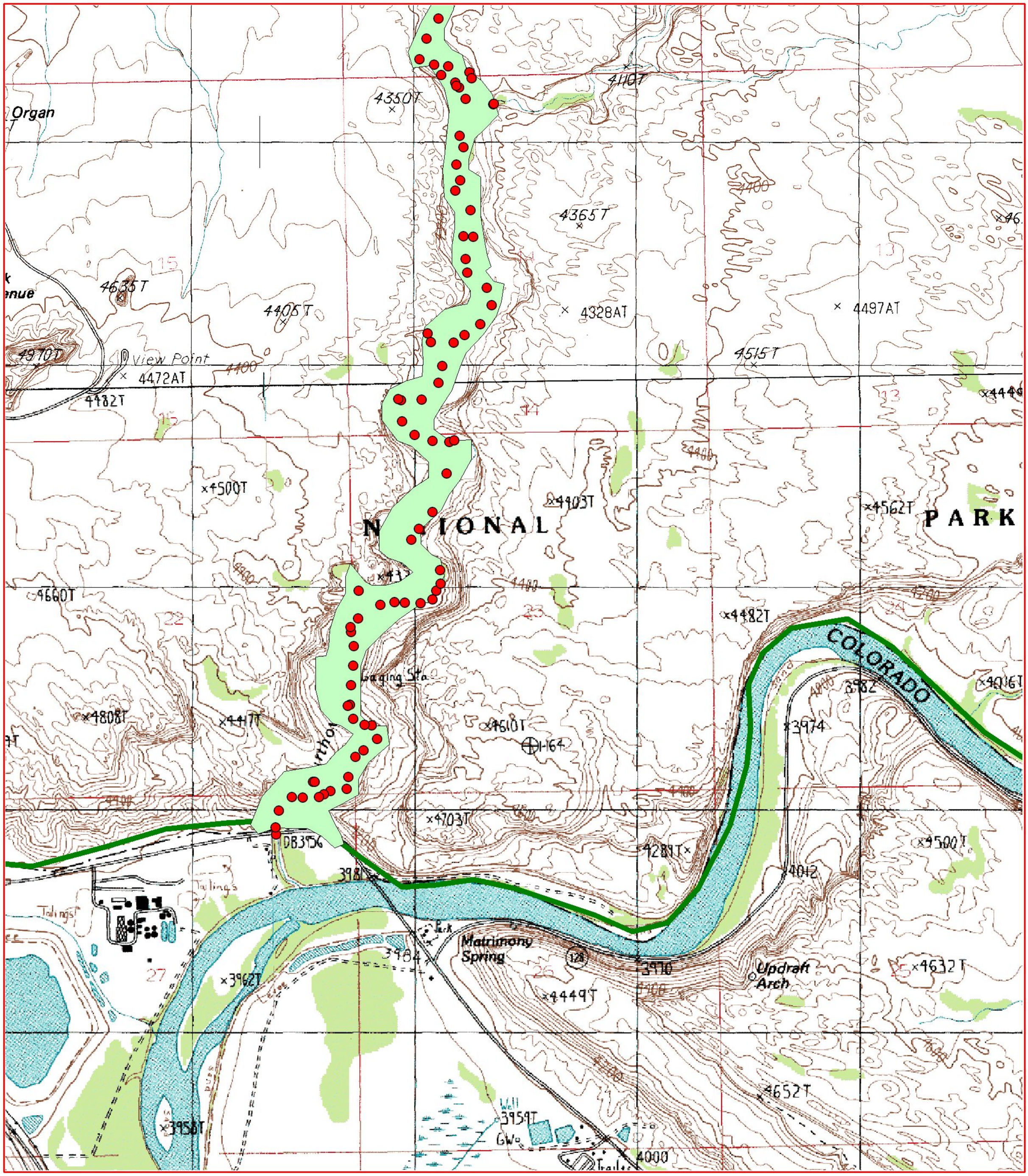
H-6

Inset F
Utah State University
Arches National Park
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

H-7. Overall Weed Distribution in Inventoried Areas - Fin Canyon (Inset G)



H-8. Overall Weed Distribution in Inventoried Areas - Matrimony Spring (Inset H)



0 2000 4000 Feet

1:24,000 Scale

N

Weed Points

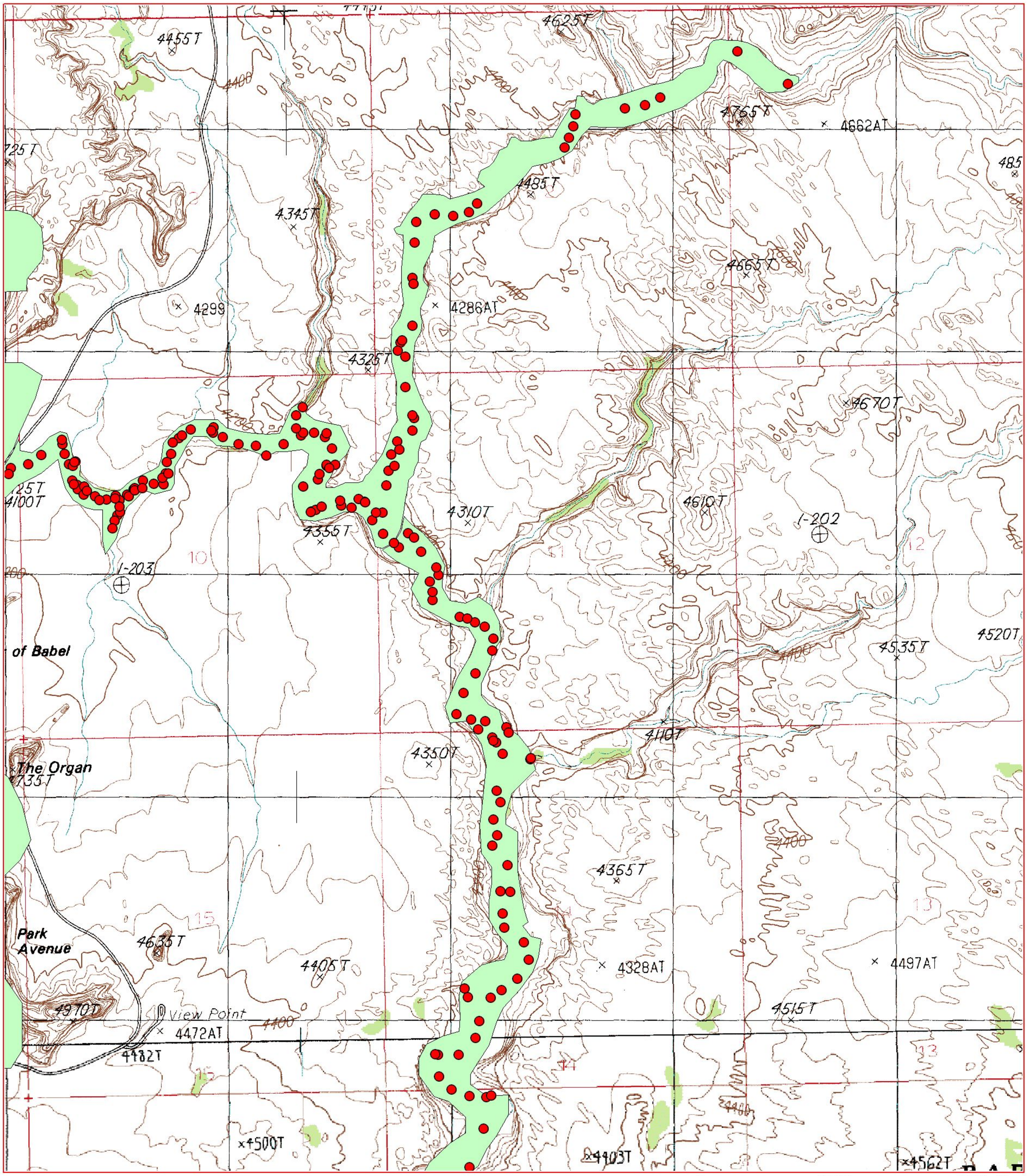
Area Inventoried

Park Boundary

H-8

Inset H
Utah State University
Arches National Park
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

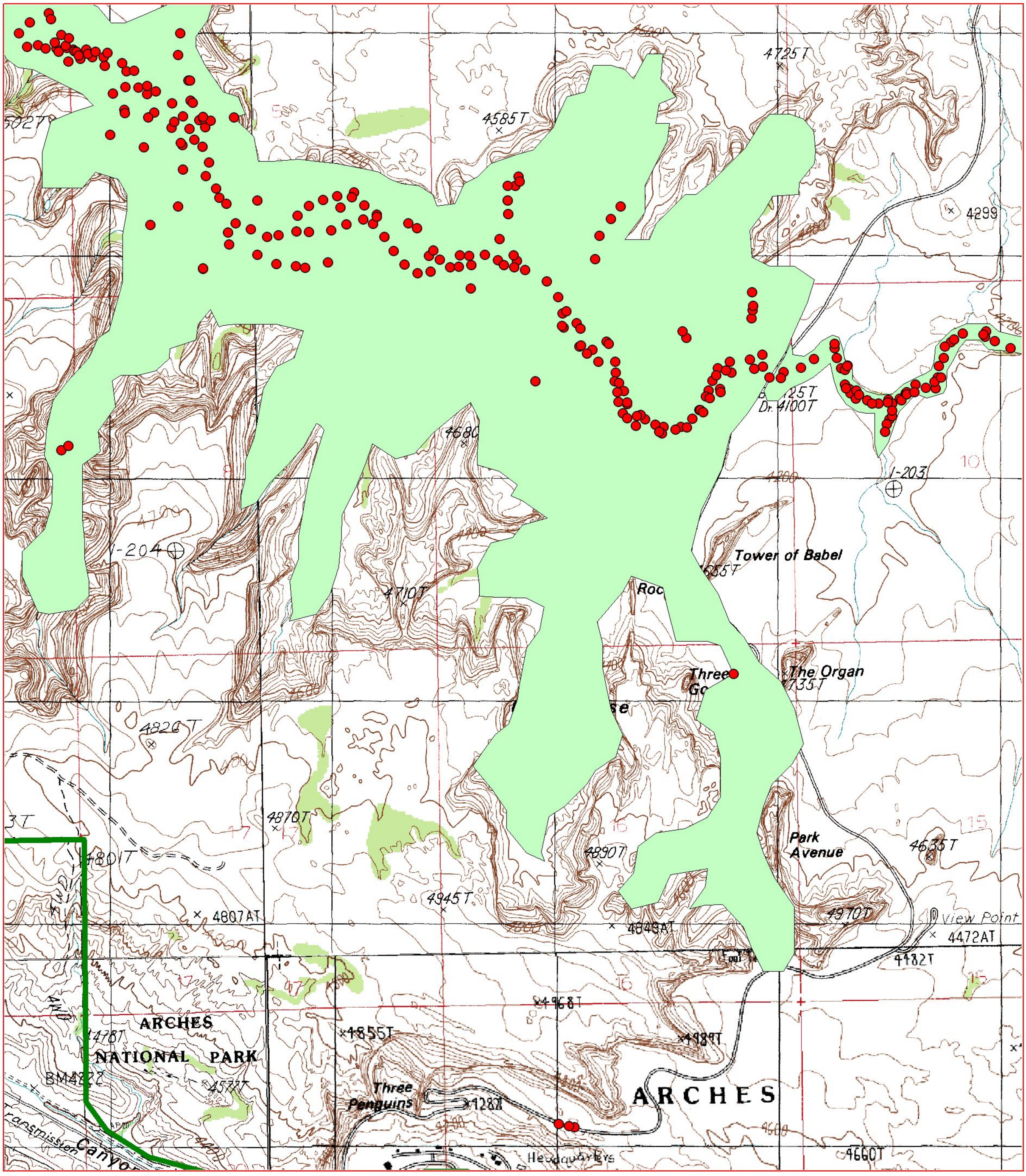
H-9. Overall Weed Distribution in Inventoried Areas - The Organ (Inset I)



H-9

Inset I
Utah State University
Arches National Park
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

H-10. Overall Weed Distribution in Inventoried Areas - Courthouse Towers (Inset J)



Weed Points

Area Inventoried

Park Boundary

0 2000 4000 Feet

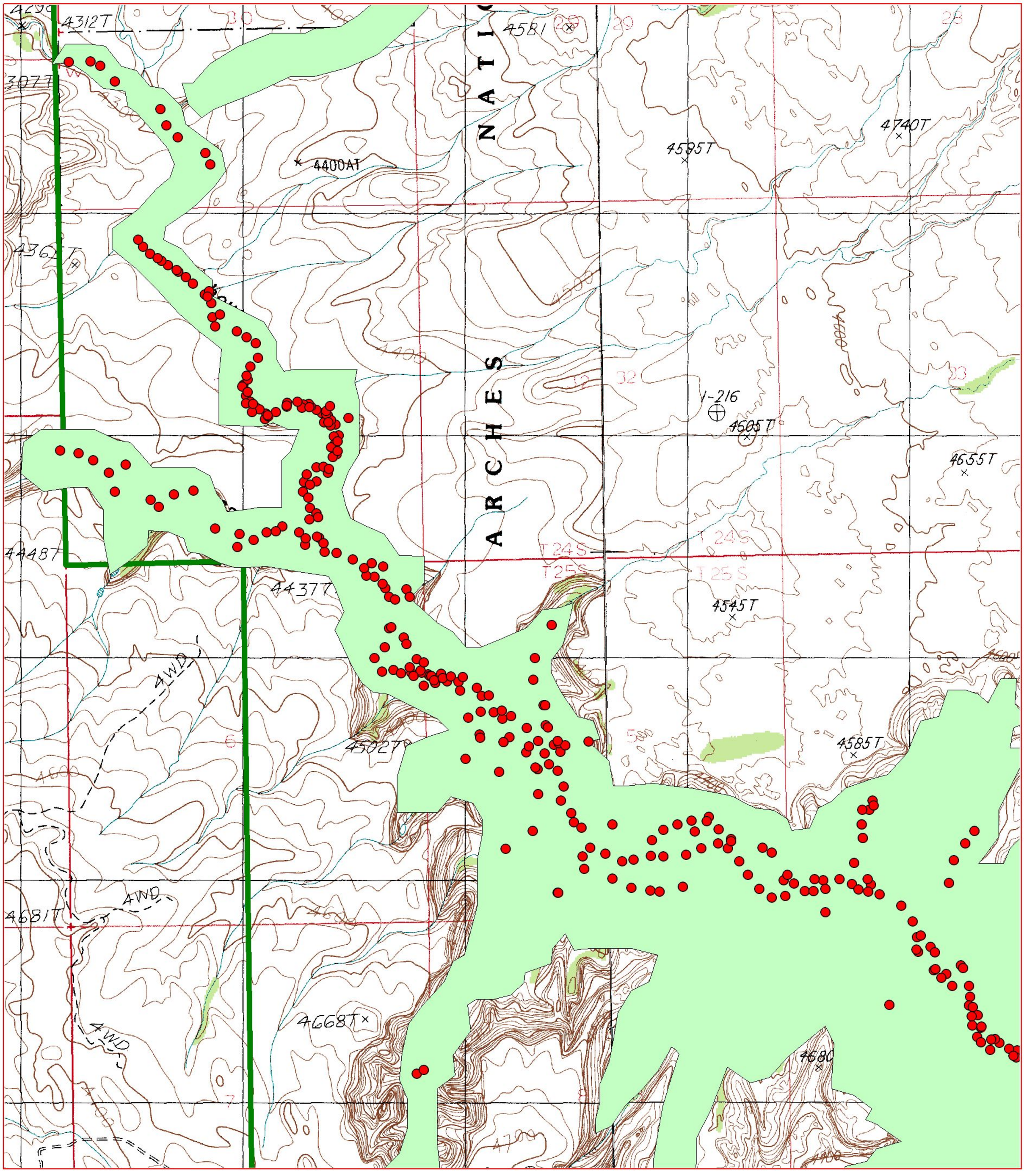
1:24,000 Scale

N

H-10

Inset J
Utah State University
Arches National Park
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

H-11. Overall Weed Distribution in Inventoried Areas - Courthouse Wash (Inset K)



Weed Points

Area Inventoried

Park Boundary

H-11

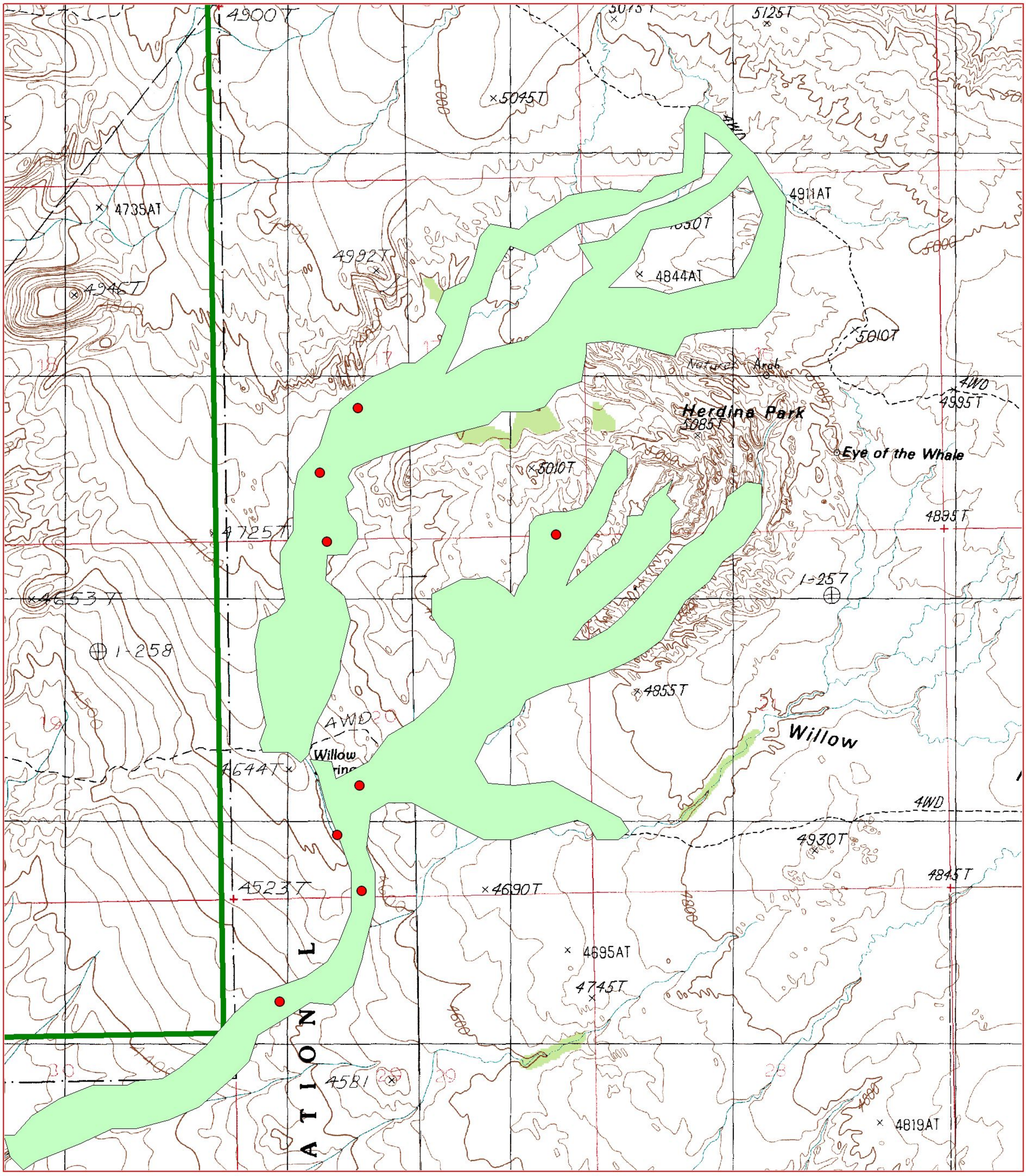
0 2000 4000 Feet

1:24,000 Scale

N

Inset K
Utah State University
Arches National Park
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

H-12. Overall Weed Distribution in Inventoried Areas - Herdina Park (Inset L)



0 2000 4000 Feet

Weed Points

Area Inventoried

Park Boundary

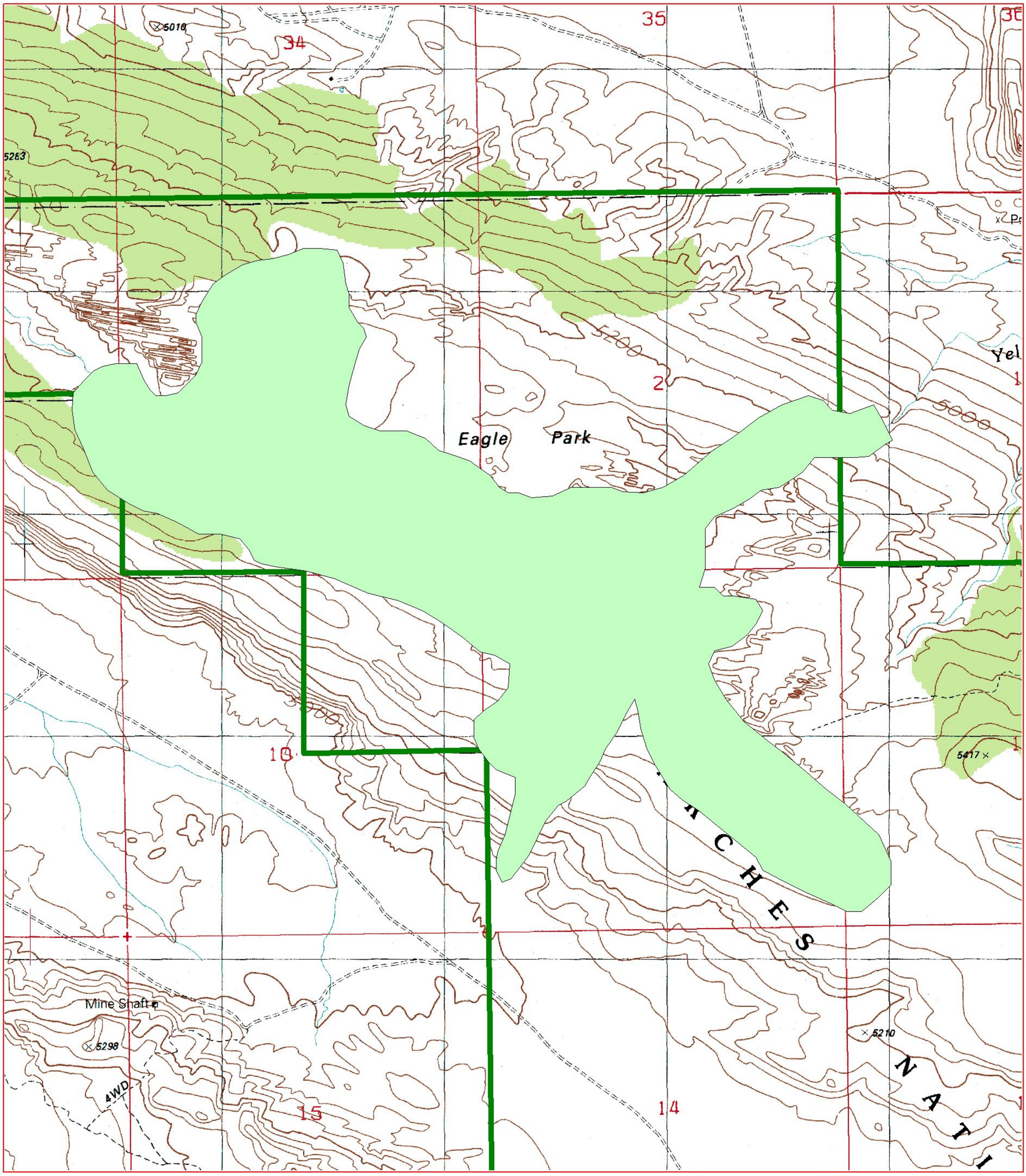
H-12

N

1:24,000 Scale

Inset L
Utah State University
Arches National Park
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

H-13. Overall Weed Distribution in Inventoried Areas - Eagle Park (Inset M)



* No target weed species recorded in this area
Area Inventoried
Park Boundary

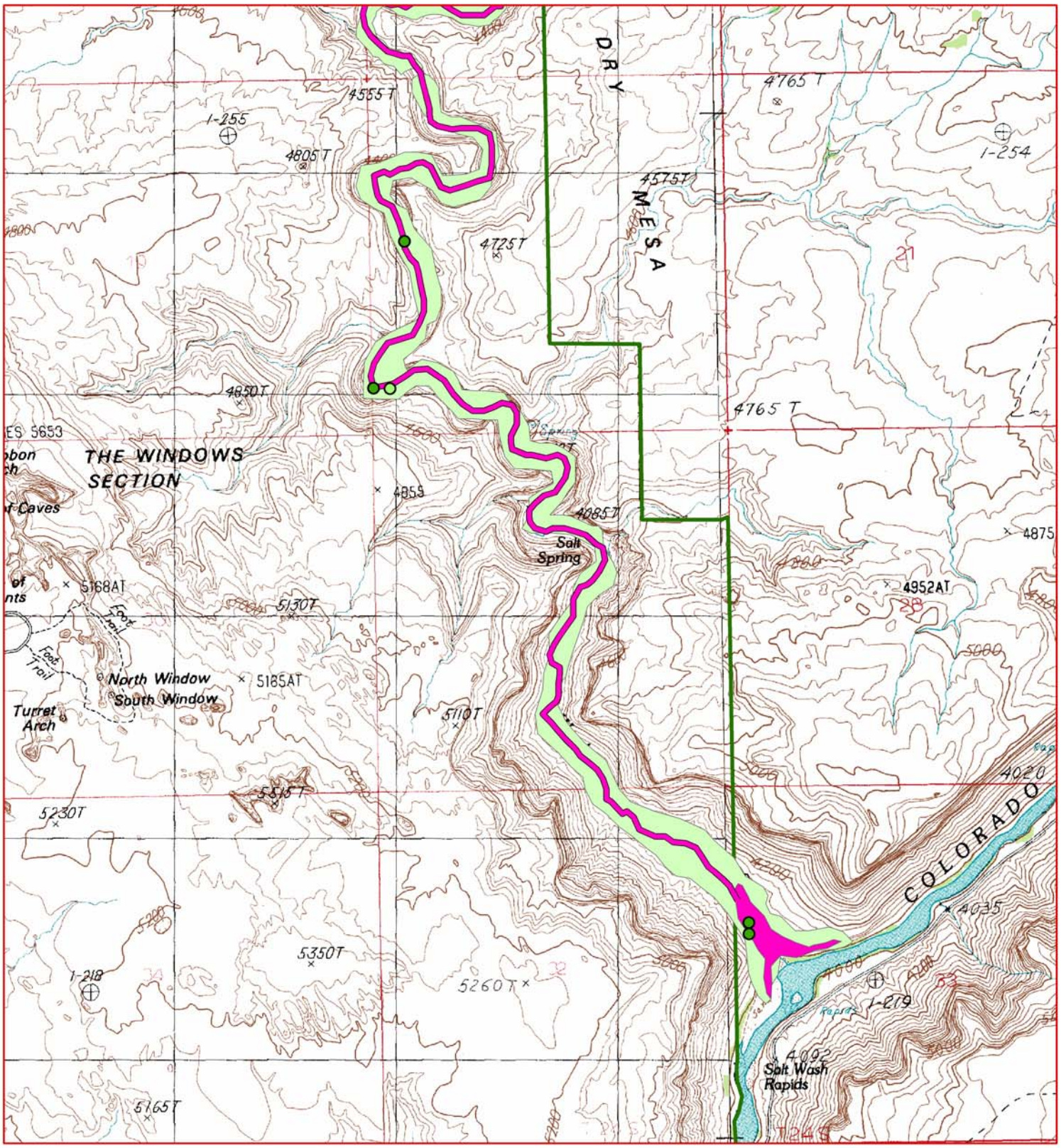
H-13

1:24,000 Scale

N

Inset M
Utah State University
Arches National Park
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

I-1. Weed Species Detected in Inventoried Areas - Salt Spring (Inset A)



- Centaurea repens
- Elaeagnus angustifolia
- Tamarix ramosissima
- Tamarix ramosissima
- Area Inventoried
- Park Boundary

0 2,000 4,000 Feet

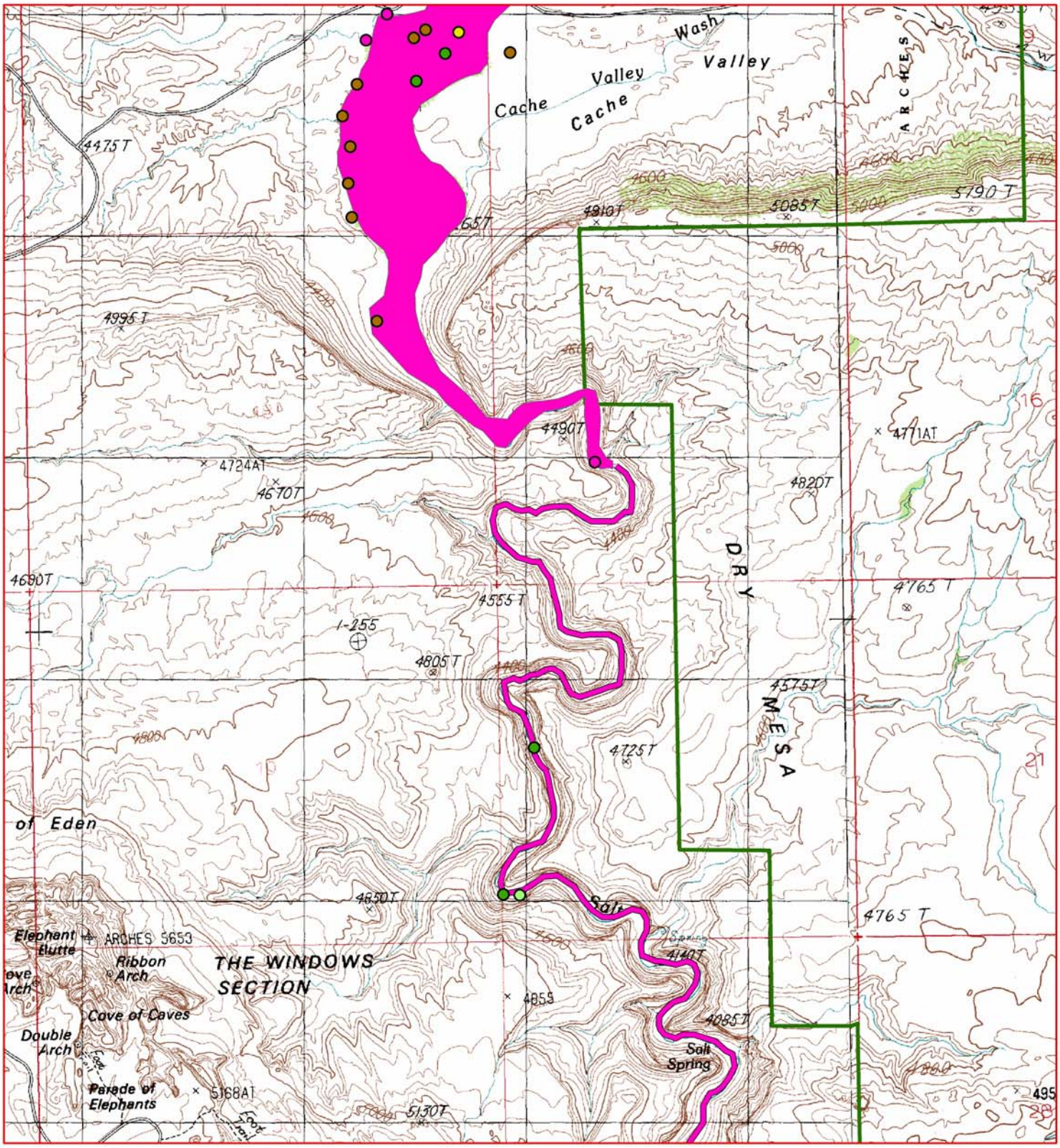
1:24,000 Scale

N

I-1

Inset A
Utah State University
Arches National Park
2003 - 2004 Invasive Non-native Plant Inventory
Northern Colorado Plateau Network

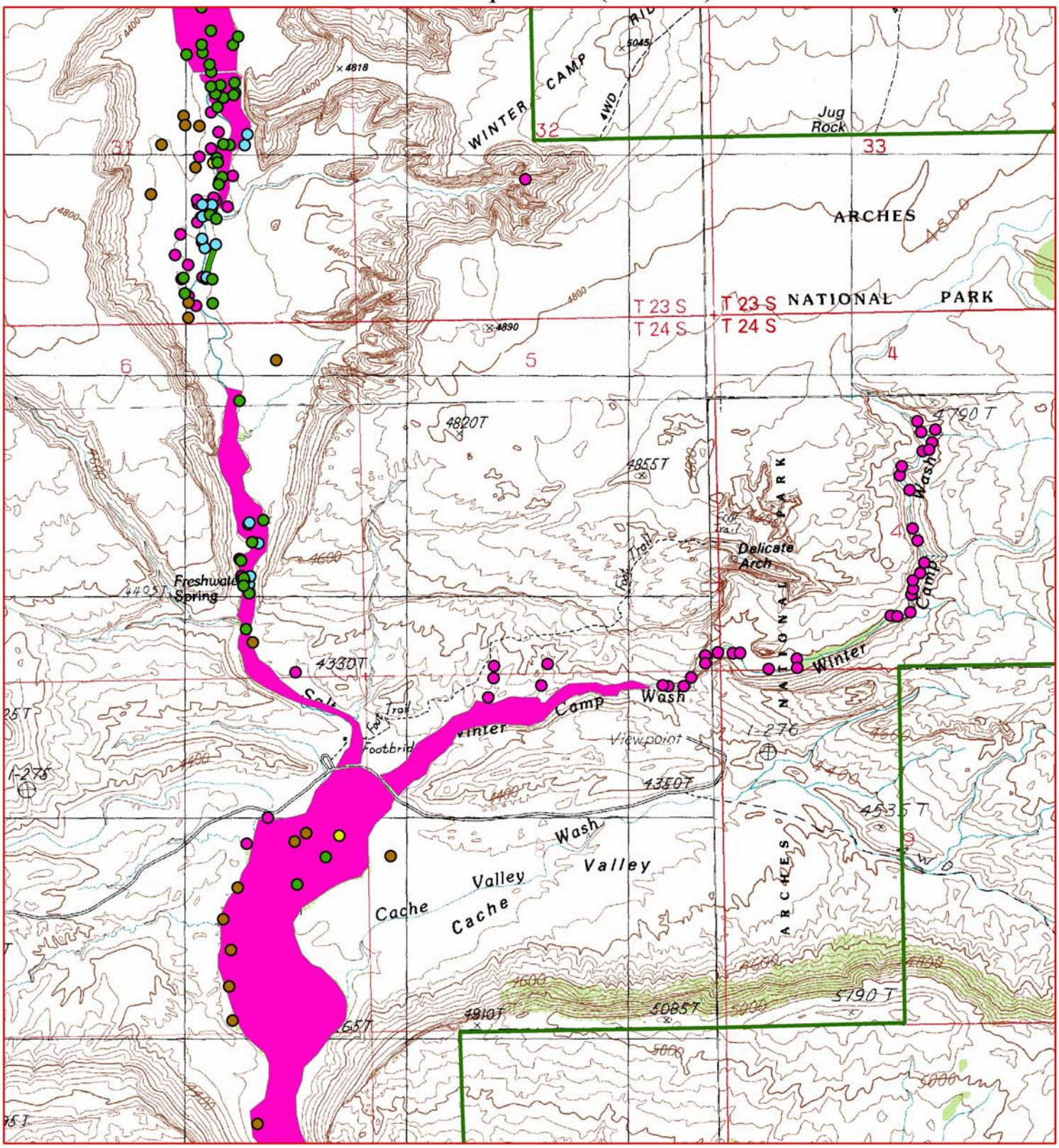
I-2. Weed Species Detected in Inventoried Areas - Salt Wash (Inset B)



I-2

Inset B
Utah State University
Arches National Park
2003 - 2004 Invasive Non-native Plant Inventory
Northern Colorado Plateau Network

I-3. Weed Species Detected in Inventoried Areas - Winter Camp Wash (Inset C)



- Centaurea repens
- Centaurea repens
- Elaeagnus angustifolia
- Halogeton glomeratus
- Rumex crispus
- Sonchus oleraceus
- Tamarix ramosissima
- Tamarix ramosissima
- Park Boundary

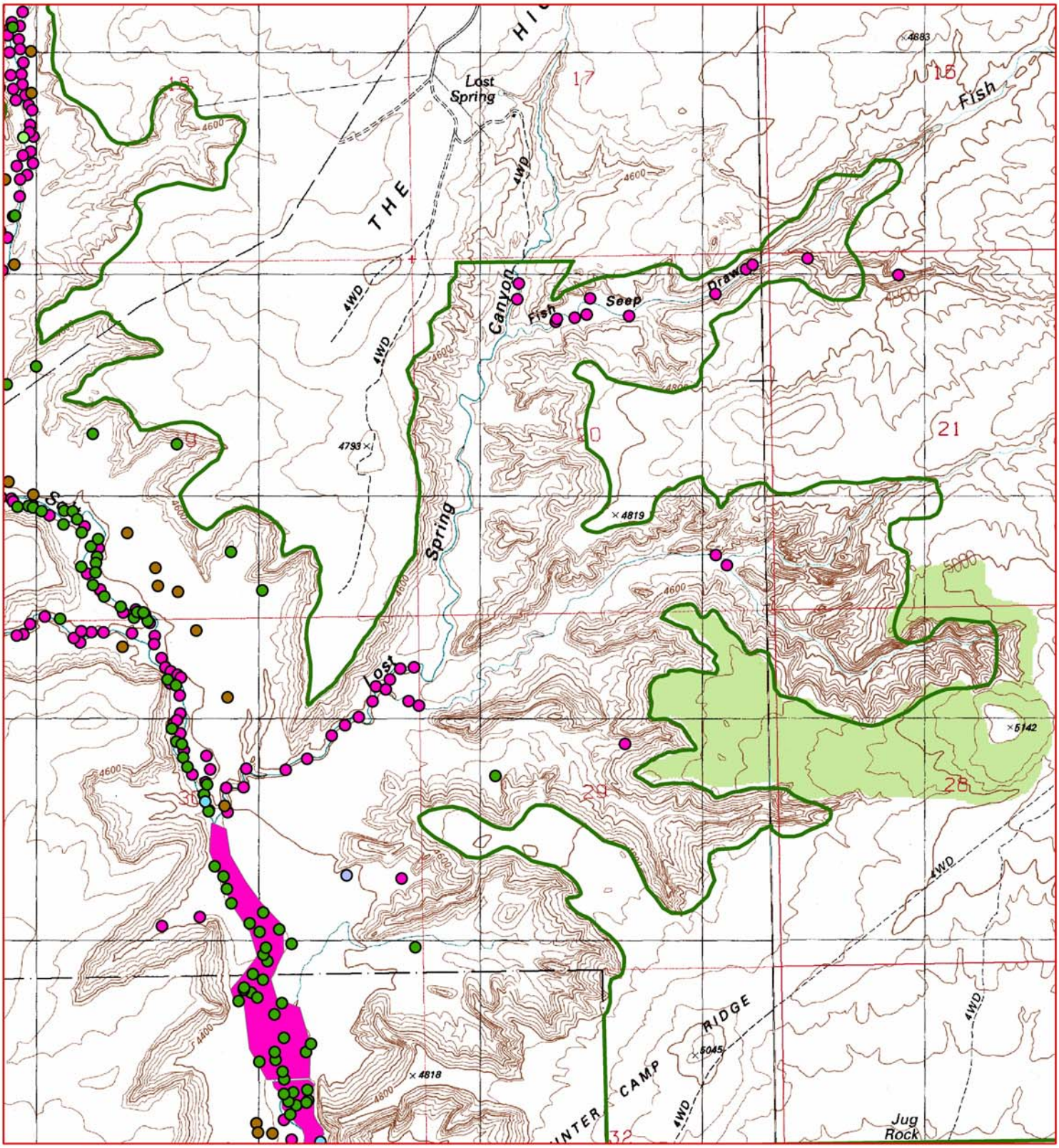
0 2,000 4,000 Feet

N

1:24,000 Scale

Inset C
Utah State University
Arches National Park
2003 - 2004 Invasive Non-native Plant Inventory
Northern Colorado Plateau Network

I-4. Weed Species Detected in Inventoried Areas - Lost Spring Canyon (Inset D)



Amaranthus albus
Centaurea repens
Elaeagnus angustifolia
Halogeton glomeratus
Rumex crispus
Tamarix ramosissima
Tamarix ramosissima
Park Boundary

0 2,000 4,000 Feet

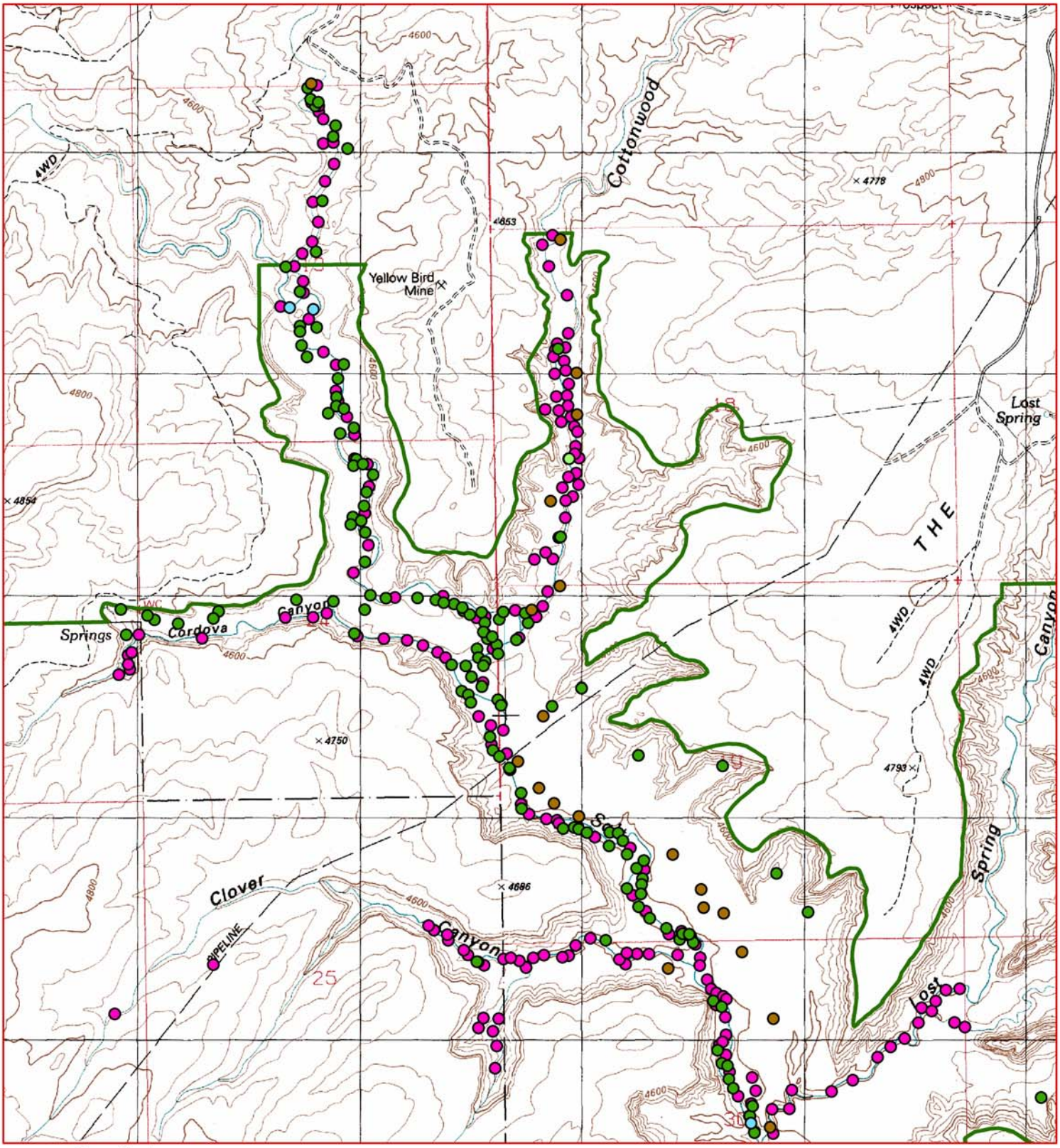
1:24,000 Scale

N

I-4

Inset D
Utah State University
Arches National Park
2003 - 2004 Invasive Non-native Plant Inventory
Northern Colorado Plateau Network

I-5. Weed Species Detected in Inventoried Areas - Cordova Canyon (Inset E)



- Centaurea repens
- Elaeagnus angustifolia
- Halogeton glomeratus
- Rumex crispus
- Tamarix ramosissima
- Park Boundary

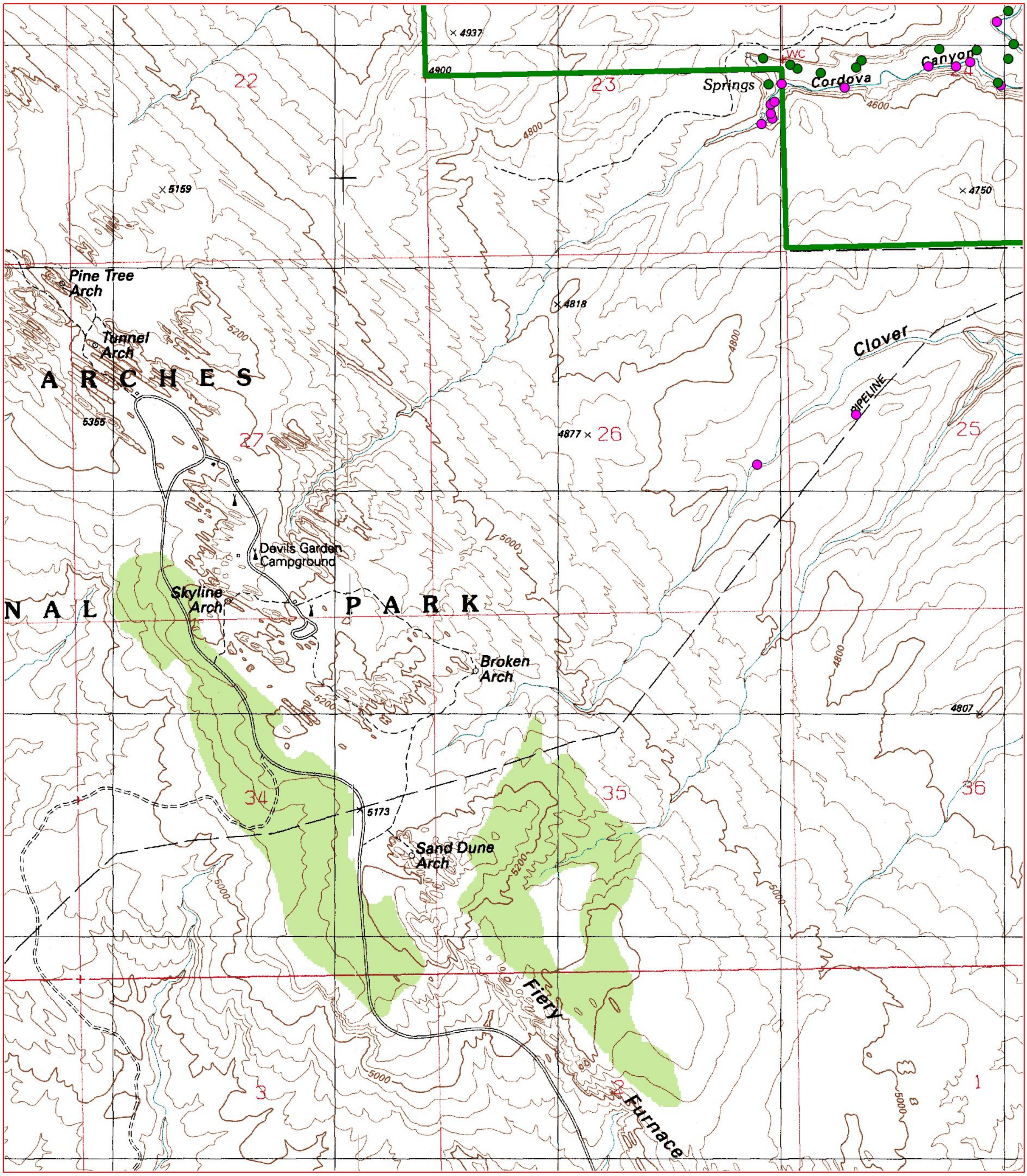
0 2,000 4,000 Feet

1:24,000 Scale

N

Inset E
Utah State University
Arches National Park
2003 - 2004 Invasive Non-native Plant Inventory
Northern Colorado Plateau Network

I-6. Weed Species Detected in Inventoried Areas - Clover Canyon (Inset F)



Centaurea repens

Tamarix ramosissima

Park Boundary

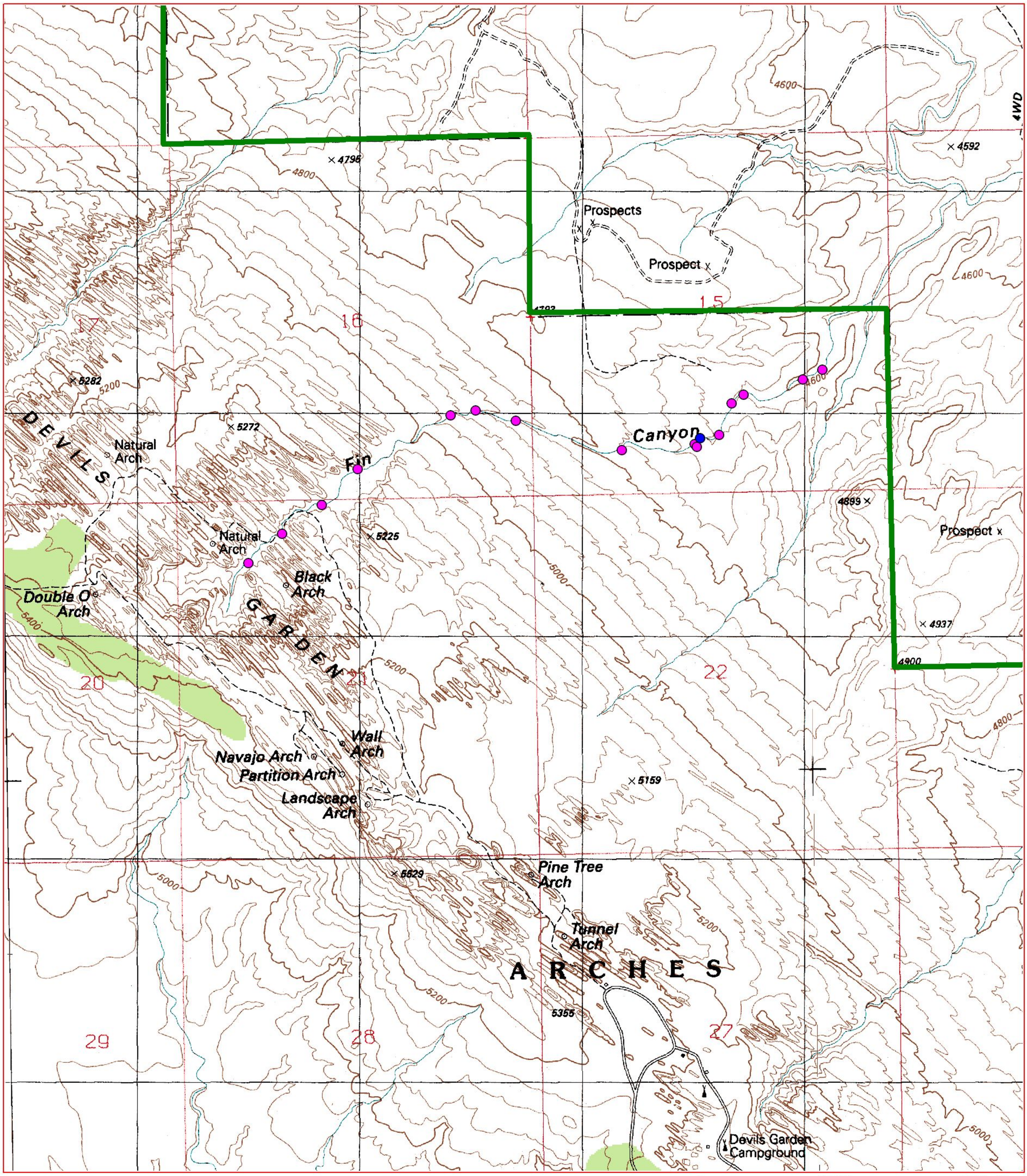
0 2000 4000 Feet

1:24,000 Scale

N

Inset F
Utah State University
Arches National Park
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

I-7. Weed Species Detected in Inventoried Areas - Fin Canyon (Inset G)



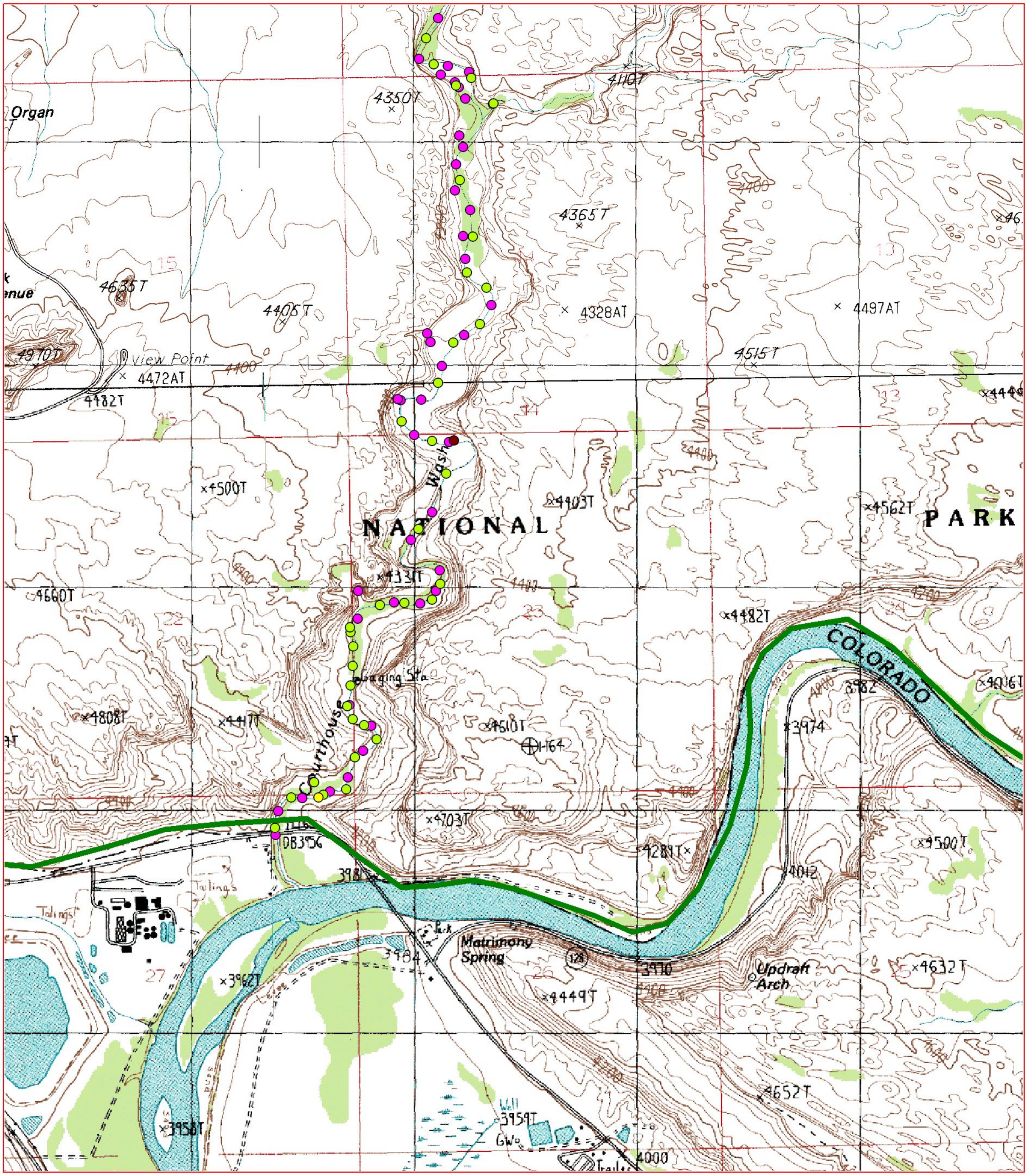
- Sisymbrium altissimum
- Tamarix ramosissima
- Park Boundary

1:24,000 Scale

N

Inset G
Utah State University
Arches National Park
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

I-8. Weed Species Detected in Inventoried Areas - Matrimony Spring (Inset H)



- Convolvulus arvensis
- Elaeagnus angustifolia
- Halogeton glomerata
- Tamarix ramosissima
- Park Boundary

I-8

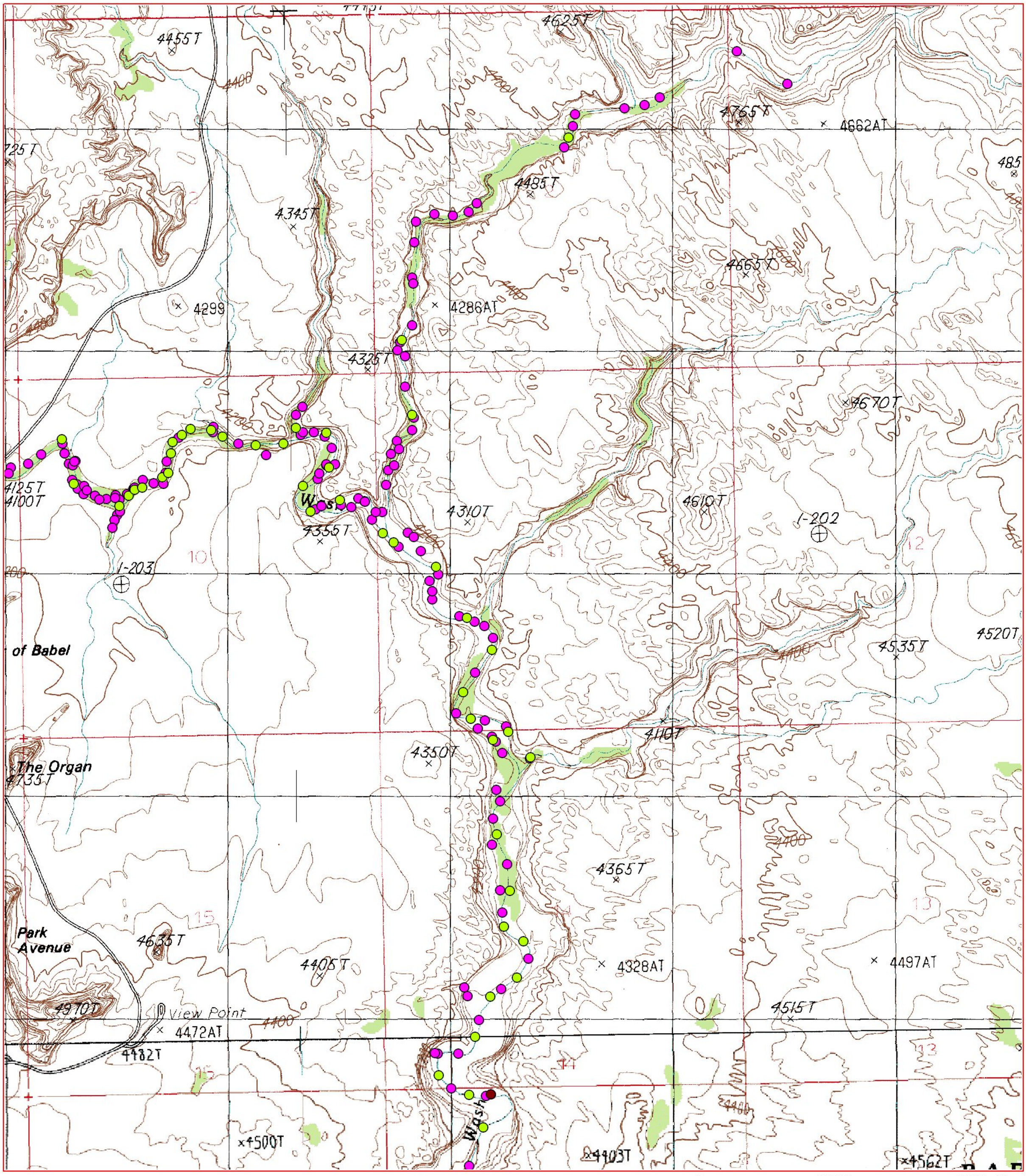
0 2000 4000 Feet

1:24,000 Scale

N

Inset H
Utah State University
Arches National Park
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

I-9. Weed Species Detected in Inventoried Areas - The Organ (Inset I)

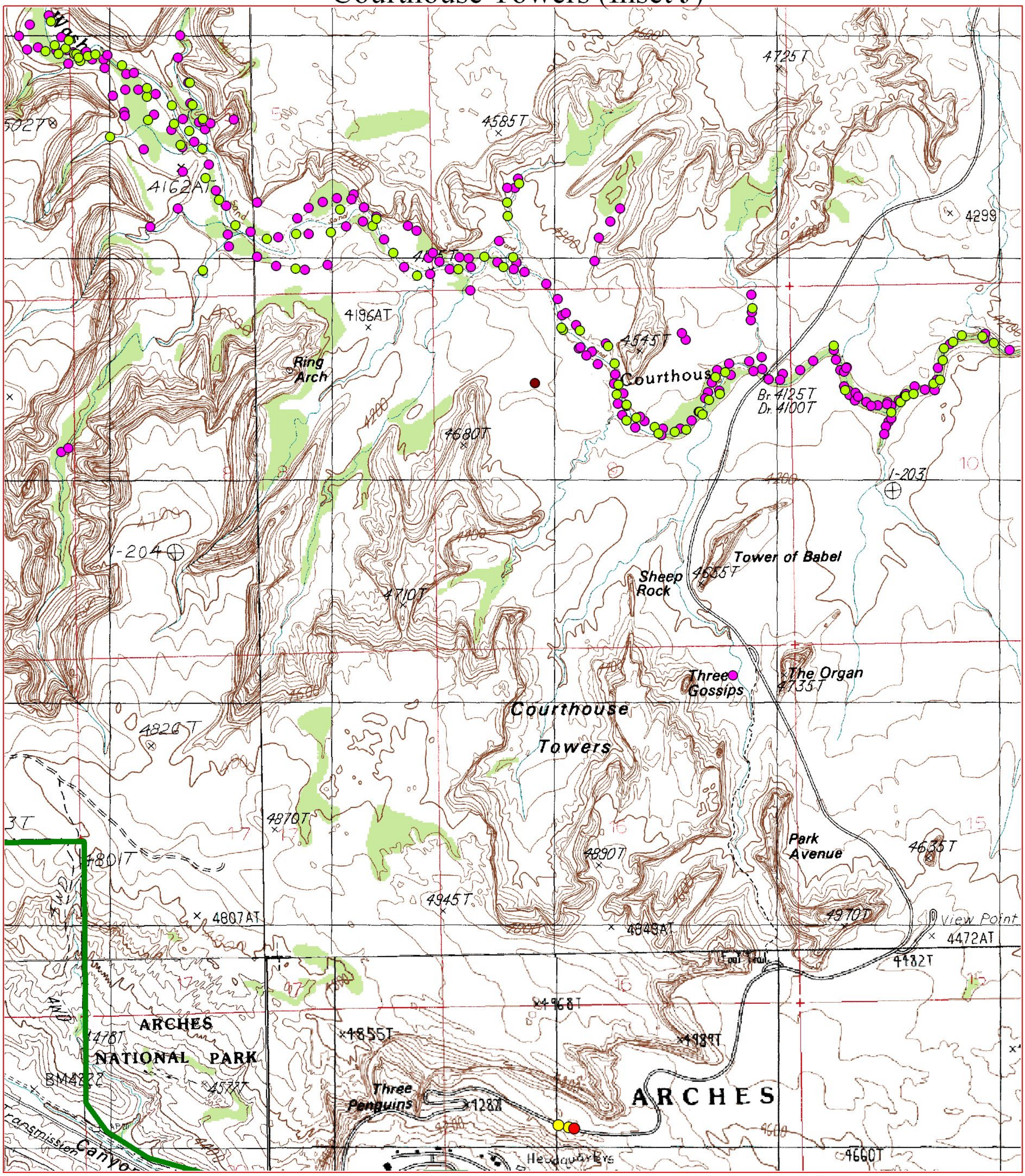


- Elaeagnus angustifolia
- Halogeton glomerata
- Tamarix ramosissima

I-9

Inset I
Utah State University
Arches National Park
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

I-10. Weed Species Detected in Inventoried Areas - Courthouse Towers (Inset J)



Elaeagnus angustifolia

Halogeton glomerata

Tamarix ramosissima

Onopordum acanthium

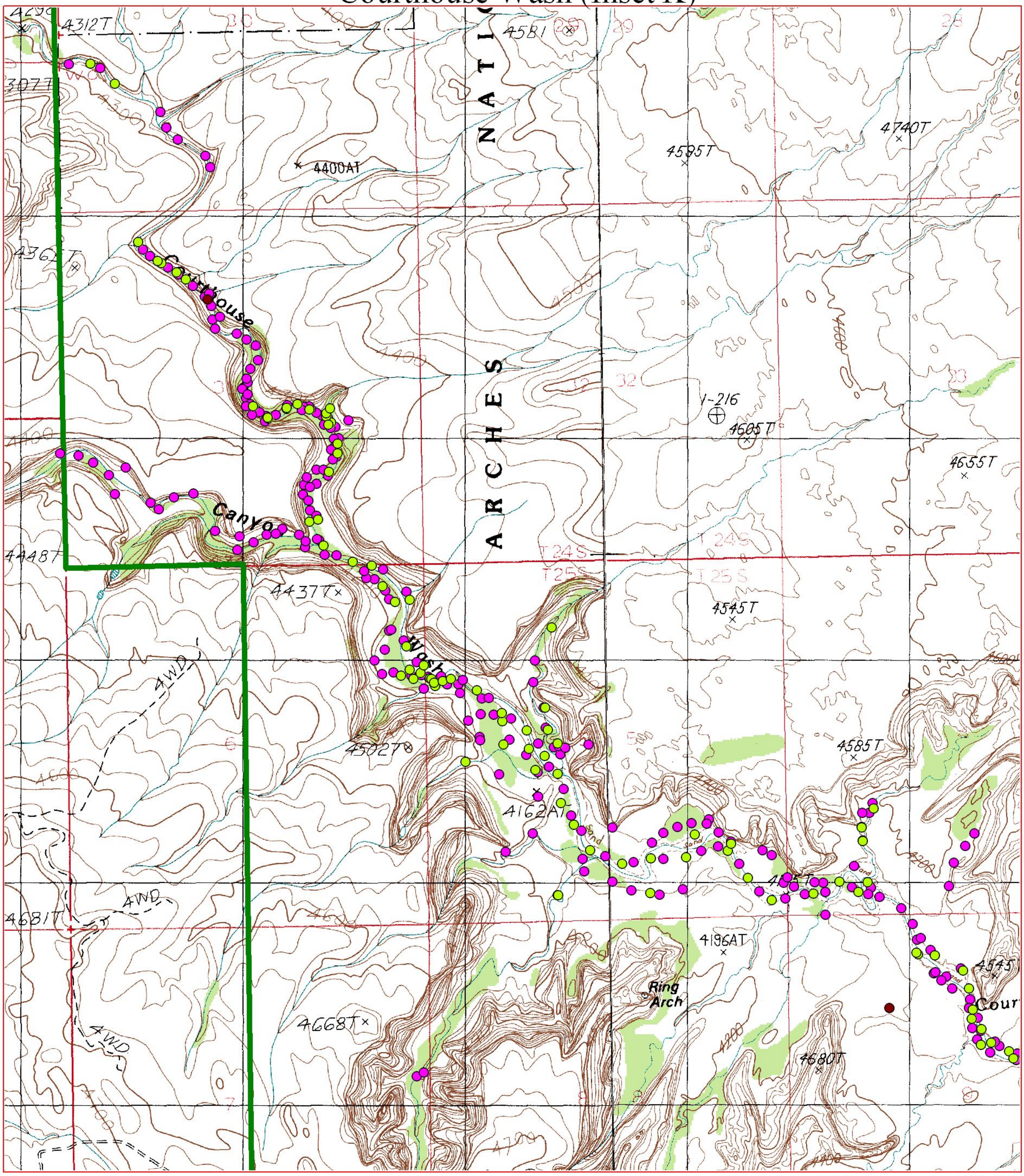
Tribulus terrestris

Park Boundary

I-10

Inset J
Utah State University
Arches National Park
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

I-11. Weed Species Detected in Inventoried Areas - Courthouse Wash (Inset K)



Elaeagnus angustifolia

Halogeton glomerata

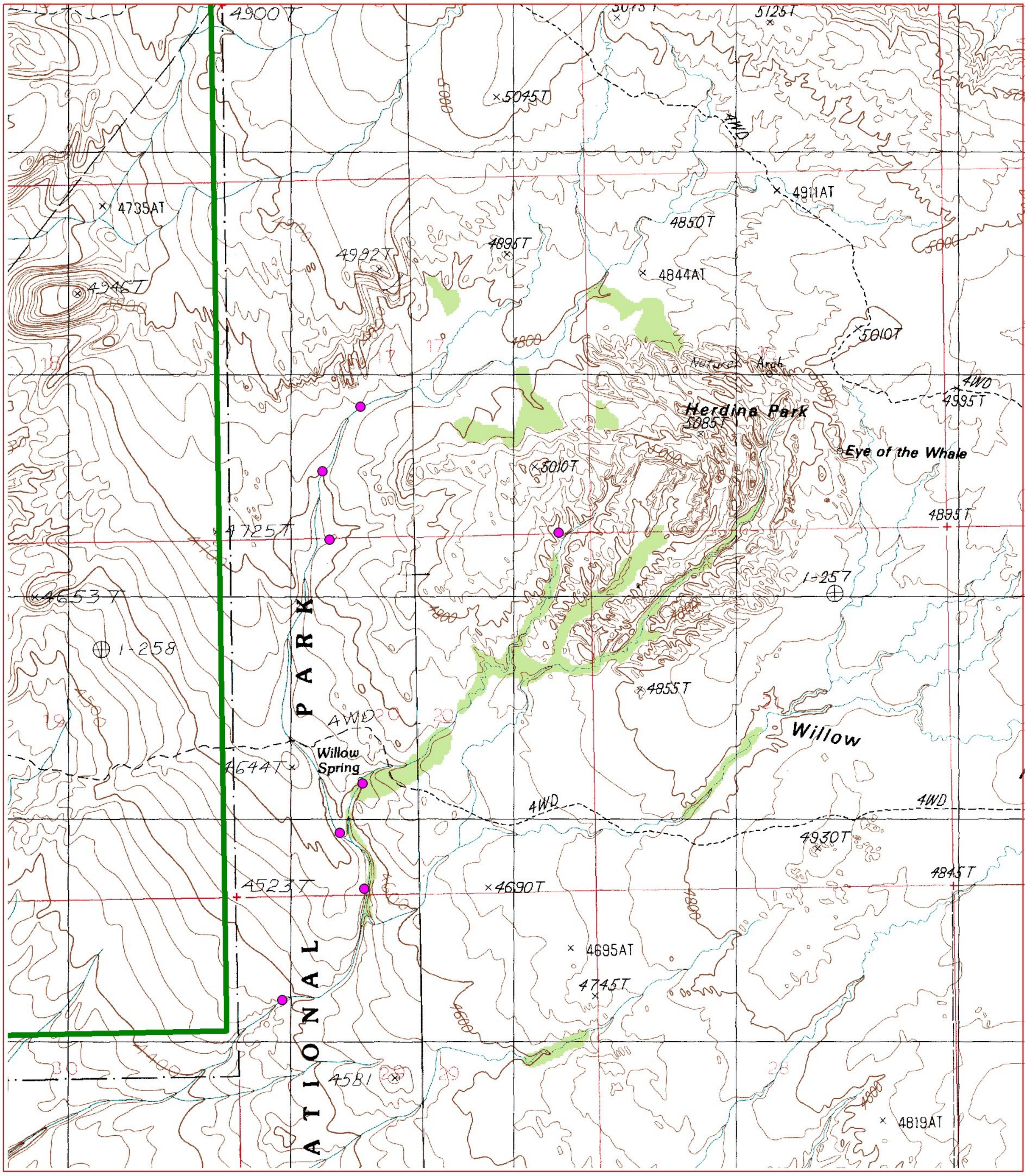
Tamarix ramosissima

Park Boundary

I-11

Inset K
Utah State University
Arches National Park
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

I-12. Weed Species Detected in Inventoried Areas - Herdina Park (Inset L)



Tamarix ramosissima

Park Boundary

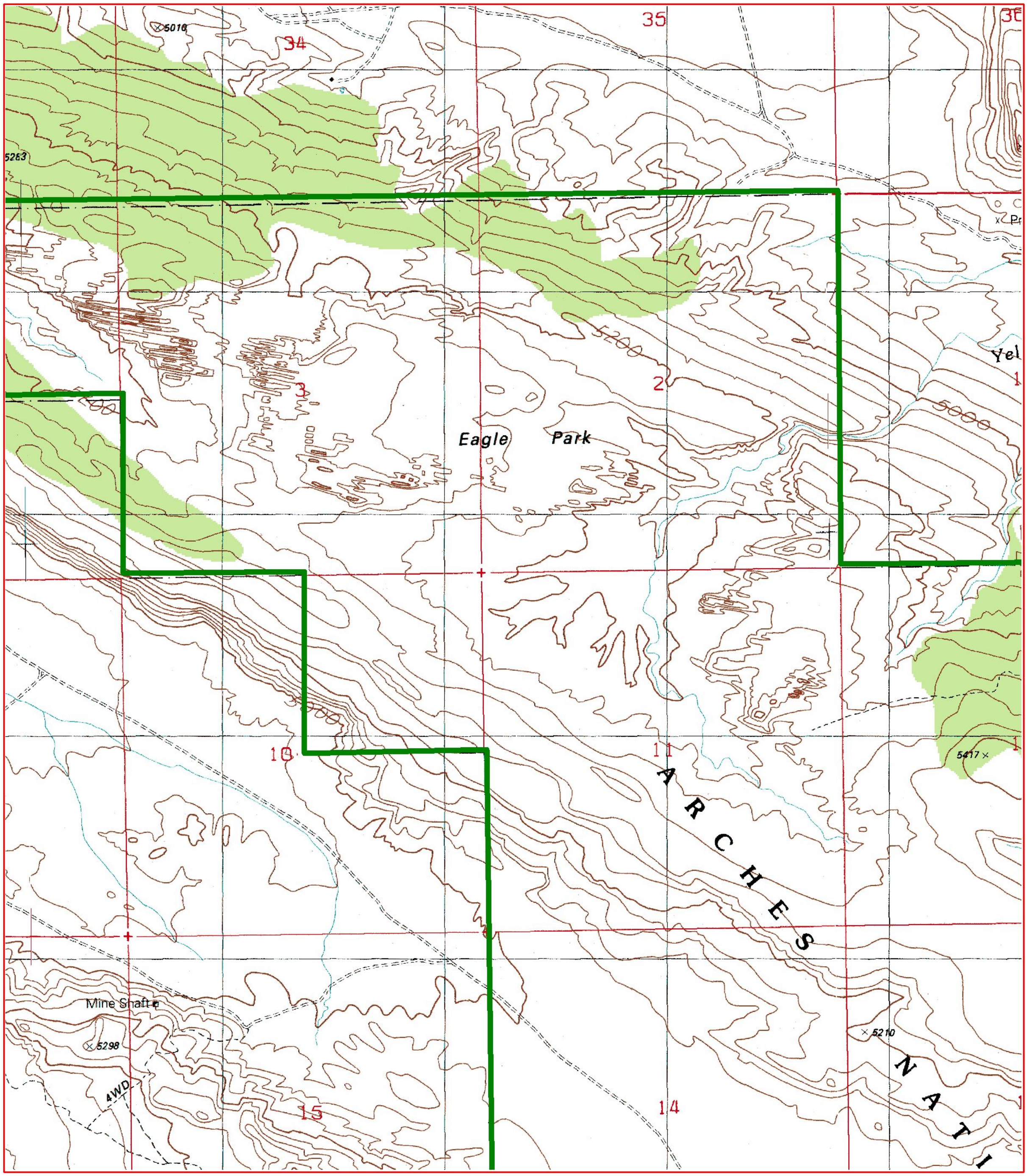
I-12

1:24,000 Scale

N

Inset L
Utah State University
Arches National Park
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

I-13. Weed Species Detected in Inventoried Areas - Eagle Park (Inset M)



0 2000 4000 Feet

1:24,000 Scale

N

* No Target Species found

Park Boundary

I-13

Inset M
Utah State University
Arches National Park
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix J. Weed Seed/Propagule Decontamination Procedures, 2004 EPMT Field Training Exercise, Arches National Park

EPMT COURTHOUSE WASH PROJECT

Arches National Park
March 9 – 14, 2004

EPMT Deployment to Arches NP:
The risk of this type of mobilization is that we will bring all types of nasty weeds from all over the country to Courthouse Wash. A recent exotic plant inventory has been conducted within the project area and the only high priority weeds detected were tamarisk and Russian olive. So we will know who to blame if nasty stuff like leafy spurge, miconia, malelueca, kudzu, and spotted knapweed show up (each team has its own signature).

Weed Seed/Propagule Decontamination Procedures:

If you are flying or driving:
Make sure that everything you bring has been cleaned/washed/decontaminated.
Especially be vigilant with gear and clothing you wear in the field at your home units:

- Backpacks
- Boots and shoes
- Socks
- Pants
- PPE

If you are driving be sure to clean/wash/decontaminate:

- Make sure your entire vehicle is power washed before you leave your home unit or go to a local car wash.
- Be extra vigilant while cleaning the undercarriage of the vehicle
- All your equipment
- Chainsaws
- Backpack sprayers
- Saw chaps
- Hard hats
- Gloves
- PPE

Demobilization Decontamination Process:
Same thing in reverse, because I know you don't want tamarisk, Russian olive or cheatgrass in your area!

- Visit a car wash in town
- Lake Mead EPMT will be bringing our steam cleaner power washer to share
- Clean boots in the hotel bath
- Wash clothes in the hotel laundry facilities

Appendix K. Summary of occurrence and inventory status of the 47 non-native species listed in the GPS data dictionary, plus any additional species noted in the 2003-2004 inventory of invasive plants in Arches National Park.

GPS Species	A	B	C	D	E	GPS Species	A	B	C	D	E
Agropyron cristatum			X			*Lepidium latifolium*				X	
Ailanthus altissima				X		*Linaria dalmatica*				X	
Alhagi pseudalhagi				X		*Linaria vulgaris*				X	
Anthemis L.					X	*Lythrum salicaria*				X	
Arctium minus				X		*Marrubium vulgare*				X	
Arundo donax				X		*Moluccella laevis*					X
Asparagus sp.					X	*Onopordum acanthium*	X				
Brassica tournefortii					X	*Phleum pratense*					X
Bromus inermis					X	*Rubus discolor*				X	
Bromus tectorum			X			*Rumex crispus*		X			
Cardaria draba				X		*Salsola kali*			X		
Carduus nutans				X		*Sorghum halepense*				X	
Centaurea diffusa				X		*Tamarix ramosissima*	X				
Centaurea maculosa				X		*Tragopogon dubius*			X		
Centaurea repens	X					*Tribulus terrestris*		X			
Centaurea solstitialis				X		*Verbascum thapsus*				X	
Centaurea virgata				X		*Ulmus pumila*				X	
Chenopodium album			X								
Cirsium arvense				X		**Other:**					
Cirsium vulgare				X							
Conium maculatum				X		*Amaranthus albus*		X			
Convolvulus arvensis		X				*Chenopodium berlandieri*			X		
Cynoglossum officinale				X		*Erodium cicutarium*			X		
Dactylis glomerata					X	*Melilotus officinalis*			X		
Elaeagnus angustifolia	X					*Sisymbrium altissimum*		X			
Euphorbia esula				X		*Sonchus oleraceus*		X			
Halogeton glomeratus		X									
Hyoscyamus niger				X							
Isatis tinctoria				X							
Iva xanthifolia					X						

A = Present - Full inventory
B = Present – Partial inventory
C = Present – Not Mapped
D = Searched For - Absent
E = No Information