Canyonlands National Park

2003- 2004 Invasive Non-Native Plant Inventory

Northern Colorado Plateau Inventory and Monitoring Network

Final Report

October 2005

Prepared by

Steven Dewey and Kimberly Andersen

Utah State University

Cover photo:

Tamarix ramosissima along the road shoulder in Salt Creek. 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 Canyonlands 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 Canyonlands 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 Canyonlands 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 natural 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. Canyonlands 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. A knowledge of current weed distribution, especially in or near riparian areas, was identified as an extremely high priority need by Canyonlands National Park and NCPN.

OBJECTIVES

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

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

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 six-person crew to inventory targeted species in designated areas of Canyonlands National Park in 2003. Two NPS seasonal staff hired by Northern Colorado Plateau Network inventoried targeted invasive plants in separate portions of Canyonlands National Park in 2003, and a six-person Utah State University crew inventoried the remaining designated areas of CANY in 2004. Crew qualifications are documented in Appendix A.

SELECTION OF TARGET SPECIES AND INVENTORY AREAS

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

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

Invasive species	Common Name
Carduus nutans	Musk thistle
Centaurea diffusa	Diffuse knapweed
Centaurea maculosa	Spotted knapweed
Centaurea repens	Russian knapweed
Centaurea solstitialis	Yellow starthistle
Centaurea squarrosa	Squarrose knapweed
Cirsium arvense	Canada thistle
Cirsium vulgare	Bull thistle
Elaeagnus angustifolia	Russian olive
Lepidium latifolium	Perennial pepperweed
Lythrum salicaria	Purple loosestrife
Onopordum acanthium	Scotch thistle
Tamarix ramosissima	Saltcedar
Ulmus pumila	Siberian elm

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 CANY 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. Lands inventoried in Canyonlands National Park primarily consisted of riparian areas, roads and highways, hiking trails, flats, and canyon bottoms.

The focus of this inventory project was NPS lands. However, in some cases a limited number of additional lands immediately adjacent to the CANY border were inventoried. This occurred if crew members found an infestation of a high-priority weed species straddling across the Park boundary and wanted to determine its full size. In other cases searches were extended if crew members suspected a possible "contamination source" of one or more species immediately adjacent to the Park boundary. Non-NPS lands inventoried included portions of the highway to the Island-in-the-Sky District, and meadows surrounding the lower portion of Salt Creek in the Needles District. These areas were inventoried as a matter of convenience and efficiency, as crew members were already working nearby.

Park natural resource staff and the NCPN Vegetation Ecologist worked closely with USU and NPS crews 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 CANY staff also helped to ensure that data were assembled and provided to the network in a useable format.

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 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 the 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. Data fields used in 2003-2004 Inventory of Invasive Non-Native Plants in Canyonlands 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	CANY	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. GPS 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 invasive non-native plants inventory in Canyonlands National Park was conducted by a six-person USU crew and a two-person NPS crew between June 24 and October 8 (Table 3). Areas inventoried by the NPS crew included Cyclone Canyon, Devil's Lane, Devil's Pocket, Red Lake Canyon, Butler Wash, Big Spring Canyon, Little Spring Canyon, Lost Canyon (upper half), and Horse Canyon in the Needles District. Areas inventoried by the USU crew in 2003 include

sections of Salt Creek in the Needles District. That year the USU crew also inventoried Upheaval Dome, Syncline Valley, Upheaval Canyon, Taylor Canyon, Trail Canyon, Lathrop Canyon and roadways in the Island-in-the-Sky District. The six-person USU crew inventoried additional portions of Salt Creek, as well as Squaw Canyon and Lost Canyon (lower half) in the Needles District during May 9-14, 2004. Additional areas inventoried in the Island-in-the-Sky District include Cabin Spring, Neck Spring Trail, Willow Flat, and Shafer Canyon on May 20, 2004 and August 20, 2004. The PI and crew leader returned to CANY on August 8, 2003 and August 20, 2004 to conduct quality assurance inspections of areas inventoried previously by USU and NPS crews.

For purposes of planning and data analysis the inventoried lands were divided into 40 areas (Table 3). The order in which areas were inventoried in 2003 and 2004 was determined by the respective NPS and USU crew leaders. 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 determine the best search methods and GPS settings needed to achieve the required level of detection confidence for the established minimum target size. 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.

The Salt Creek drainage in the Needles District of Canyonlands is very large and includes numerous side canyons. It was agreed by USU and Park staff that Salt Creek's side canyons would be included in this project since any infestations of invasives found therein would likely be small and feasible for eradication (and thereby become weed-free areas), despite the heavily infested status of much of the main drainage. There are over 60 side canyons within the Salt Creek drainage, many of which are either not obvious from the main trail, or which may be confused with similar-appearing canyons. To reduce the potential for missing a side canyon, or duplicating efforts of other crew members, an identifying number was assigned to each canyon at the beginning of the field season, and the numbers were written on the master topographic field planning maps. The UTM coordinates of the mouth and head of each side canyon were determined from the maps, and corresponding waypoints were created and imported into the GPS units prior to the start of the project. A map illustrating these waypoints and their locations is included as Appendix D. By this method crew members were able to identify and navigate easily to their specific assigned side canyons. In an effort to conserve batteries, GPS units were typically turned on only at the mouths and ends of side canyons, and whenever a weed infestation was found. Even when GPS units were left on, satellite reception was often poor in side canyons. As a result, relatively few between-feature positions were collected during inventories of Salt Creek. However, despite the scarcity of between-feature positions, all targeted side canyons within Salt Creek were inventoried thoroughly. If the location of weed species detected in side canyons could not be determined by GPS, its approximate position was noted on the appropriate field map, and its UTM coordinates were determined later in the office.

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. Areas such as Taylor Canyon, Willow Flat, Lathrop Canyon, and Shafer Canyon were open and visibility was generally good, allowing relatively broad EDSW's (typically 50 to 100 yards). In areas such as narrow canyons, or stream corridors in which vegetation cover was heavy, EDSW's were usually narrower, sometimes less than 25 yards. Whenever 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. Daily inventory routes of each crew member were recorded and mapped using the BFP tracking function of the GeoExplorer GPS units. BFP tracking distance settings were adjusted as needed to correspond closely to the EDSW distance for each area.

Each inventoried area within Canyonlands National Park was assigned a detection confidence value based on the crews' 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%).

As inventory units were traversed, locations of all target species were documented by the USU and NPS crews using handheld Trimble GeoExplorer 3, Trimble XM, or Trimble XT global positioning system (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. GPS configuration settings used in this project are listed in Appendix E. Additional equipment used by crew members included laser rangefinders, compasses, binoculars, topographic maps, calculators, and radios. Appendix F 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 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 mapped as point features. 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, scattered plants with individuals or clusters 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.)

Table 3: Invasive plant inventory areas, inventory dates, crew members, and acres inventoried in 2003-2004 in the Island-in-the-Sky District and Needles District of Canyonlands National Park.

Area Number *	Area Description	Dates Inventoried	Crew Members **	Acres Inventoried ***	Corresponding Inset Map Names and Letter Codes****
I-1	Upheaval Dome, Syncline Valley	June 24, 2003	KA, MB, SD, JS, EL, RR	3713.7	Whale Rock - J Upheaval Dome – K Trail Canyon - N
I-2	Upheaval Canyon	June 25, 2003	MB, JS, EL	472.2	Upheaval Canyon – L
I-3	Taylor Canyon Trail Canyon	June 25, 2003 June 27, 2003	KA, MB, JS, EL, RR	2082.7	Whale Rock – J Upheaval Dome – K Upheaval Canyon – L Big Draw – M Trail Canyon - N
I-4	Main roads	Aug. 8, 2003	KA, SD	2649.6	The Knoll – A Big Flat Reservoir – B Whitebeck Rock – C Neck Spring – D Grays Pasture – F Willow Flat – H Grand View – I Whale Rock – J Upheaval Dome – K
I-5	Lathrop Canyon	June 26, 2003	KA, MB, JS, EL, RR	1120.3	Grays Pasture – F Lathrop Canyon - G
I-6	Cabin Spring, Neck Spring Trail	May 5, 2004 Aug. 20, 2004	BA, KA, MB, SD, HH, RR	235.2	Neck Spring – D
I-7	Willow Flat	May 5, 2004 Aug. 20, 2004	BA, KA, MB, SD, HH, RR	168.7	Willow Flat – H Whale Rock – J
I-8	Shafer Canyon – East Fork	May 5, 2004 Aug. 20, 2004	BA, KA, MB, SD, HH, RR	335.1	Shafer Canyon – E
I-9	Shafer Canyon - mouth	May 5, 2004 Aug. 20, 2004	BA, KA, MB, SD, HH, RR	51.6	Shafer Canyon – E
I-10	Shafer Canyon – South Fork, Middle Fork	May 5, 2004 Aug. 20, 2004	BA, KA, MB, SD, HH, RR	515.2	Neck Spring – D Shafer Canyon – E
N-1	The Grabens (Including Cyclone Canyon, Devil's Lane, Devil's Pocket, Red Lake Canyon, Butler Wash)	July 16-18, 2003 July 30-21, 2003	HR, LB	1440	Red Lake Canyon – D Lower Red Lake Canyon - E The Grabens – F Chesler Park - G
N-2	Big Spring Canyon, Little Spring Canyon	July 30, 2003 Aug. 2, 4 in 2003	HR, LB	214.5	Little Spring Canyon – A Lower Jump – B
N-3	Lower Salt Creek – Visitor Center to Lower Jump	July 8-11, 2003	KA, MB, SD, JS, EL, RR	1708.2	Little Spring Canyon – A Lower Jump – B Squaw Flat – C Cave Spring – H
N-4	Horse Canyon, Portions of Salt Creek	July 1-11, 14-16, 22 in 2003 August 1-2 in 2003	KA, MB, SD, HR, JS, EL, RR, LB	6540.1	Cave Spring – H Salt Creek Pocket – I Horse Canyon – J Lost Canyon – L Peekaboo Spring – M Angel Arch – N Salt Creek – O West Fork – P Fisheye Arch – Q

					Big Pocket – R Cathedral Butte – S
N-5	Lost Canyon	Aug. 3, 2003; Oct. 8, 2003	HR, LB, volunteers	340	Squaw Canyon – K Lost Canyon – L Peekaboo Spring – M Salt Creek – O
N-6	Salt Creek – Lower Jump to Colorado River	May 13, 2004	BA, MB, HH, RR	188	Little Spring Canyon – A Lower Jump – B
N-7	Salt Creek – North of Entrance road	May 15, 2004; May 18, 2004	BA, RR	104.7	Squaw Flat – C
N-8	Squaw Canyon	May 14, 2004	BA, MB, HH, RR	786.5	Cave Spring – H Squaw Canyon – K Lost Canyon – L
N-9	Lost Canyon	May 14, 2004	HH, RR	463.1	Cave Spring – H Squaw Canyon – K
N-10	Salt Creek – Side canyons 1-10	May 17, 2004	BA, MB, HH, RR	390	Peekaboo Spring – M
N-11	Salt Creek – Side Canyon 16	May 10, 2004	BA, MB	69.6	Angel Arch – N Salt Creek – O
N-12	Salt Creek – Side Canyons 34-35	May 11, 2004	KA	21	Salt Creek – O West Fork – P
N-13	Salt Creek – Side Canyon 37	May 11, 2004	RR	54.1	Angel Arch - N
N-14	Salt Creek – Side Canyon 41	May 11, 2004	RR	59.3	Fisheye Arch - Q
N-15	Salt Creek – Side Canyon 42	May 10, 2004	KA	129.2	Fisheye Arch – Q
N-16	Salt Creek – Side Canyon 44	May 10, 2004	RR	178.9	Fisheye Arch – Q
N-17	Salt Creek – Side Canyon 40	May 10, 2004	HH	17.2	West Fork - P Fisheye Arch – Q
N-18	Salt Creek – Side Canyon 43	May 10, 2004	RR	16.0	Fisheye Arch – Q
N-19	Salt Creek – Side Canyons 35-39	May 10, 2004	HH, KA	109.3	West Fork – P Fisheye Arch – Q
N-20	Salt Creek – Side Canyons 54-56	May 9, 2004	HH, KA, RR	172.6	Big Pocket – R Cathedral Butte – S
N-21	Salt Creek – Side Canyon 57	May 9, 2004	HH	20.7	Big Pocket – R Cathedral Butte – S
N-22	Salt Creek – Side Canyon 58	May 9, 2004	RR	9.0	Cathedral Butte – S
N-23	Salt Creek – Side Canyons 36, 38-39	May 11, 2004	HH, KA	88.2	West Fork – P Fisheye Arch – Q
N-24	Salt Creek – Side Canyon 11	May 9, 2004	BA, MB, SD	15.0	Peekaboo Springs - M
N-25	Salt Creek – Side Canyons 12-13	May 9, 2004	BA, MB, SD	44.8	Horse Canyon - J Angel Arch – N
N-26	Salt Creek – Side Canyons 14-15	May 10, 2004	BA, MB, SD	99.4	Horse Canyon - J Angel Arch – N
N-27	Salt Creek – Side Canyon 17	May 10, 2004	BA, MB	26.1	Angel Arch – N
N-28	Salt Creek – Side Canyons 18-20	May 10, 2004	SD	56.7	Angel Arch – N
N-29	Salt Creek – Side Canyon 21	May 10, 2004	SD	13.8	Angel Arch – N

N-30	Salt Creek – Side Canyons 22-32	May 11, 2004	BA, MB, SD	440.6	Angel Arch – N West Fork – P Fisheye Arch – Q
	TOTAL			**25,160.9**	

* Area Number abbreviations: I = Island-in-the-Sky District, N = Needles District

** Crew abbreviations: BA = Bridget Atkin, KA = Kim Andersen, Melanie Ballard = MB, EL = Eric Lamalfa, SD = Steve Dewey, HH = Hillary Hudson, JS = Janna Simonsen, RR = Ruth Richards, LZ = Liz Ballenger, HR = Heather Rickleff.

*** Year 2003 = 20,281.3 acres. Year 2004 = 4,879.6 acres. A 2-yr average of 173.8 acres inventoried per person per 10-hr day.

****Indicates the key to mapped areas presented later in Figures 4 and 5.

Crew members were given the option to record infestations between 1 and 5 acres in size as points, polygons (either 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 Canyonlands National Park (with the exception of the extensive *Tamarix ramosissima* infestations in the main canyon of Salt Creek). The few other polygon and line features recorded within this size range were later converted in the office to point features in order to facilitate viewing on GIS-generated maps.

Extensive weed infestations (greater than 5 acres in size) were mapped either as "actual" or "gross" areas (see 2003 NAWMA Weed Mapping Standards for definitions). When mapping an actual area of this size, crew members either hand-drew the infestation perimeter on field maps or collected GPS "generic points" at key locations as they walked along the boundary of the infestation. This information then was used later to digitize the infestation as a polygon on the computer in the office. Generic points were deleted after such polygons were created, and are not included in the final report. This type of mapping was used only for large infestations of *Tamarix ramosissima* along portions of Salt Creek. Gross areas were used only in situations in which an invasive species was too abundant and widespread to fully inventory within the time and budget constraints of this project, and yet its general distribution was considered important to note in map form. To create a "gross" area, crew members drew on field maps and/or described in field notebooks the borders of an area observed to be infested. A sample survey then was conducted by walking through a portion of the area to estimate the percentage of land within the overall gross area boundary that was infested by the weed, and also to estimate its average canopy cover within the infested portions. The gross area method was used in CANY only for infestations of *Tamarix ramosissima* in Salt Creek. Gross area acreage values were included in the total number of acres infested in CANY because it is felt that conditions allowed the infestation estimates to be more accurate than usual for gross areas -- much closer to the values that would have been achieved if the infestations had been mapped as actual areas.

In deciding on the dominant vegetation cover, crews identified the two most prevalent or most dominant native species in the immediate vicinity of the weedy infestation. The full list was not a part of the data dictionary due to its size, but a paper copy (Appendix G) 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 a digital camera, or 35-mm slide film and later digitized. Pertinent photographs are included with this report (see Appendix H). 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 Canyonlands National Park. No voucher specimens were collected in 2003. Voucher specimens of *Centaurea diffusa* were collected in 2004. The voucher specimens of *Centaurea diffusa* were collected from an infestation on the north shoulder of the main road at Willow Flat, south of Aztec Butte. Duplicate voucher specimens were processed for deposit in herbaria at USU and Canyonlands National Park. The specimen deposited at USU is considered "on loan" from NPS and documented in a loan agreement. 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 automatically 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, "R071013.ssf" would be the file name for raw GPS data collected by Ruth Richards beginning in the thirteenth hour (24-hr local time) on July 10.

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 created 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 Ruth Richards on July 10 would be July10-R2.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: Jul10-R2.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 04-psnpnt.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.

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. In 2003 the USU and NPS crew leaders, and USU crew members, completed an intensive 2-week pre-season training course consisting of classroom presentations and field exercises to familiarize them with all inventory procedures and standards, and to improve all skills related to the job. Each NPS crew leader and all USU crew members were provided with a copy of the training manual. The training was repeated in 2004 for USU crew members.

During the first few weeks of the 2003 and 2004 field seasons, and periodically thereafter, the Crew Supervisor (CS) and/or the Principal Investigator (PI) worked individually with each USU 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 2004 field season, the CS and/or PI conducted inservice training for the USU crew in the form of weed I.D. quizzes or demonstrations, reviewing the key identifying characteristics of targeted and other invasive weed species at various stages of growth. Each time any new weed species was found during an inventory, the identity was verified by the CS and/or PI. At the end of the 2003 and 2004 seasons the PI and CS conducted random field inspections of areas previously inventoried by individual crew members. Field inspections were conducted on August 8, 2003 and August 20, 2004. 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 25,160.9 acres in Canyonlands National Park during the summers of 2003 and 2004 (Table 3), an amount representing approximately 7.5 percent of the entire 337,598-acre Park. The general location and relative 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. An average of 173.8 acres was inventoried per person per 10-hr day during the two seasons.

Figures 2 and 3 show the 40 inventory areas used in planning and field operations. The identification number, drainage description, and acreage of each inventory area are listed in the legend. Each inventory area is also color-coded for ease in identification. Figures 4 and 5 serve as orientation maps for the smaller 1:24,000 scale weed-distribution "inset" maps found in Appendices I, J, K and L. Inset maps are distinguished by letters A – N for the Island-in-the-Sky District and letters A – S for the Needles District, plus the name of a distinct geographic feature found within its boundaries. The corresponding inventory area numbers from Figures 2 and 3 are included in the legend in parentheses behind each inset map name. Thirty-two inset maps are required to cover all 40 of the inventory areas, and large inventory areas may span over several inset maps. For example, different sections of Salt Creek (Inventory Area 4) appear on Squaw Flat, Cave Spring, Salt Creek Pocket, Horse Canyon, Lost Canyon, Peekaboo Spring, Angel Arch, Salt Creek, West Fork, Fisheye Arch, Big Pocket, and Cathedral Butte inset maps (Insets C, H-J, L-S).

Invasive plants infested a total of 774.5 acres (Table 4), an amount equal to 3.1 percent of the land inventoried. Of the 14 targeted species, only *Carduus nutans, Centaurea diffusa, Cirsium arvense, Cirsium vulgare, Elaeagnus angustifolia, Tamarix ramosissima,* and *Ulmus pumila* were found in the Park. No infestations of *Centaurea maculosa, Centaurea repens, Centaurea solstitialis, Centaurea squarrosa, Lepidium latifolium, Lythrum salicaria,* or *Onopordum acanthium* were discovered. Non-target species mapped were *Arctium minus, Convolvulus arvensis,* and *Halogeton glomeratus.*

The most abundant target species found in the Park was *Tamarix ramosissima.* This species, which was especially common along much of Salt Creek, Big Spring Canyon, Little Spring Canyon, Taylor Canyon, Trail Canyon, and Lathrop Canyon, comprised 99.6 percent of the total infested acreage inventoried. The remaining infestations (0.4 percent of the total infested acreage) were comprised of the other six targeted species and the three additional non-native species that were mapped.

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. Species such as *Bromus tectorum, Bromus inermis, Lactuca serriola, Erodium cicutarium, Sonchus oleraceus, Melilotus officinalis, Dactylis glomeratus, Salsola kali, Sisymbrium altissimum,* and *Chenopodium album* were present in many areas but were ignored due to their previously recognized presence and relative abundance in the Park. Species such as *Halogeton glomeratus* were mapped by some but not all crew members; and those who chose to map them often did so only in locations of unusually low abundance. As a result, the acreage values and corresponding

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

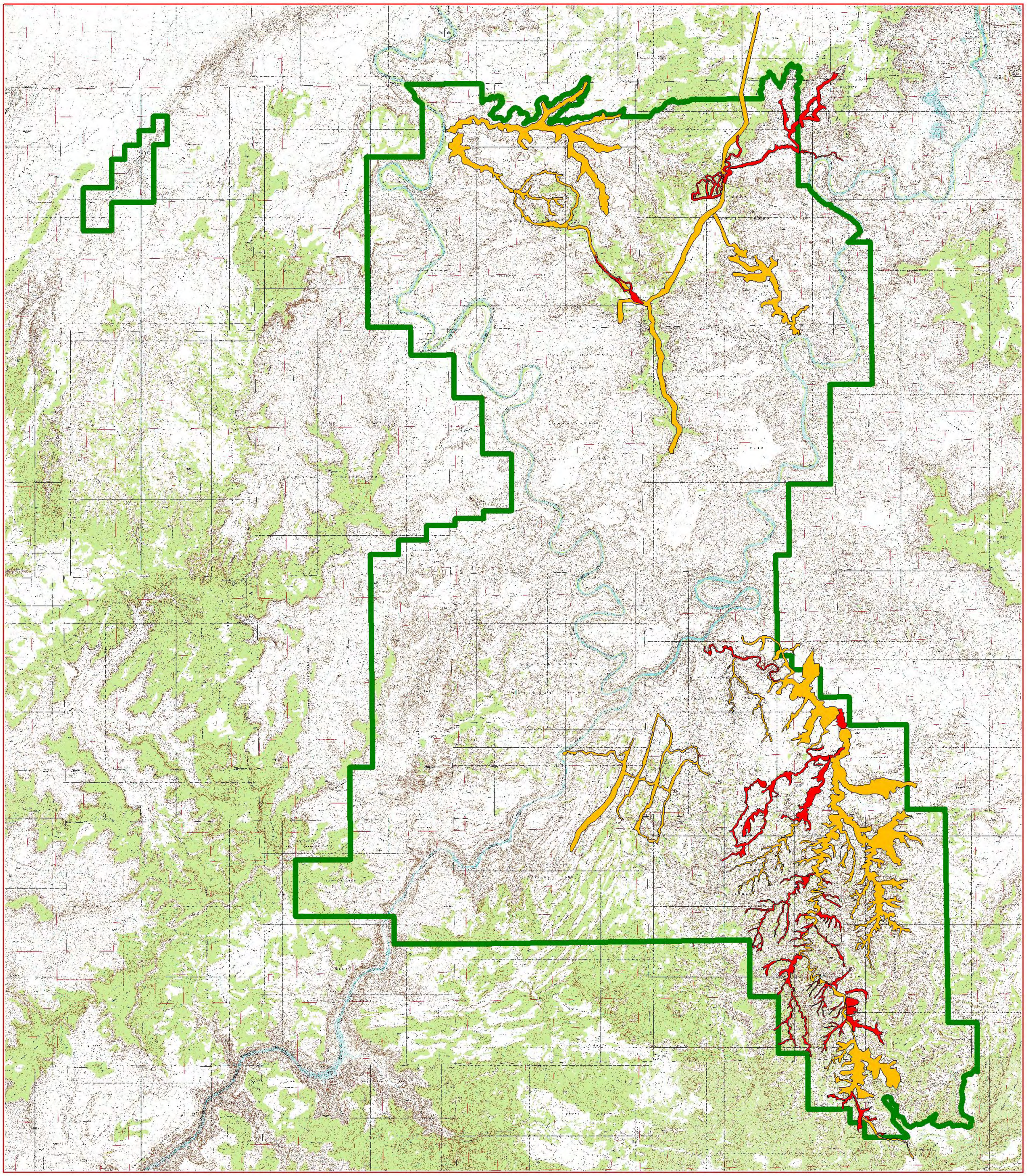

Figure 2. Identification number and acreage of individual areas inventoried for non-native invasive plant species in the Island in the Sky District of Canyonlands National Park during 2003 and 2004.

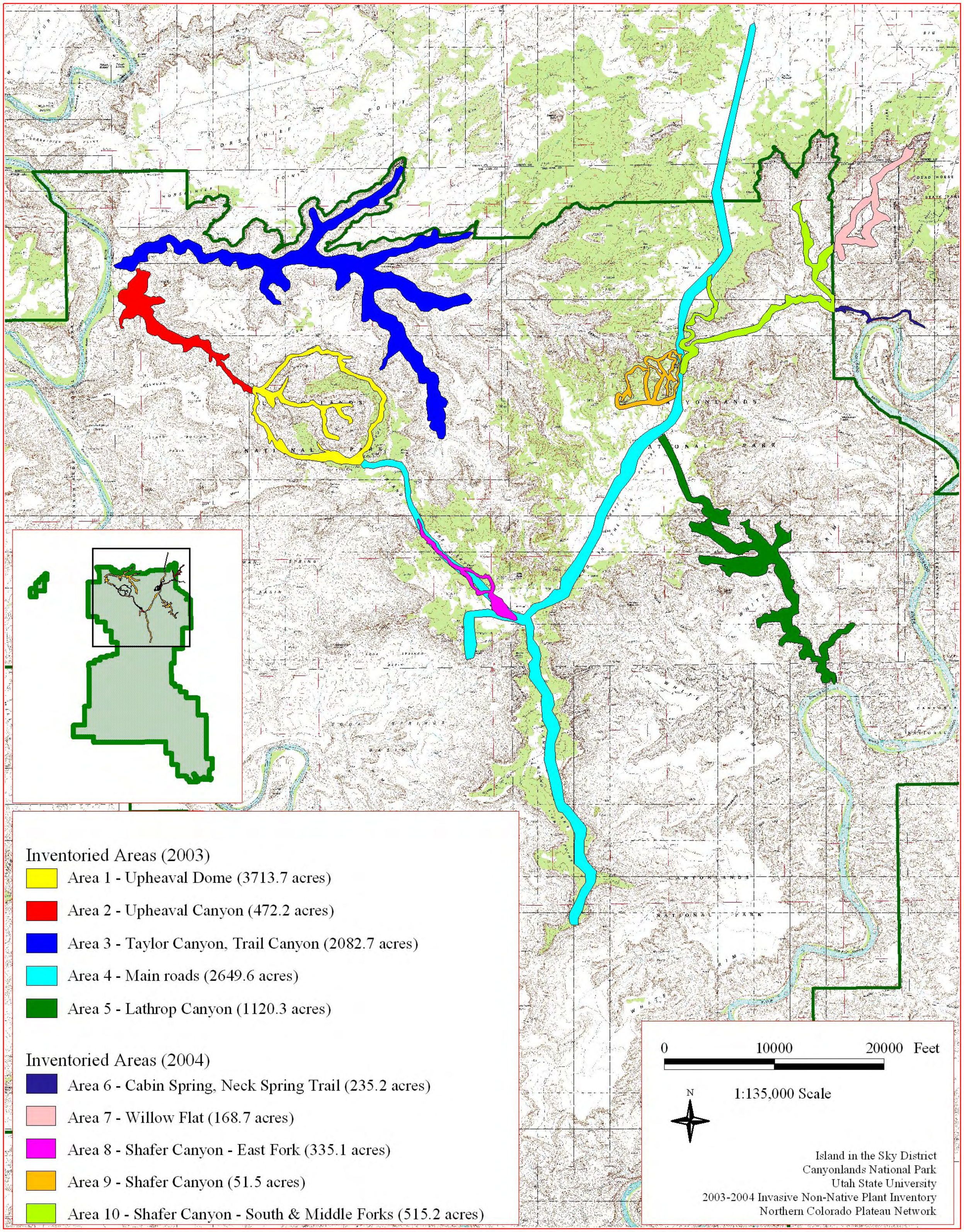

Figure 3. Identification number and acreage of individual areas inventoried for non-native invasive plant species in the Needles District of Canyonlands National Park during 2003 and 2004.

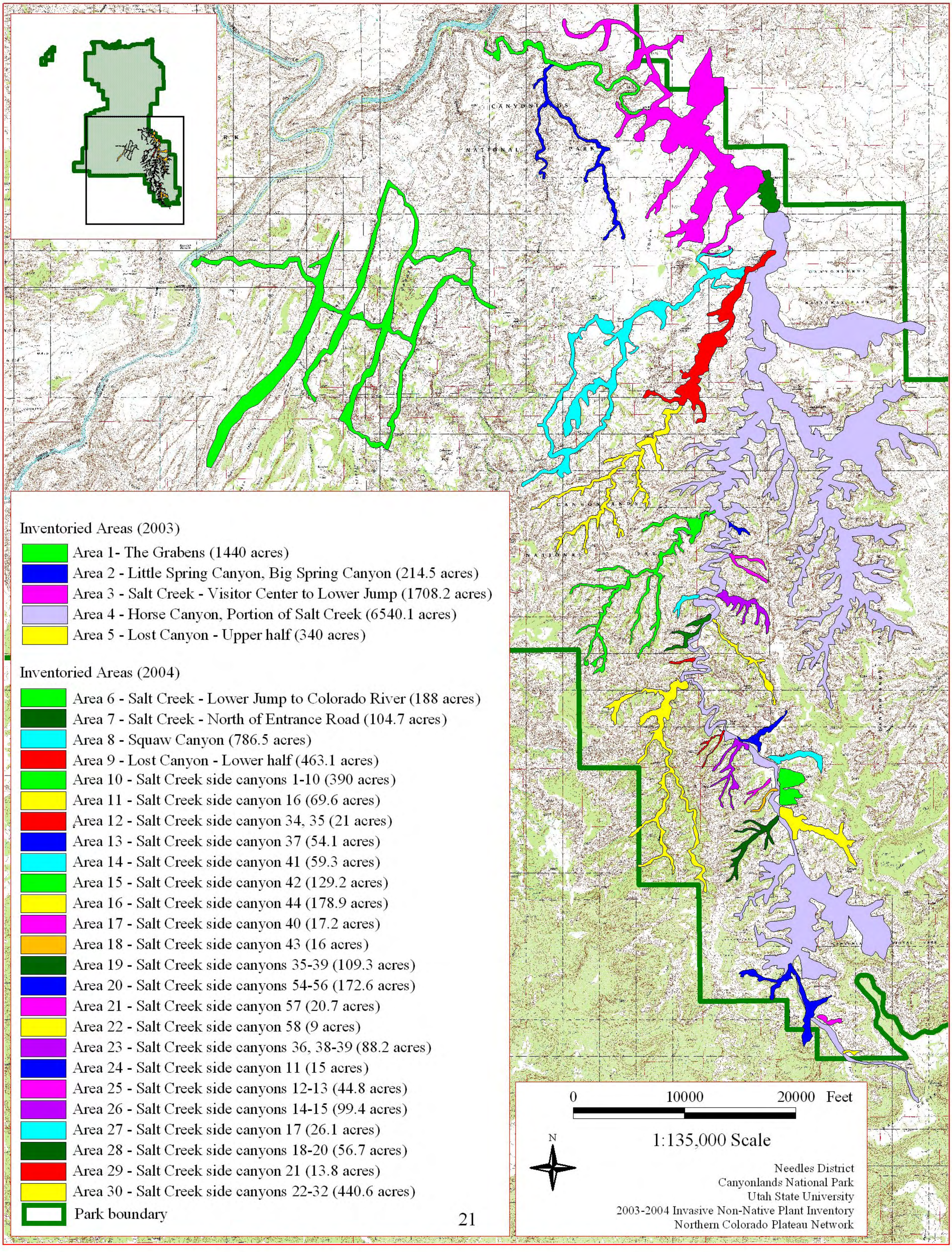

Figure 4. Insets indicating the location, letter code, and name of the fourteen 1:24,000 scale maps used in Appendix tables to show weed distribution within individual inventoried areas in the Island in the Sky District of Canyonlands National Park during 2003 and 2004.

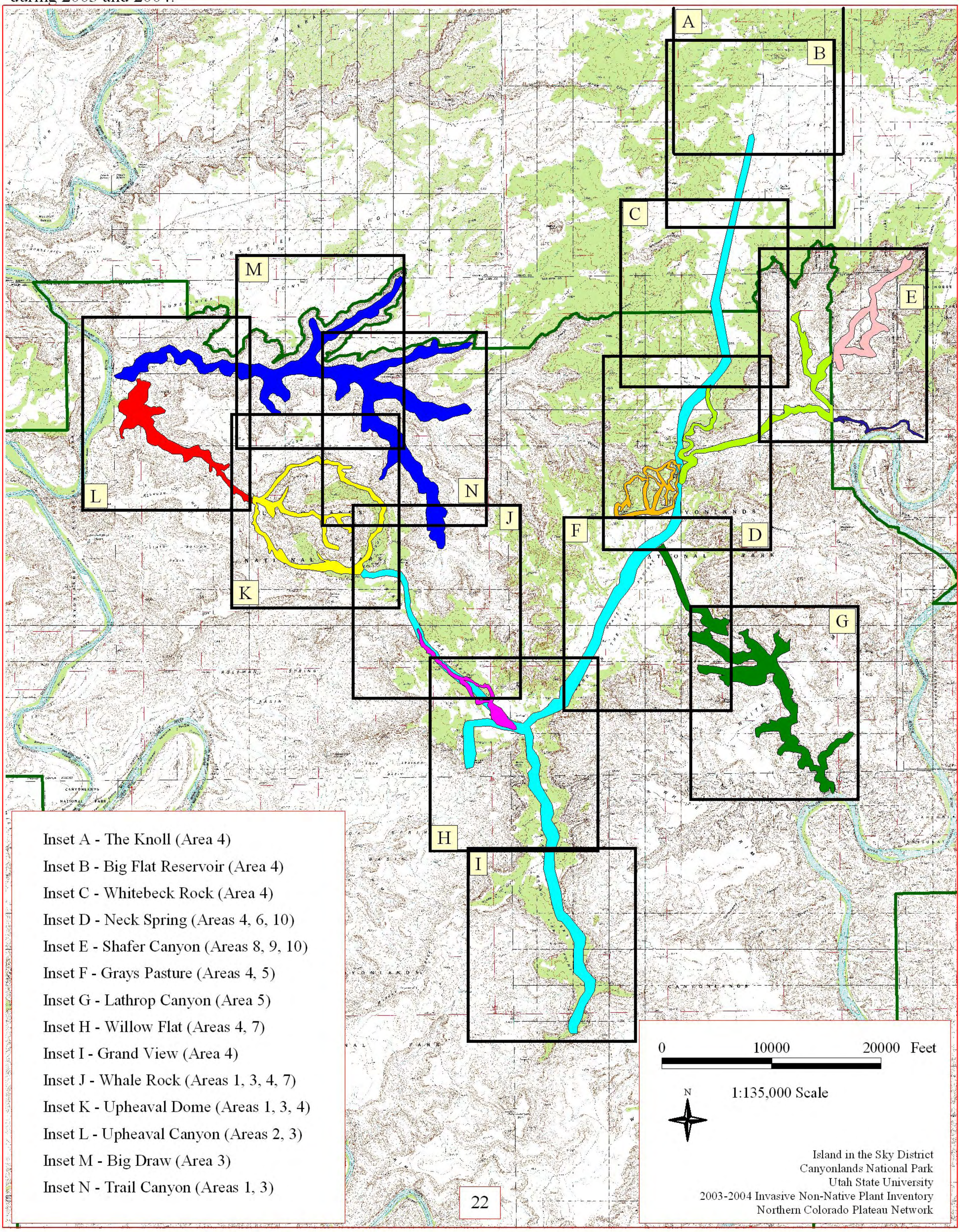

Figure 5. Insets indicating the location, letter code, and name of the nineteen 1:24,000 scale maps used in Appendix tables to show weed distribution within individual inventoried areas in the Needles District of Canyonlands National Park.

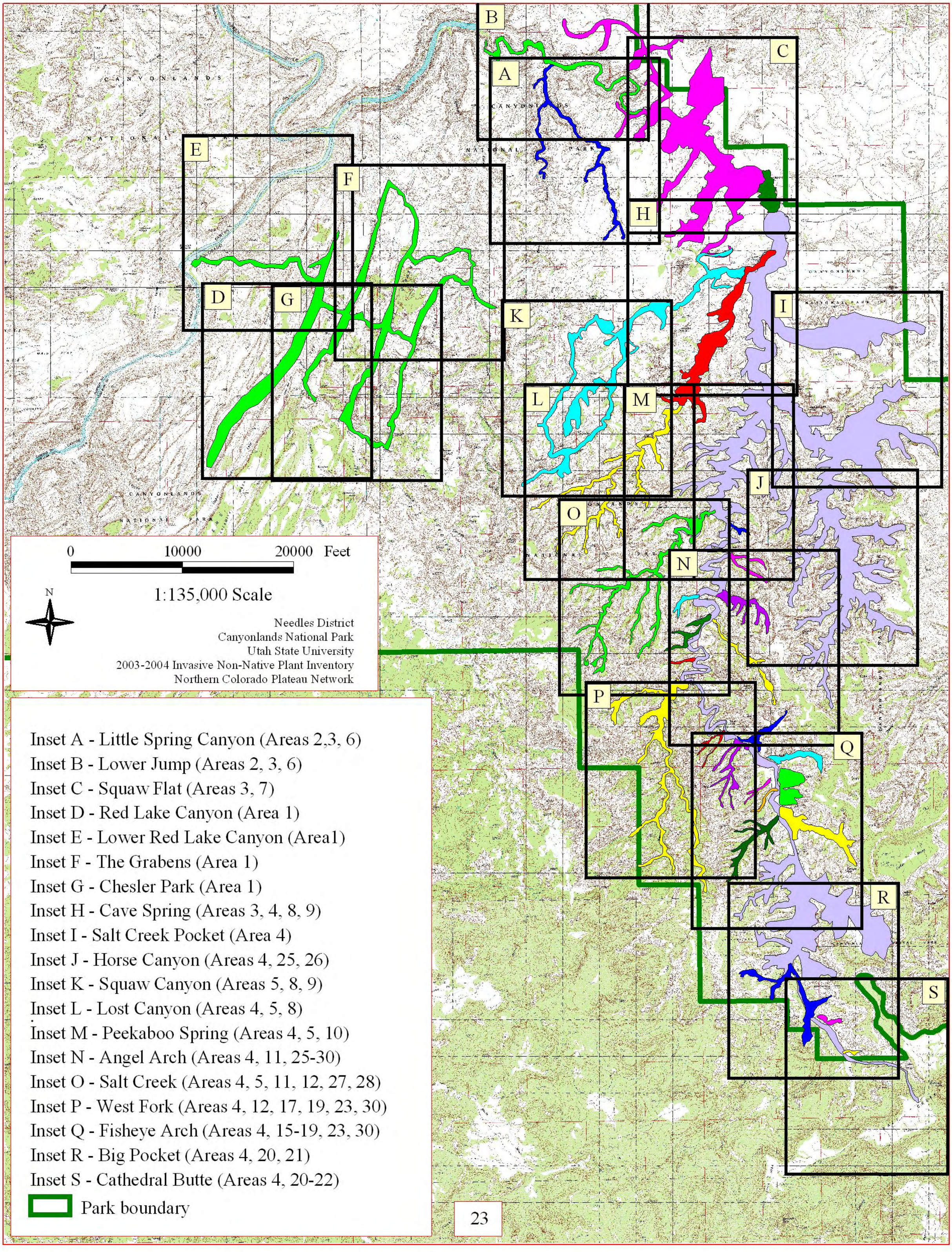

Table 4: Acres infested by invasive plant species within inventoried areas of Canyonlands National Park and adjacent lands in 2003-2004.

Species	ISKY	NEED	2003	2004	Acres (Inside Park)	Acres (Outside Park)	Total Acres Infested
Arctium minus	--	X	0.030	0.071	0.101	--	0.101
Carduus nutans	--	X	0.010	0.010	0.020	--	0.020
Centaurea diffusa	X	--	0.270	--	0.270	--	0.270
Cirsium arvense	--	X	0.600	0.155	0.755	--	0.755
Cirsium vulgare	--	X	0.030	0.036	0.066	--	0.066
Convolvulus arvensis	--	X	0.600	--	0.600	--	0.600
Elaeagnus angustifolia	--	X	0.090	--	0.090	--	0.090
Halogeton glomeratus	X	X	0.830	--	0.830	--	0.830
Tamarix ramosissima	X	X	743.149	28.589	769.93	1.808	771.738
Ulmus pumila	X	--	0.030	--	--	0.030	0.030
Totals			**745.639**	**28.861**	**772.662**	**1.838**	**774.500**

distribution maps for these non-target species should be considered less than complete inventories.

Appendix I contains maps showing the overall distribution and relative abundance of all mapped weeds (no species distinction) within the boundaries of inventoried areas in the Island-in-the-Sky District. Appendix J contains the maps showing the overall distribution and relative abundance of all mapped weeds (no species distinction) within the boundaries of inventoried areas in the Needles District. Appendix K and L contains maps of individual species occurrences and weed-free areas within all inventoried portions of the Island-in-the-Sky District and Needles District of Canyonlands National Park, respectively. Following is a summary of the weed situation in individual drainages and other inventory units within Canyonlands National Park. The inventory units are discussed by District within the Park.

ISLAND-IN-THE-SKY DISTRICT

Upheaval Dome, Syncline Valley (Area Number I-1; Inset Maps J, K)

Upheaval Dome and Syncline Valley were inventoried in 2003 by the USU crew. Areas inventoried within this area include the hiking trail around Syncline Valley and the drainage bottoms within the Upheaval Dome itself. The crew found only one targeted species, *Tamarix ramosissima*, infesting the trails and drainages. *Tamarix ramosissima* was distributed along the majority of the trail as well as throughout the drainage below Upheaval Dome. The majority of infestations were comprised of small dense stands of mature trees. The infestations also appeared to be restricted to the bottom of the main drainages. A single infestation of *Halogeton glomeratus* was recorded at the junction of Upheaval Canyon and Syncline Valley. Although

this infestation was the only one recorded, it is likely that other small infestations of *Halogeton glomeratus* occur along or near the trail.

Visibility was generally good and the inventoried areas were generally open. The crew was confident of finding at least 90 percent of all targeted species infestations 0.01 acre or greater in size. The area did not appear to have any recent obvious disturbances aside from seasonal flooding. The area inventoried was assigned at ecological status three.

Upheaval Canyon (Area Number I-2; Inset Map L)

Upheaval Canyon and Upheaval Bottom were inventoried by the USU crew in 2003. The area inventoried consisted of the main drainage and side drainages along Upheaval Canyon including Upheaval Bottom at its mouth. The only targeted species found was *Tamarix ramosissima*. These infestations varied in size from 0.01 to 2.5 acres and were comprised of mature trees. Infestations appeared to be restricted to the main drainage and did not appear to be actively spreading into the smaller side drainages at the time of the inventory. The only species not mapped but noted was a *Rumex* species.

The inventory area was open, and visibility was generally good. No recent disturbances were noted by the crew during the inventory. The crew was confident of finding at least 90 percent of all targeted species infestations 0.01 acre or greater in size. The inventoried area was assigned an ecological status of three.

Taylor Canyon, Trail Canyon (Area Number I-3; Inset Maps J, K, L, M, N)

Taylor Canyon was inventoried in 2003 by the USU crew. The unit consisted of Taylor Canyon, The Big Draw, and a large section of Trail Canyon. The area was comprised of mostly sagebrush, greasewood, and sparse annuals and native grasses. *Tamarix ramosissima* was the only targeted weed species found and mapped during the inventory. *Tamarix ramosissima* was found throughout the entire inventoried area, and was found hugging the streambed in all cases. These infestations ranged from single plants to moderately dense patches. Occasional infestations were found in the smaller side washes, but most were restricted to the main washes in both Taylor Canyon and Trail Canyon. No other targeted species were found during the inventory of this unit.

A single patch of *Halogeton glomeratus* was found and mapped in Trail Canyon, near Alcove Spring. Although this patch was identified and inventoried, it is likely there were other infestations of *Halogeton* that were not inventoried in this area. Species seen but not mapped include *Lactuca serriola* and *Salsola kali*.

The inventory area was extremely open, and visibility was very good. The crew was very confident of finding at least 90 percent of all targeted species infestations 0.01 acre or greater in size. The native plant community still retained some diversity in plant composition despite the invasion of *Tamarix ramosissima* along the washes. No obvious disturbances were noted in the assigned areas during the inventory. The area was assigned an ecological status level of three.

Main Roads, Willow Flat (Area Number I-4, I-7; Inset Maps A, B, C, D, F, H, I, J, K)
The main paved roads throughout the Island-in-the-Sky District were driven and their shoulders inventoried in August of 2003 by the USU crew. A swath approximately 25 yards wide was inventoried on each side of the road, beginning from the edge of the pavement. Three separate infestations of *Centaurea diffusa* were found on the road shoulder of Willow Flat, near the Aztec Butte Trail. Two of the three patches were 0.01 acres in size, and the third infestation was 0.25 acre. These three infestations had already flowered at the time of their discovery. Also discovered was a single sapling of *Tamarix ramosissima* in a small drainage across the street from Willow Seep. A single *Tamarix* was also discovered on the road shoulder several miles outside the Park boundary, but was included in this inventory. Three separate saplings of *Ulmus pumila* were also along the road shoulder less than two miles outside the Park boundary. These infestations were included in this inventory due to their potential to spread into the Park. The crew returned in 2004 to re-inventory Willow Flat and Willow Seep, and to look for additional infestations of *Centaurea diffusa*. Nearly all plants within the previously-discovered infestations had been controlled by the Park, and no new infestations were found.

Species seen but not mapped include *Salsola kali, Polygonum aviculare, Chenopodium album,* and *Erodium cicutarium.* The road shoulder is constantly disturbed by vehicles and this was the most obvious disturbance seen during the inventory. Visibility was very good along the road shoulders. The crew felt confident in finding 90 percent or more of all 0.01-acre infestations of the targeted species. The overall ecological status of the roads was given a rating of two.

Lathrop Canyon (Area Number I-5; Inset Maps F, G)
Lathrop Canyon was inventoried by the USU crew in 2003. This inventory unit includes Lathrop Canyon, several drainages feeding into the head of Lathrop Canyon, and the Lathrop Canyon Trail from Grays Pasture to the White Rim Road. *Tamarix ramosissima* was the only targeted species found during the inventory of this area. *Tamarix ramosissima* was found throughout Lathrop Canyon and infestations increased in size and density down canyon. The largest infestations were found at the mouth of the canyon, along the banks of the Colorado River. Infestations appeared to be primarily in the main drainage, although small trees were found in the side drainages branching from the main wash. *Tamarix ramosissima* was also widely scattered along a large drainage that the Lathrop Canyon Trail paralleled. Infestations in this drainage were small but still comprised mature trees. No targeted species were found along the hiking trail across Grays Pasture.

Several patches of *Halogeton glomeratus* were found growing on open arid hillsides. Few other weedy species, targeted or non-targeted, were noted in these areas. The inventory area was open, and visibility was generally very good. Crews were confident of seeing at least 90 percent of all targeted species infestations 0.01 acre or larger in size. The native plant community appeared relatively undisturbed in areas not infested by Tamarix ramosissima. Grays Pasture contained a healthy diversity of native grasses, forbs, and shrubs. Lathrop Canyon also contained sections of willows, cottonwoods, and rabbitbrush. No obvious recent disturbances were noted, although the vehicles traveling the road along the bottom of Lathrop Canyon could be a seed source for new introductions. The area was assigned an ecological status level three.

Cabin Spring, Neck Spring Trail (Area Number I-6; Inset Map D)
The Neck Spring Trail as well as Cabin Spring and Neck Spring were inventoried by a USU crew in 2004. The trail was hiked in its entirety and the several drainages were also searched for invasive species in this unit. The area was relatively free of invasive species, and only *Tamarix ramosissima* was found during this inventory. Two separate infestations of *Tamarix ramosissima* were discovered near Cabin Spring. One 0.001-acre infestation was found below Cabin Spring and a second 0.01-acre infestation was found in the drainage east of Cabin Spring. Both patches contained mature trees. A patch of *Bromus tectorum* was also recorded at the pour-off above Taylor Canyon. Although not a target species, this patch was marked due to the relatively rare occurrence of *Bromus tectorum* throughout the inventoried areas in the Island-in-the-Sky District of Canyonlands National Park.

Native vegetation appeared to be very healthy along the bottoms of the drainages. Willows, skunkbush sumac, single-leaf ash, and rabbitbrush were all common species found below spring sites. Visibility was generally good and the majority of the trail was very open. Vegetation tended to be thicker around spring sites and visibility was not as good. However, the crew still felt confident of finding 90 percent or more of all 0.01-acre infestations of the targeted species in this area. No obvious recent signs of disturbance were noted by the crew during the time of the inventory and the overall ecological status of the unit was given a rating of two.

Shafer Canyon (Area Numbers I-8, I-9, I-10; Inset Maps D, E)
The South, Middle, and East Forks of Shafer Canyon were inventoried by the USU crew in 2004. The East Fork of Shafer Canyon lies outside the Park boundary but was included in this inventory at the request of Ian Torrence. *Tamarix ramosissima* was the only targeted species found in Shafer Canyon. It was found extensively and consistently throughout the East Fork and intermittently in the Middle Fork. The South Fork of Shafer Canyon was found to be relatively non-infested with *Tamarix* and the majority of the infestations were contained in the other two forks. Several of the infestations in the Middle and South Forks showed signs of control treatments and none of the treated sites showed signs of regrowth at the time of the inventory.

No other targeted species were noted in this unit. Species seen but not mapped include *Salsola kali* and *Polygonum aviculare*. Visibility was generally very good throughout the drainages in Shafer Canyon. The area is continually disturbed by flash flood events as well as vehicle traffic along the Shafer Basin Road along the South Fork. The crew felt confident in finding at least 90 percent of all 0.01-acre infestations or larger of the targeted species. The three forks of Shafer Canyon were assigned an ecological status of three.

NEEDLES DISTRICT

The Grabens (Including Cyclone Canyon, Devil's Lane, Devil's Pocket, Red Lake Canyon, Butler Wash) (Area Number N-1; Inset Maps D, E, F, G)
The Grabens including Cyclone Canyon, Devil's Lane, Devil's Pocket, Red Lake Canyon, and Butler Wash were inventoried by the NPS crew in 2003. Two infestations of *Tamarix ramosissima* were found in Lower Red Lake Canyon. A third patch of *Tamarix ramosissima* was also found below the junction of Red Lake Canyon and Lower Red Lake Canyon. No other

targeted species were discovered in the Grabens at the time of the inventory. The crew did photograph *Amaranthus retroflexus* in some depressions between Devils Pocket and Devils Lane, since it did not appear to be on the list of known species for the Park. Upper Red Lake Canyon was not inventoried in 2003 due to time constraints. However, the crew felt it is likely non-infested due to the lack of targeted species in the other areas within the Grabens.

Other non-native species observed but not mapped include *Bromus tectorum, Melilotus officinalis,* and *Salsola kali.* Visibility was very good throughout the canyons in the Grabens and the crew was confident of finding 90 percent or greater of all 0.01-acre infestations or larger of the targeted species. The crew noted the presence of cottonwoods and other riparian vegetation in Butler Wash but the remaining areas appeared arid. Little disturbance was noted aside from the road and trails throughout the Grabens. The area was assigned an ecological status level of two.

Big Spring Canyon, Little Spring Canyon (Area Number N-2; Inset Maps A, B)
Little Spring Canyon and a portion of Big Spring Canyon were inventoried in 2003 by the NPS crew. *Tamarix ramosissima* was found throughout both canyons. Infestations of *Tamarix ramosissima* ranged in size from 0.01 to 0.25 acres and were a mixture of stands of saplings and mature trees. Two single plants of *Cirsium vulgare* were found in Little Spring Canyon at a spring site in 2004 and pulled upon their discovery. A single infestation of *Halogeton glomeratus* was also mapped at a pullout for Pothole Point near Little Spring Canyon.

A species noted in both canyons was *Polypogon monspeliensis,* an introduced annual. Other species seen but not mapped include *Bromus tectorum, Salsola kali, Tragopogon dubius,* and *Melilotus officinalis.* Visibility was generally open and it is assumed the crew conducted the inventory in such a way to ensure that 90 percent of all 0.01-acre infestations of the targeted species could be found. No obvious disturbances were noted in the two canyons. An ecological status level three was assigned to the inventoried area.

Squaw Canyon (Area Number N-8; Inset Maps H, K, L)
Squaw Canyon was inventoried in 2004 by the USU crew. *Tamarix ramosissima* was the only targeted species found within this inventory unit. Patches were found scattered throughout the canyon, but the majority of infestations showed prior control treatments. The crew noted that several patches had resprouted and small seedling patches also existed in places.

Other non-native species seen but not mapped include *Bromus tectorum, Salsola kali, Melilotus officinalis,* and *Tragopogon dubius.* No obvious disturbances were noted aside from flash flood events. Dense stands of willow were noted in both the mouth and head of the canyon. Visibility varied, but was generally quite good. The crew felt confident in its ability to see at least 90 percent of all 0.01-acre or larger infestations of the targeted species. The area was assigned an ecological status level of three.

Lost Canyon (Area Number N-5, N-9; Inset Maps H, K, L, M, O)
The upper half of Lost Canyon was inventoried in 2003 by the NPS crew and the remaining lower half was inventoried by the USU crew in 2004. *Tamarix ramosissima* was the only target species found in the entire Lost Canyon drainage system. The lower half of Lost Canyon was

comprised of numerous 0.01 – 0.1 acre patches of saplings while the upper half was only lightly infested with a few small patches of saplings and seedlings. Control efforts were evident on several of the infestations in Lost Canyon.

Other species seen but not inventoried include *Bromus tectorum, Salsola kali,* and *Melilotus officinalis*. Visibility was generally good and the crew was confident of finding at least 90 percent of the 0.01-acre or large infestations of the targeted species. No obvious disturbances were seen during the inventory. The lower portion of Lost Canyon was assigned an ecological status level three and the upper portion of the canyon was assigned a status of two.

Salt Creek – Lower Jump to Colorado River (Area Number N-6; Inset Maps A, B)
This section of Salt Creek was inventoried by the USU crew in 2004. The inventory area stretched from the base of the Lower Jump of Salt Creek to the Colorado River. The only targeted species recorded was *Tamarix ramosissima,* which was found almost continuously along this stretch of Salt Creek. *Tamarix* was found growing in seeps along the walls of the canyon in several places as well. Infestations ranged in density, but the crew noted that it increased toward the Colorado River. No other targeted species were found along this stretch of Salt Creek. The crew noted an abundance of *Bromus tectorum* along the bottom of the canyon.

Visibility was sometimes difficult due to thick *Tamarix* stands. The crew often inventoried such stands from slightly above on the hillside, and could not penetrate some stands to check for other targeted species underneath. However, the crew was confident that they could see at least 90 percent of the 0.01-acre or larger infestations of the targeted species along this portion of Salt Creek. Little native vegetation was noted along the drainage bottom. No obvious disturbances were noted aside from flash flood events. The area was assigned an ecological status level of four.

Salt Creek – Visitor Center to Lower Jump (Area Number N-7; Inset Map C)
The area of Salt Creek between the Visitor Center and the Lower Jump was inventoried by the USU crew in both 2003 and 2004. The creek bed was walked as well as several side drainages that run across Squaw Flat. Areas away from Salt Creek were also included in this unit whenever possible. The primary species found in this section of Salt Creek was *Tamarix ramosissima*. It was distributed consistently along the creek bed, with the heaviest infestations of *Tamarix* found at the Lower Jump, near the Visitor Center, and where Salt Creek crosses the main road. Some efforts to control this species were evident near the paved road, with little regrowth noted in the controlled area. *T. ramosissima* trees were primarily mature, and infestations ranged in size from 0.01 to 2.5 acres. Line features were used to map some of these infestations.

The crew also noted that *Salsola kali* and *Chenopodium album* were common along this portion of Salt Creek and were particularly heavy in sites where earlier *Tamarix ramosissima* control activities were evident. Other species noted but not inventoried include *Bromus tectorum, Tragopogon dubius, Halogeton glomeratus, Lactuca serriola,* and *Melilotus officinalis.* Visibility was generally good although it was difficult at times to see underneath dense patches of *Tamarix* at times. Squaw Flat had very good visibility. The crew noted some cottonwood and willow in Salt Creek in places; however the primary vegetation was *Tamarix ramosissima*. The

crew was confident of their ability to see at least 90 percent of the 0.01-acre infestations or larger of the targeted species. No obvious recent disturbance was noted during the inventory. There were several large areas closed for revegetation and the crew did not inventory those areas. However, the crew did note that the revegetation sites contained a high amount of *Salsola kali* and bare ground at the time of the inventory. This section of Salt Creek was assigned an ecological status level of three.

Horse Canyon (Area Number N-4; Inset Maps I, J, N)

Horse Canyon was inventoried in 2003 by the NPS crew and included all major branches within the Horse Canyon drainage system. *Tamarix ramosissima* was the only targeted species found within the inventoried area. Infestations were heaviest near the mouth of Horse Canyon at its junction with Salt Creek. The majority of infestations were concentrated along the main wash although one small infestation was found in the east fork of Horse Canyon above Tower Ruin. Infestations also were found in the west fork above Gothic Arch. Patch sizes ranged from 0.01 to 5 acres and the majority of infestations were comprised of mature trees. Infestations at the head of Horse Canyon were comprised mostly of seedlings and saplings, suggesting that the direction of spread is up-canyon.

Other species noted but not mapped include *Salsola kali, Chenopodium album, Melilotus officinalis, Bromus tectorum, Tragopogon dubius,* and *Erodium cicutarium*. *Lepidium montanum* was inventoried initially by the crew as it resembles *Lepidium latifolium*. However, these points were later deleted and are not included in this data set.

Visibility varied depending on the concentration of *Tamarix ramosissima* in the wash. It is assumed the NPS crew conducted their inventory in a way to ensure at least 90 percent of all 0.01-acre infestations of the targeted species would be found. The crew noted that disturbances were heavy due to the road corridor. There was also some historical evidence of cattle grazing. The area was assigned an ecological status level of four.

Salt Creek – Visitor Center to Upper Jump, including side canyons #1-21 (Area Numbers N-4, 10, 11, 24-27, 29; Inset Maps C, H, I, J, L, M, N)

The main drainage of Salt Creek between the Visitor Center and Upper Jump was inventoried in 2003 by the USU crew. Side canyons # 1-21 were inventoried by the USU crew in 2004. Included in this inventory unit were Salt Creek Pocket and the Angel Arch trail. The main targeted species found was *Tamarix ramosissima*. Extensive infestations of *Tamarix* dominated much of the main drainage in this and other sections of Salt Creek. Such infestations were generally mapped as gross area polygons representing the outer boundaries of the core infestation. The percentage of land estimated to be infested within each gross area ranged from 1 to 20 percent, with the average canopy cover of those infested areas ranging from low to high. *Tamarix* was also found extensively up a large branch of Salt Creek consisting of side canyons # 1-10. Additional side canyons containing Tamarix were numbers 11, 12, 14, and 16. Infestations in these latter side canyons generally consisted of single individuals or small patches of saplings.

Elaeagnus angustifolia was discovered at the mouth of side canyons #14-15 as well as the mouth of the West Fork. *Cirsium arvense* was found in the wash near the entrance road as well as at the

mouth of the West Fork. Other species seen but not inventoried include *Bromus tectorum, Salsola kali, Chenopodium album, Tragopogon dubius, Melilotus officinalis, Erodium cicutarium,* and *Amaranthus retroflexus.*

The main Salt Creek canyon in this section is heavily infested with *Tamarix ramosissima* and *Salix* sp., making it difficult in some instances to inventory for other lower-growing species that might be underneath the woody canopy. Some sections of Salt Creek were nearly impossible to penetrate on foot due to the size and density of the *Tamarix.* The trail through the middle portion of Salt Creek was hard to find in many places, and essentially non-existent in other portions. There were no obvious recent soil disturbances besides the old road corridor and periodic flooding events. Native vegetation such as willows, cottonwoods, rabbitbrush, and sedges are still abundant in most portions of Salt Creek. The ecological status level of this section of Salt Creek was assigned a four for the main canyon and from 1-3 for side canyons.

Salt Creek – West Fork, including side canyons #22-32 (Area Number N-30; Inset Maps P, Q)
The West Fork of Salt Creek was inventoried in by the USU crew in 2004. The crew hiked as many side canyons as possible based on distance and time constraints. *Tamarix ramosissima* was found scattered throughout the two branches of the West Fork, although it was much more common in the "west" fork of West Fork. *Tamarix* was also found in side canyons #22, 28, and 29. Infestation size ranged from 0.001 to 0.25 acres. Some saplings were found but many of the plants were mature. A large flood event had recently occurred prior to the inventory and it is likely that some *Tamarix ramosissima* were broken off and not evident at the time of the search. These plants have likely resprouted since the time of inventory in 2004.

A single *Cirsium vulgare* rosette was found in side canyon # 31 and pulled upon its discovery. Other species seen but not mapped include *Bromus tectorum, Salsola kali,* and *Melilotus officinalis.* Visibility was very good for *Tamarix ramosissima* and other targeted species and the crew felt they had achieved at least 90 percent detection of all 0.01-acre or larger infestations from canyon wall to canyon wall. A large heavy flood had scoured much of the canyon prior to the inventory and disturbance from this event was clearly evident. No other disturbances were noted. The area was assigned an ecological status level three.

Salt Creek – Upper Jump to Cathedral Butte, including side canyons # 34 – 58 (Area Numbers N-4, 12 – 23, Inset Maps N, P, Q, R, S)
The main wash between the Upper Jump and Cathedral Butte in Salt Creek was inventoried in 2003 by a single member of the USU crew. The remaining side canyons in this section were inventoried by USU crew members in 2004. Included in this inventory unit area are side canyons # 34 - 58, Big Pocket, and the East Fork of Salt Creek. As in other sections of Salt Creek, the primary target species found in this section of Salt Creek was *Tamarix ramosissima,* which occurred more or less continuously along the main drainage between the Upper Jump and the southern Park boundary. Small patches of *Tamarix* also were found in the heads of side canyons # 35, 38, 54, and 57-58. These infestations were typically small and comprised of either a single tree or a patch of a few trees.

Other target species detected include *Cirsium arvense, Cirsium vulgare, Arctium minus,* and *Carduus nutans. Cirsium arvense* was found scattered along the mouth of side canyon # 54 as

well as in the main wash above the Upper Jump. *Cirsium vulgare* was found in side canyons # 54 and 56. Rosettes of *Cirsium vulgare* were also found along the trail in the main canyon near the mouth of side canyon #54. These infestations often consisted of single plants or small groups of plants. Several small patches of *Arctium minus* were also found at the in the mouth of side canyon #54 as well as along the trail above the spring site near side canyon #54. A small patch of *Carduus nutans* was also found along the trail near the mouth of side canyon #54. The patch consisted of rosettes growing underneath the *Tamarix*. The smaller infestations of *Cirsium vulgare, Arctium minus,* and *Carduus nutans* were pulled by the USU crew.

Although not a targeted species, two small patches of *Convolvulus arvensis* were also mapped in the main drainage near the mouth of side canyon #54. Other species seen but not mapped include *Bromus tectorum, Melilotus officinalis, Chenopodium album, Salsola kali, Tragopogon dubius, Sonchus asper, Phragmites australis, Asclepias speciosa, Amaranthus retroflexus, Erodium cicutarium,* and *Halogeton glomeratus.*

As stated earlier, visibility varied because much of the main Salt Creek canyon is heavily infested with *Tamarix ramosissima* and *Salix* sp., making it difficult to inventory for other shorter species under the tall and dense brushy canopy. However, the crew was confident that it was able to find at least 90 percent of all 0.01-acre infestations of the targeted species within this inventory unit. Native plants such as cottonwoods, willows, rabbitbrush, sedges, oak, and skunkbrush sumac were still present in many places. Side canyons # 36-37, 39, 41-42, 45-50, 52-53, and 55-56 did not contain any targeted species and contained little other non-native vegetation. Several of the large meadows were characterized as having a high diversity of native grasses and forbs. An ecological status level of four was given to the inventoried areas in the main Salt Creek wash, while the side canyons ranged from one to three.

CONCLUSIONS / RECOMMENDATIONS

The primary objective of this project was to document the distribution and relative abundance of targeted non-native invasive plant species across the range of habitats and areas of management concern within Canyonlands 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 Canyonlands National Park is already implementing many effective weed control strategies and practices, for which they are to be commended. For example, control of *Tamarix ramosissima* was evident near the Visitor Center and along Squaw Canyon and Lost Canyon. In fact, most sites of *Tamarix* inventoried in Squaw Canyon were previously controlled. Additionally, the three infestations of *Ulmus pumila* and the single *Tamarix ramosissima* found outside the Park boundary of the Island-in-the-Sky District in 2003 had been treated and no evidence of their existence could be found upon a revisit to these sites in 2004. It is also known that the *Centaurea diffusa* found on Willow Flat has been treated since its discovery in 2003, and it is targeted for eradication in the near future.

If it does not already exist, the Park is urged to develop a comprehensive written management plan for invasive plant species in CANY, similar to the plan currently being finalized by Utah State University for Dinosaur National Monument. If there currently is a written plan, 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 managed lands should be an ongoing part of any 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 Canyonlands National Park to inventory a portion of their land each year, so that within a reasonable 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, Canyonlands National Park also should consider establishing permanent monitoring sites to evaluate the impact and spread of weeds, and to 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, Canyonlands 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, as are some other NCPN Parks. If interested in more information and advice, we suggest contacting 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 CANY would mean that species such as *Centaurea diffusa, Ulmus pumila, Arctium minus, Cirsium vulgare, Cirsium arvense, Elaeagnus angustifolia,* and *Carduus nutans* should be given the highest control priority of the species mapped, and should be targeted for prompt Park-wide eradication. 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. For example, *Tamarix ramosissima* was prevalent along the main Salt Creek canyon as well as in Shafer Canyon, Trail Canyon, and Taylor Canyon and probably beyond feasibility of eradication there, at least in the near term. However, *Tamarix ramosissima* could be eliminated in areas such as the side canyons of Salt Creek, Lost Canyon, Squaw Canyon, the Neck Spring Loop Trail, and possibly Lathrop Canyon. Plants that we would place in the third management category (lowest priority) include *Bromus tectorum* and *Salsola kali* which were widespread throughout the Park and too abundant for meaningful mapping.

The Park will likely need additional inventory information before deciding in which management category to place *Convolvulus arvensis, Tragopogon dubius, Halogeton glomeratus, Amaranthus retroflexus, Chenopodium album, Erodium cicutarium, Polypogon monspeliensis, Melilotus officinalis, Phragmites australis, Sonchus asper,* and *Asclepias speciosa*. These non-natives appeared scattered lightly throughout some or many of the inventory areas in the Park, but our assessment is based on an incomplete survey rather than a full inventory of these species. If further studies reveal that these species are truly infrequent in the Park, we suggest that they be targeted for eradication even though they were not originally considered high-priority species.

The second objective of this project was to identify potential sources of weed introduction and significant vectors involved in weed spread in the Park. Humans are the most likely vectors for new introductions of invasive plant species into Canyonlands National Park and all 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. Millions of visitors come from all over the world to enjoy the unique beauty of the Northern Colorado Plateau region, and over 378,000 per year visit Canyonlands National Park. Every 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. A good example is the infestations of the newly invading *Centaurea diffusa* and *Ulmus pumila*, both of which were discovered on the road shoulder. 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, 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 introduction and spread. This might be done in the form of written information distributed at the Park's Visitor Centers, through displays or a video program, and evening fireside presentations to visitors made by NPS 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 M). 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 as a significant source of introduction and spread. 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 targeted invasive weeds. In Canyonlands National Park 96.9 percent of the inventoried acres were free of all targeted species. And, because areas selected for this inventory were generally considered the sites most likely to be infested, it can be assumed that those CANY lands not inventoried have an even higher proportion of weed-free acres. Furthermore, 100 percent of all inventoried lands were completely free of at least 22 species of great concern to the region (Appendix N).

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 Canyonlands 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 all Parks in the Northern Colorado Plateau Network. Programs based on prevention, early detection, and rapid response to eradicate 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 should be recognized as a highly significant accomplishment, and land 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 "invasive weed free"). WPA's also present an opportunity for Parks to help the general public feel more involved as visitors see more clearly the value of 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. As part of our effort to meet that objective, USU 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. In addition, several documents were published containing detailed information about USU inventory procedures and techniques (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).

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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 Canyonlands 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. Christine Craig and Stephanie Shoemaker each hold a Bachelor's degree in the field of natural resources and met the necessary job requirements for the positions set by the National Park Service.

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 Canyonlands 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 Canyonlands National Park.

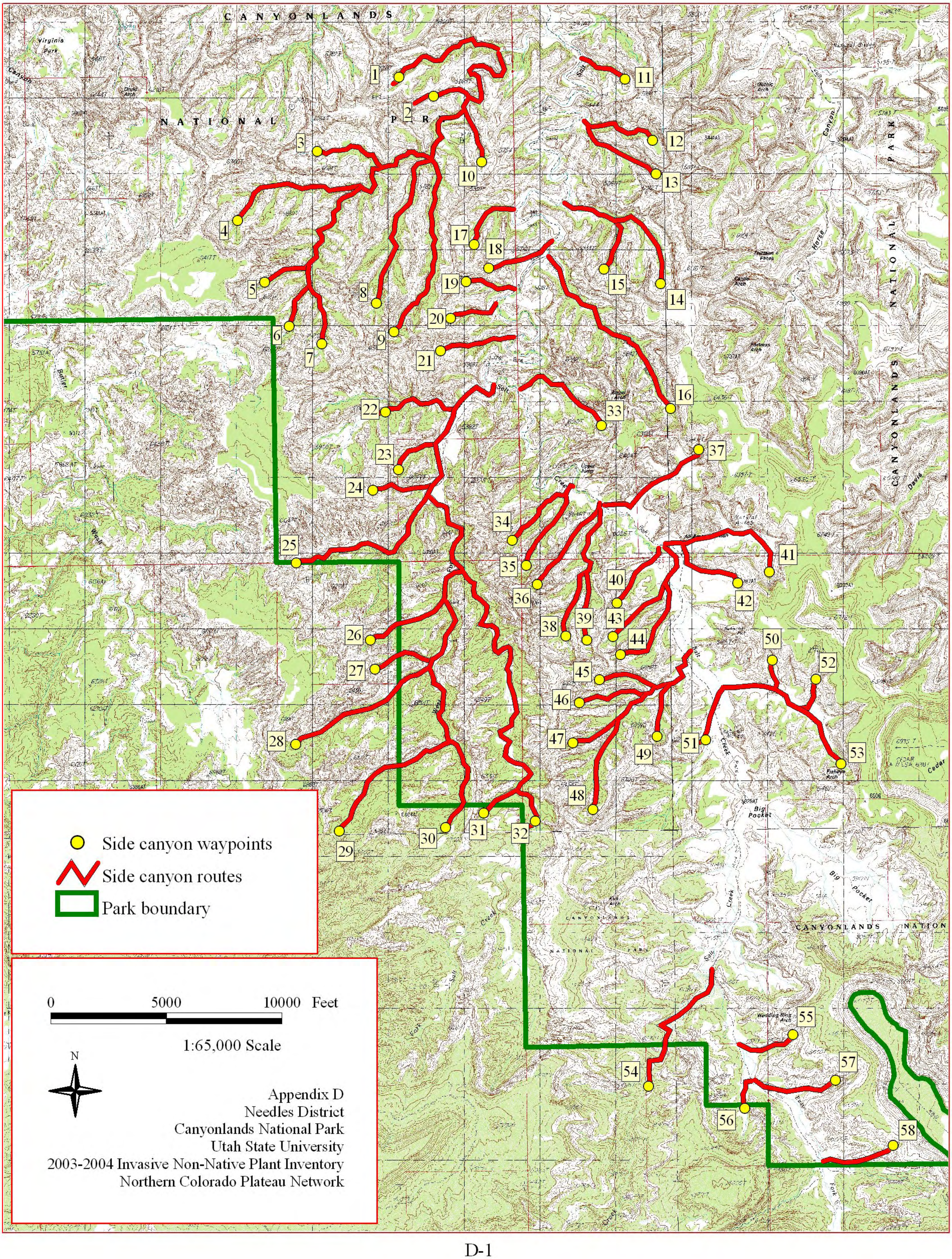
Relationship of NCPN Weed Mapping Project Database Elements to proposed IMR Weed Mapping Data Elements and NAWMA Standards. Column labeled 'NCPN Data Element Status' indicates whether or not data element were included in NCPN Weed Mapping Database. If data element was included (=YES) an indication is 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. Map of Waypoints for Side Canyons in Salt Creek of the Needles District of Canyonlands National Park Used in the 2003-2004 Invasive Non-native Plant Inventory.



Appendix E. GPS Settings using in the 2003-2004 Invasive Non-native Plant Inventory in Canyonlands 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

Appendix E . GPS Settings using in the 2003-2004 Invasive Non-native Plant Inventory in Canyonlands National Park. (cont)

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 F. Photograph and list of equipment used in the 2003-2004 Invasive Non-Native Plant Inventory in Canyonlands National Park.

EquipmentFF

- 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 G. Dominant Vegetation Types Key used in 2003-2004 Invasive Non-native Plant Inventory, Canyonlands National Park.GG

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 G. Dominant Vegetation Types Key used in 2003-2004 Invasive Non-native Plant Inventory, Canyonlands 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 H. Project Photographs of Weed Species Detected, Inventoried Landscapes, and Crew Working in Canyonlands National Park During the 2003-2004 Invasive Non-native Plant Inventory.

Target Weeds Detected

Figure 1. *Cirsium arvense* growing under heavy *Tamarix* and willow canopy in Salt Creek. CANY-N PR58.

Figure 2. Single *Cirsium vulgare* rosette mapped and pulled in West Fork of Salt Creek. CANY-N PR65.

Figure 3. *Cirsium vulgare* in bloom. File photo.*

Figure 4. Flower heads of *Cirsium vulgare* (Left) and *Cirsium arvense* (Right). File photo.*

* Photographs not taken in Canyonlands National Park but are representative of the species found there.

Target Weeds Detected

Figure 5. *Centaurea diffusa* growing on road shoulder in Willow Flat. CANY-I PR1.

Figure 6. *Centaurea diffusa* rosettes on road shoulder in Willow Flat. CANY-I PR1.

Figure 7. Close-up of *Centaurea diffusa* flower heads, Willow Flat. CANY-I PR1.

Figure 8. Close-up of *Elaeagnus angustifolia* flowers. File photo.*

* Photographs not taken in Canyonlands National Park but are representative of the species found there.

Target Weeds Detected

Figure 9. *Carduus nutans* rosettes and seedlings growing along trail in upper Salt Creek. CANY-N PR104.

Figure 10. *Carduus nutans* in early bolting stage in upper Salt Creek. CANY-N PR104.

Figure 11. *Carduus nutans* in bloom. File photo.*

Figure 12. Close-up of *Carduus nutans* flower head. File photo.*

* Photographs not taken in Canyonlands National Park but are representative of the species found there.

Target Weeds Detected

Figure 13. *Ulmus pumila* growing outside of Park boundary on road to Upheaval dome. CANY-I PR8.

Figure 14. Close-up of *Ulmus pumila* leaves. CANY-I PR8.

Figure 15. *Tamarix ramosissima* growing outside of Park boundary on road to Upheaval dome. CANY-I PR2.

Figure 16. *Tamarix ramosissima* growing along Salt Creek in Needles District. CANY-N PR98.

Other Weeds Detected

Figure 17. *Halogeton glomeratus.* File photo.*

Figure 18. *Convolvulus arvensis.* File photo.*

Figure 19. *Phragmites* species. File photo.*

Figure 20. *Asclepias speciosa*. File photo.*

* Photographs not taken in Canyonlands National Park but are representative of the species found there.

Other Weeds Detected

Figure 21. *Bromus tectorum*. File photo.*

Figure 22. *Arctium minus*. File photo.*

Figure 23. *Sonchus asper*. File photo.*

Figure 24. *Amaranthus retroflexus* in upper Chesler Park. CANY-N PR49.

* Photographs not taken in Canyonlands National Park but are representative of the species found there.

Landscapes

Figure 25. *Tamarix ramosissima* growing in cliff face of Lower Jump, Salt Creek. CANY-N PR57.

Figure 26. Close-up of *Tamarix ramosissima* growing in cliff face of Lower Jump, Salt Creek. CANY-N PR57.

Figure 27. *Tamarix ramosissima* infesting Salt Creek in flats above the Lower Jump. CANY03-R10F18.

Figure 28. View of Salt Creek winding through large open area near Park entrance. CANY03-R10F21.

Landscapes

Figure 29. Evidence of *Tamarix ramosissima* control where the Needles entrance road crosses Salt Creek. CANY-N PR56.

Figure 30. *Tamarix ramosissima* lining the dirt road to Peekaboo Springs. CANY03-R25F02.

Figure 31. View of *Tamarix ramosissima* and cottonwoods in Salt Creek near junction of trail to Angel Arch. CANY03-R24F07.

Figure 32. Bridget Atkin mapping *T. ramosissima* on trail to Angel Arch. CANY-N PR82.

Landscapes

Figure 33. Large *Tamarix ramosissima* trees estimated to be 20 or more feet tall, Salt Creek. CANY-N PR13.

Figure 34. Dense *Tamarix ramosissima* and willows in Salt Creek Wash. CANY-N PR08.

Figure 35. *Tamarix ramosissima* and willows filling Salt Creek wash near Big Pocket. CANY-N PR10.

Figure 36. View of Cathedral Butte from Salt Creek. CANY-N PR15.

Landscapes

Figure 37. *Tamarix ramosissima* mixed with cottonwoods along Horse Canyon road. CANY-N PR26.

Figure 38. *Tamarix ramosissima* in Horse Canyon. CANY-N PR27.

Figure 39. Tower Ruin side-canyon in Horse Canyon. CANY-N PR31.

Figure 40. View down-canyon in Fortress Arch Canyon. CANY-N PR19.

Landscapes

Figure 41. *Tamarix ramosissima* in Big Spring Canyon. CANY-N PR55.

Figure 42. *Tamarix ramosissima* in Little Spring Canyon. CANY-N PR44.

Figure 43. Upper Chesler Park. CANY-N PR48.

Figure 44. View upstream in east fork of Lost Canyon. CANY-N PR47.

Landscapes

Figure 45. View looking north into Cyclone Canyon. CANY-N PR53.

Figure 46. Red Lake Canyon. CANY-N PR50.

Figure 47. *Tamarix ramosissima* lining banks of the Green River at the mouth of Taylor Canyon. CANY03-R08F22.

Figure 48. Looking east up Taylor Canyon. CANY-I PR10.

Landscapes

Figure 49. *Tamarix ramosissima* in bloom on edge of White Rim Road in Lathrop Canyon. CANY-I PR06.

Figure 50. Near top of Lathrop Canyon. CANY-I PR04.

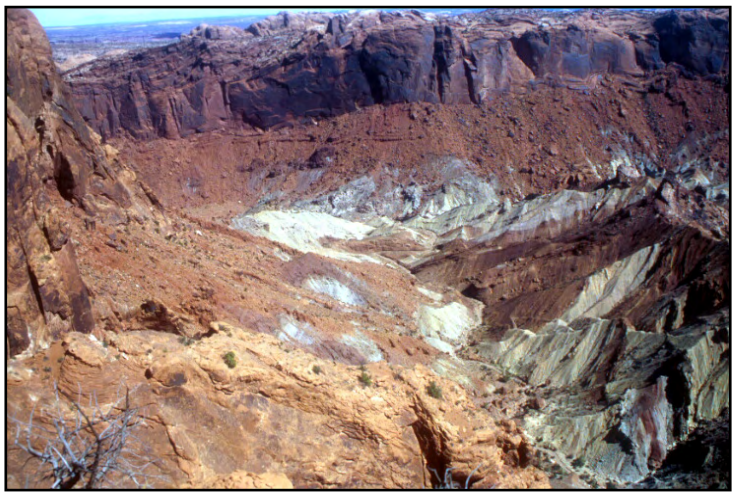


Figure 51. View into bottom of Upheaval Dome from rim trail. CANY03-R19F10.

Figure 52. Location of roadside *Centaurea diffusa* infestation in Willow Flats. CANY-I PR25.

Landscapes

Figure 53. View into Shafer Canyon from road at its head. CANY-I PR20.

Figure 54. View into head south fork of Shafer Canyon seen from road. CANY-I PR22.

Figure 55. Single *Tamarix ramosissima* in lower Shafer Canyon outside of Park boundary near Colorado River. CANY-I PR24.

Figure 56. *Tamarix ramosissima* lining banks of Colorado River near mouth of Shafer Canyon. CANY-I PR23.

Crew

Figure 57. USU crew at Needles NPS housing. CANY04-R05F23.

Figure 58. Bridget Atkin and Melanie Ballard starting up Salt Creek at Peekaboo Spring. CANY04- R02F17.

Figure 59. Dr. Steven Dewey eating dinner at a campsite in Salt Creek. CANY04-R03F03.

Figure 60. Bridget Atkin and Melanie Ballard hiking down West Fork of Salt Creek. CANY-N PR-69.

Crew

Figure 61. Steve Dewey and Janna Simonsen at Peekaboo Springs in Salt Creek. CANY03-R09F11.

Figure 62. Heather Rickleff under a large overhang in Horse Canyon. CANY-N PR20.

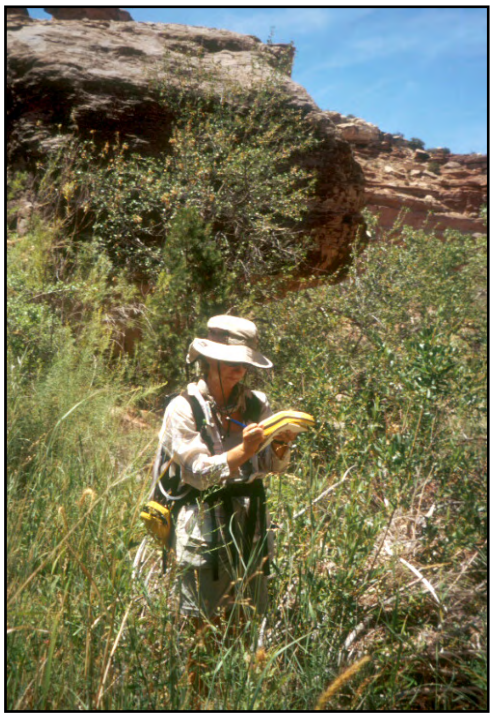


Figure 63. Liz Ballenger in Big Spring Canyon. CANY-N PR54.

Figure 64. Heather Rickleff in Big Spring Canyon. CANY-N PR35.

Crew

Figure 65. Hillary Hudson and Ruth Richards filtering water. CANY04-R08F10.

Figure 66. R08F08. Ruth Richards and Hillary Hudson hiking in upper Salt Creek. CANY04-R08F08.

Figure 67. Melanie Ballard, Kim Andersen, Ruth Richards, Hillary Hudson, and Bridget Atkin at designated campsite SC#4. CANY-N PR-70.

Figure 68. USU crew hiking out of Salt Creek after 4-day backpacking trip. CANY-N PR-72.

Crew

Figure 69. Kim Andersen mapping west of the Neck in Island-in-the-Sky District. CANY04-R40F15.

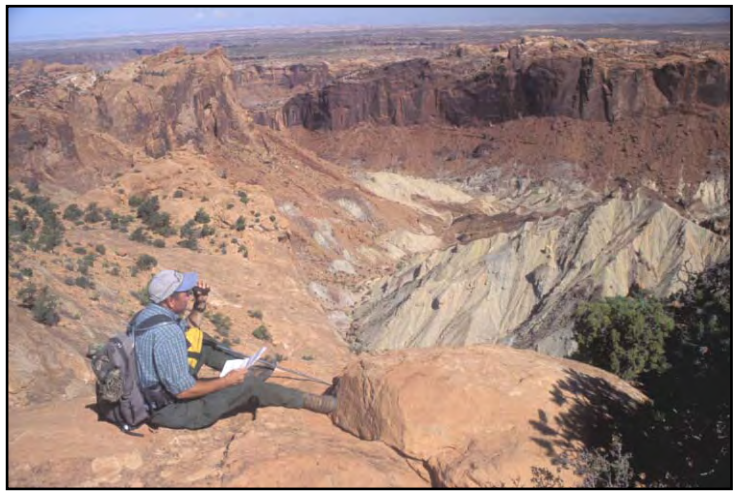
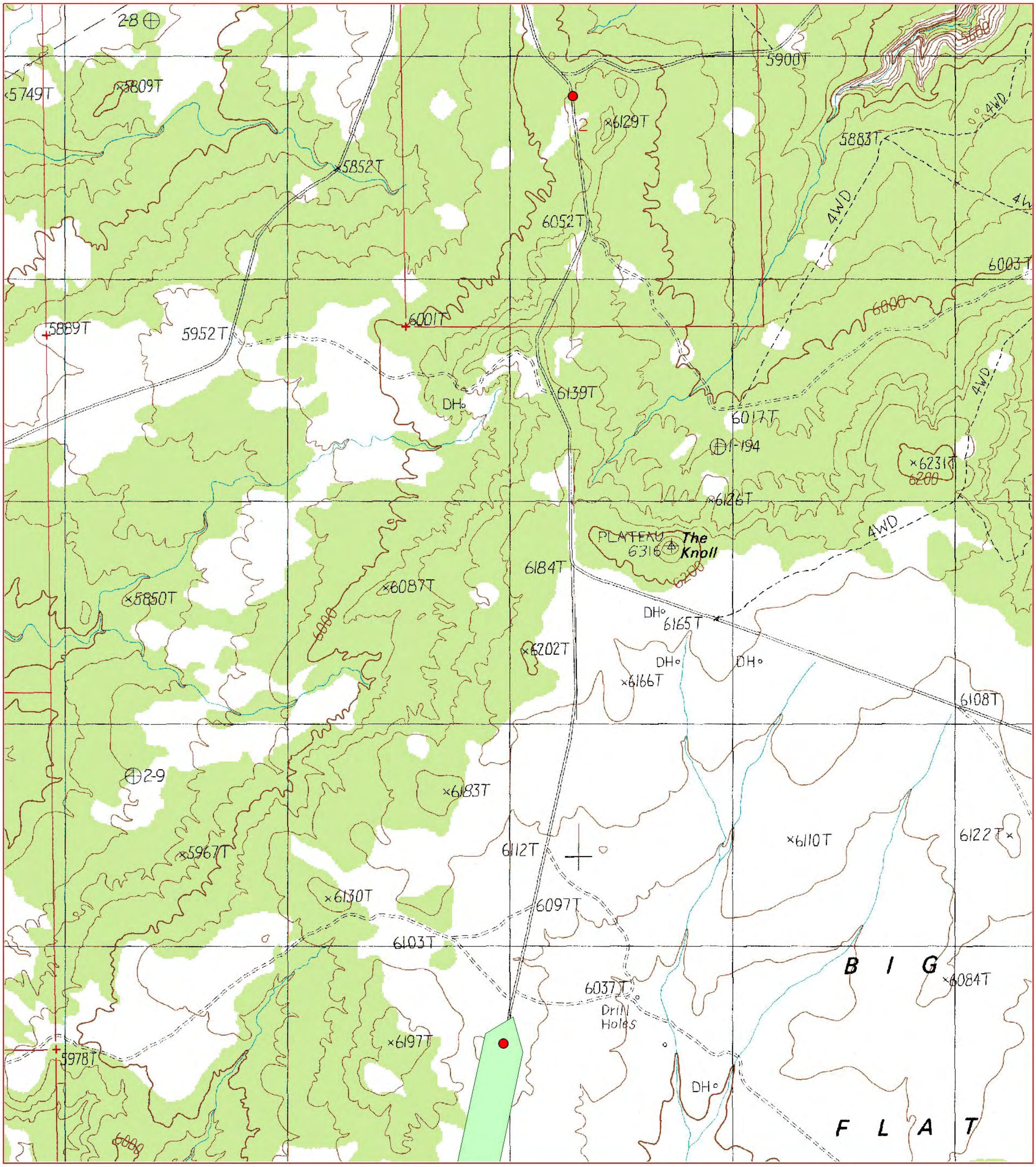


Figure 70. Steve Dewey inspecting results of USU crew's inventory in Upheaval Dome area. CANY03-R19F08.

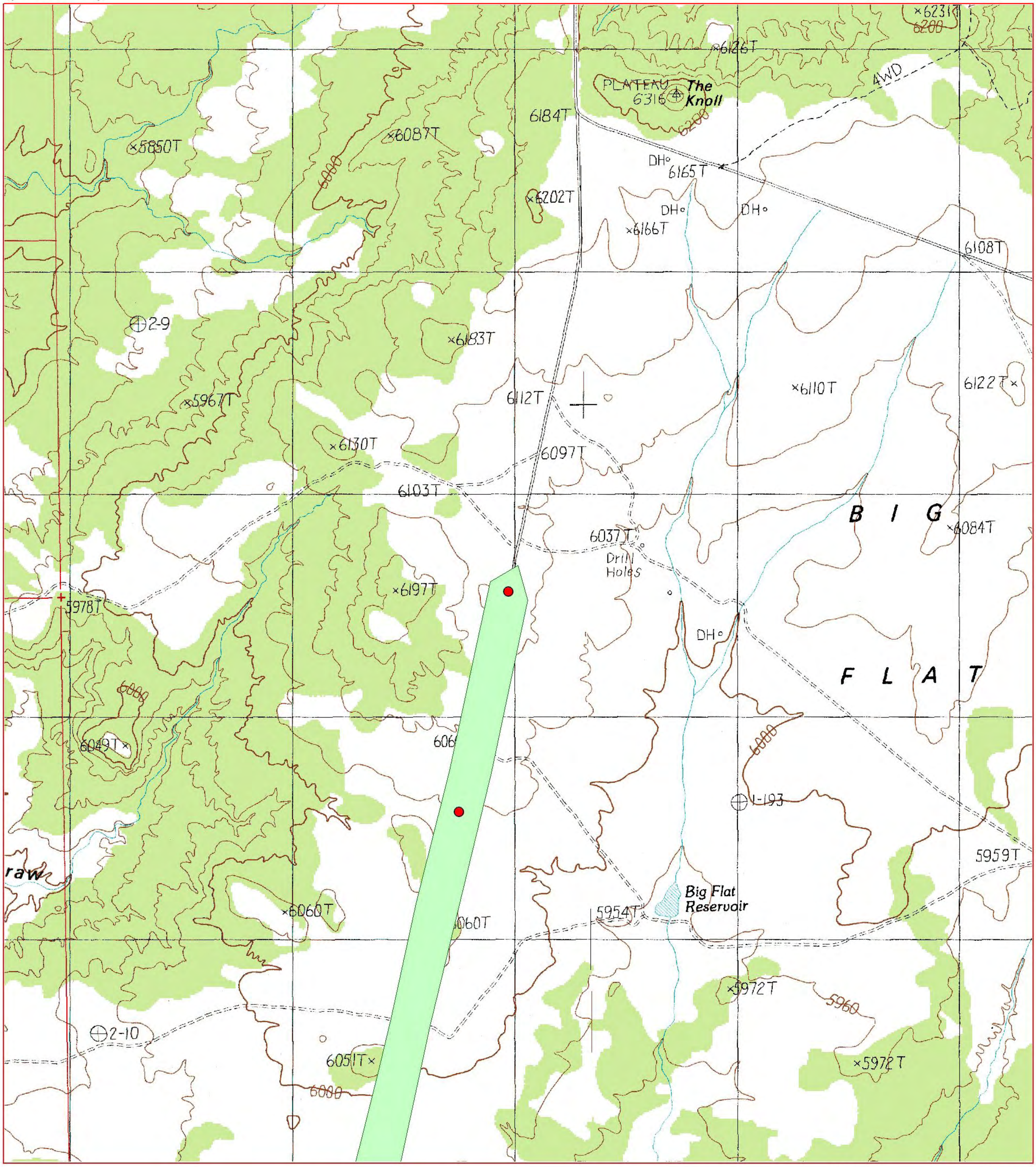
Figure 71. Kim Andersen recording location of Willow Flat *Centaurea diffusa* infestation. CANY-I PR1.

Figure 72. Hillary Hudson standing mapping *Tamarix ramosissima* in Canyon side-canyon #3 of Salt Creek drainage. CANY-N PR100.

Appendix I. Overall Weed Distribution in Inventoried Areas - The Knoll (Inset A)



Appendix I. Overall Weed Distribution in Inventoried Areas - Big Flat Reservoir (Inset B)



0 2000 4000 Feet

1:24,000 Scale

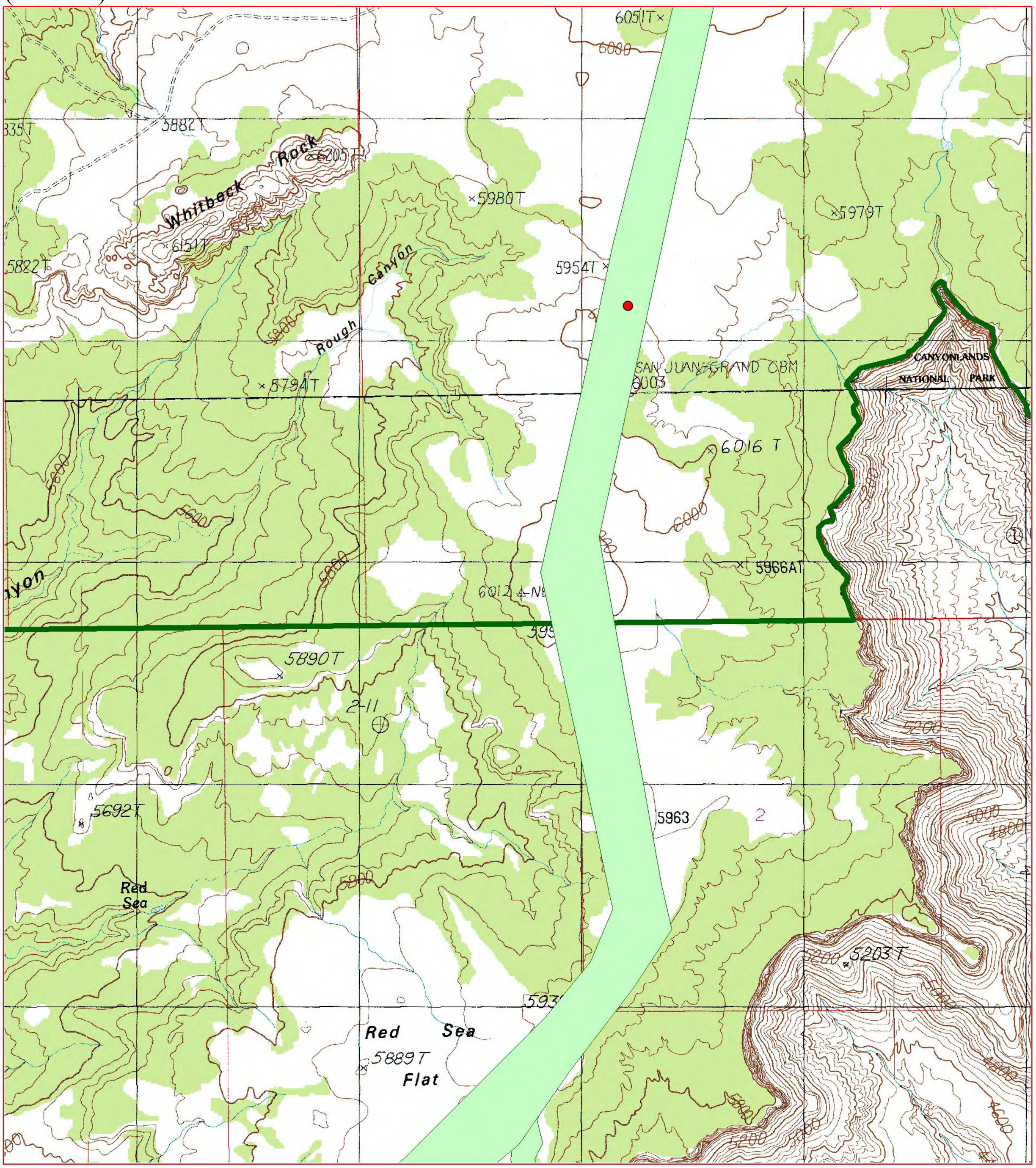
N

Weed Points

Area Inventoried

Inset B
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix I. Overall Weed Distribution in Inventoried Areas - Whitebeck Rock (Inset C)



0 2000 4000 Feet

1:24,000 Scale

N

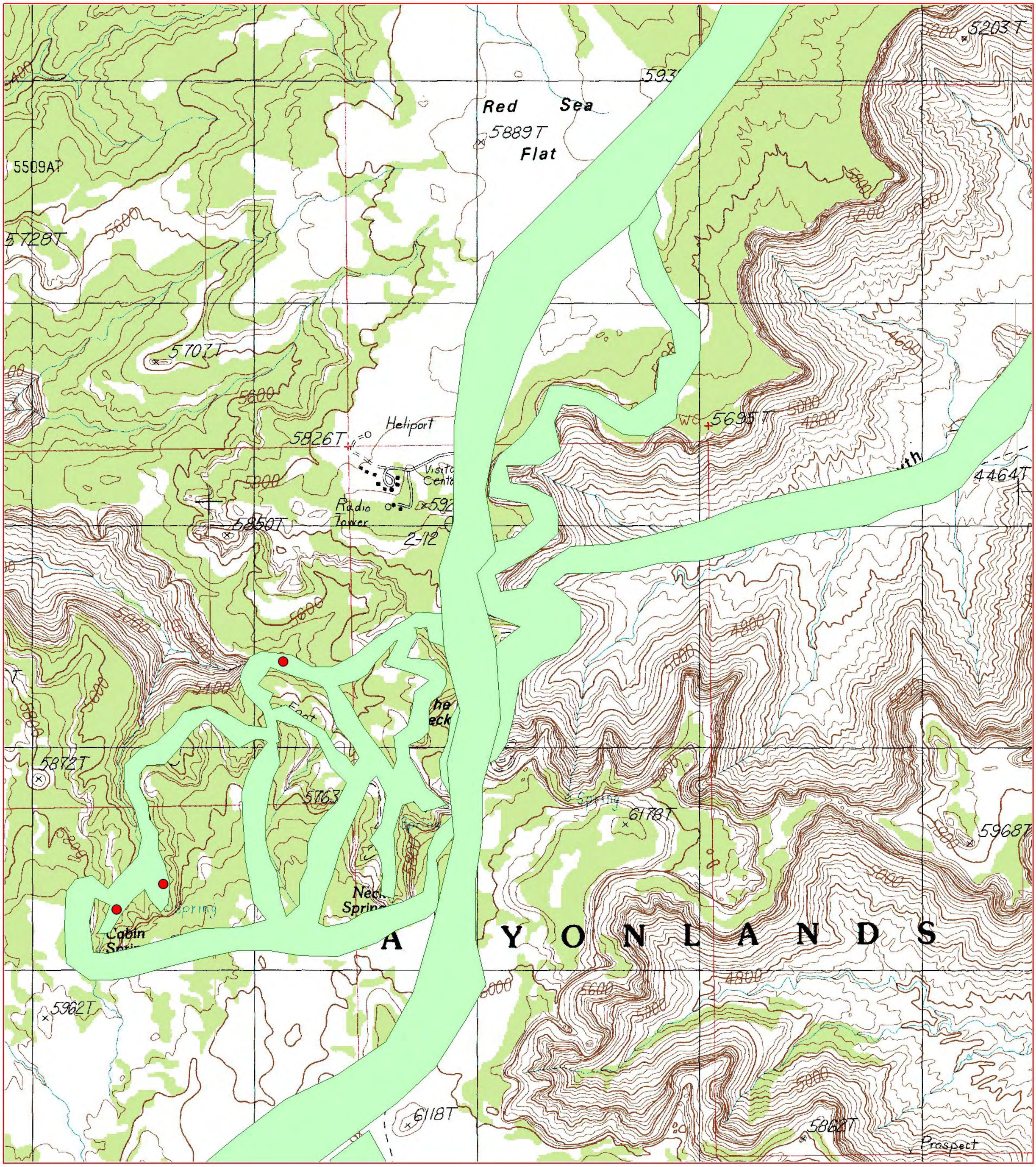
Weed Points

Area Inventoried

Park boundary

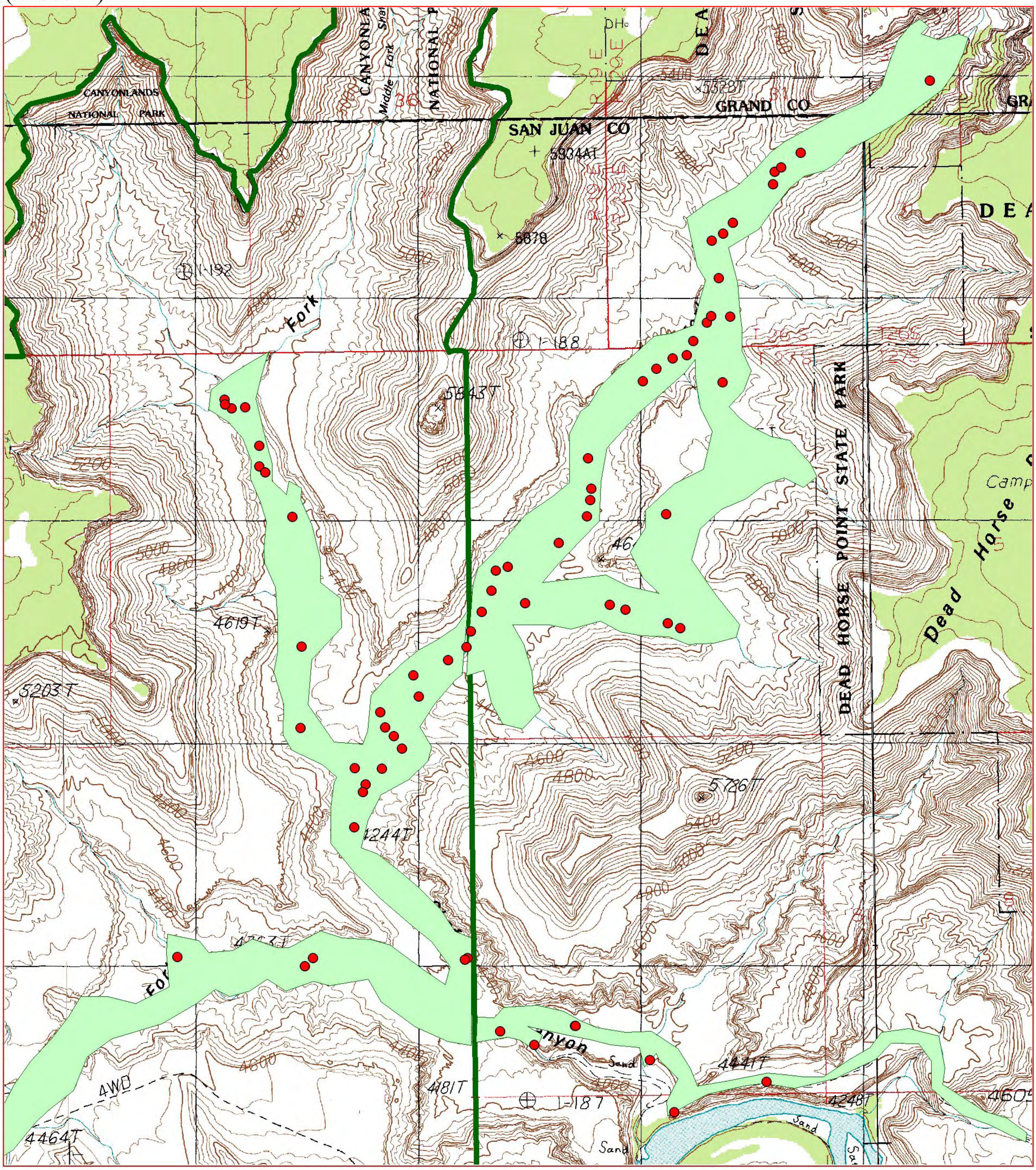
Inset C
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix I. Overall Weed Distribution in Inventoried Areas - Neck Spring (Inset D)

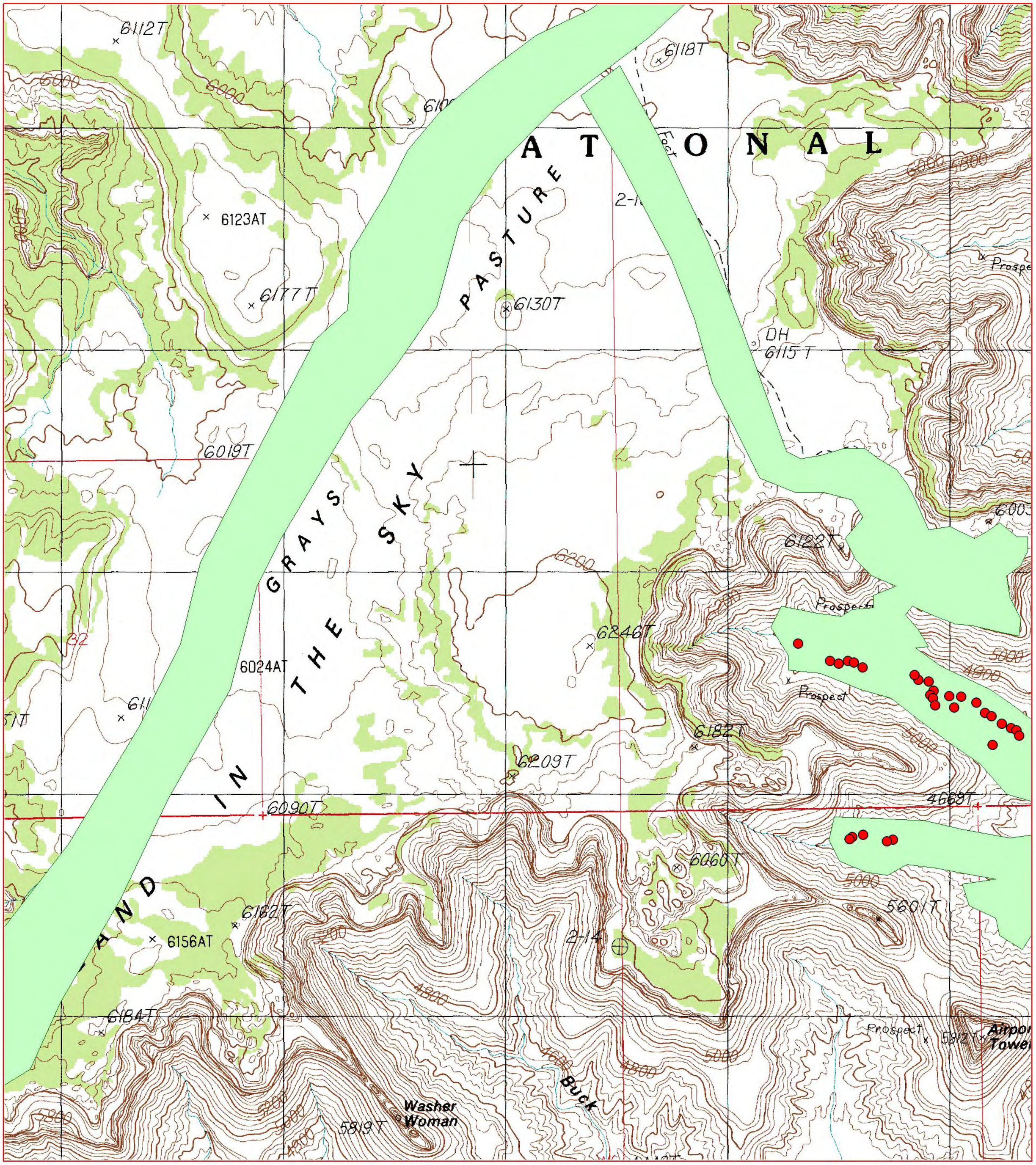


Inset D
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix I. Overall Weed Distribution in Inventoried Areas - Shafer Canyon (Inset E)



Appendix I. Overall Weed Distribution in Inventoried Areas - Grays Pasture (Inset F)



Weed Points

Area Inventoried

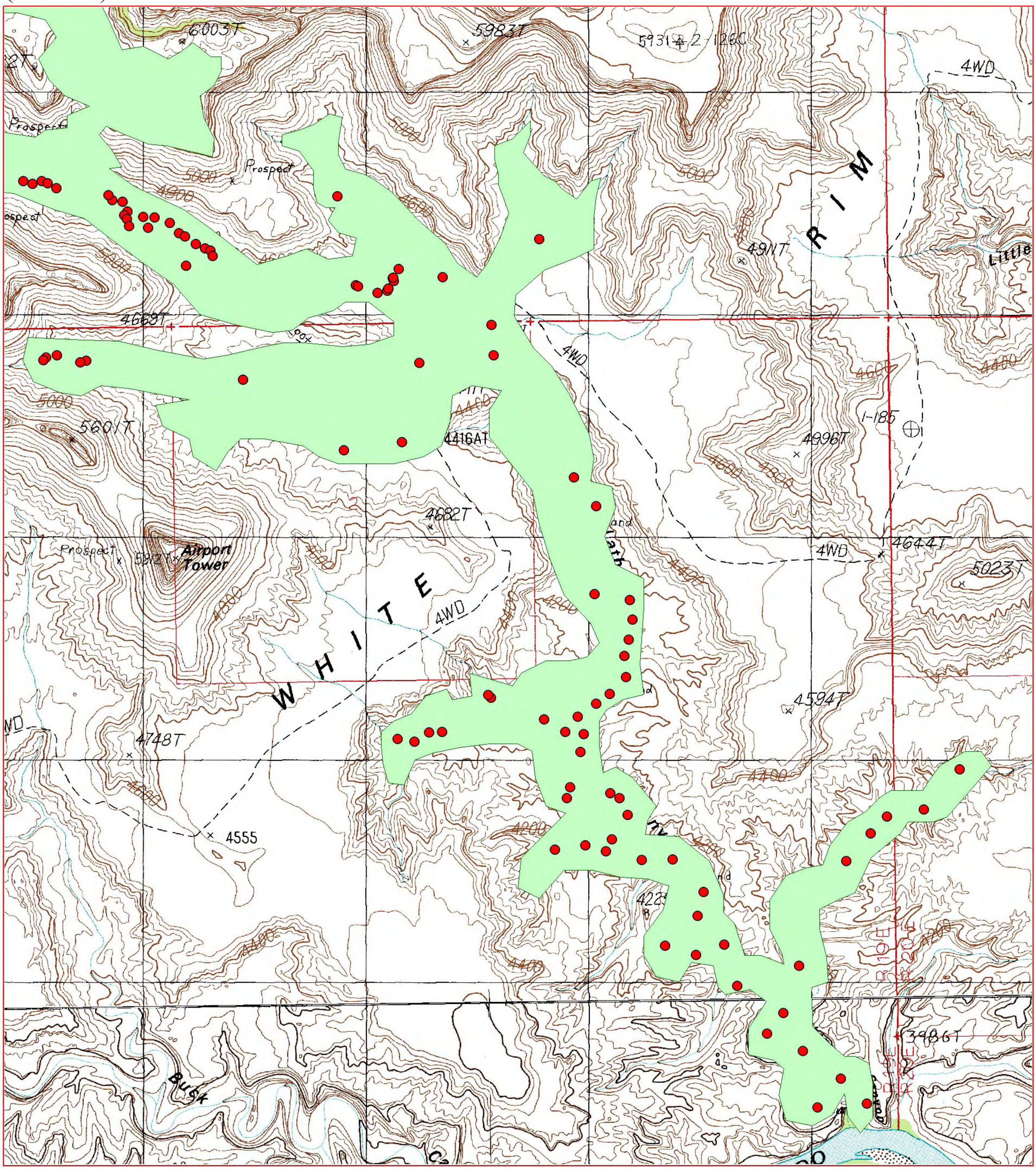
0 2000 4000 Feet

1:24,000 Scale

N

Inset F
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix I. Overall Weed Distribution in Inventoried Areas - Lathrop Canyon (Inset G)



Weed Points

Area Inventoried

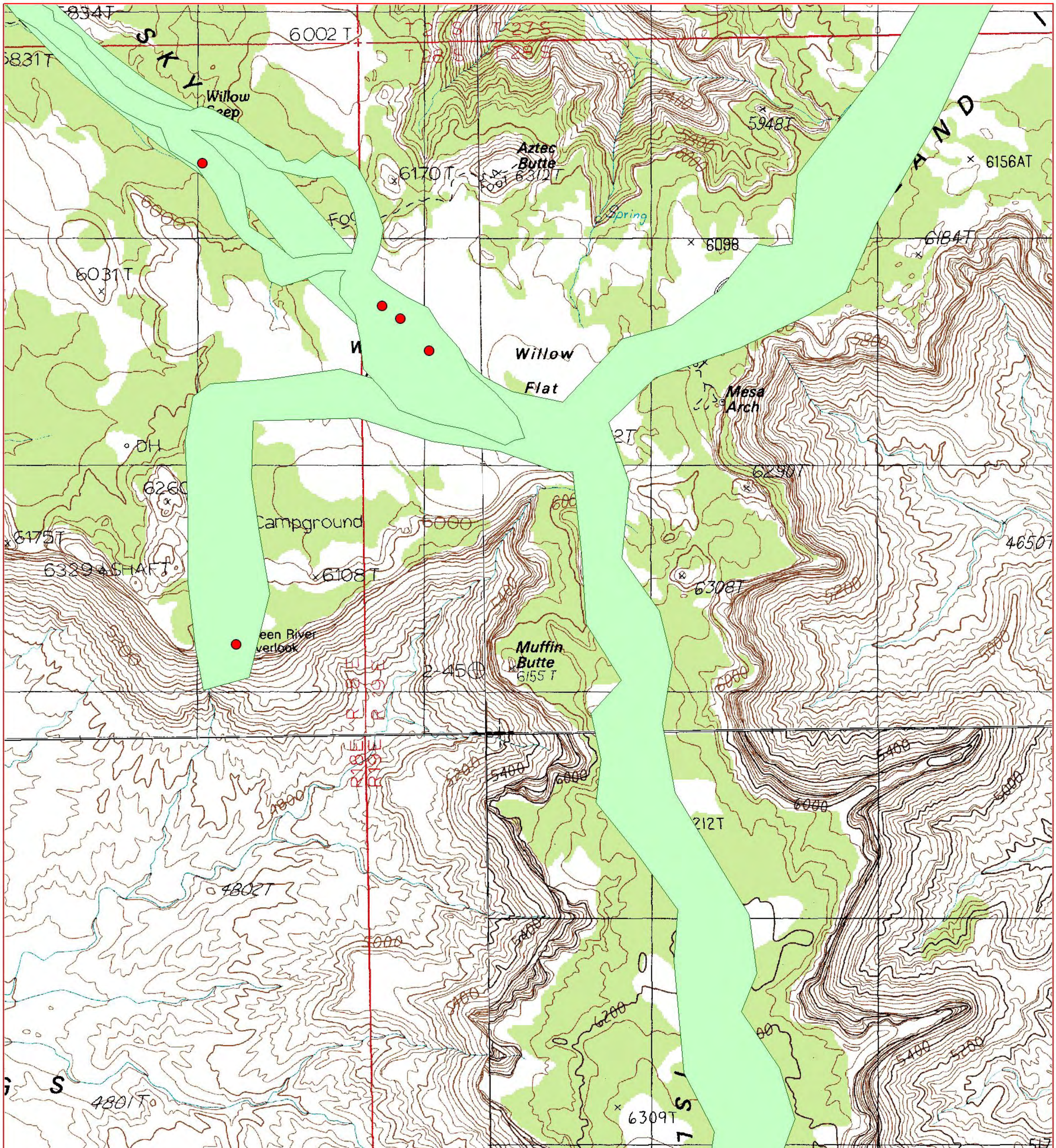
0 2000 4000 Feet

1:24,000 Scale

N

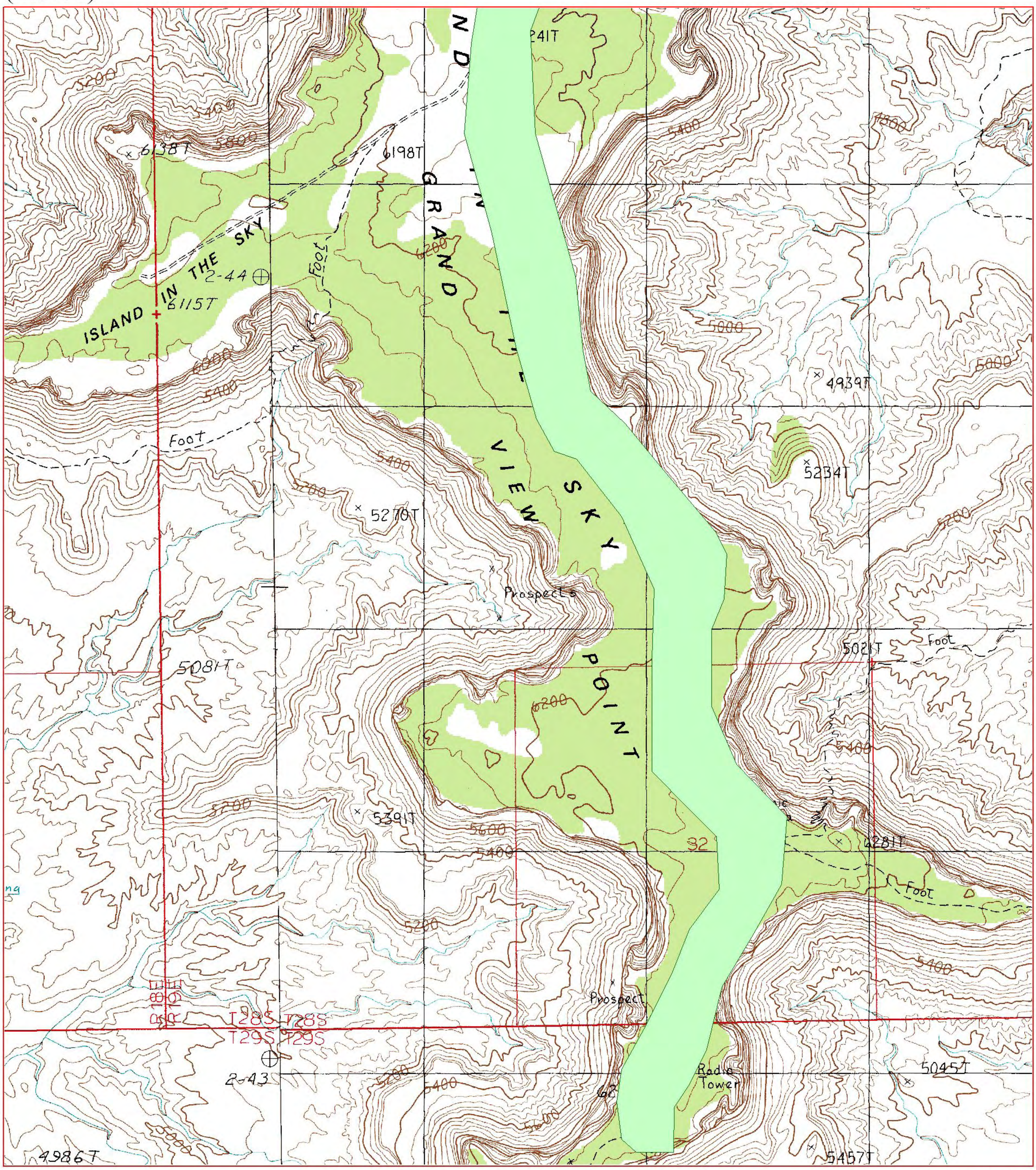
Inset G
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix I. Overall Weed Distribution in Inventoried Areas - Willow Flat (Inset H)



Inset H
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix I. Overall Weed Distribution in Inventoried Areas - Grand View Point (Inset I)



0 2000 4000 Feet

1:24,000 Scale

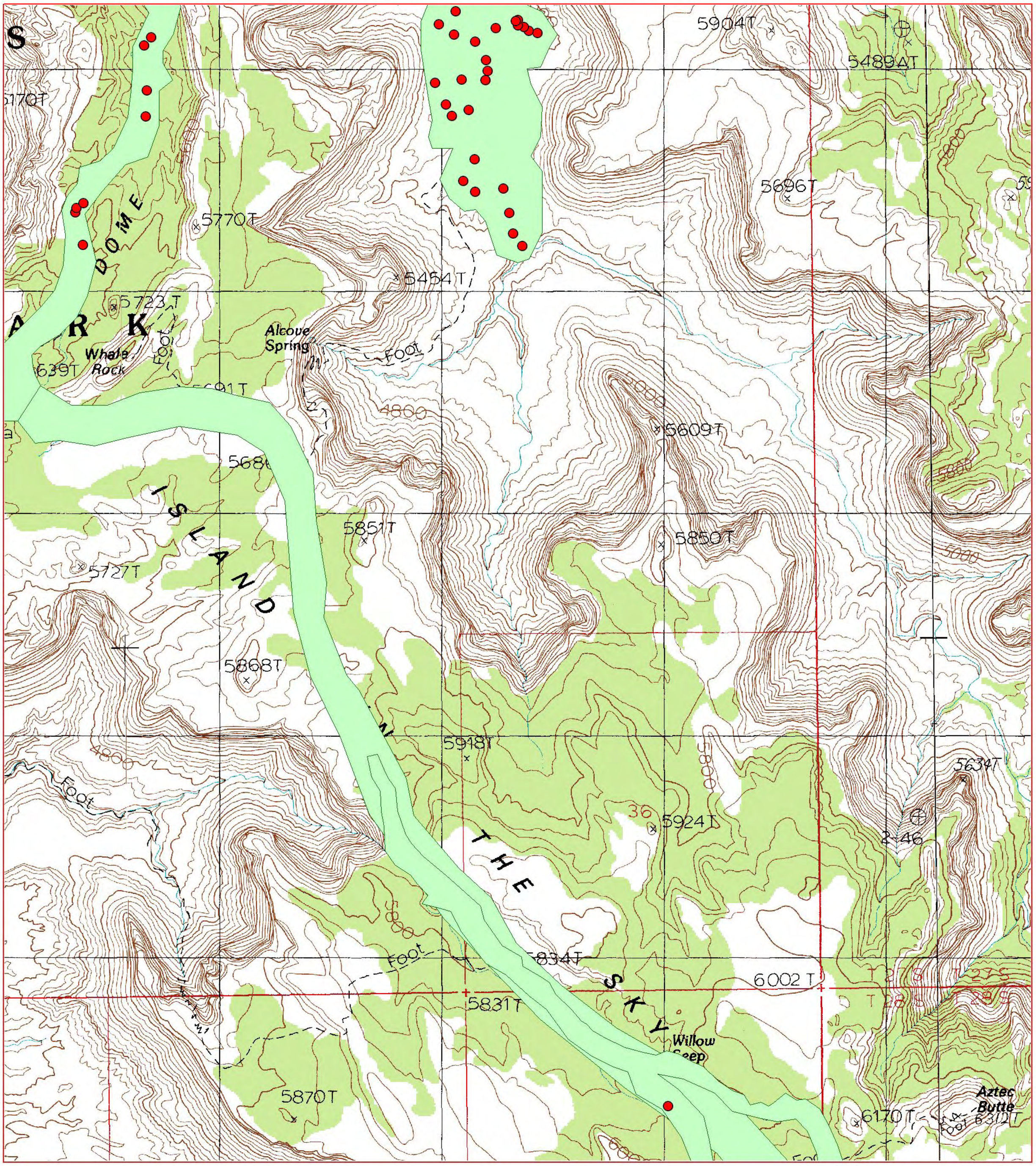
N

* No Weeds Detected in Inventory

Area Inventoried

Inset I
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix I. Overall Weed Distribution in Inventoried Areas - Whale Rock (Inset J)



0 2000 4000 Feet

1:24,000 Scale

N

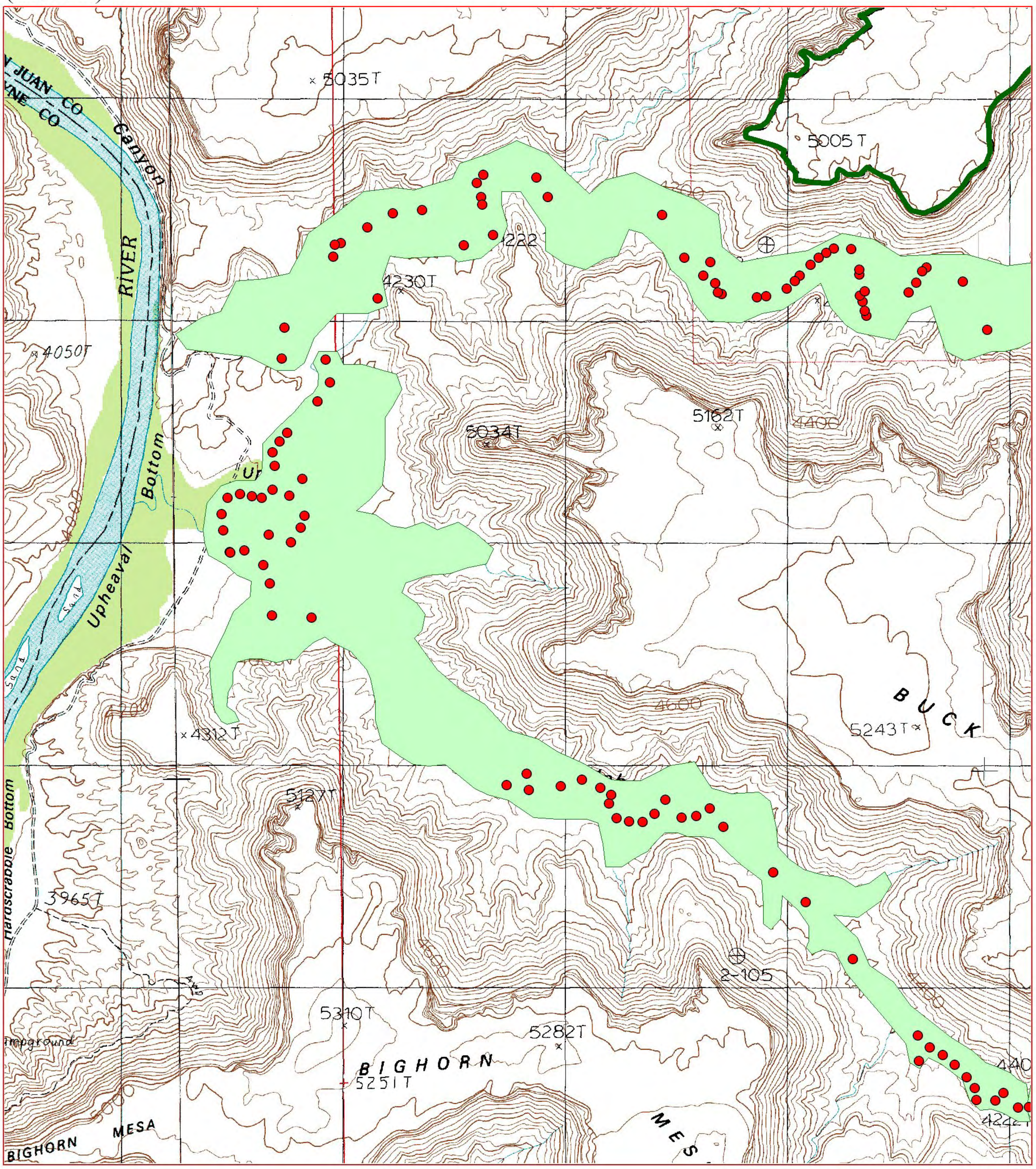
- Weed Points
- Area Inventoried

Inset J
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix I. Overall Weed Distribution in Inventoried Areas - Upheaval Dome (Inset K)

Inset K
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix I. Overall Weed Distribution in Inventoried Areas - Upheaval Canyon (Inset L)



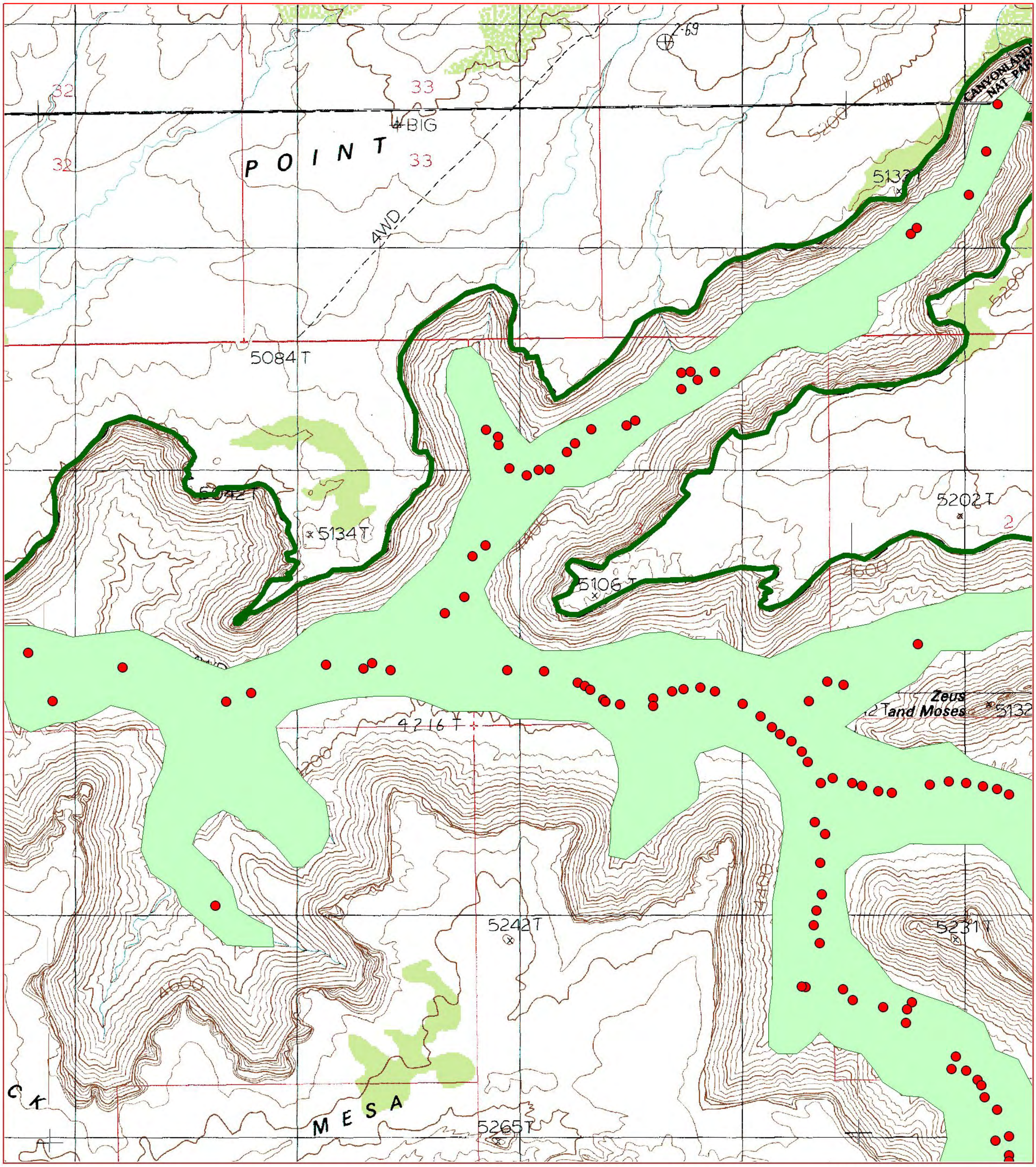
Weed Points

Area Inventoried

Park boundary

Inset L
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix I. Overall Weed Distribution in Inventoried Areas - Big Draw (Inset M)



Weed Points

Area Inventoried

Park boundary

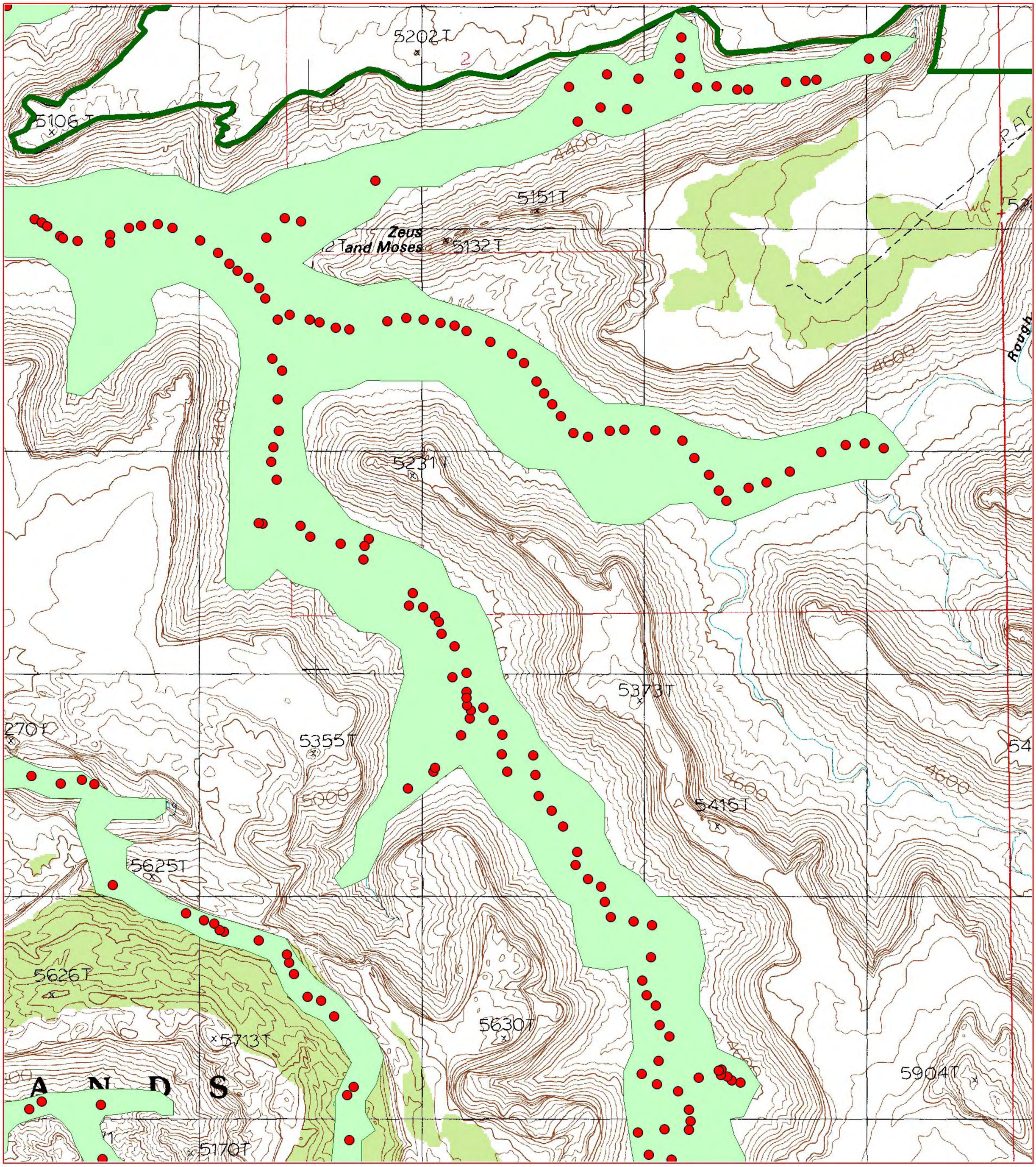
0 2000 4000 Feet

1:24,000 Scale

N

Inset M
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix I. Overall Weed Distribution in Inventoried Areas - Trail Canyon (Inset N)



0 2000 4000 Feet

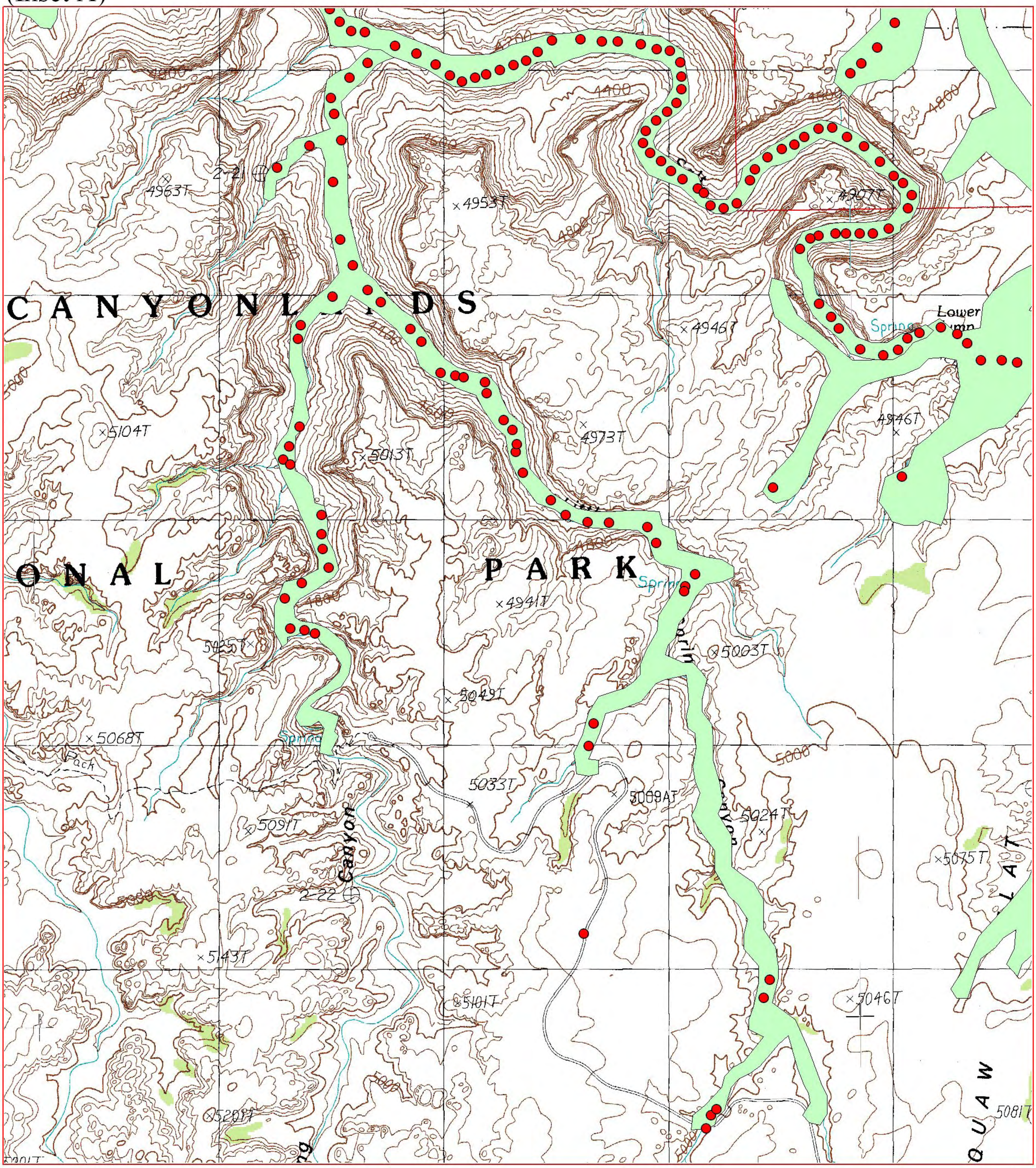
1:24,000 Scale

- Weed Points
- Area Inventoried
- Park boundary

N

Inset N
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix J. Overall Weed Distribution in Inventoried Areas - Little Spring Canyon (Inset A)



Weed Points

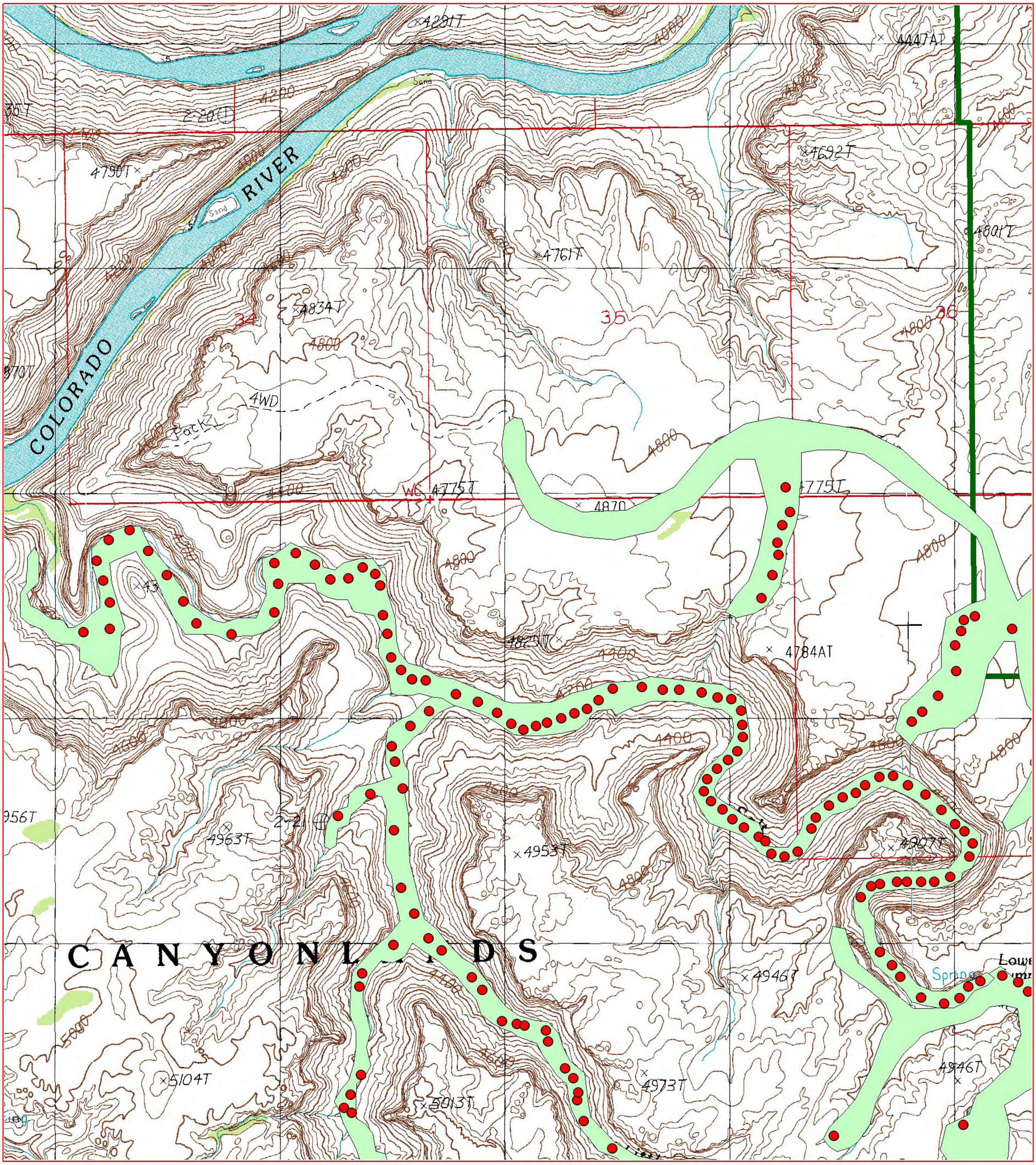
Area Inventoried

1:24,000 Scale

N

Inset A
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix J. Overall Weed Distribution in Inventoried Areas - Lower Jump (Inset B)



Weed Points

Area Inventoried

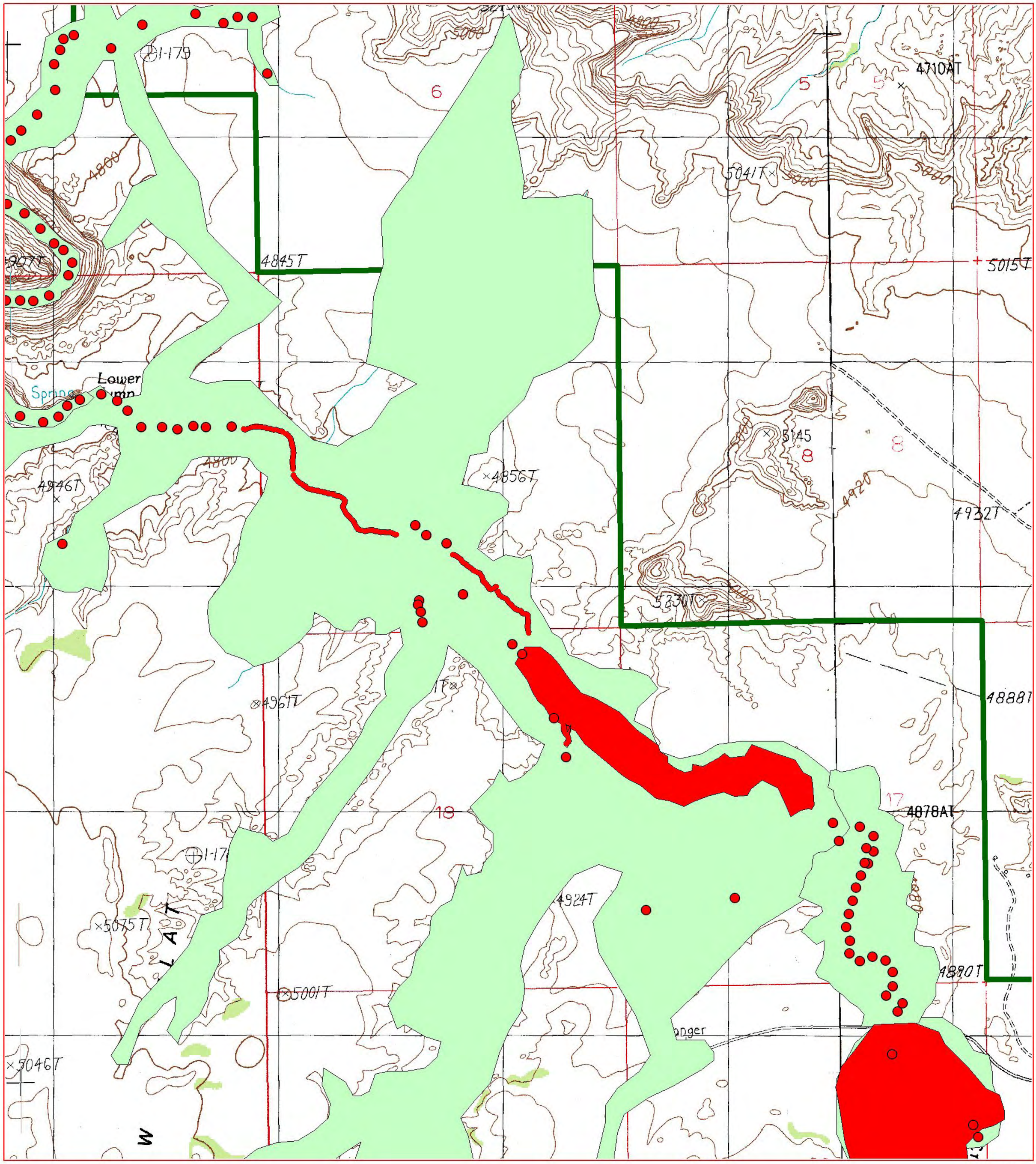
Park boundary

1:24,000 Scale

N

Inset B
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix J. Overall Weed Distribution in Inventoried Areas - Squaw Flat (Inset C)



Weed Points

Weed Lines

Weed Areas

Area Inventoried

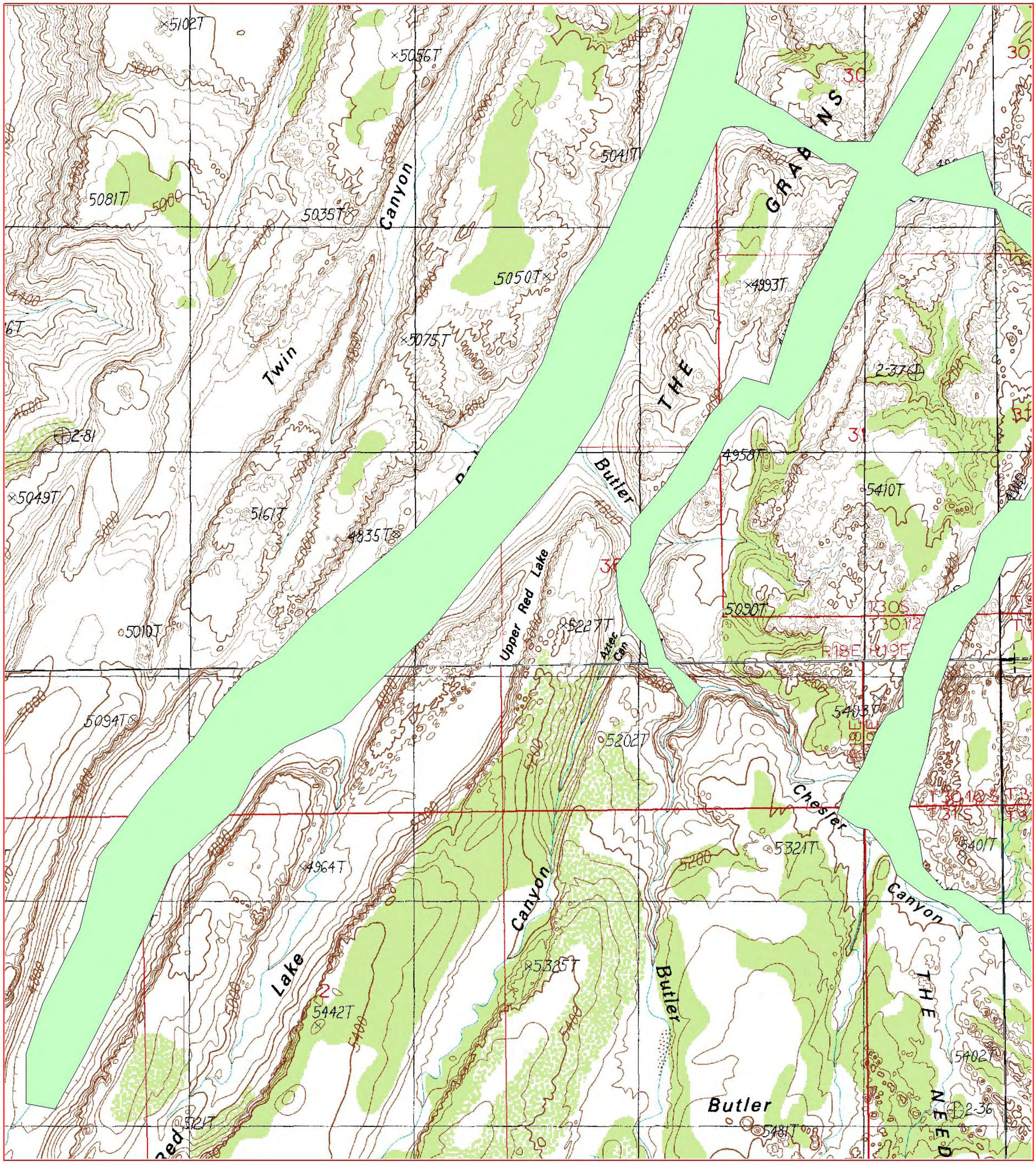
Park boundary

1:24,000 Scale

N

Inset C
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix J. Overall Weed Distribution in Inventoried Areas - Red Lake Canyon (Inset D)



✱ No targeted weed species detected

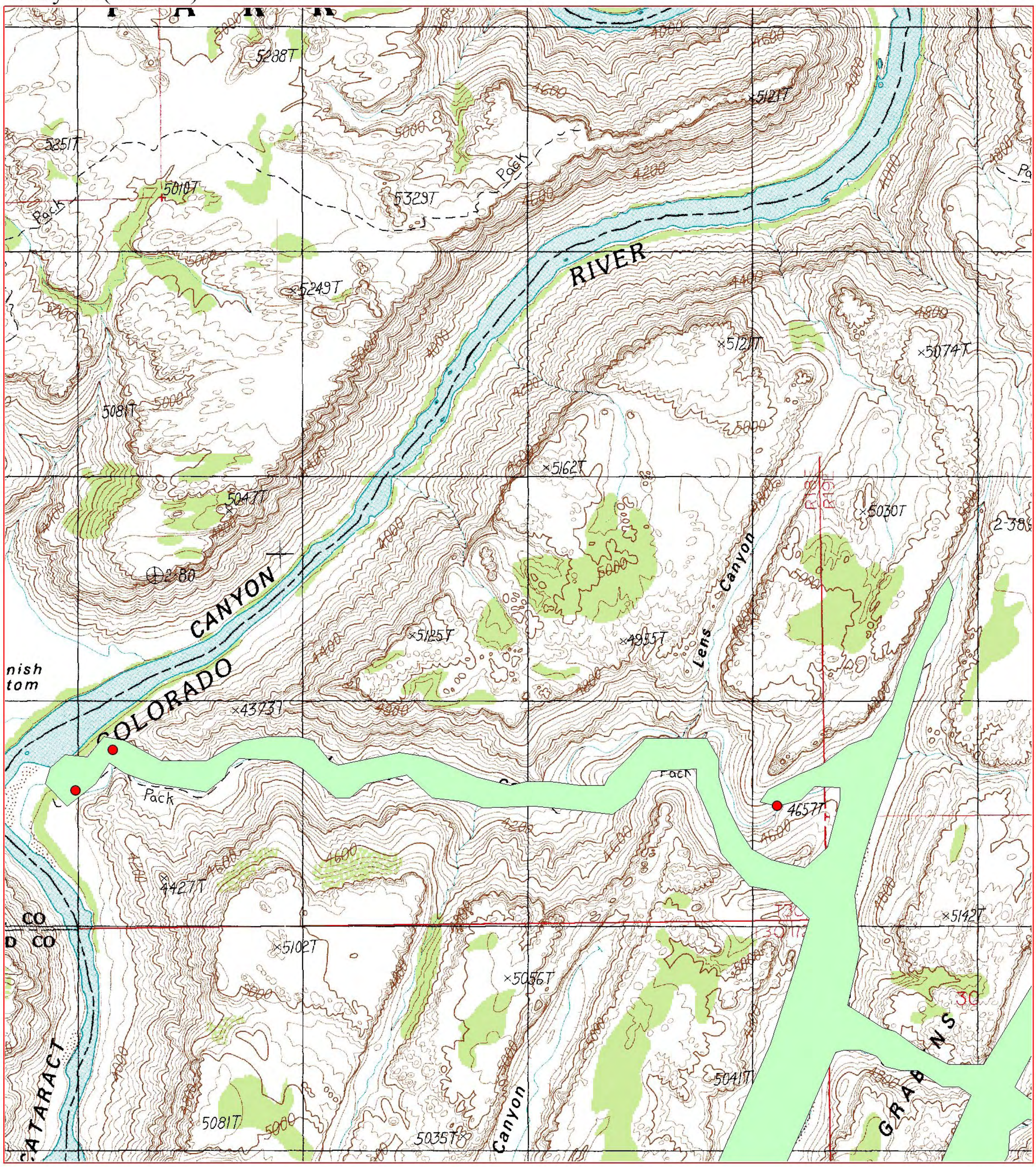
Area Inventoried

N

1:24,000 Scale

Inset D
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix J. Overall Weed Distribution in Inventoried Areas - Lower Red Lake Canyon (Inset E)



Weed Points

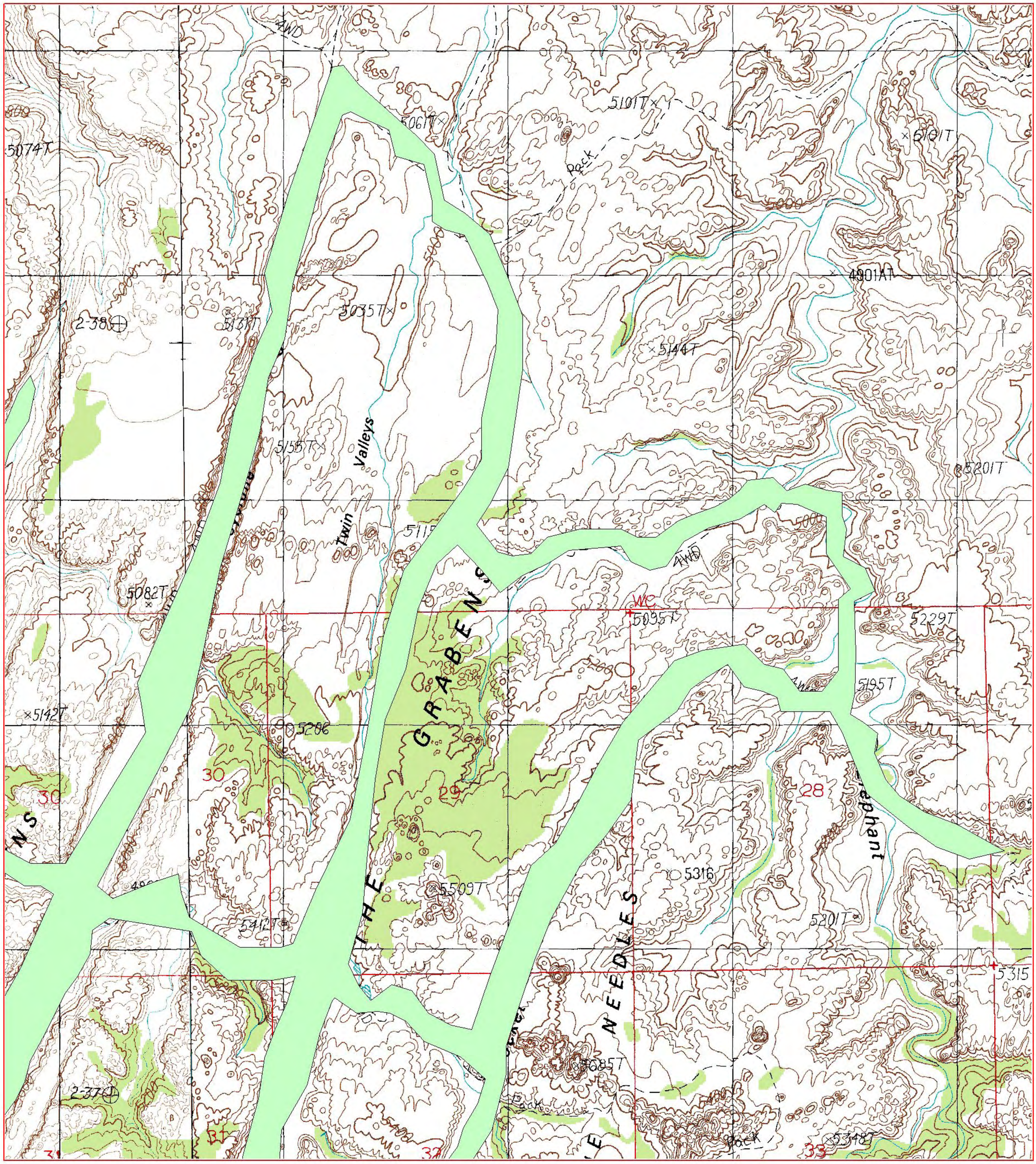
Area Inventoried

N

1:24,000 Scale

Inset E
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix J. Overall Weed Distribution in Inventoried Areas - The Grabens (Inset F)



0 2000 4000 Feet

✱ No targeted weed species detected

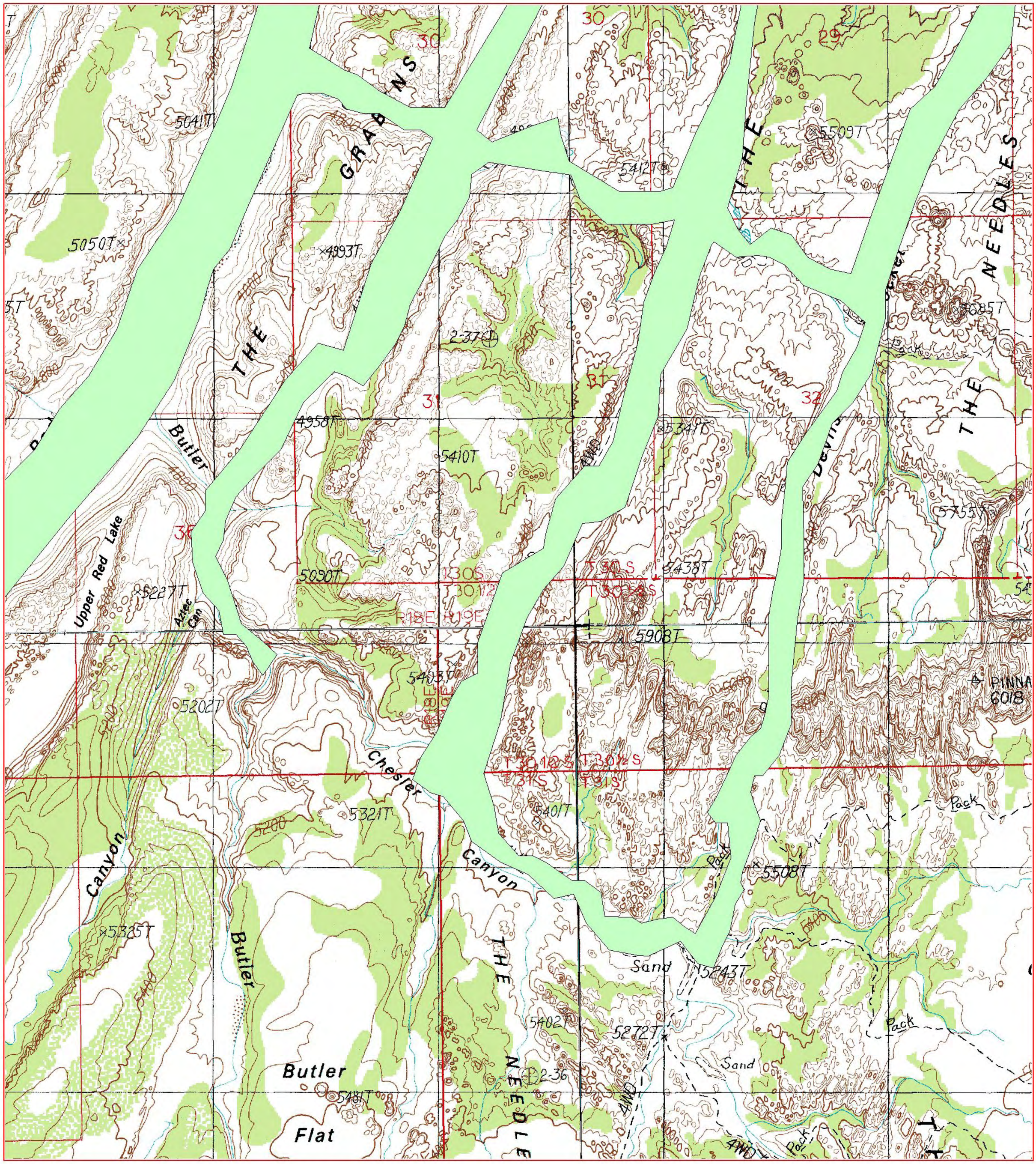
Area Inventoried

N

1:24,000 Scale

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

Appendix J. Overall Weed Distribution in Inventoried Areas - Chesler Park (Inset G)



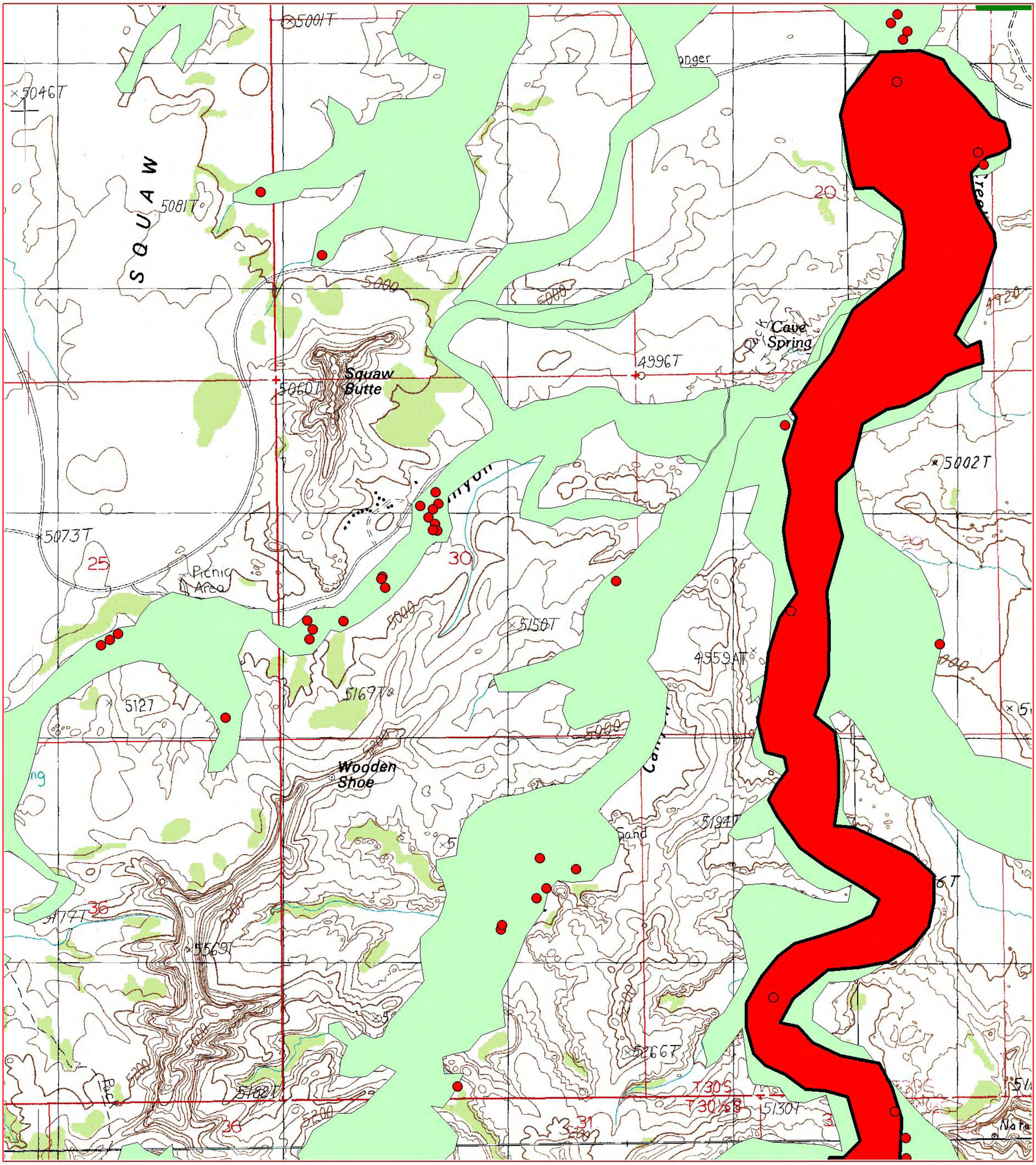
✱ No targeted weed species detected

Area Inventoried

1:24,000 Scale

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

Appendix J. Overall Weed Distribution in Inventoried Areas - Cave Spring (Inset H)



Weed Points

Weed Areas

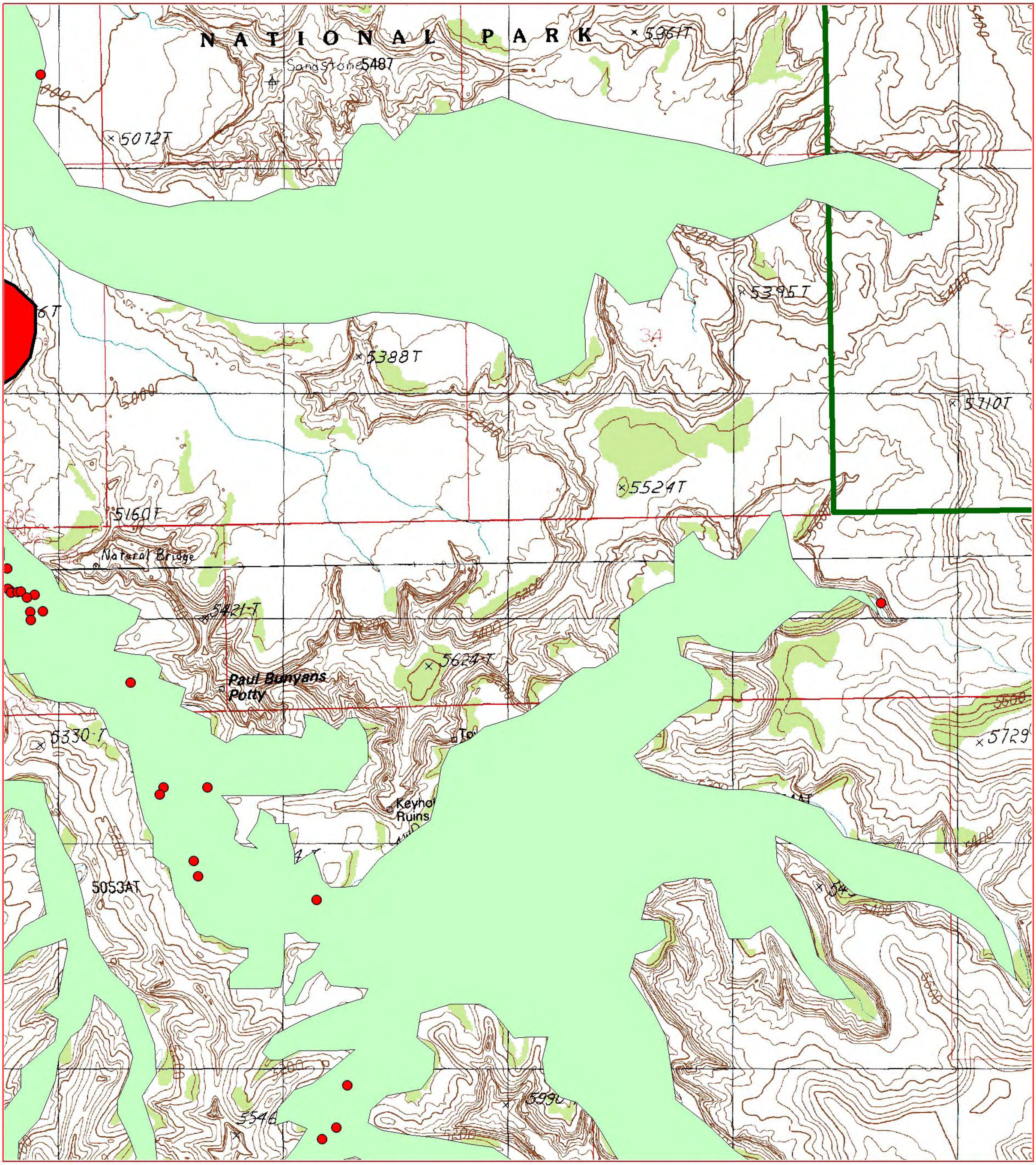
Area Inventoried

N

1:24,000 Scale

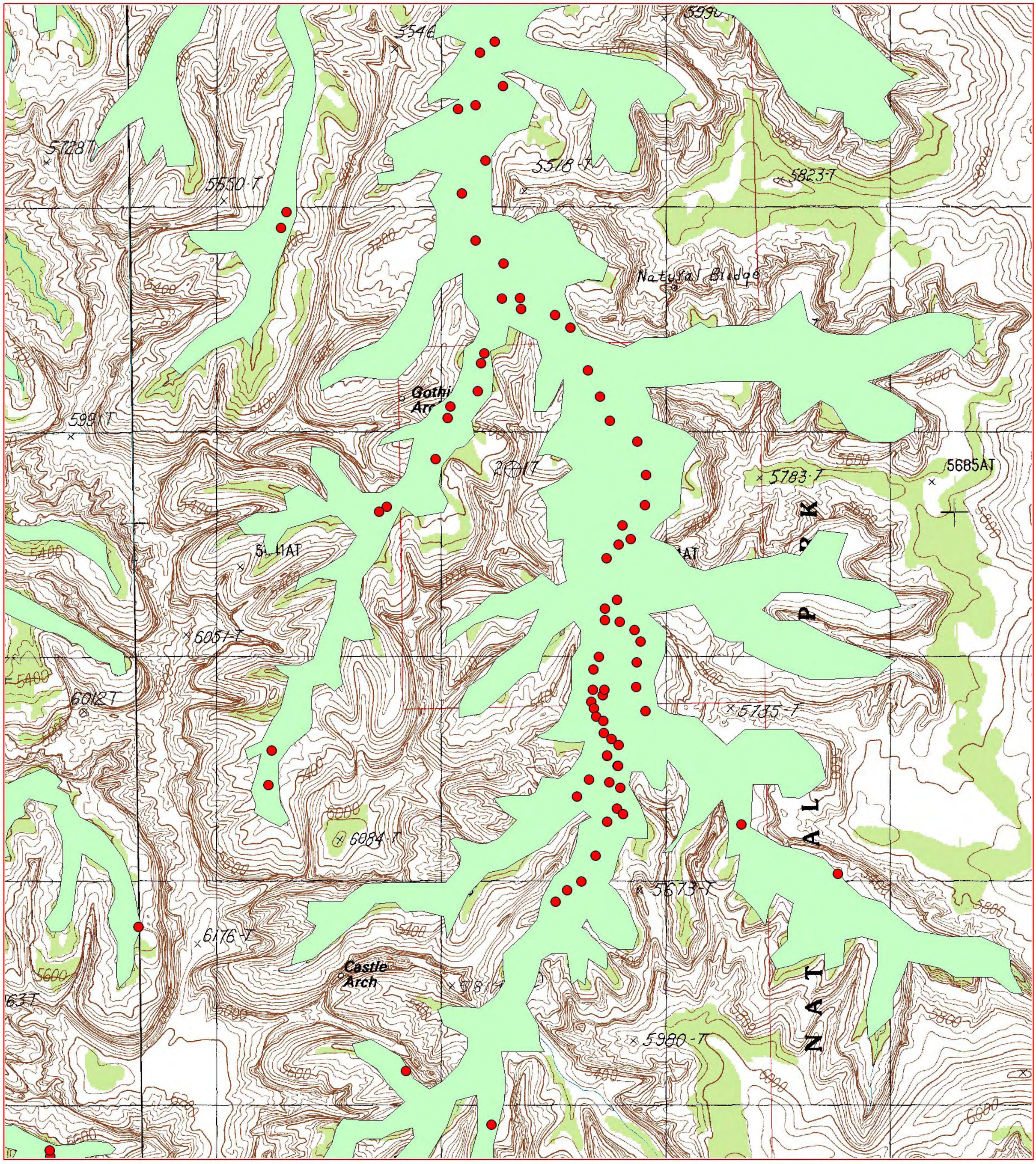
Inset H
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix J. Overall Weed Distribution in Inventoried Areas - Salt Creek Pocket (Inset I)

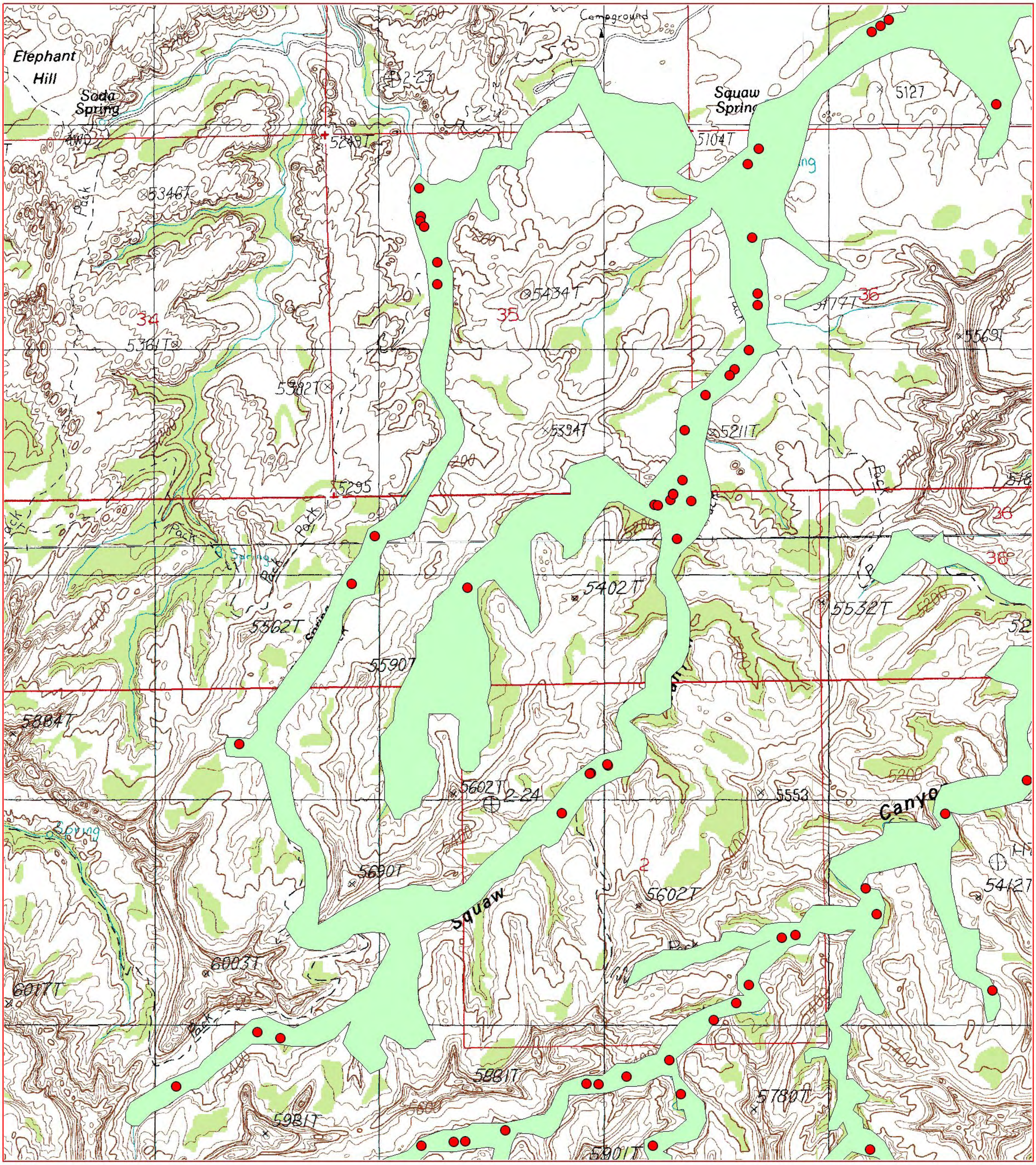


Inset I
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

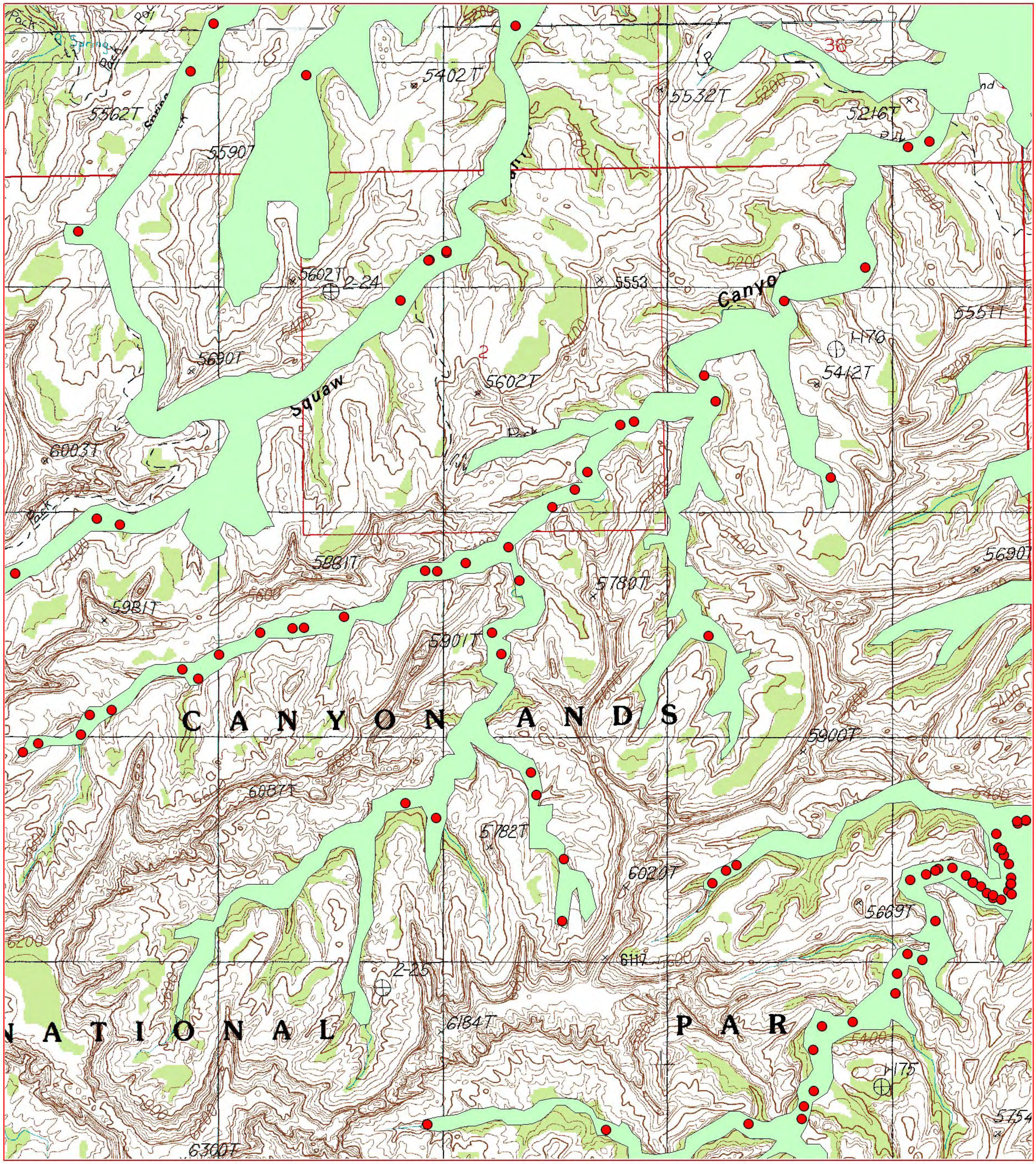
Appendix J. Overall Weed Distribution in Inventoried Areas - Horse Canyon (Inset J)



Appendix J. Overall Weed Distribution in Inventoried Areas - Squaw Canyon (Inset K)



Appendix J. Overall Weed Distribution in Inventoried Areas - Lost Canyon (Inset L)



0 2000 4000 Feet

Weed Points

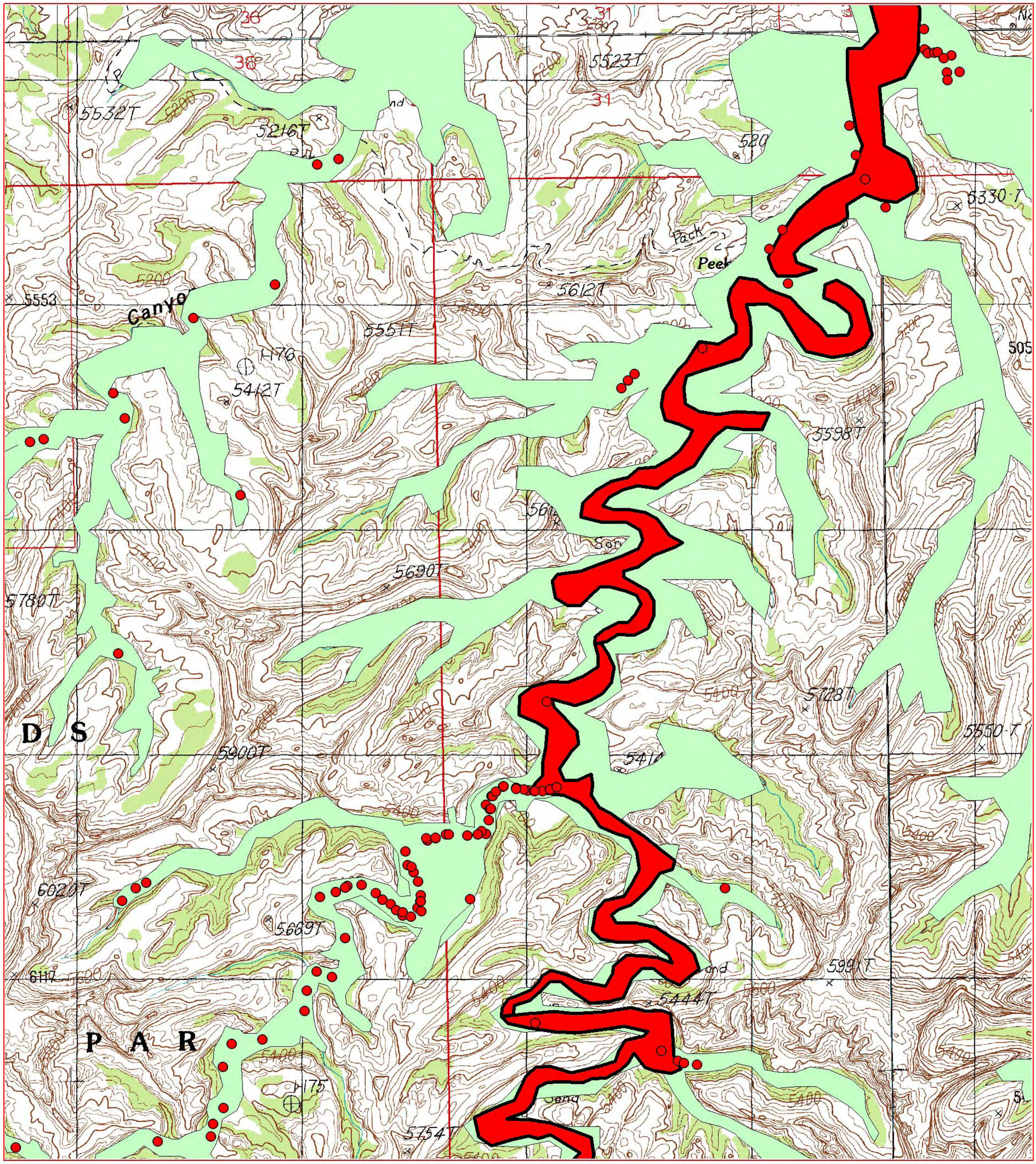
Area Inventoried

N

1:24,000 Scale

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

Appendix J. Overall Weed Distribution in Inventoried Areas - Peekaboo Springs (Inset M)



0 2000 4000 Feet

Weed Points

Weed Areas

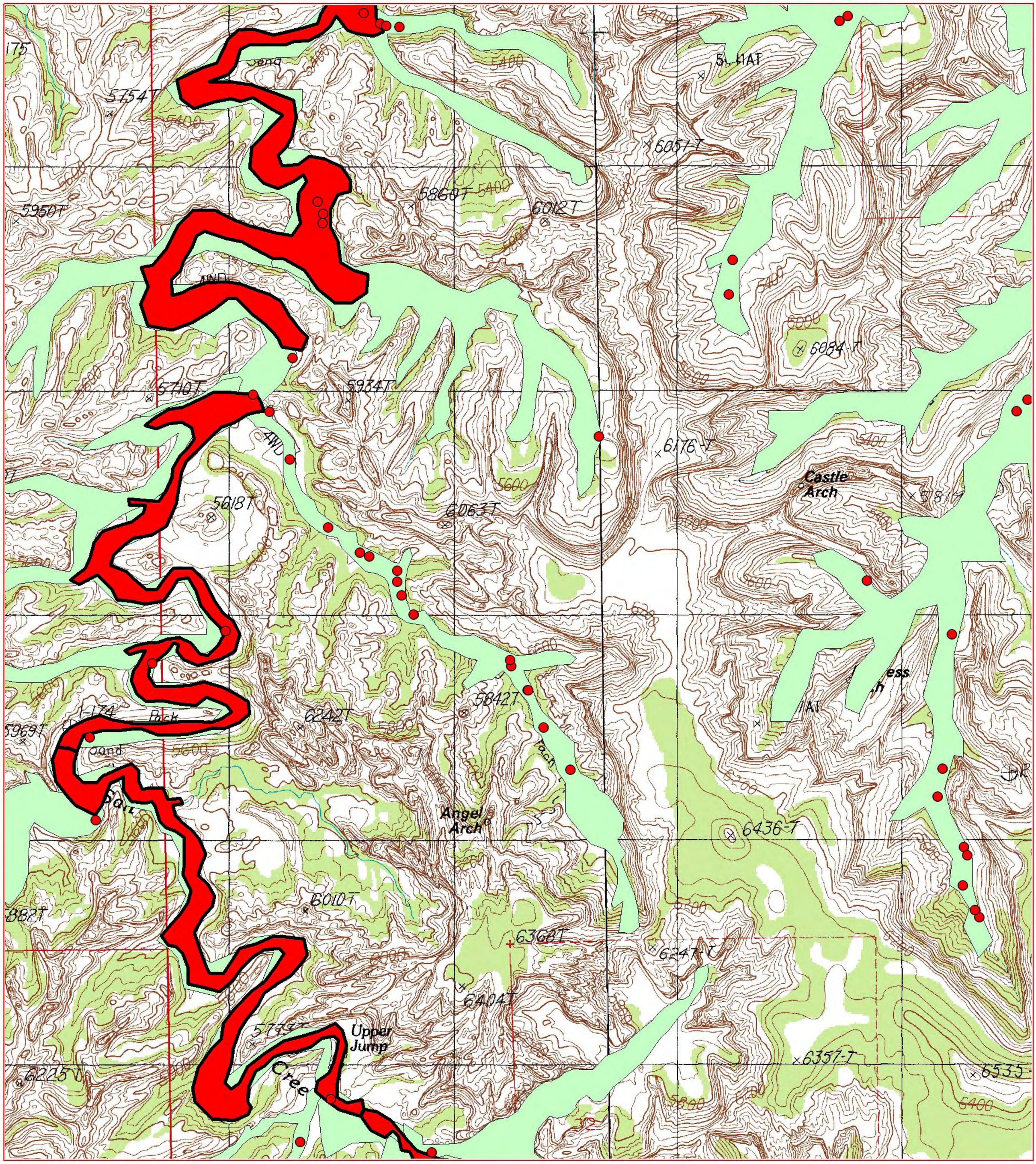
Area Inventoried

N

1:24,000 Scale

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

Appendix J. Overall Weed Distribution in Inventoried Areas - Angel Arch (Inset N)



Weed Points

Weed Areas

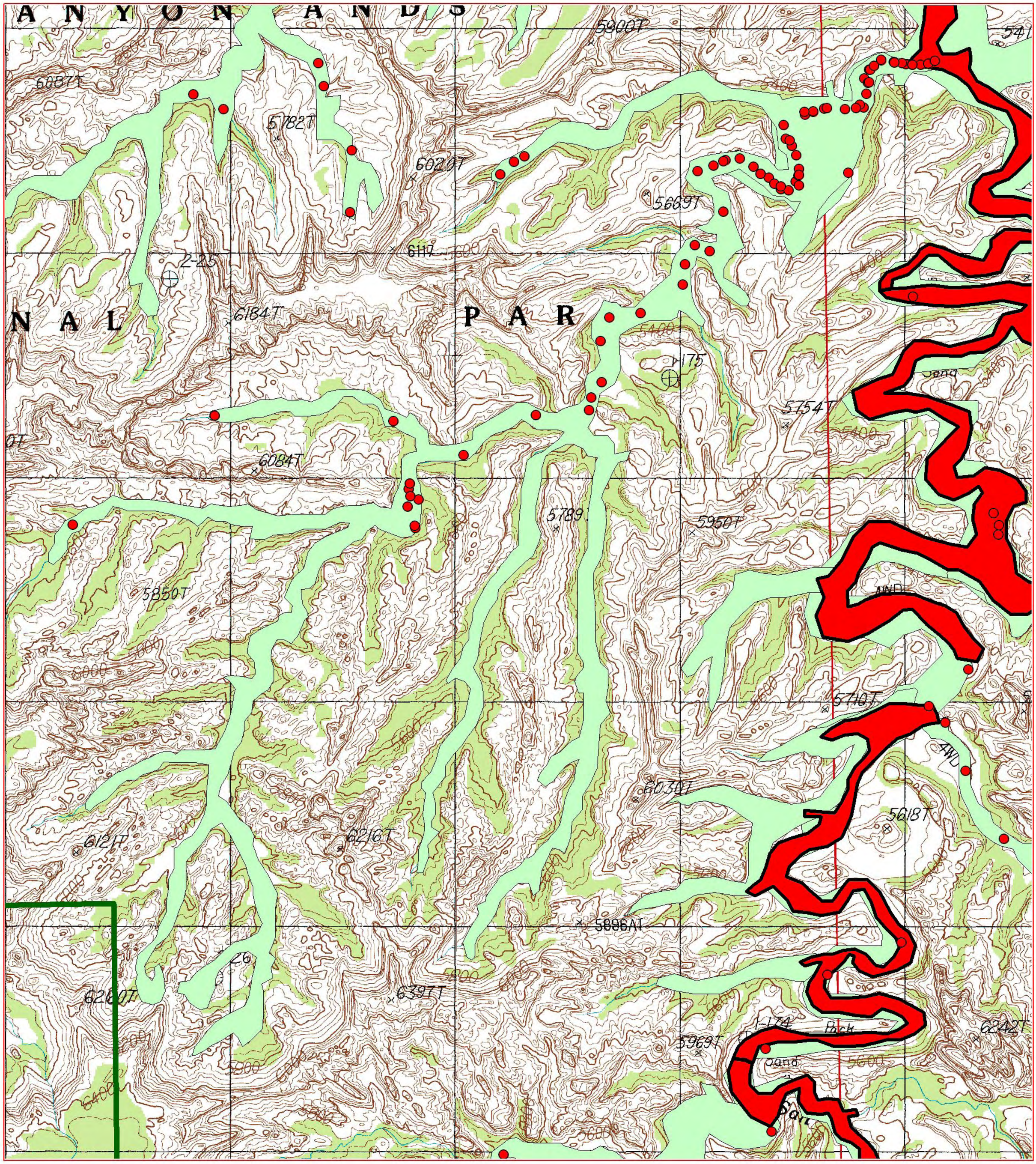
Area Inventoried

N

1:24,000 Scale

Inset N
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix J. Overall Weed Distribution in Inventoried Areas - Salt Creek (Inset O)



Weed Points

Weed Areas

Area Inventoried

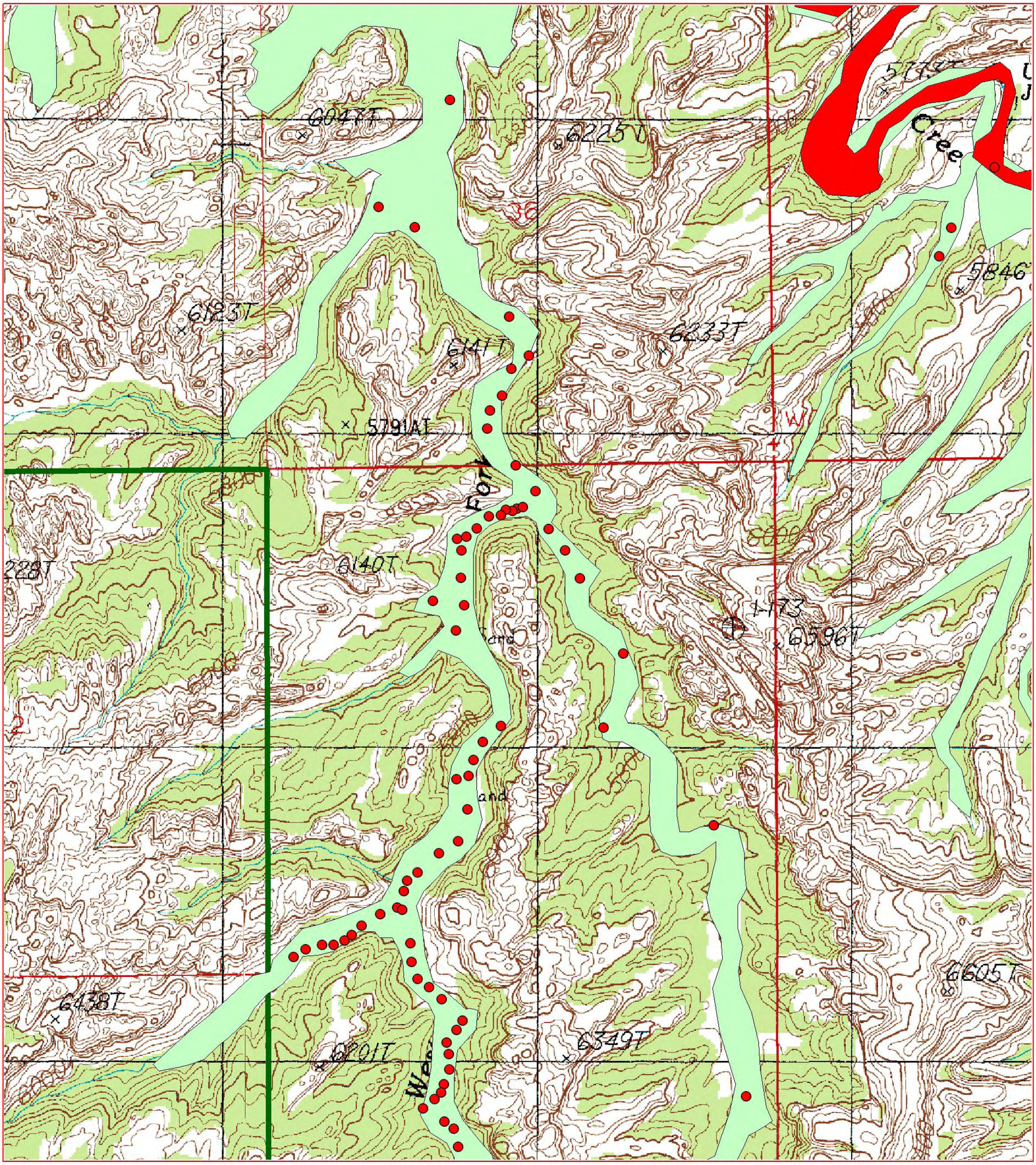
Park boundary

1:24,000 Scale

N

Inset O
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix J. Overall Weed Distribution in Inventoried Areas - West Fork (Inset P)



Weed Points

Weed Areas

Area Inventoried

Park boundary

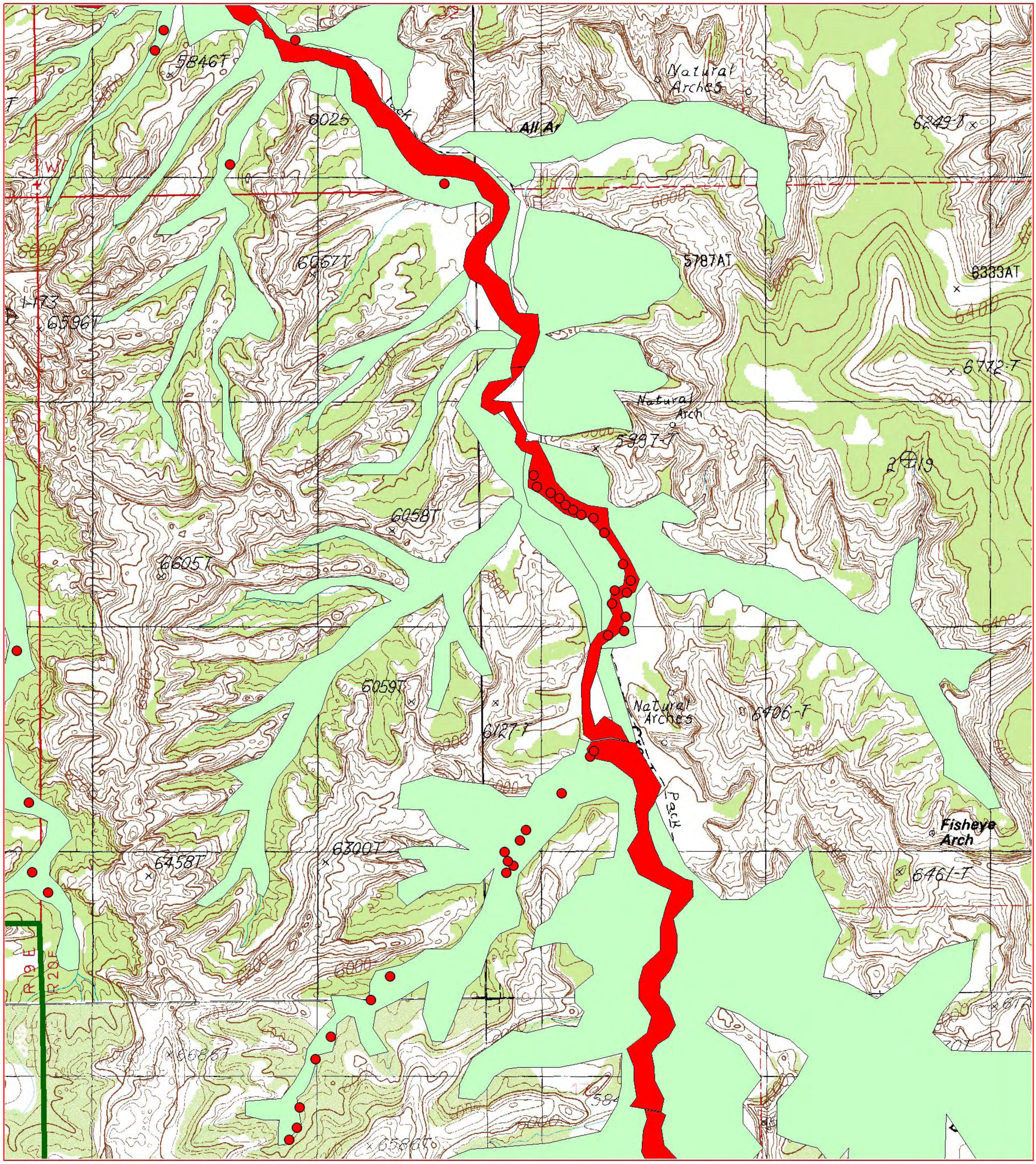
0 1000 2000 Feet

1:24,000 Scale

N

Inset P
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix J. Overall Weed Distribution in Inventoried Areas - Fisheye Arch (Inset Q)



Weed Points

Weed Areas

Area Inventoried

Park boundary

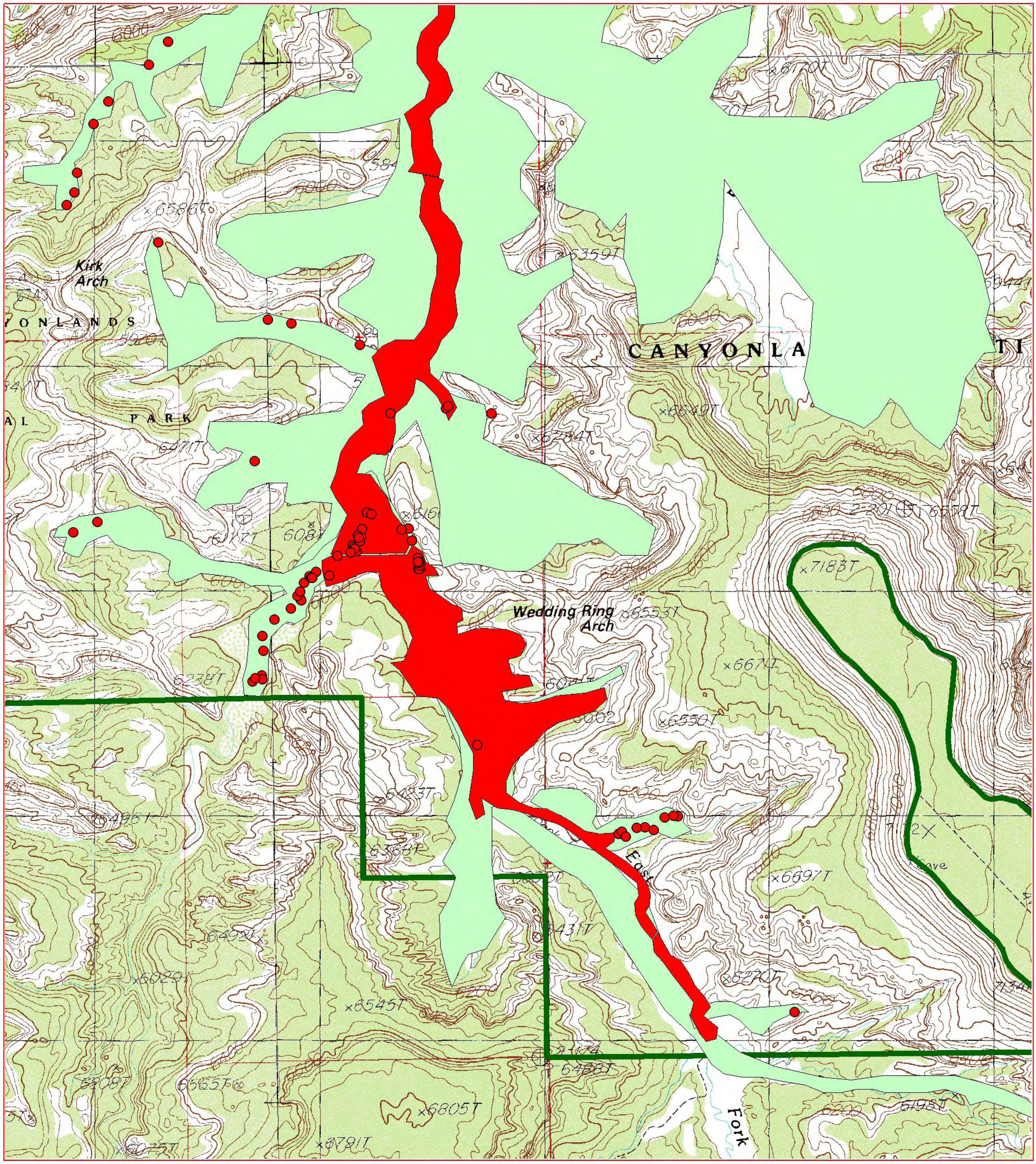
0 2000 4000 Feet

1:24,000 Scale

N

Inset Q
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix J. Overall Weed Distribution in Inventoried Areas - Big Pocket (Inset R)



Weed Points

Weed Areas

Area Inventoried

Park boundary

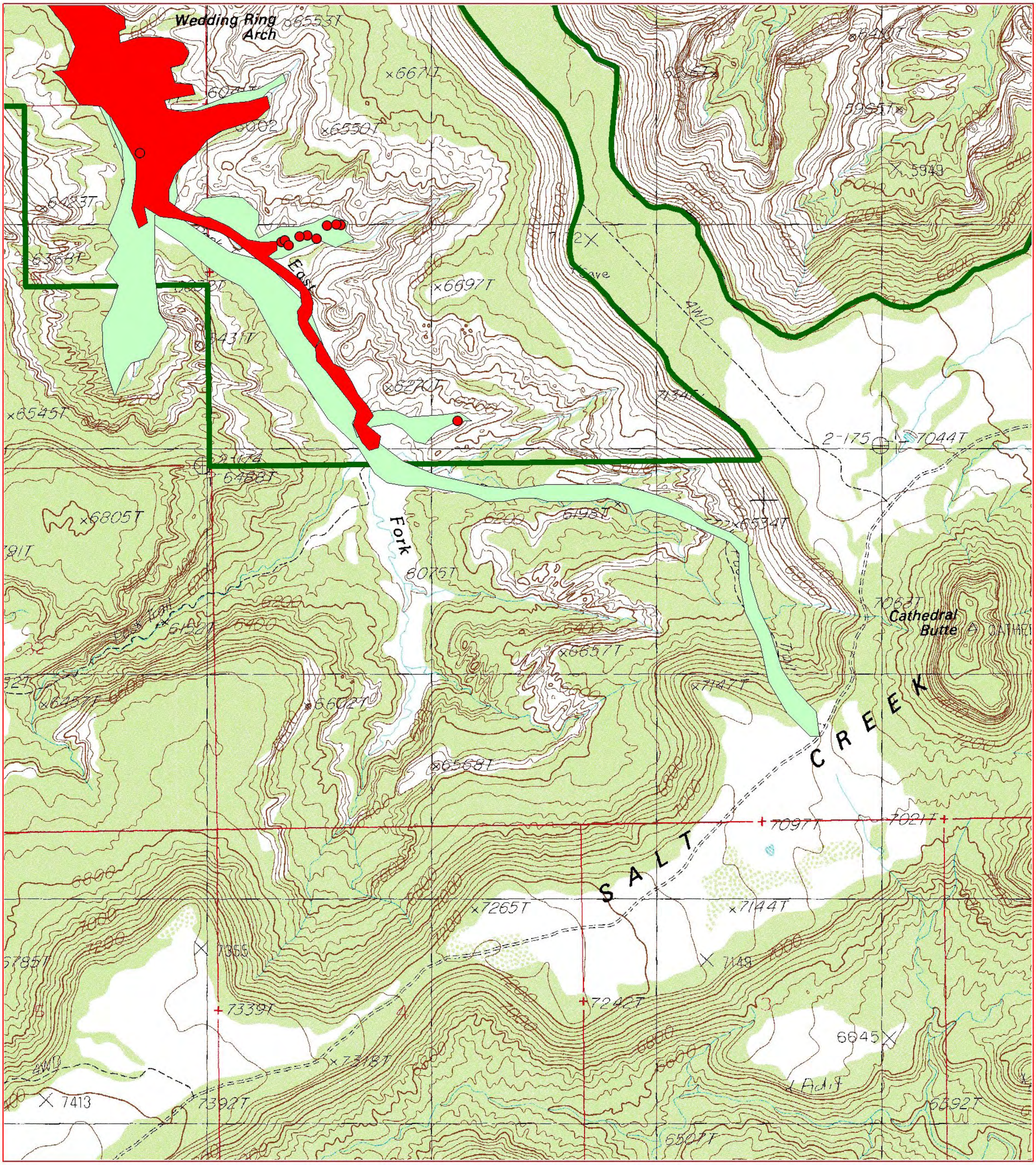
0 2000 4000 Feet

1:24,000 Scale

N

Inset R
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix J. Overall Weed Distribution in Inventoried Areas - Cathedral Butte (Inset S)



0 2000 4000 Feet

1:24,000 Scale

N

Weed Points

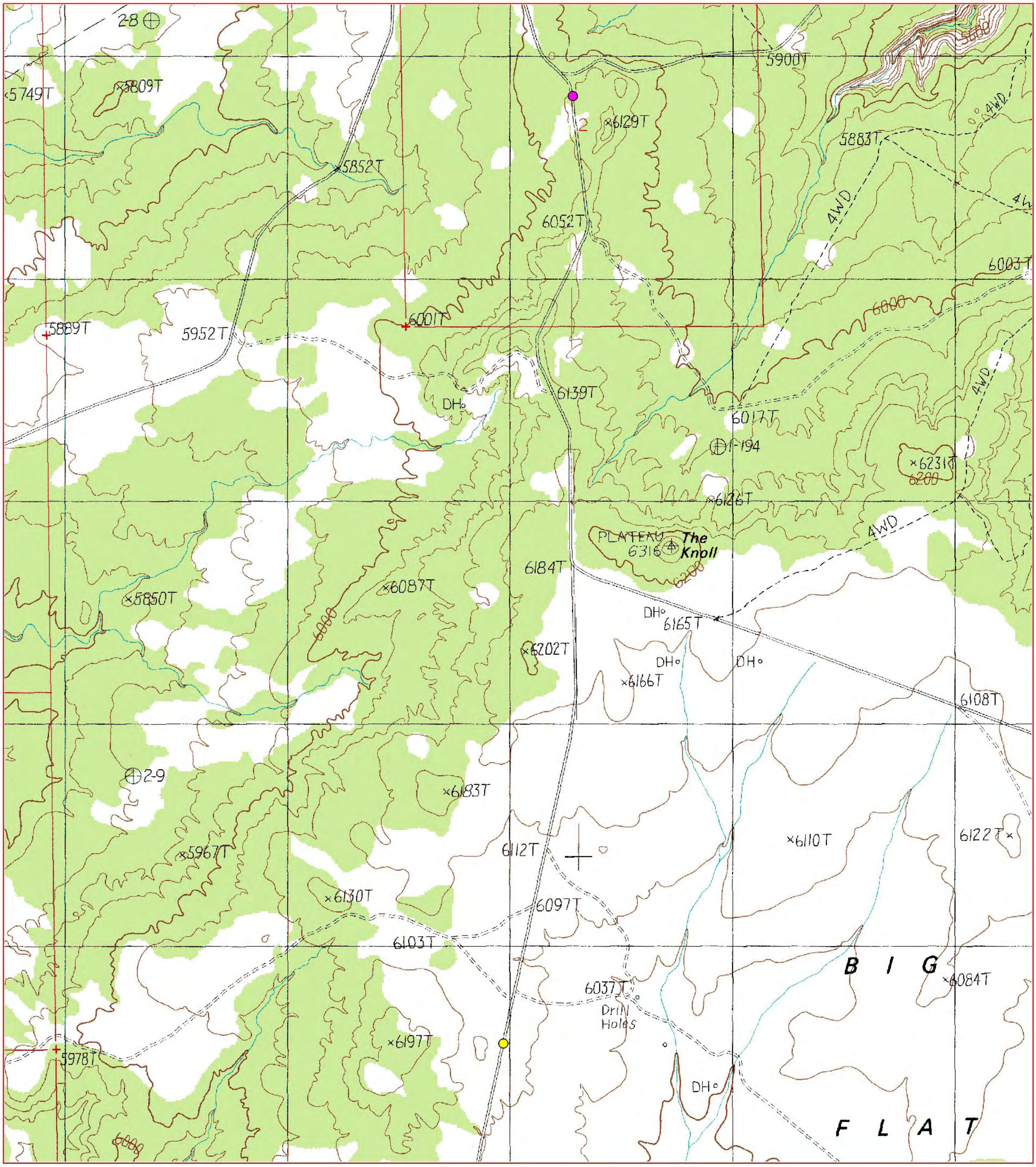
Weed Areas

Area Inventoried

Park boundary

Inset S
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix K. Weed Species Detected in Inventoried Areas - The Knoll (Inset A)



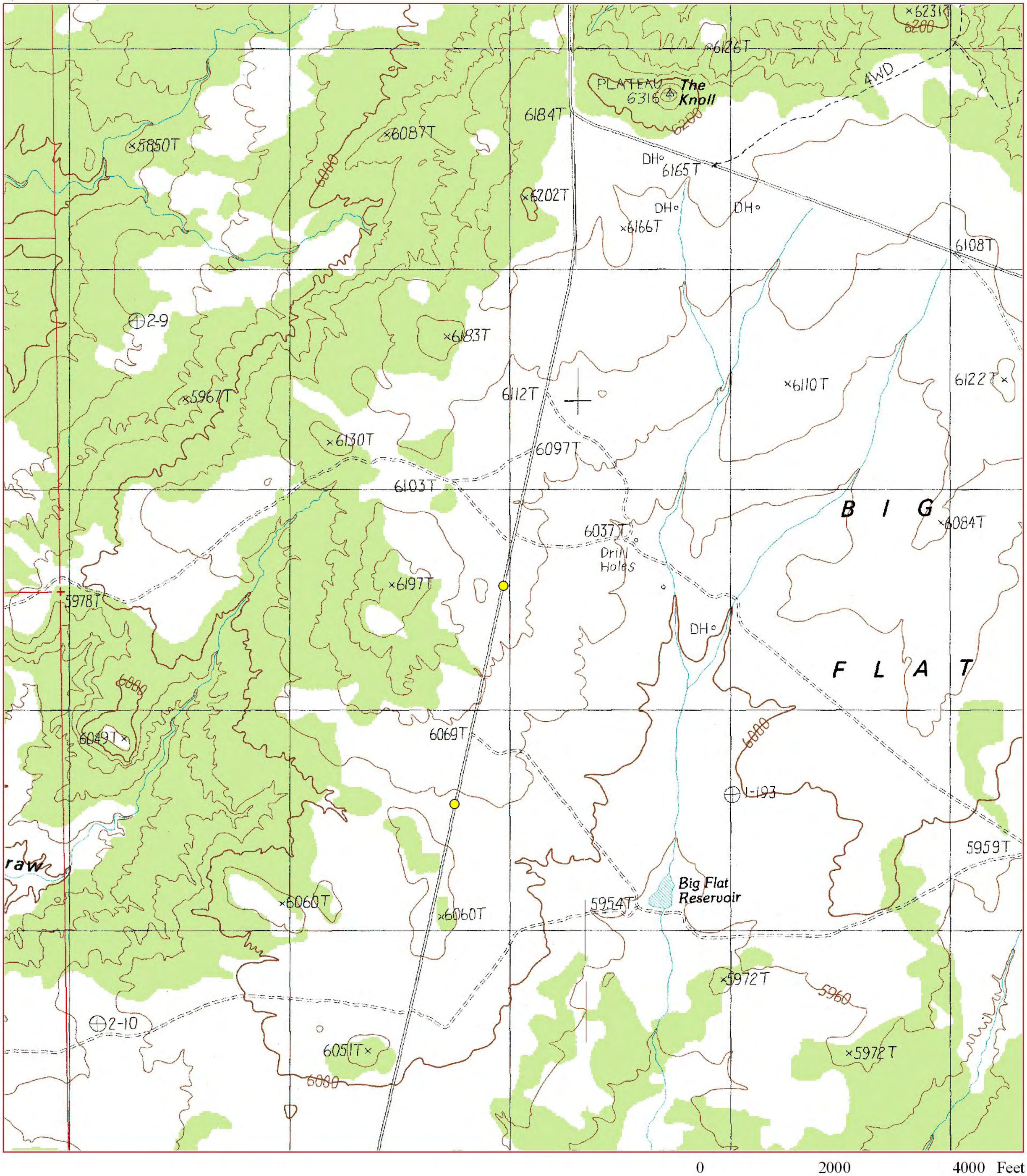
- *Tamarix ramosissima*
- *Ulmus pumila*

1:24,000 Scale

N

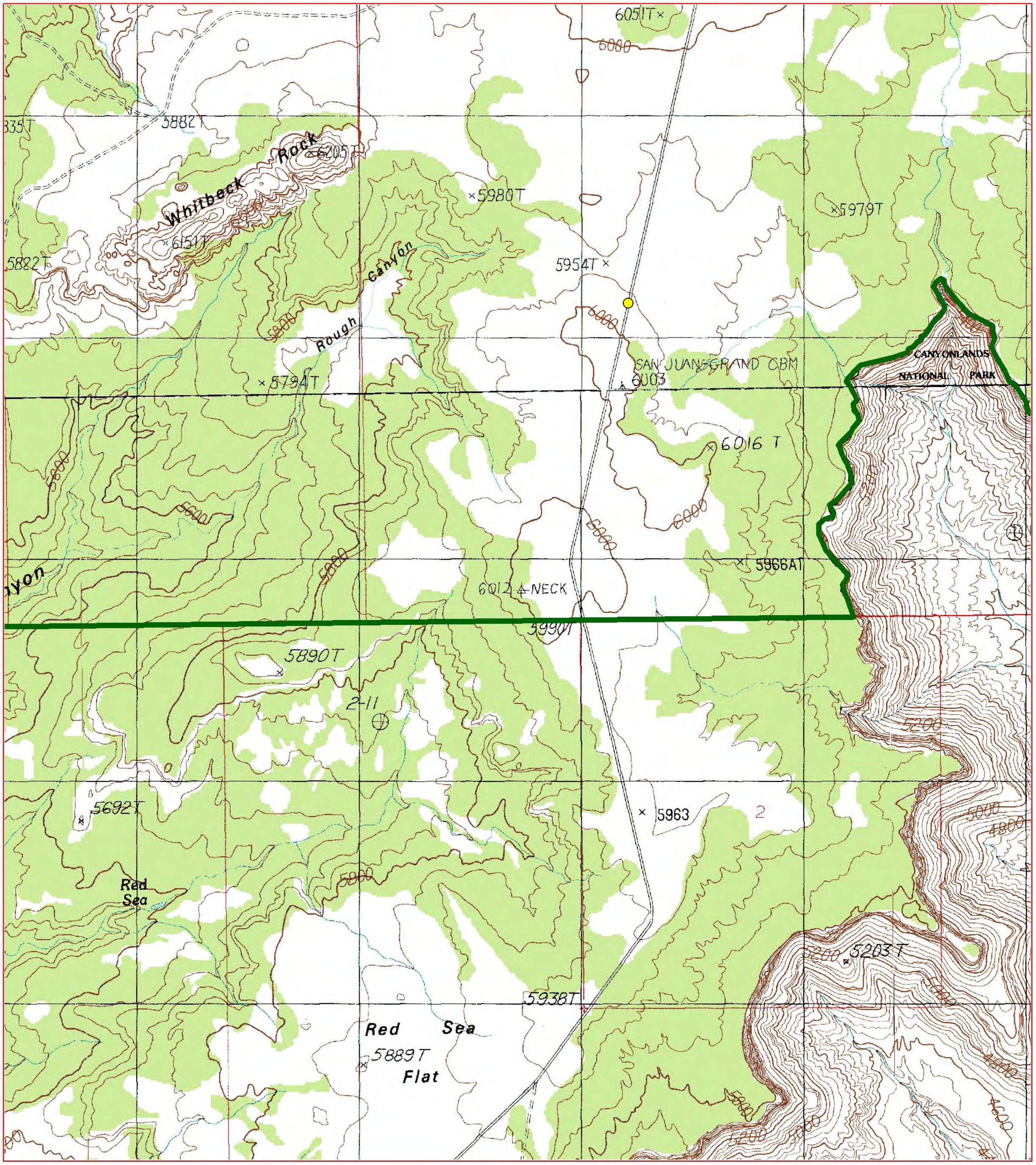
Inset A
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix K. Weed Species Detected in Inventoried Areas - Big Flat Reservoir (Inset B)



● *Ulmus pumila*

Appendix K. Weed Species Detected in Inventoried Areas - Whitebeck Rock (Inset C)



Ulmus pumila

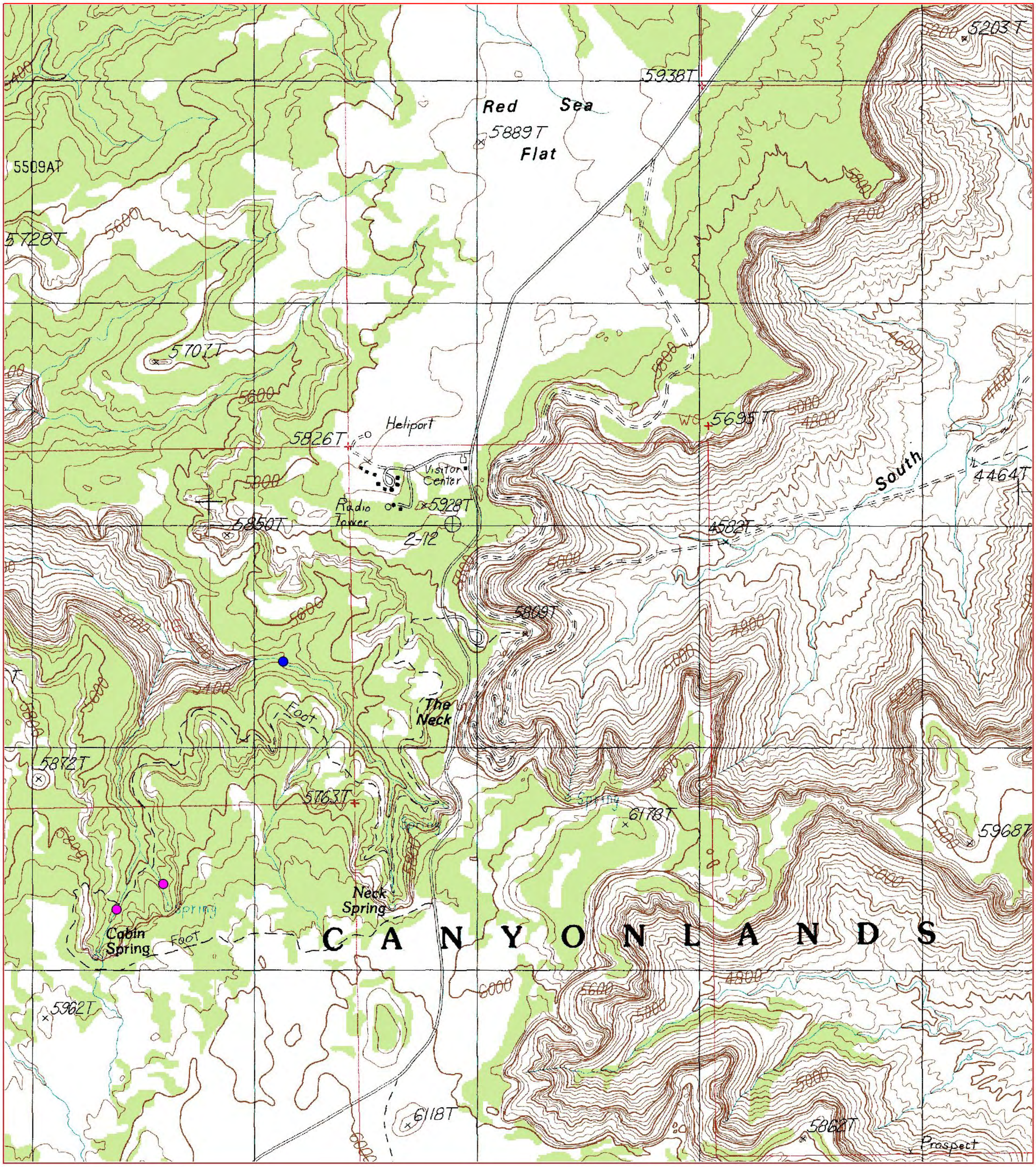
Park boundary

1:24,000 Scale

N

Inset C
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix K. Weed Species Detected in Inventoried Areas - Neck Spring (Inset D)



0 2000 4000 Feet

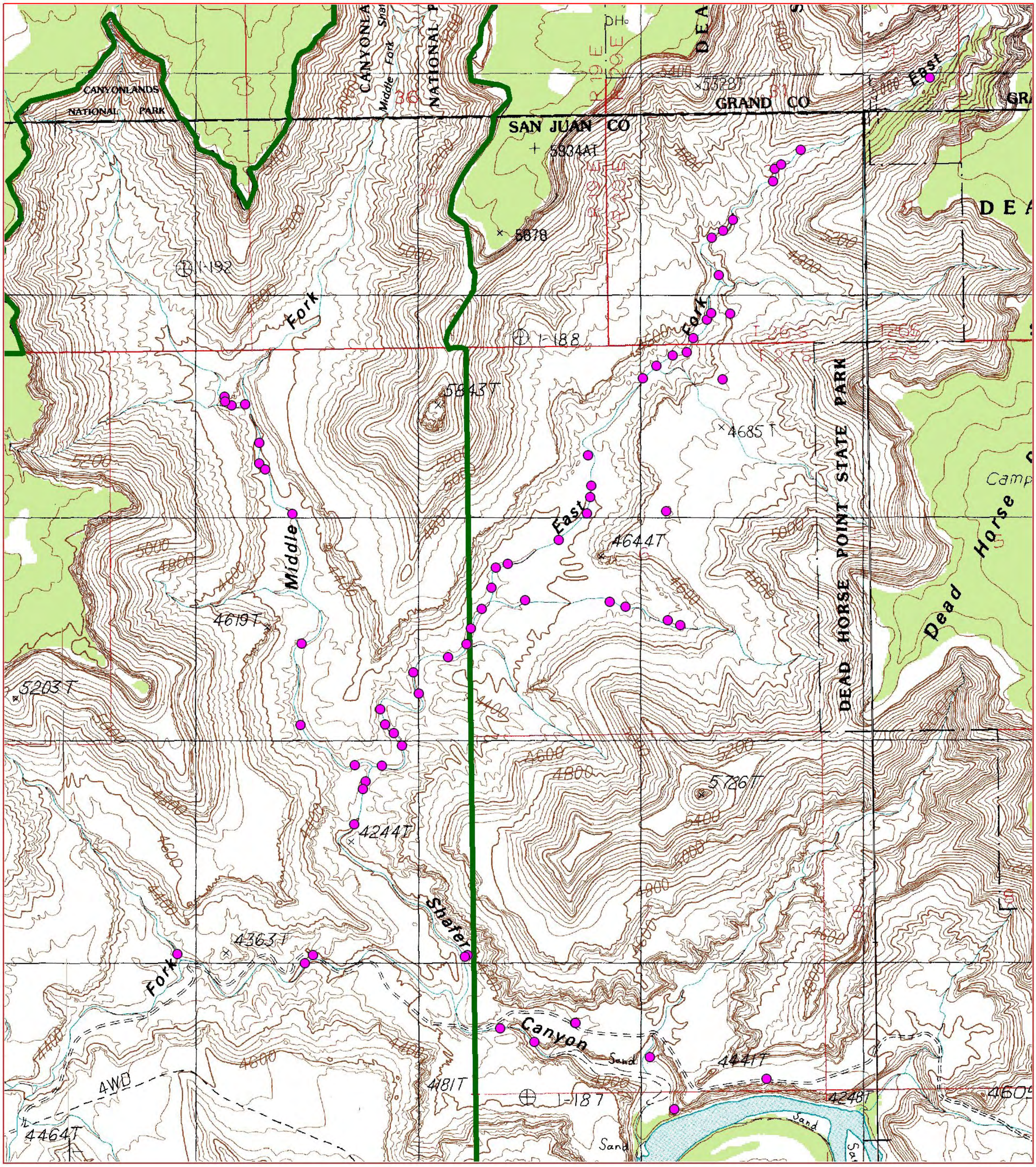
1:24,000 Scale

- *Bromus tectorum*
- *Tamarix ramosissima*

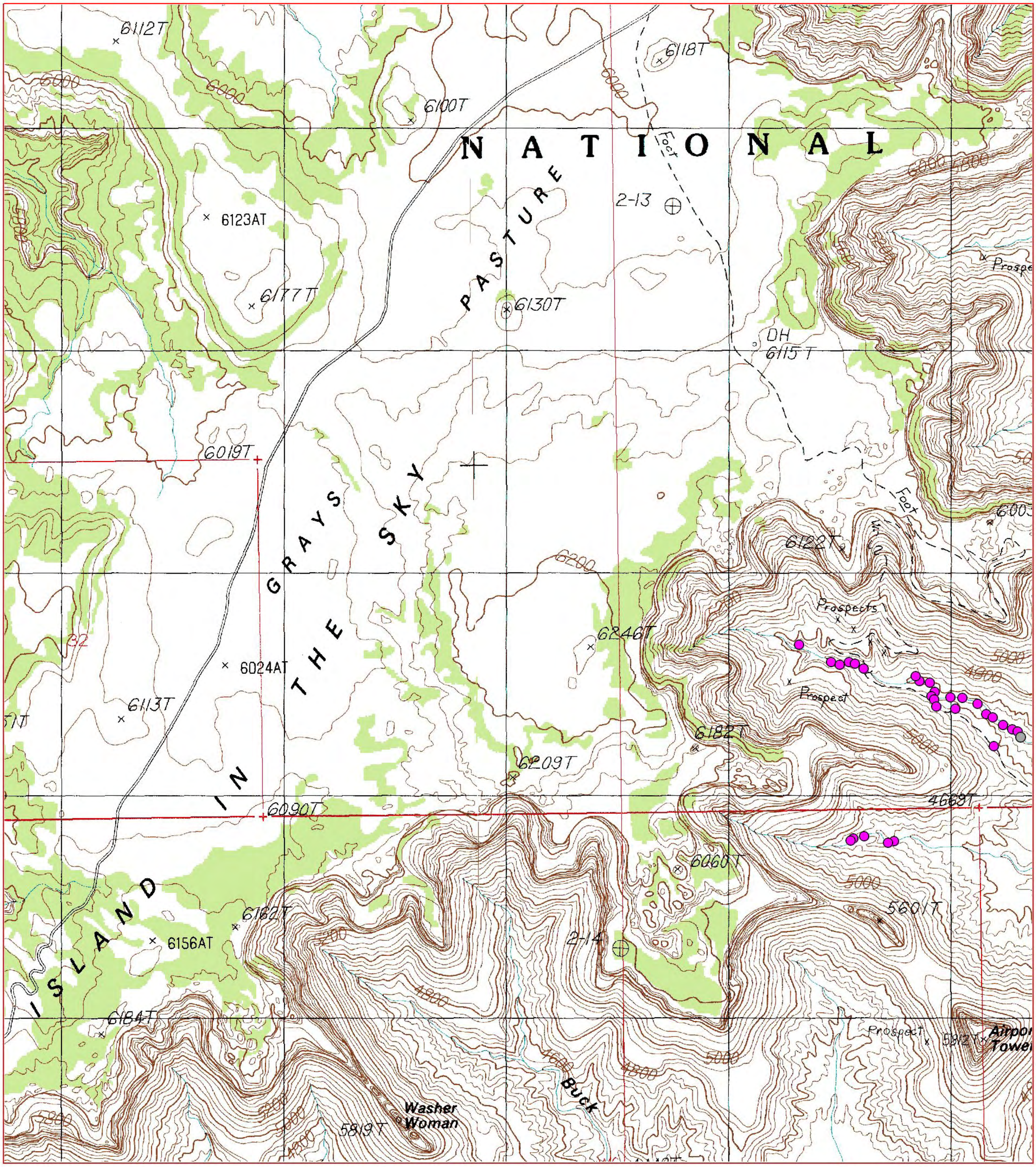
N

Inset D
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix K. Weed Species Detected in Inventoried Areas - Shafer Canyon (Inset E)



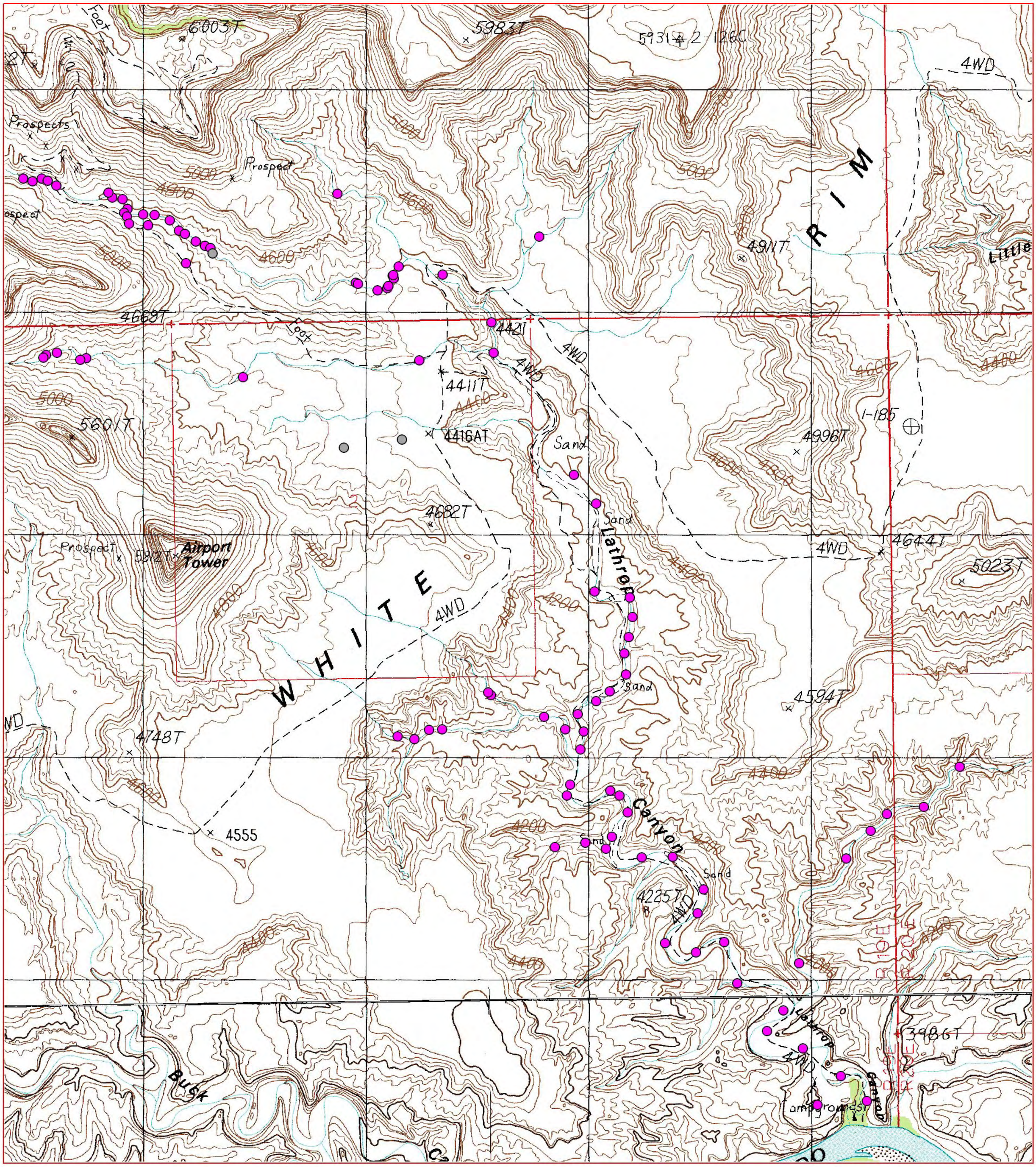
Appendix K. Weed Species Detected in Inventoried Areas - Grays Pasture (Inset F)



- *Halogeton glomeratus*
- *Tamarix ramosissima*

Inset F
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix K. Weed Species Detected in Inventoried Areas - Lathrop Canyon (Inset G)



- *Halogeton glomeratus*
- *Tamarix ramosissima*

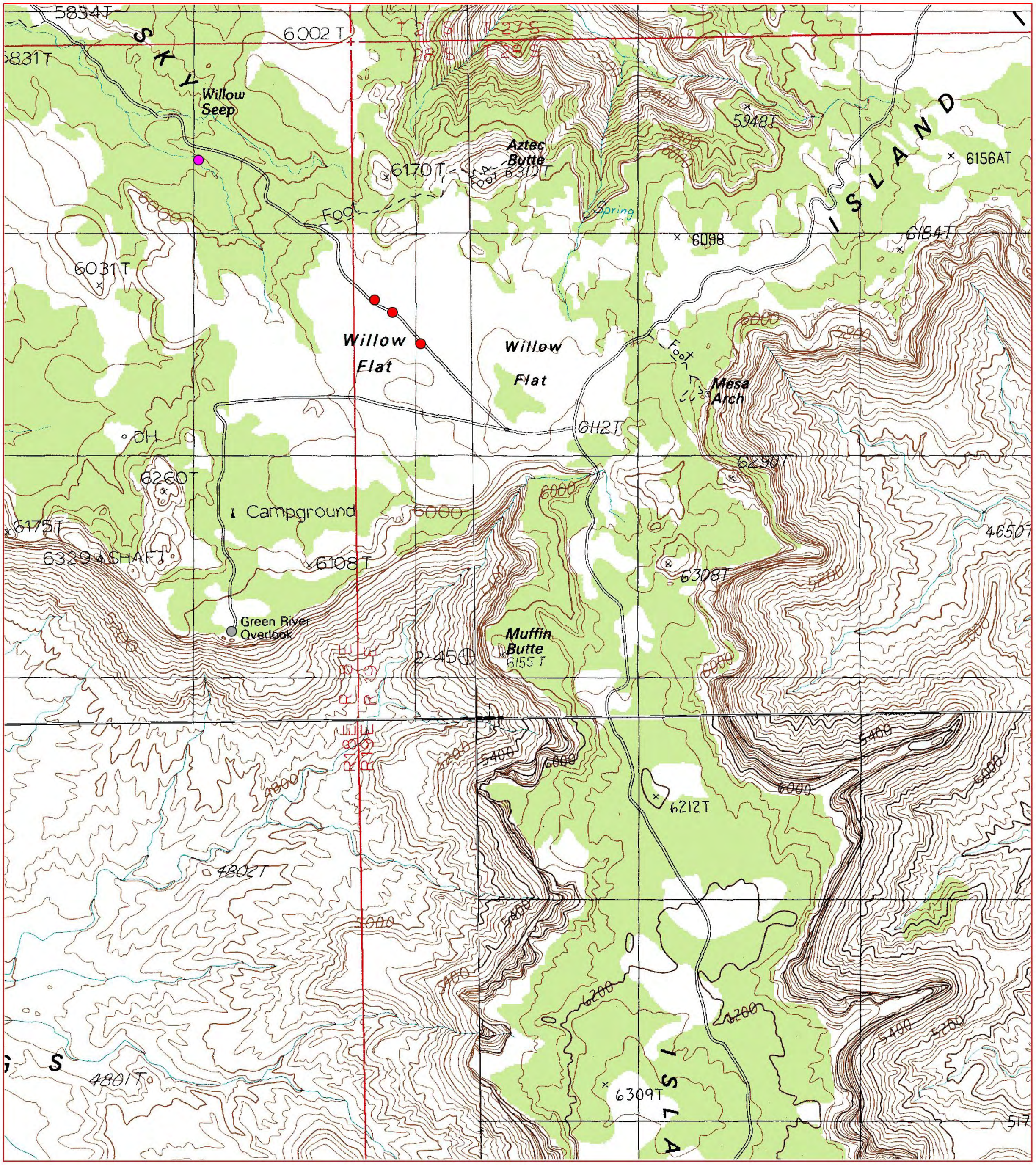
0 2000 4000 Feet

1:24,000 Scale

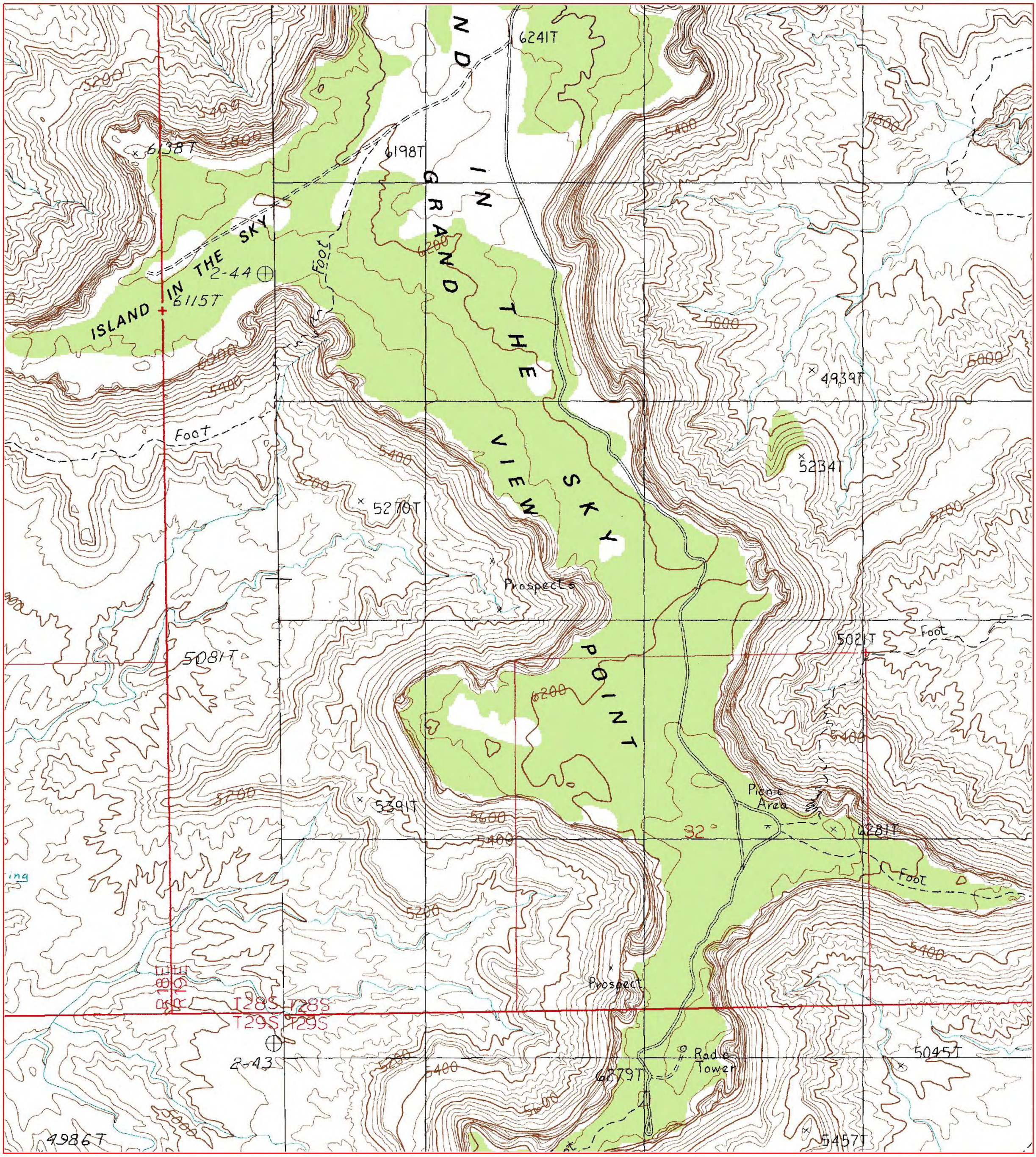
N

Inset G
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix K. Weed Species Detected in Inventoried Areas - Willow Flat (Inset H)



Appendix K. Weed Species Detected in Inventoried Areas - Grand View Point (Inset I)



0 2000 4000 Feet

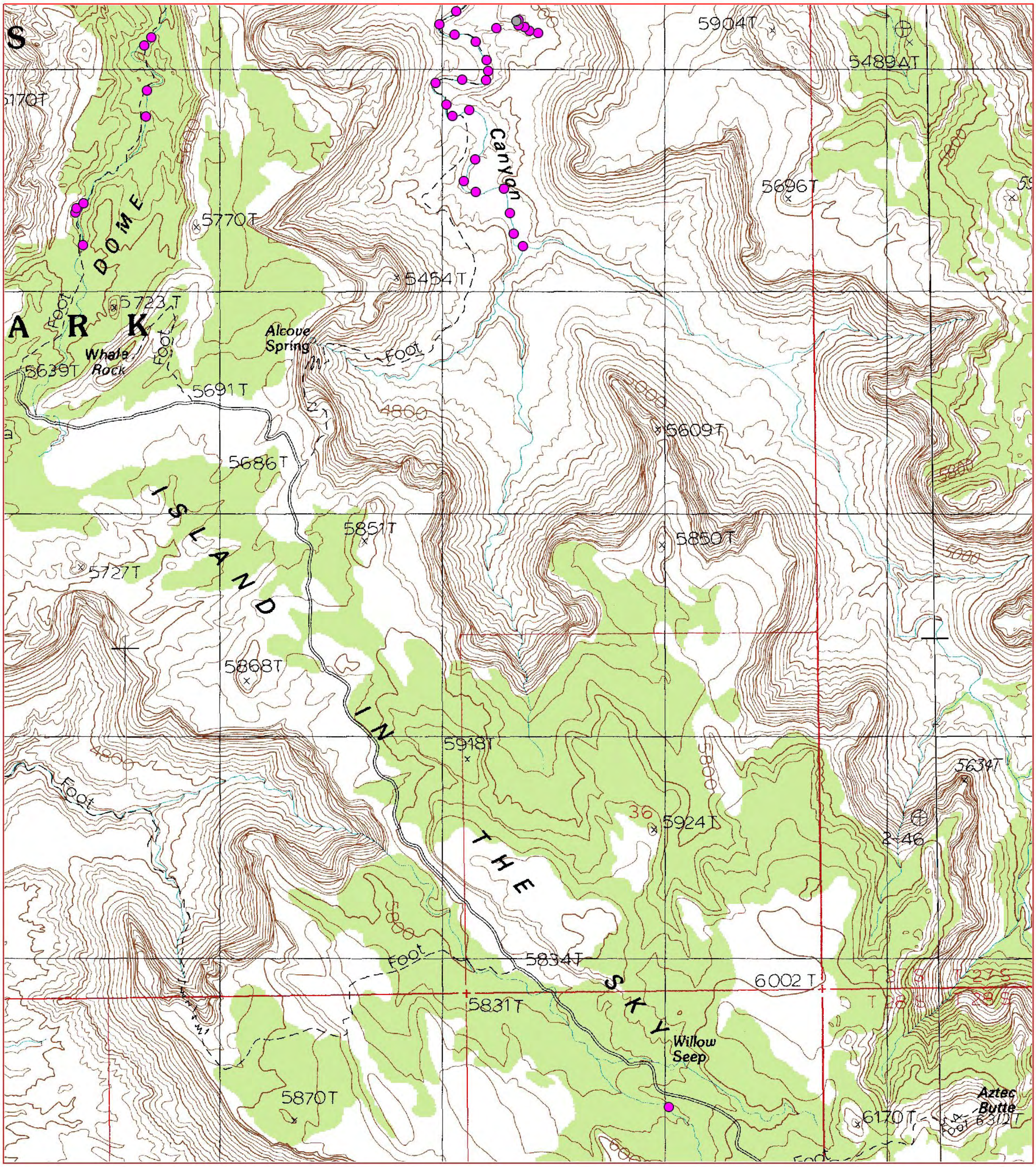
1:24,000 Scale

N

✱ No targeted weed species detected

Inset I
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix K. Weed Species Detected in Inventoried Areas - Whale Rock (Inset J)



0 2000 4000 Feet

1:24,000 Scale

Halogeton glomeratus

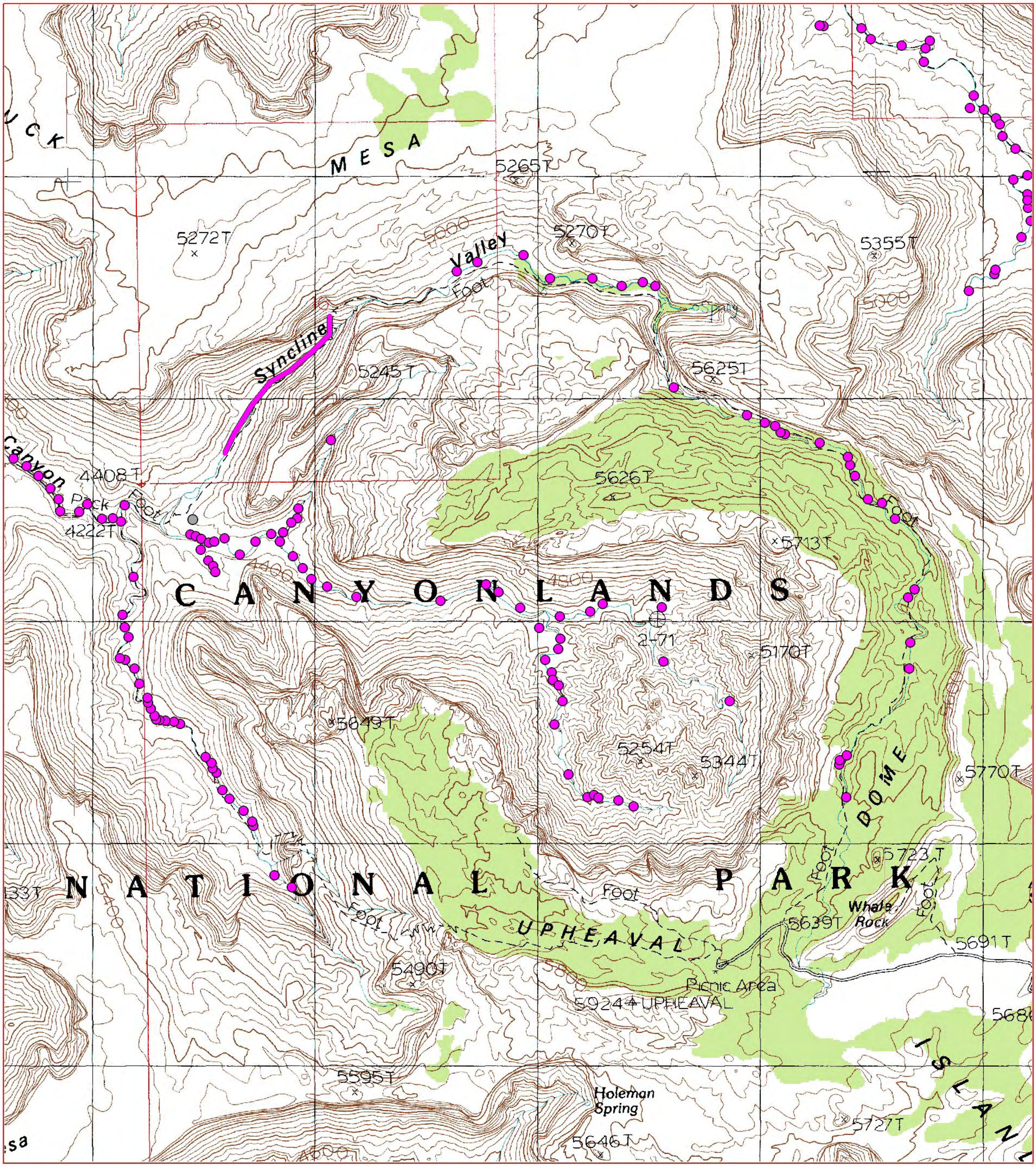
Tamarix ramosissima

Park boundary

N

Inset J
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix K. Weed Species Detected in Inventoried Areas - Upheaval Dome (Inset K)



Halogeton glomeratus

Tamarix ramosissima

Tamarix ramosissima

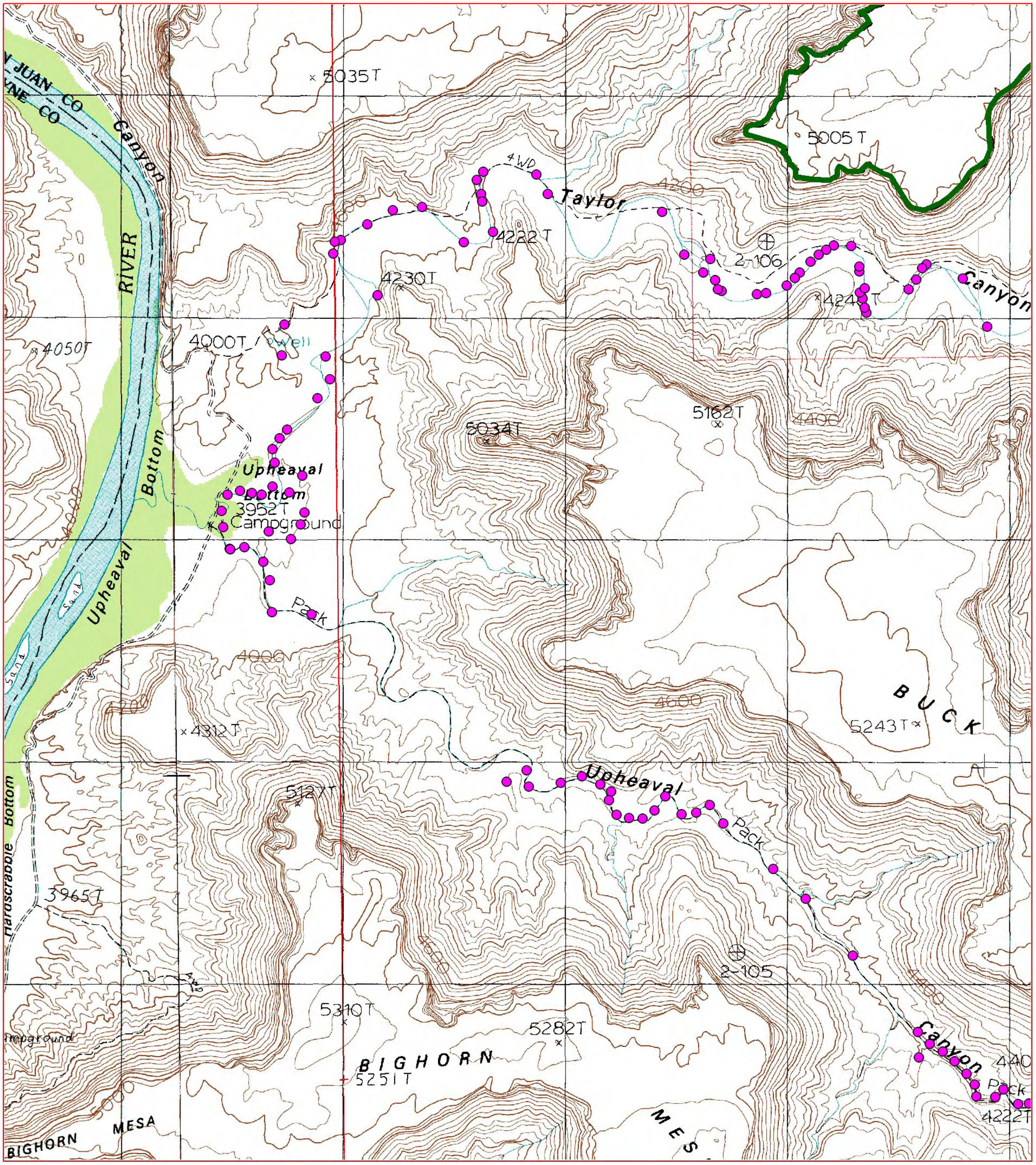
0 2000 4000 Feet

1:24,000 Scale

N

Inset K
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix K. Weed Species Detected in Inventoried Areas - Upheaval Canyon (Inset L)



Tamarix ramosissima

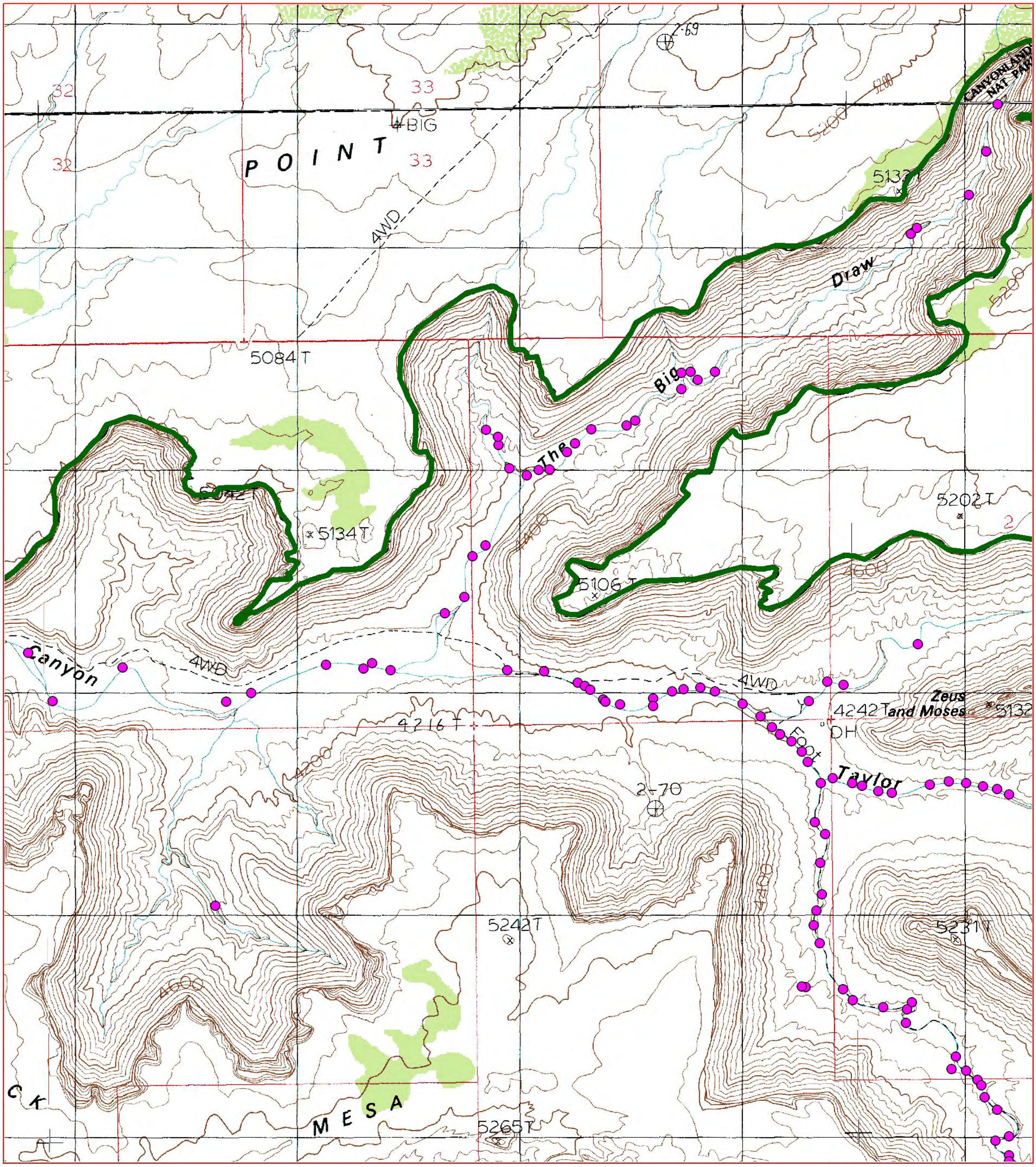
Park boundary

1:24,000 Scale

N

Inset L
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix K. Weed Species Detected in Inventoried Areas - Big Draw (Inset M)



0 2000 4000 Feet

1:24,000 Scale

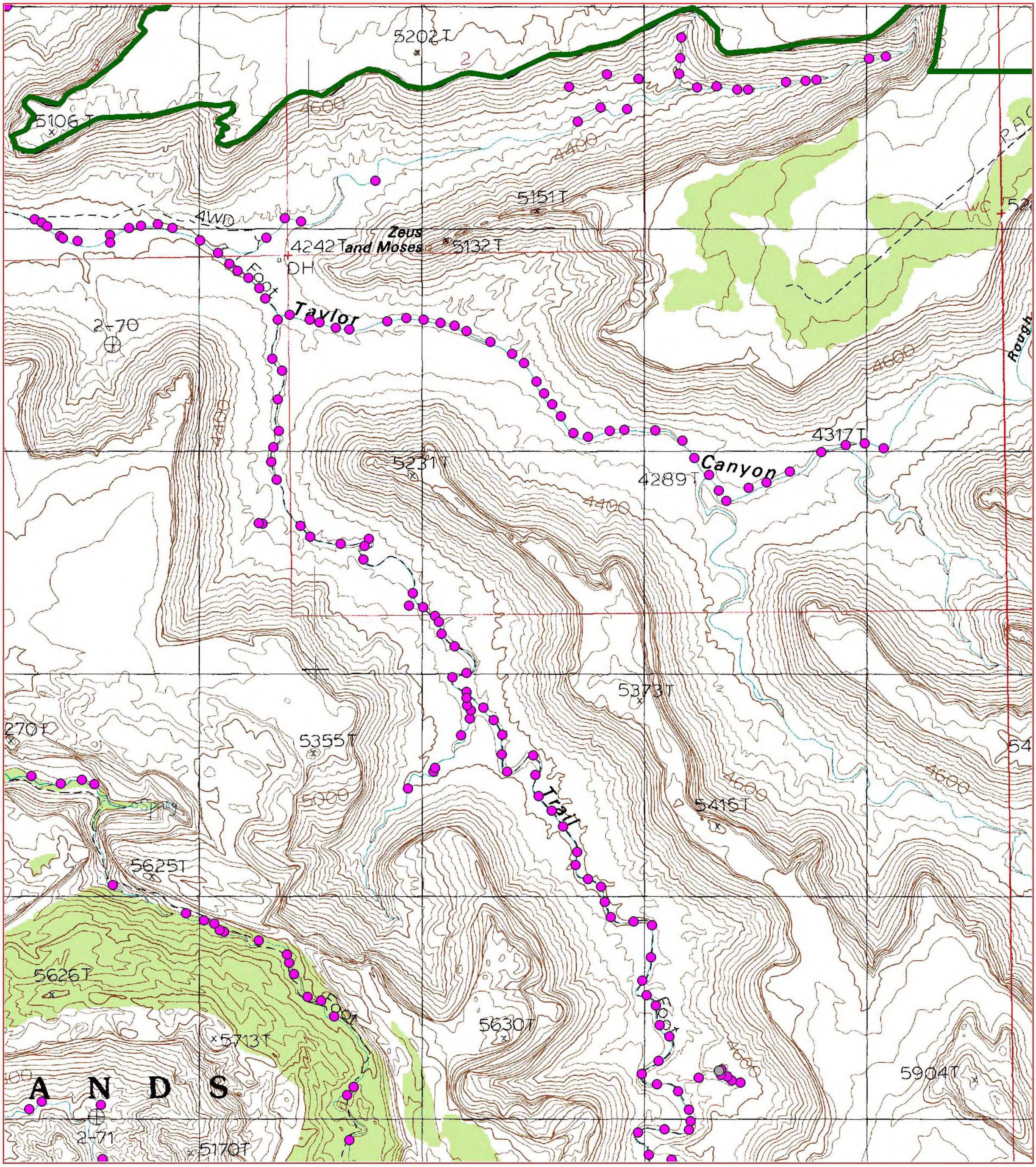
● *Tamarix ramosissima*

Park boundary

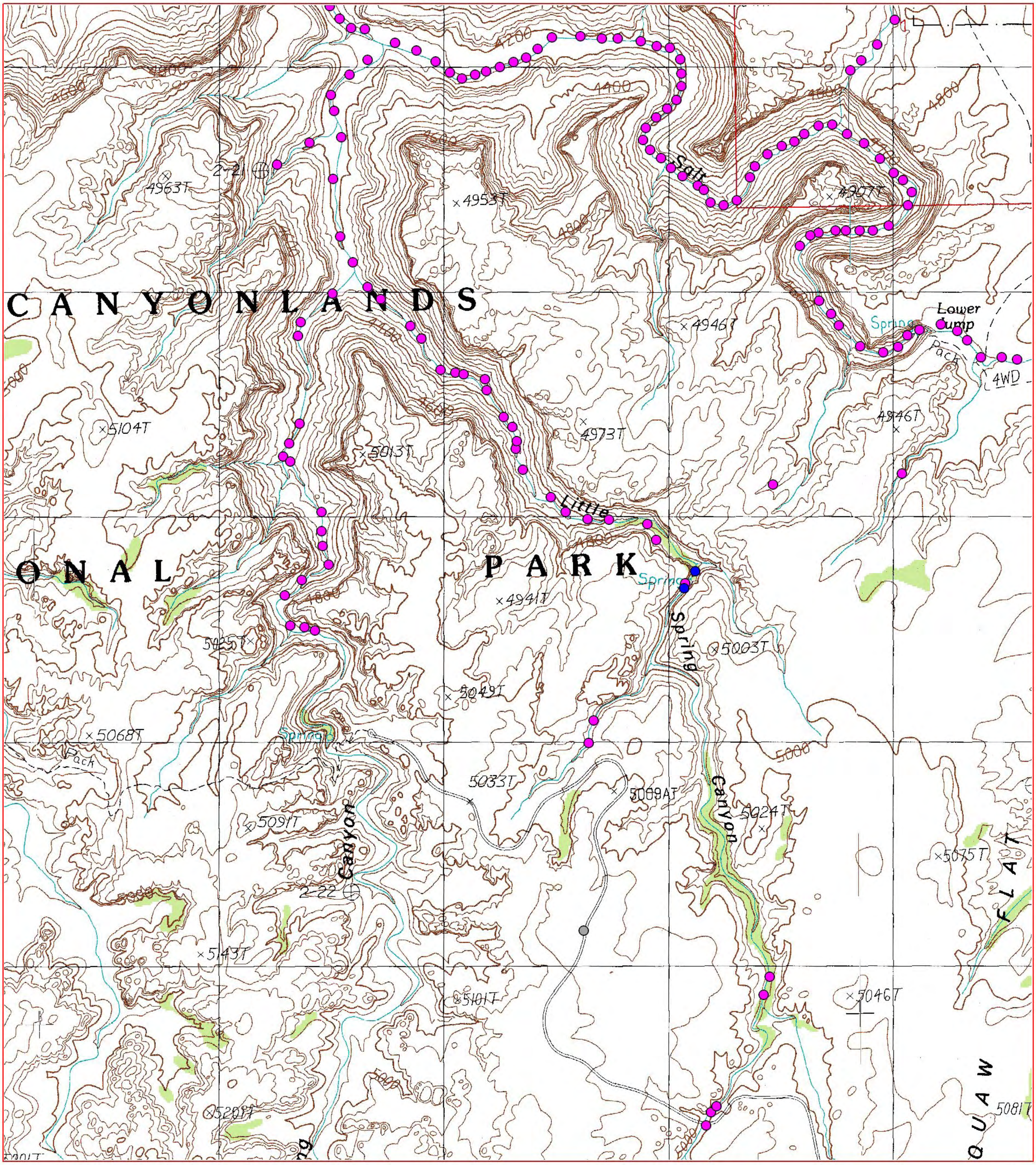
N

Inset M
Island in the Sky District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix K. Weed Species Detected in Inventoried Areas - Trail Canyon (Inset N)



Appendix L. Weed Species Detected in Inventoried Areas - Little Spring Canyon (Inset A)



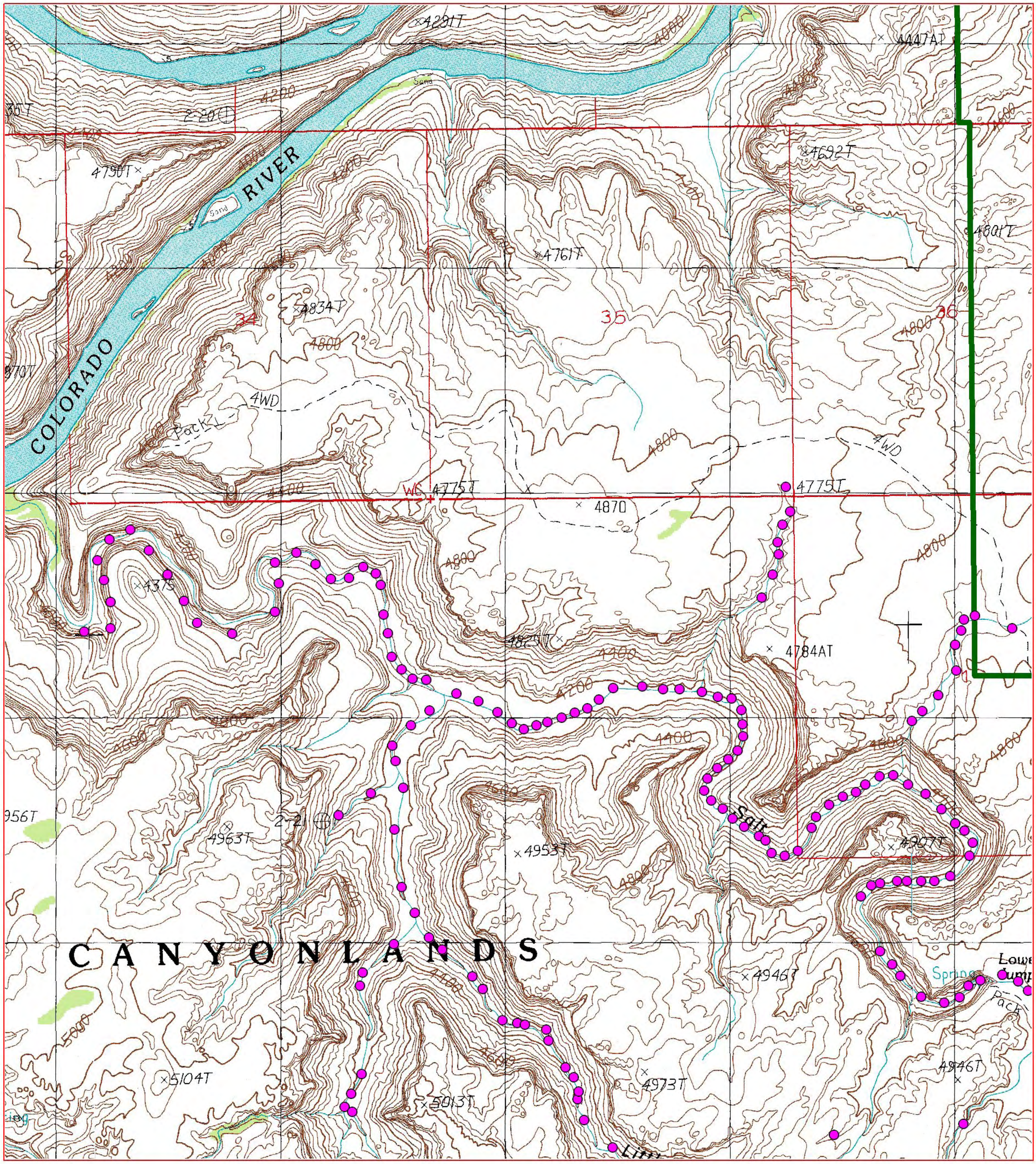
- *Cirsium vulgare*
- *Halogeton glomeratus*
- *Tamarix ramosissima*

N

1:24,000 Scale

Inset A
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix L. Weed Species Detected in Inventoried Areas - Lower Jump (Inset B)



Tamarix ramosissima

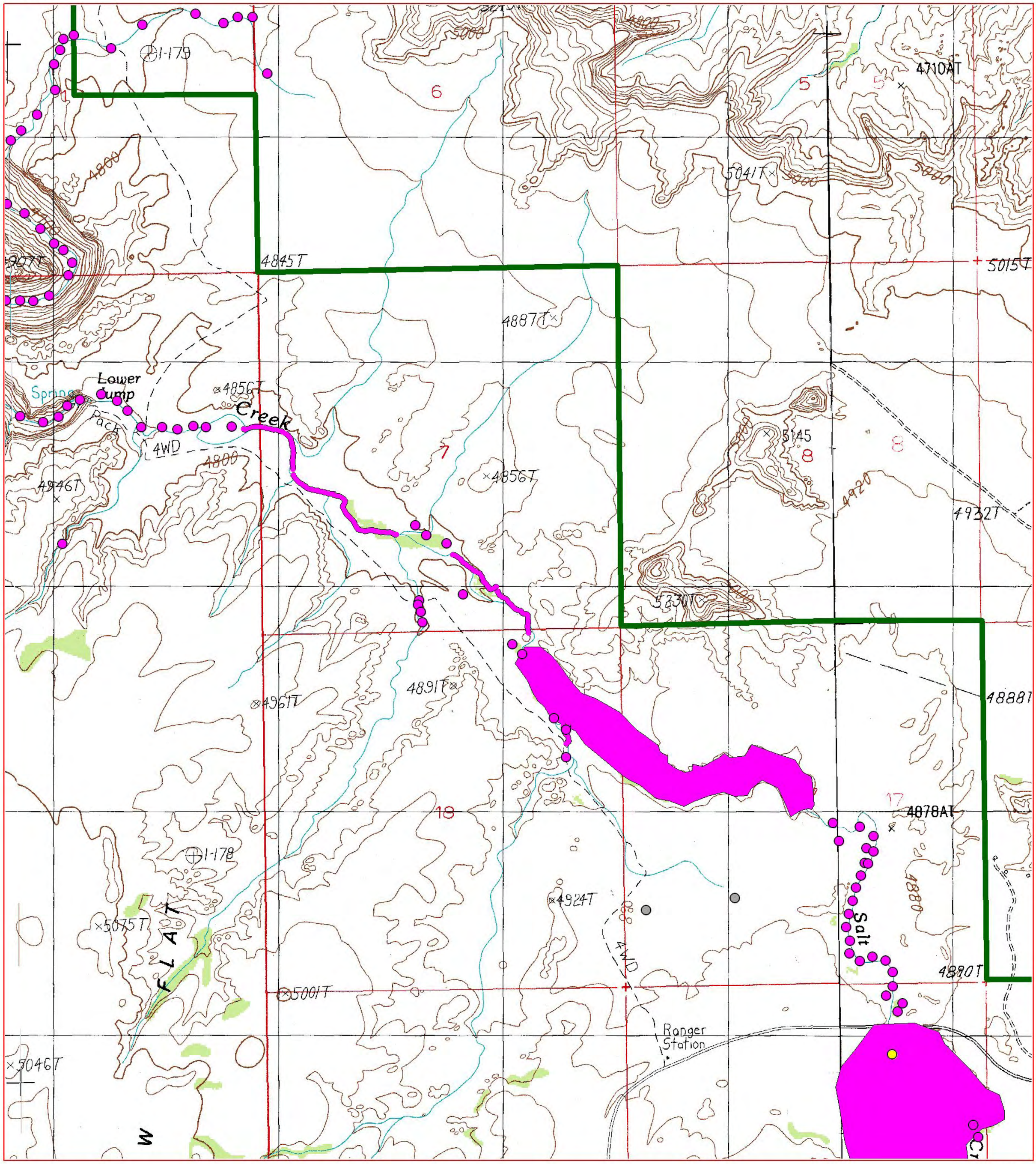
Park boundary

1:24,000 Scale

N

Inset B
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix L. Weed Species Detected in Inventoried Areas - Squaw Flat (Inset C)



Cirsium arvense

Halogeton glomeratus

Tamarix ramosissima

Tamarix ramosissima

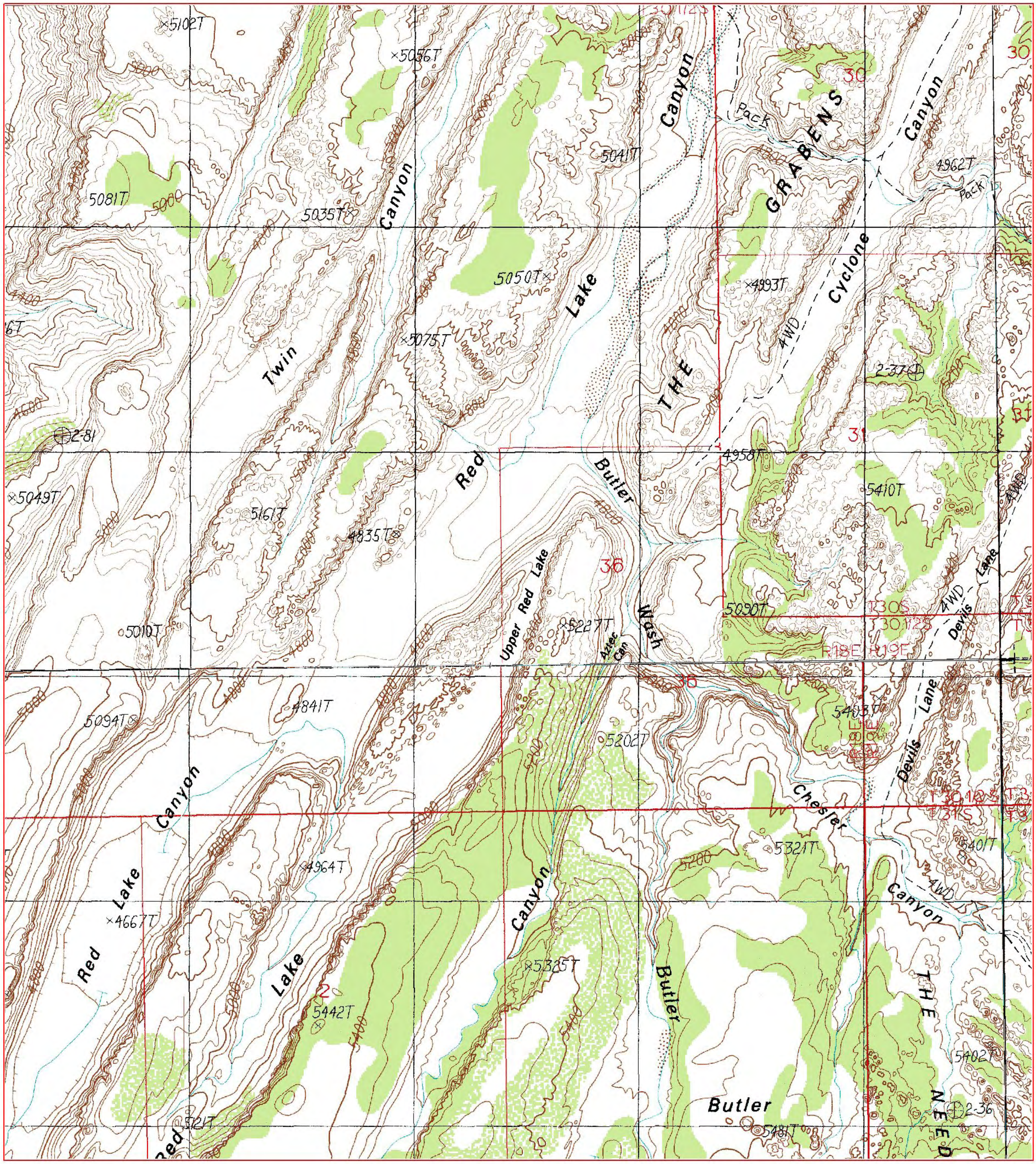
Tamarix ramosissima

Park boundary

1:24,000 Scale

Inset C
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix L. Weed Species Detected in Inventoried Areas - Red Lake Canyon (Inset D)



0 2000 4000 Feet

1:24,000 Scale

N

* No targeted weed species detected

Inset D
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix L. Weed Species Detected in Inventoried Areas - Lower Red Lake Canyon (Inset E)

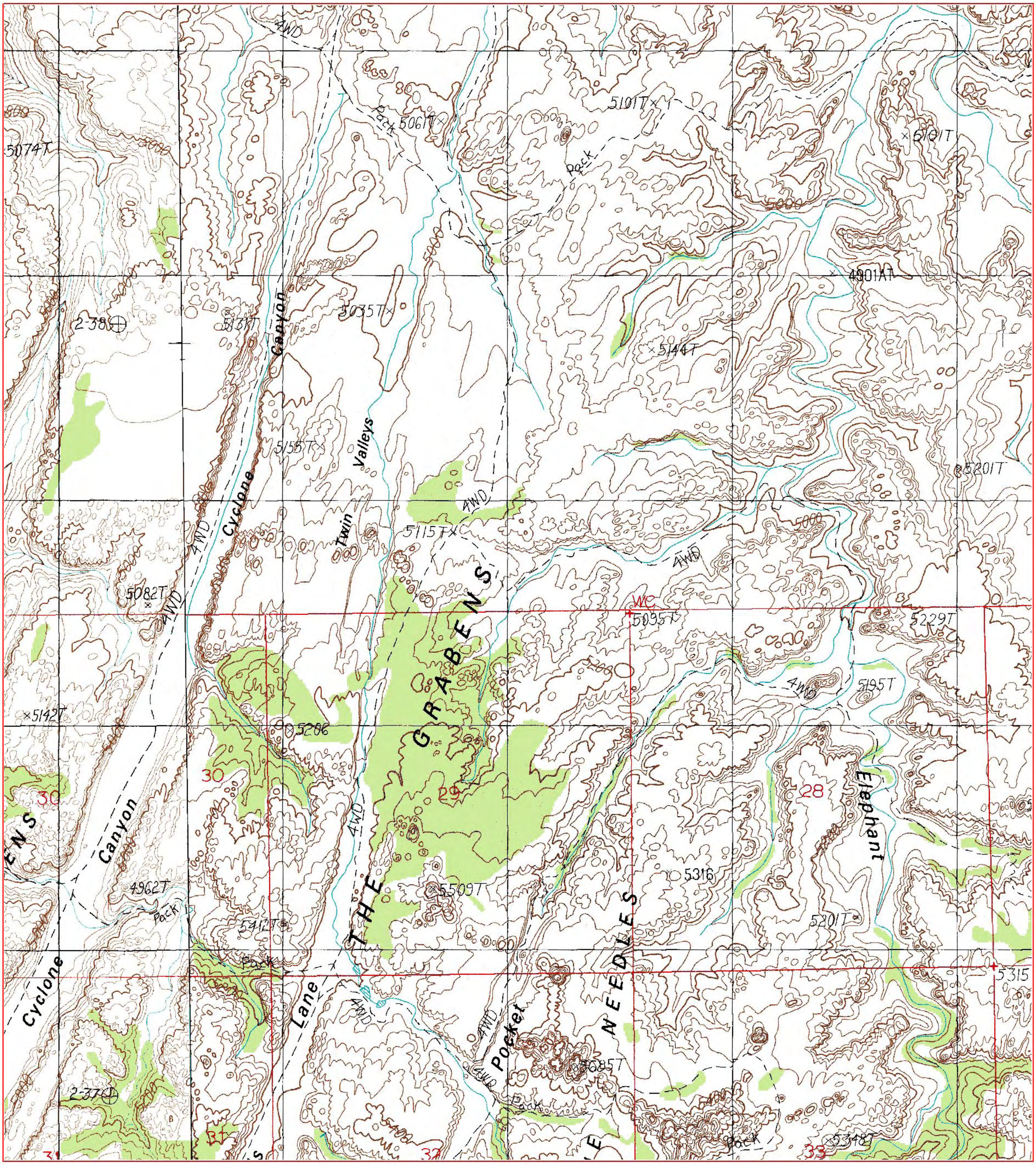
1:24,000 Scale

N

● *Tamarix ramosissima*

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

Appendix L. Weed Species Detected in Inventoried Areas - The Grabens (Inset F)



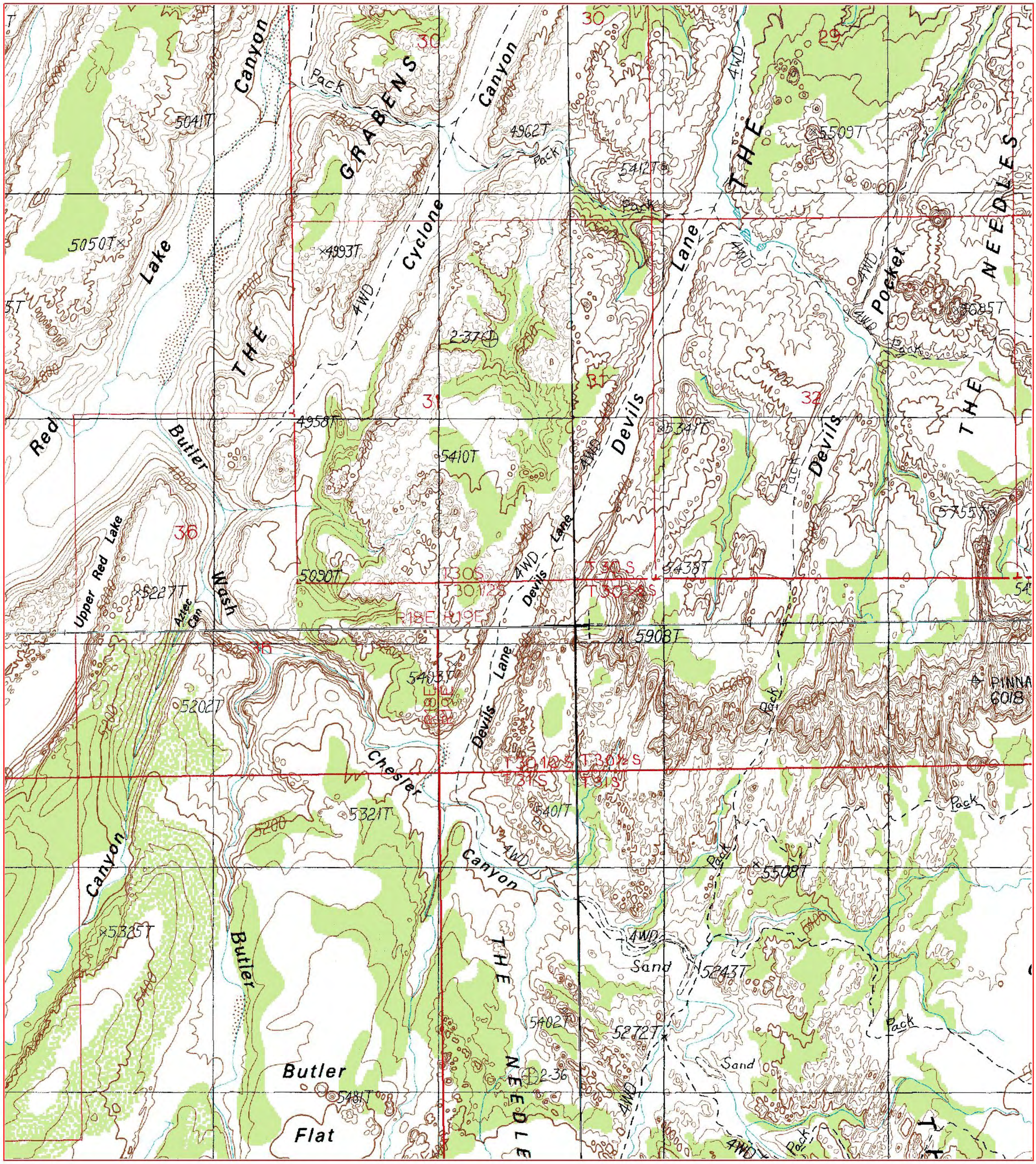
1:24,000 Scale

✱ No targeted weed species detected

N

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

Appendix L. Weed Species Detected in Inventoried Areas - Chesler Park (Inset G)



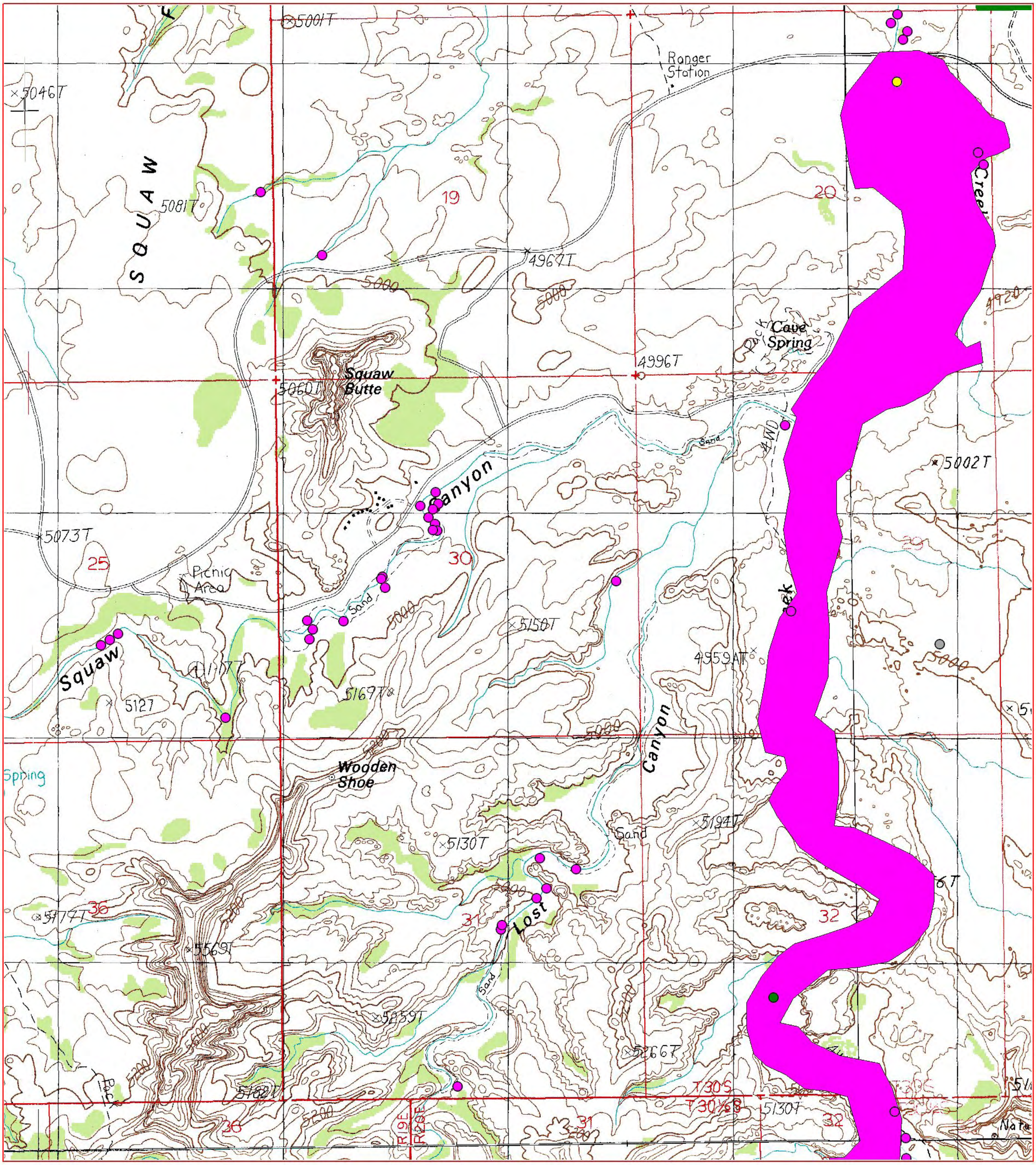
1:24,000 Scale

* No targeted weed species detected

N

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

Appendix L. Weed Species Detected in Inventoried Areas - Cave Spring (Inset H)



0 2000 4000 Feet

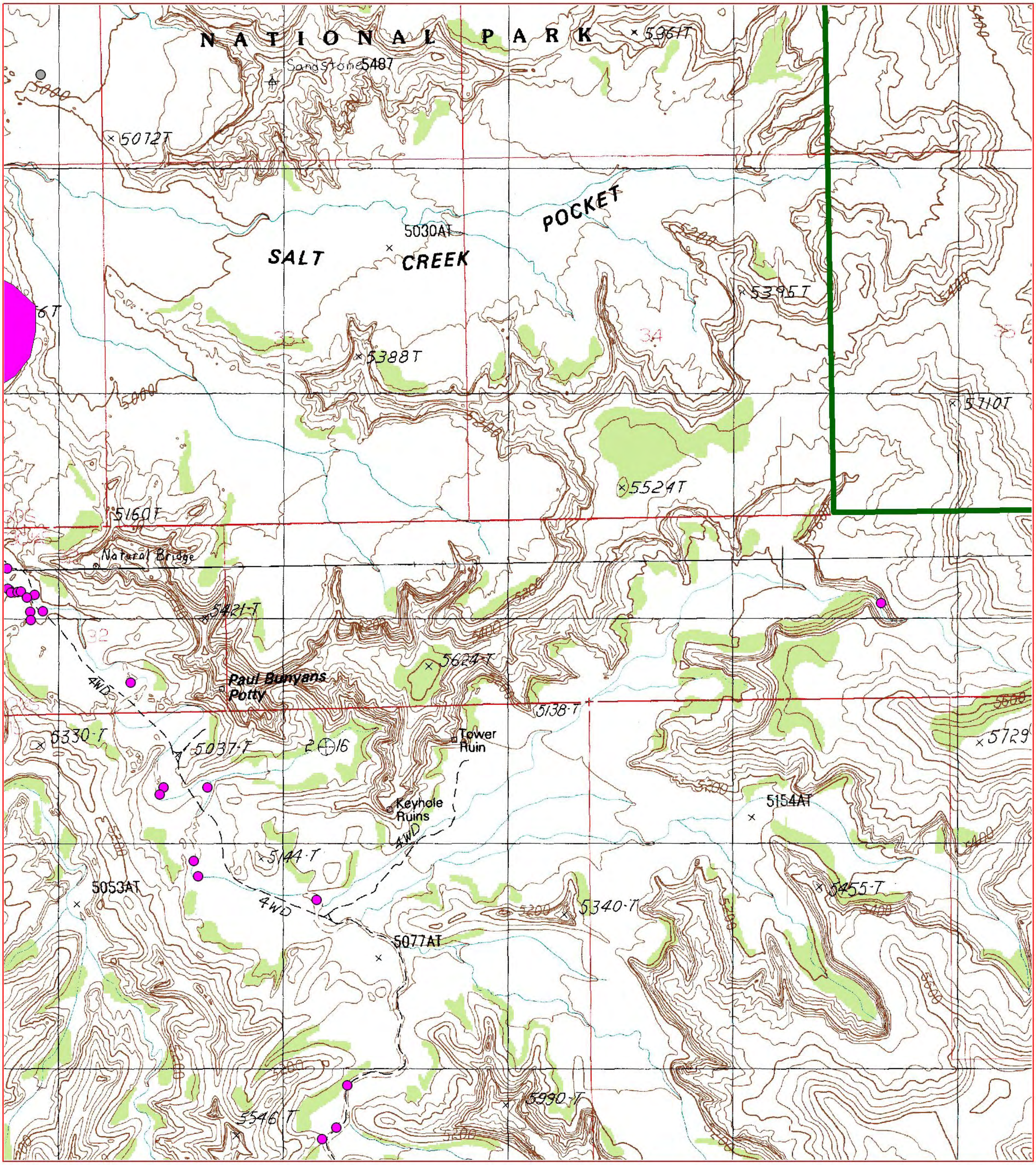
1:24,000 Scale

N

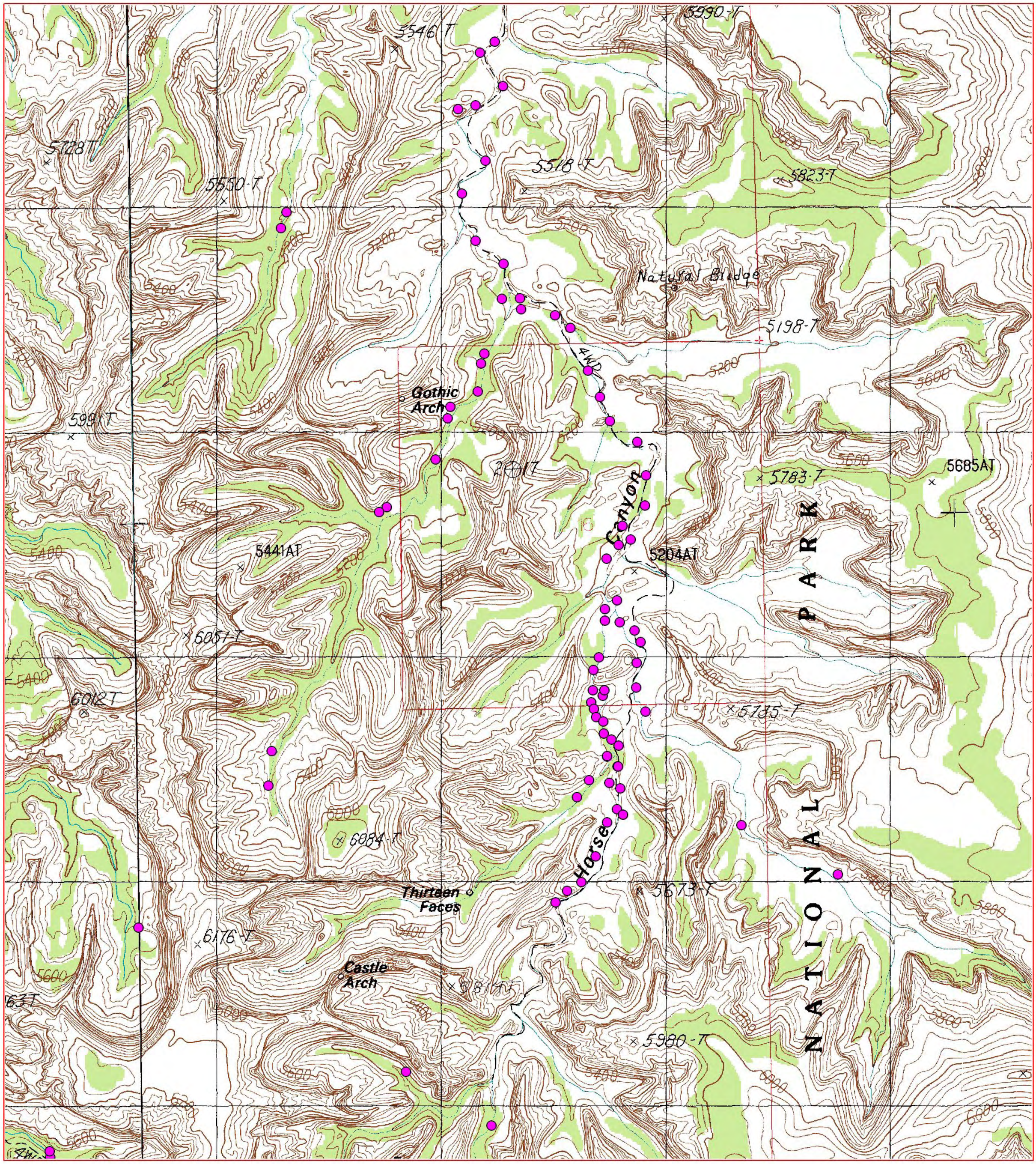
- *Cirsium arvense*
- *Elaeagnus angustifolia*
- *Halogeton glomeratus*
- *Tamarix ramosissima*
- *Tamarix ramosissima*

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

Appendix L. Weed Species Detected in Inventoried Areas - Salt Creek Pocket (Inset I)



Appendix L. Weed Species Detected in Inventoried Areas - Horse Canyon (Inset J)



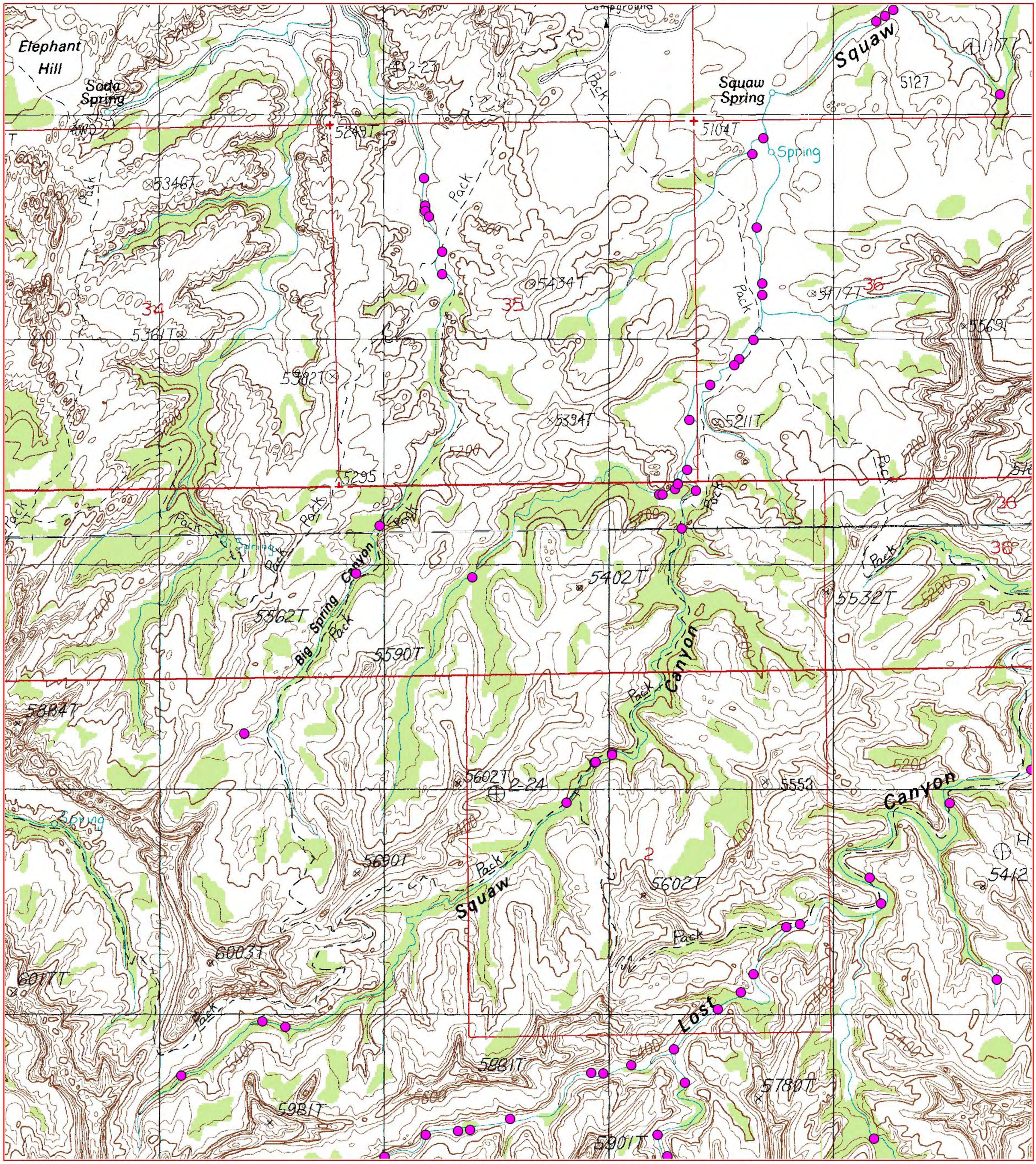
● *Tamarix ramosissima*

1:24,000 Scale

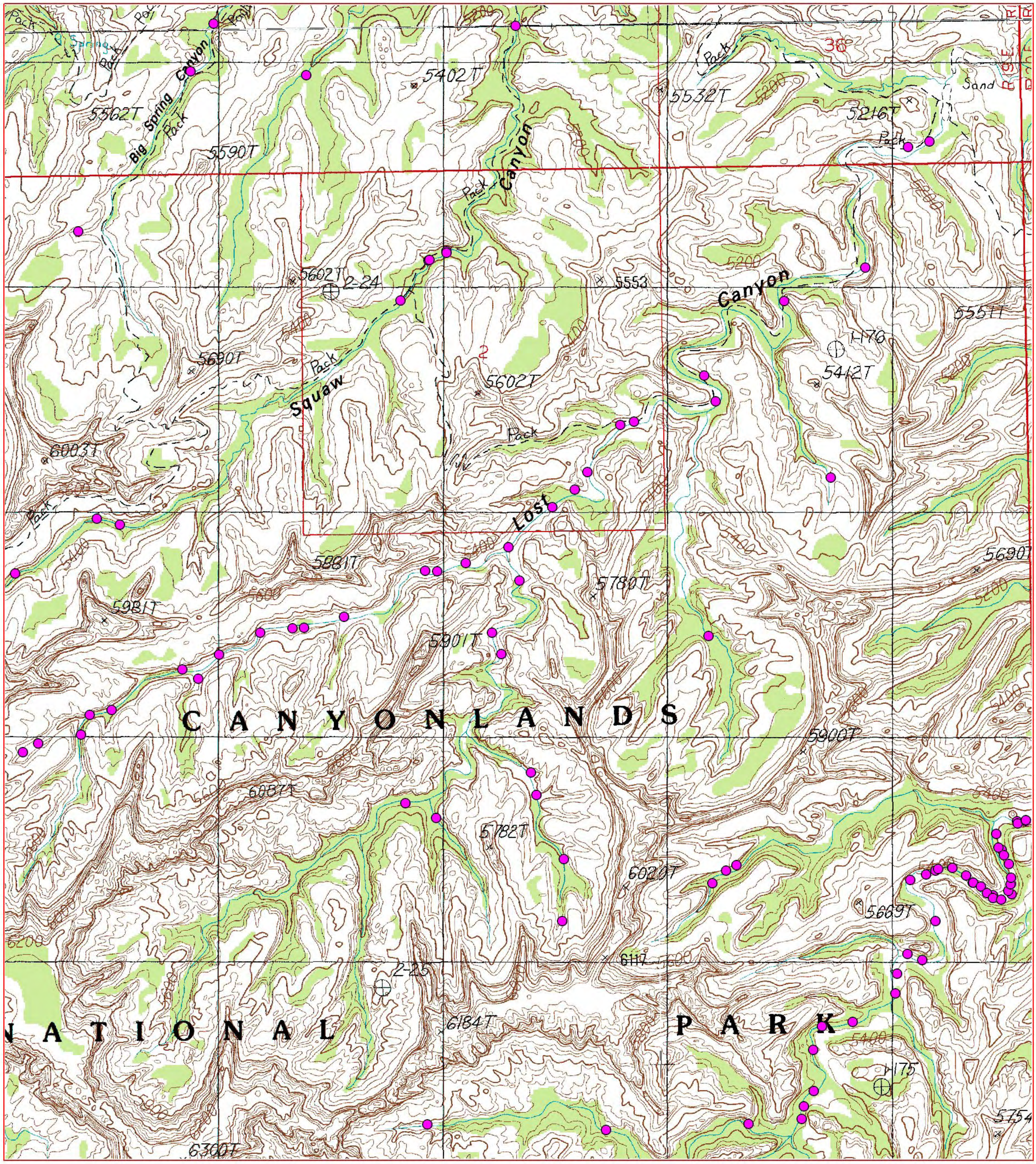
N

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

Appendix L. Weed Species Detected in Inventoried Areas - Squaw Canyon (Inset K)



Appendix L. Weed Species Detected in Inventoried Areas - Lost Canyon (Inset L)



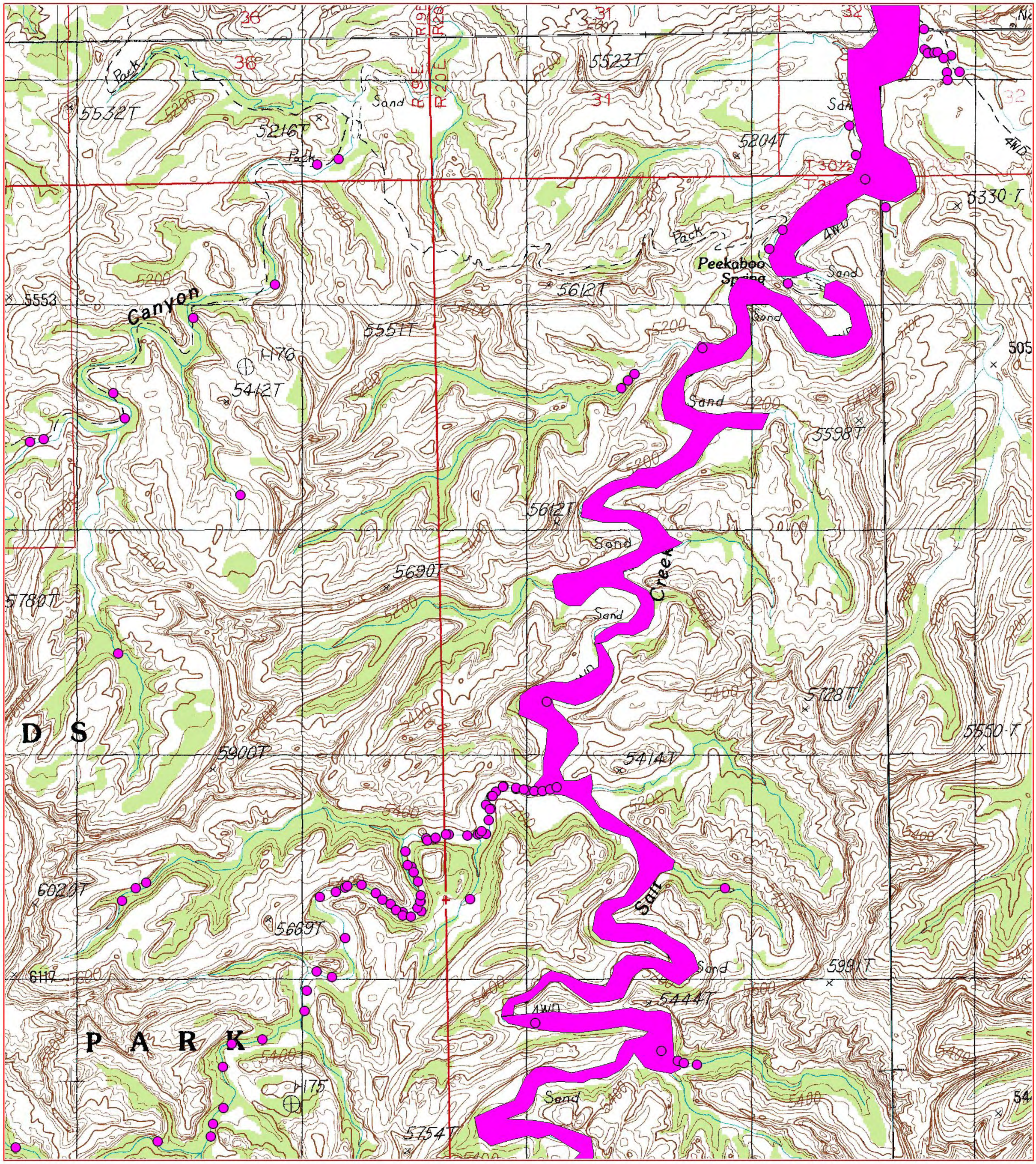
1:24,000 Scale

● *Tamarix ramosissima*

N

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

Appendix L. Weed Species Detected in Inventoried Areas - Peekaboo Spring (Inset M)



0 2000 4000 Feet

1:24,000 Scale

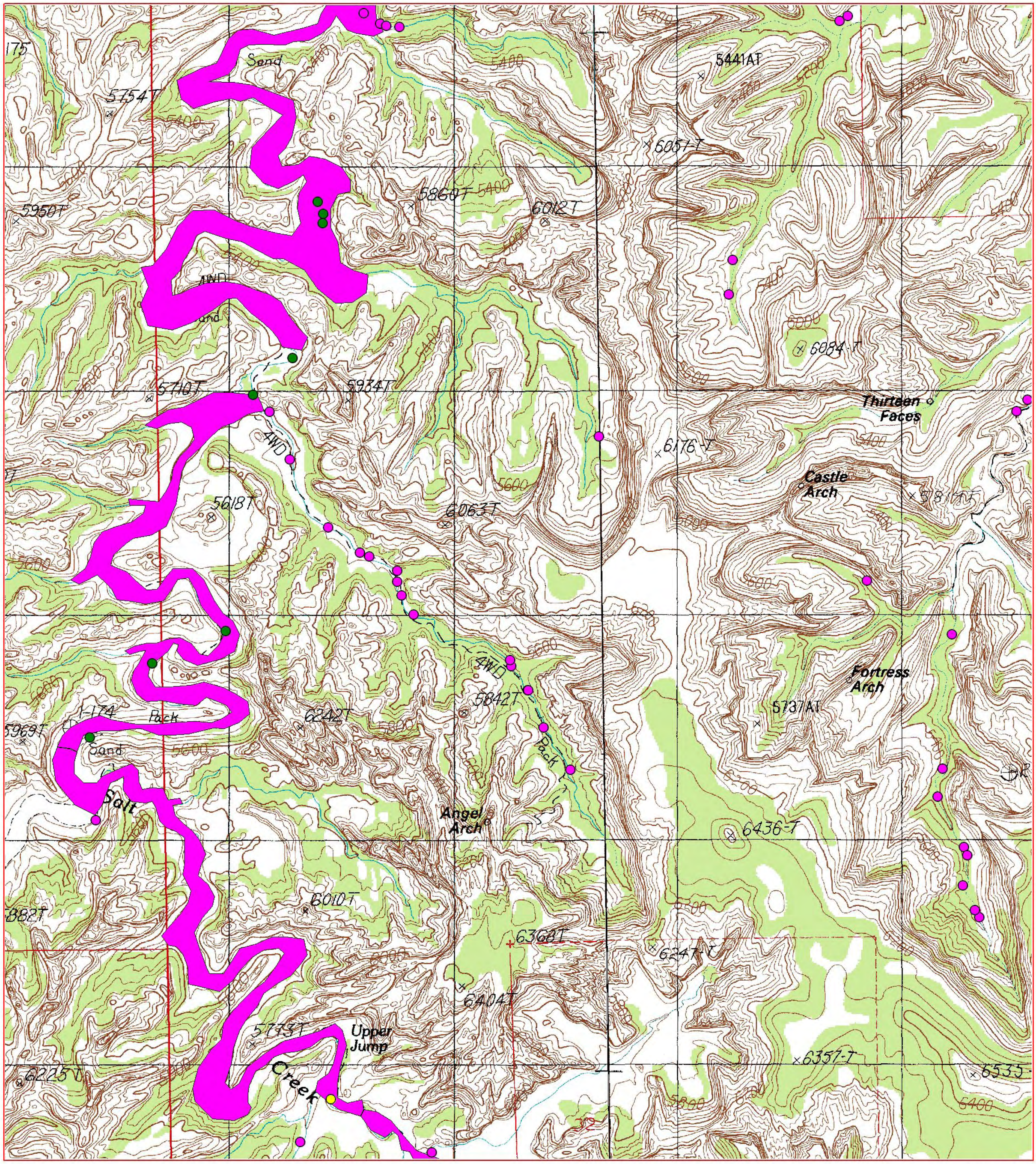
Tamarix ramosissima

Tamarix ramosissima

N

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

Appendix L. Weed Species Detected in Inventoried Areas - Angel Arch (Inset N)



Cirsium arvense

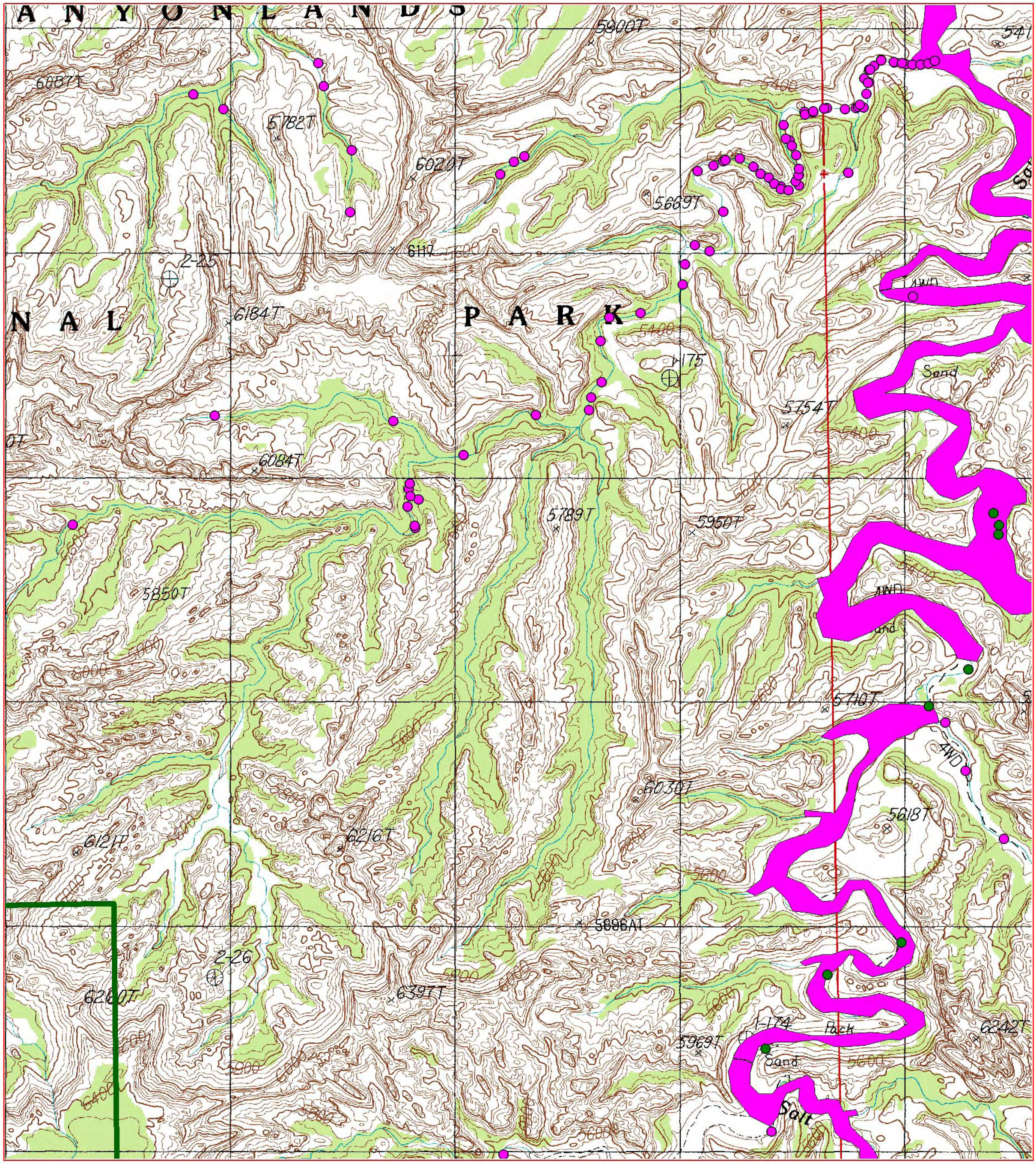
Elaeagnus angustifolia

Tamarix ramosissima

Tamarix ramosissima

Inset N
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix L. Weed Species Detected in Inventoried Areas - Salt Creek (Inset O)



Elaeagnus angustifolia

Tamarix ramosissima

Tamarix ramosissima

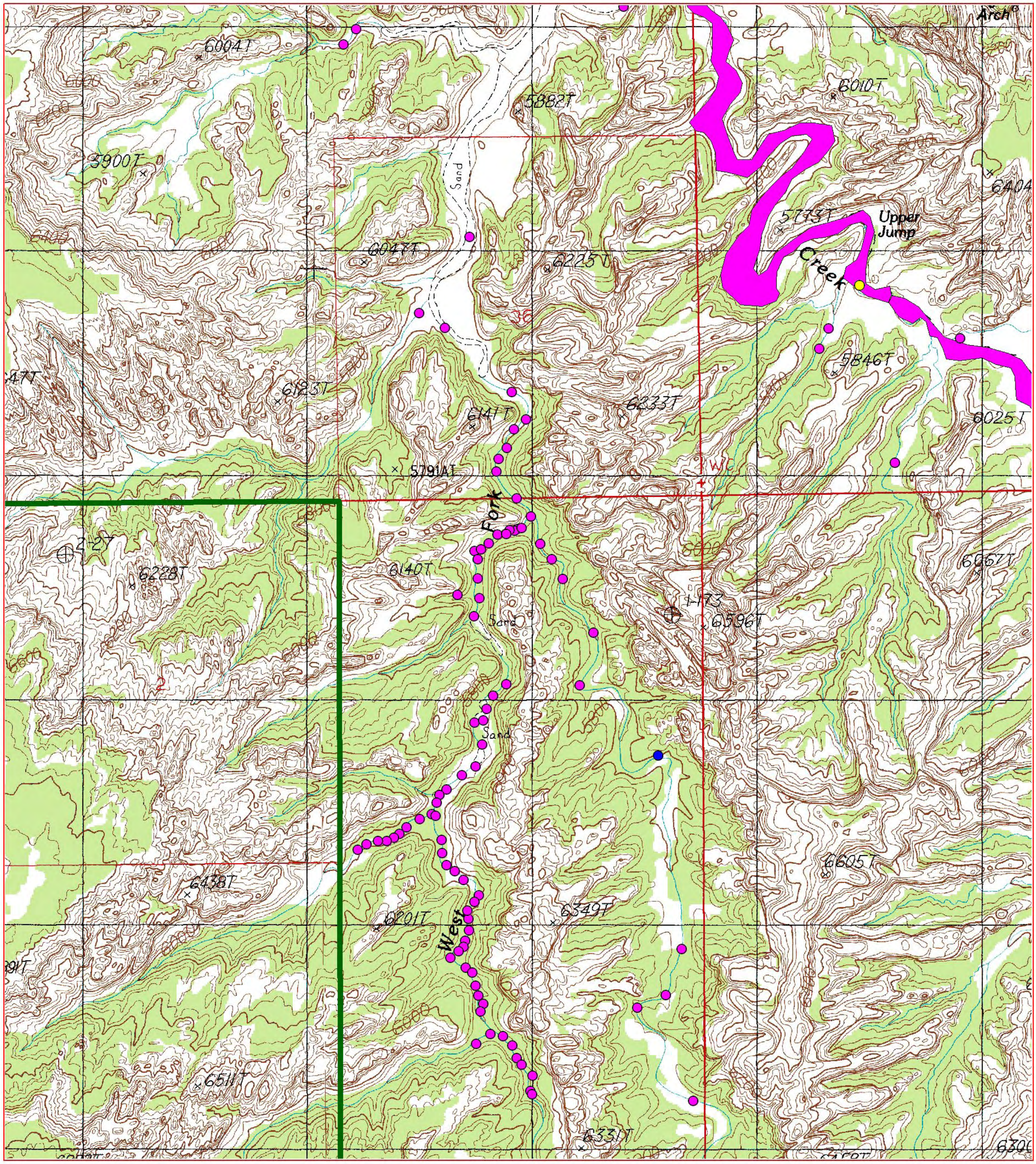
Park boundary

1:24,000 Scale

N

Inset O
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix L. Weed Species Detected in Inventoried Areas - West Fork (Inset P)



Cirsium arvense

Cirsium vulgare

Tamarix ramosissima

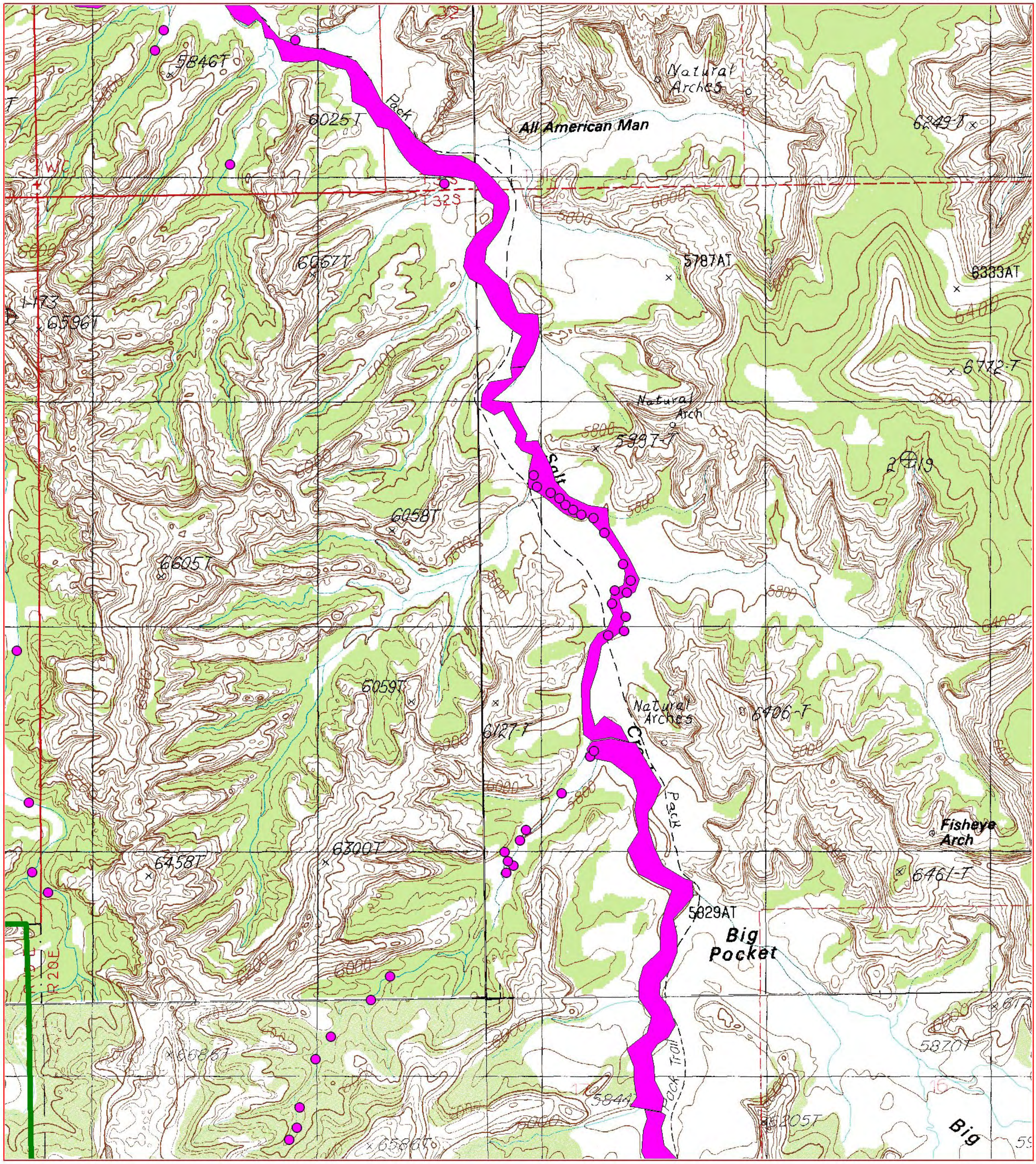
Tamarix ramosissima

Park boundary

1:24,000 Scale

Inset P
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix L. Weed Species Detected in Inventoried Areas - Fisheye Arch (Inset Q)



Tamarix ramosissima

Tamarix ramosissima

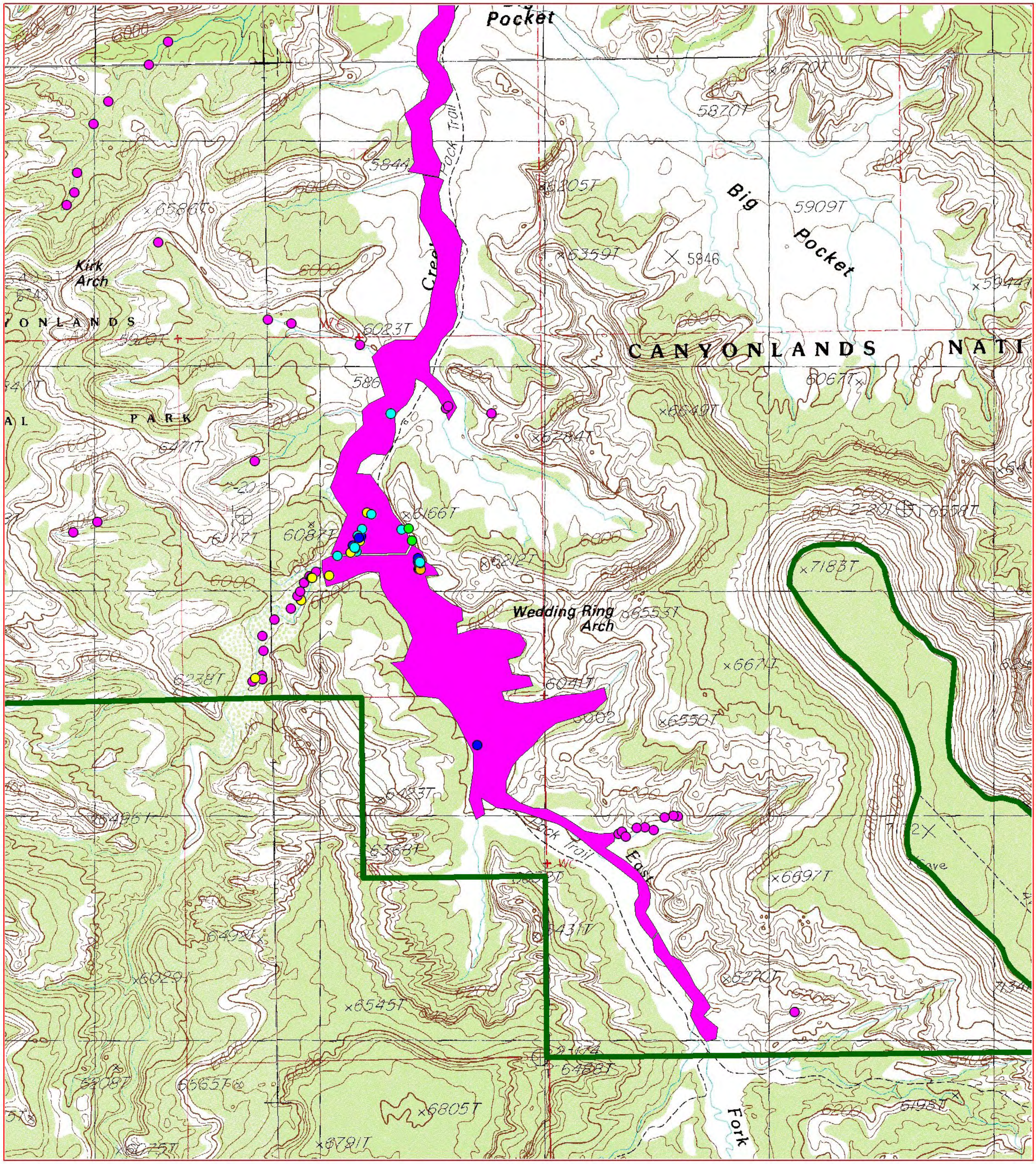
Park boundary

1:24,000 Scale

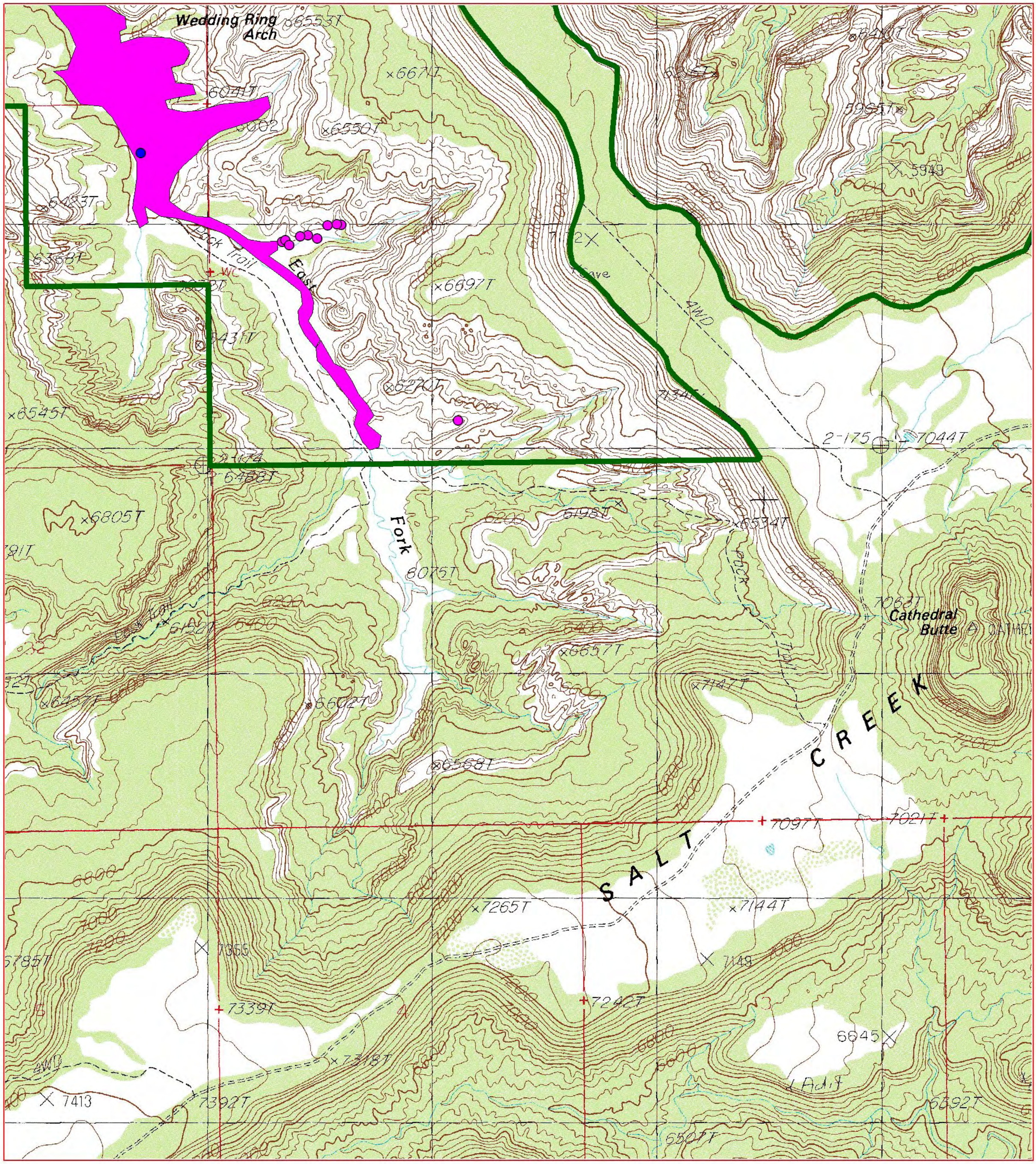
N

Inset Q
Needles District
Canyonlands National Park
Utah State University
2003-2004 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix L. Weed Species Detected in Inventoried Areas - Big Pocket (Inset R)


Pocket
Kirk Arch
CANYONLANDS NATI
PARK
Big Pocket
Wedding Ring Arch
Fork
Trail
East
WC
5846
5844
6023T
6067T
6205T
5909T
6358T
6247T
6087T
6212T
6238T
6211T
6550T
6649T
6284T
6697T
7183T
6655T
6565T
6805T
6791T
6545T
6492T
6368T
6437T
6431T
6488T
6270T
6602T
6575T
6208T
6496T
6602T
6447T
6447T
6447

Appendix L. Weed Species Detected in Inventoried Areas - Cathedral Butte (Inset S)



Appendix M. 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 N. 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 Canyonlands 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					*Amaranthus retroflexus*			X		
Conium maculatum				X		*Ascelpias speciosa*		X			
Convolvulus arvensis		X				*Erodium cicutarium*			X		
Cynoglossum officinale				X		*Melilotus officinalis*			X		
Dactylis glomerata			X			*Phragmites australis*		X			
Elaeagnus angustifolia	X					*Polypogon monspeliensis*			X		
Euphorbia esula				X		*Sonchus asper*		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