Colorado National Monument

2003 Invasive Non-native Plant Inventory

Northern Colorado Plateau Inventory and Monitoring Network

Final Report

June 2005

Prepared by

Steven Dewey and Kimberly Andersen

Utah State University

Cover photo:

Bromus tectorum along the wildland/urban interface near the West Entrance of the Monument. Photo by H. Rickleff.

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FINAL REPORT

Inventory of Invasive Non-native Plants Conducted during 2003 in Portions of Colorado National Monument, 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), Dinosaur National Monument (DINO), Hovenweep National Monument (HOVE), Natural Bridges National Monument (NABR), and Zion National Park (ZION). In addition to lands inventoried by USU, the National Park Service inventoried invasive non-native plants in portions of Arches National Park, Capitol Reef National Park, Colorado National Monument (COLM), and Mesa Verde National Park (MEVE). This document contains only the results of the NPS inventory conducted in Colorado National Monument. Results from other Parks are documented in separate Park-specific project reports. Also, please not that this report updates and replaces the 2003 Colorado National Monument 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 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. Colorado National Monument is a member of the Northern Colorado Plateau Inventory and Monitoring Network. A knowledge of current weed distribution, especially in or near previously disturbed areas and riparian areas, was identified as an extremely high priority need by the Northern Colorado Plateau Network.

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 Colorado National Monument. 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 Monument.

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

METHODS

The National Park Service supplied a 4-person crew in 2003 to inventory designated areas within Colorado National Monument. Crew qualifications are documented in Appendix A.

SELECTION OF TARGET SPECIES AND INVENTORY AREAS

Eleven species were identified as high-priority targets in the COLM inventory (Table 1), and searched for systematically by all inventory crew members. Any other non-native species recognized as relatively new to COLM 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 Colorado National Monument in the 2003 Non-native Plant Inventory.

Invasive species	Common Name
Bromus tectorum	Downy brome
Centaurea repens	Russian knapweed
Convolvulus arvensis	Field bindweed
Elaeagnus angustifolia	Russian olive
Erodium cicutarium	Redstem filaree
Rumex crispus	Curly dock
Salsola kali	Russian thistle
Sisymbrium altissimum	Tumble mustard
Tamarix ramosissima	Saltcedar
Tragopogon dubius	Salsify
Verbascum thapsus	Common mullein

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 Monument 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 Colorado National Monument in 2003 included everything in the original Implementation Plan, plus additional areas added after consultation with, Dave Price, Chief of Resources for Colorado National Monument. Lands inventoried consisted primarily of plateaus, riparian areas, roads, and hiking trails.

Monument 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 field inventory, and in gathering and analyzing data. NCPN and COLM 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.

Table 2. Description of data fields used in 2003 Inventory of Invasive Non-Native Plants in Colorado National Monument.

Data Field	Description	Options / Values	Priority	Entry
Species Name	Latin name of species	Pick-list to be provided by Monument 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	COLM	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

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).

FIELD PROCEDURES

Some of the terms used in this and subsequent sections of the report have been created by the authors to describe new or modified 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 estimated 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 detection target size. EDSW must be adjusted according to factors influencing target visibility, such as species, stage of growth, topography, and associated vegetative cover, in order to maintain the 90 percent minimum detection standard. Data dictionary choices for effective detection swath widths in this project were 25, 50, 100, 150, 200, 250, and 300 yards.

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

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

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

The 2003 inventory in Colorado National Monument was conducted between June 3 and June 9 and between June 18 and June 25, and involved a four-person crew (Table 3). Sites inventoried included the Liberty Cap Trail, the Wildland/Urban interface on the eastern portion of the Monument, Devil's Kitchen, Monument Canyon, Ute Canyon, Coke Ovens, Squaw Fingers, Gold Star Canyon, No Thoroughfare Canyon, and the Black Ridge Trail.

For purposes of planning and data analysis the inventoried lands were divided into eleven areas (Table 3). The order in which areas were inventoried was determined by the NPS crew leader. Potential invasive plant habitat within each targeted inventory area was considered prior to planning each day's travel route. Field crew members were expected to search along the planned inventory routes, spending more time in priority areas and areas of concentrated invasive plant habitat.

When arriving at a site, crews would 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.

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. 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. In situations of extremely steep or otherwise inaccessible terrain where vegetation could be identified clearly from a distance, crew members sometimes used binoculars

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

As inventory units were traversed, locations of all target species were documented by the NPS crew using Trimble GeoExplorer 3 global positioning system (GPS) units and GeoExplorer XM GPS units with 2- to 5-meter accuracy. Crews also recorded the location and documented the identity of any other non-target species they encountered if that species has a known history of invasiveness in other regions in the West. GPS configuration settings used in this project are listed in Appendix D. Additional equipment used by crew members included laser rangefinders, compasses, binoculars, topographic maps, calculators, and radios. Appendix E contains a photograph and complete list of equipment used in this study. Field locations were recorded by GPS as UTM coordinates, and were later differentially corrected in the production of final digital products. The crews recorded invasive plant occurrence data on hard-copy (USGS 7.5-minute topographical maps) in any situation where GPS satellite reception was not possible (such as in narrow 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.)

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 Colorado National Monument.

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 F) was carried and referred to by each crew member while working in the field. The vegetation list was compiled by Tamara Naumann, Botanist at Dinosaur National Monument, for an inventory conducted by

Table 3: Invasive plant inventory areas, inventory dates, crew members, and acres inventoried during 2003 in Colorado National Monument.

Area Number	Area Description	Dates Inventoried	Crew Members*	Acres Inventoried**	Corresponding Inset Map Names and Letter Codes ***
1	North Wildland/Urban Interface	June 5	SS, CC, LB, HR	103.8	Monument Canyon – A
2	Black Ridge Trail	June 23	SS, CC	9.7	Monument Canyon – A
3	Otto's Trail	June 9	SS, CC, HR	6.9	Monument Canyon – A
4	Black Ridge Trail, Monument Mesa	June 3 June 23	SS, CC, LB, HR	157.7	Monument Canyon – A Monument Mesa – B
5	Ute Canyon, South Urban Interface	June 4 – 6	SS, CC, LB, HR	296.9	Monument Canyon – A Monument Mesa – B Ute Canyon – C
6	East Entrance, Devil's Kitchen	June 7 – 8	SS, CC, HR	176.7	Serpent's Trail – D
7	No Thoroughfare Canyon	June 24	SS, CC, LB, COLM staff	80.0	Serpent's Trail – D No Thoroughfare Canyon – E
8	Independence Canyon	June 19	SS, CC	59.5	Monument Canyon – A
9	Gold Star Canyon	June 25	SS, CC	19.7	Monument Canyon – A Ute Canyon – C
10	Ute Canyon	June 6, June 22	SS, CC, HR	44.2	Monument Mesa – B
11	Monument Canyon	June 18 - 21	SS, CC, LB, COLM staff	147.8	Monument Canyon – A Monument Mesa – B
	TOTALS			**1103**	

* Crew abbreviations: LB = Liz Ballenger, SS = Stephanie Shoemaker, CC = Christine Craig, HR – Heather Rickleff.
** An average of 20.43 acres inventoried per person per 10-hr day in 2003.
*** Indicates the key to mapped areas presented later in Figure 2.

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, Monument 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 Monument. 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 which was later digitized. Pertinent photographs are included with this report (see Appendix G). Digital copies of all photographs were submitted to NCPN as part of the final deliverables.

VOUCHER SPECIMENS

Voucher plant specimens were to be collected to document any new or otherwise unique occurrences of invasive species encountered within Colorado National Monument. Duplicate voucher specimens were to be processed for deposit in herbaria at USU and Colorado National Monument. The specimens deposited at USU would be considered "on loan" from NPS and documented in a loan agreement. Specimens were to be curated and managed following NPS service-wide protocols. The specimens collected as part of this project would be affixed with labels containing information on species, collector, collection date, collection site, and NPS record number. Specimen data would be provided in electronic format. However, no voucher specimens were collected in Colorado National Monument during the inventory in 2003.

FIELD DATA PROCESSING

At the end of each day, field crews marked and dated all inventoried areas on USGS 7.5' topographic maps to assist in determining project progress and thoroughness of coverage. The GPS between-feature positions recorded each day were used for reference when marking the topographic maps. Each crew member kept a daily log of where they searched, what species they encountered, disturbances noted, thoroughness of coverage, and any additional information that they felt might be of importance to the project. Data were downloaded from GPS units onto

a laptop computer each day using Pathfinder Office GIS software. Edits (such as eliminating any duplicate features) were made to the data, and any additional information (such as infestations drawn by hand on field maps or other data not recorded with a GPS unit) were added at this time. Four sub-folders were created within the main project folder on the computer hard drive. These were for: 1) unedited raw GPS rover files, 2) edited GPS rover files, 3) differentially corrected edited GPS rover files, and 4) GIS shapefiles created from the differentially corrected rover files (for export and use in ArcView). Separate disks were used for raw and edited rover files.

Raw data consisted of rover files transferred directly from GPS units to the computer, and stored without any editing or modification. They were named using a 6-digit code (month-day-hour) preceded by a single letter (corresponding to the first letter in the crew member's last name), and ending in ".ssf." For example, "S051913.ssf" would be the file name for raw GPS data collected by Stephanie Shoemaker beginning in the thirteenth hour (24-hr local time) on June 19.

Edited data files were created from raw files that were viewed in Pathfinder Office and checked for accuracy. Features were added or deleted in the process of editing to eliminate any duplicate reporting (two crew members finding the same infestation), and to add locations drawn on field maps (as when satellite signals could not be obtained). Any locations added in the editing process were noted as "hand mapped" in the notes section and are denoted as "Non-GPS" under the differential correction section. Notes were sometimes expanded during the editing process to include more detailed information about the surrounding habitat. Gross area features also were added during this process. File names were changed after editing to avoid confusion with the raw files. Edited files were named as a 3-letter month and 2-digit day abbreviation, followed by a dash and the first letter of the crew member's last name. If a crew member collected more than one file for that day, a number would follow the crew identification letter. For example, the edited version of the second file of GPS data collected by Stephanie Shoemaker on June 19 would be Jun19-S2.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: Jun19-S2.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 2004 are compiled into one shapefile labeled as 04pt-weed.shp. Between-feature points from 2004 are labeled 04psnpnt.shp. Shapefiles were then imported into ArcView GIS 3.3 for map-making and data analysis. When shapefiles were imported into ArcView, additional data fields were added to comply with the task agreement. These fields include scientific name, ITIS code, life form of the species, county, state, country, and Park code. Individual record numbers, including the four-letter Park code, were assigned to each weed infestation location entry. It was decided to enter this information after the field season to minimize the amount of time spent collecting non data in the field and maximize the acres inventoried. The data were checked again for any duplication of entries. Any gaps in the sequence of record numbers are due primarily to elimination of duplicated entries.

Polygons of areas inventoried within the various drainages of the Monument 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 (1:75,000) were created to show the total area inventoried during the 2003 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 were compiled for the final 2003 dataset by Utah State University using ArcGIS ArcCatalog software. The metadata were 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. NPS crew leaders (Liz Ballenger and Stephanie Shoemaker) completed an intensive 2-week pre-season training course conducted by the USU Principal Investigator. The course consisted of classroom presentations and field exercises to familiarize crew members with all inventory procedures and policies, and to improve all skills related to the job. Each crew leader was provided with a copy of the training manual. The remaining 2 NPS crew members participated with their crew leaders and the full USU crew in an additional 1-week field training exercise held at the beginning of the season in Zion National Park.

During the first few weeks of the field season, and periodically thereafter, NPS crew leaders worked individually with each crew member to ensure that all skills had been mastered and that procedures were consistent among all crew members. Crew leaders reviewed each crew member'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. Each time any new weed species was found, the identity was verified by a crew leader.

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 1,103 acres in Colorado National Monument during the summer of 2003 (Table 3), an amount representing approximately 5.4 percent of the entire 20,534-acre Monument. An average of 20.4 acres was inventoried per person per 10-hr day in 2003.

The location and size of the eleven areas inventoried in 2003 are represented in Figure 1. The identification number, name, and acreage of each inventory area are listed in the legend. Each inventory area is also color-coded for ease in identification. Figure 2 serves as an orientation map for the smaller 1:24,000 scale weed-distribution "Inset" maps found in Appendices H and I. Inset maps are distinguished by letters A - E, plus the name of a distinct geographic feature found within its boundaries. The corresponding inventory area numbers from Figure 1 are included in the legend in parentheses behind each inset map name. Five inset maps are required to cover all eleven inventory areas, and large inventory areas may span over several subunit maps. For example, different sections of the No Thoroughfare Canyon (Inventory Area 7) appear on Serpent's Trail and No Thoroughfare Canyon, inset maps D and E.

Invasive plants infested a total of 240.19 acres within the mapped areas (Table 4), an amount equal to 21.8 percent of the land inventoried. Of the 11 initial targeted species, crews found *Bromus tectorum, Convolvulus arvensis, Elaeagnus angustifolia, Erodium cicutarium, Rumex crispus, Salsola kali, Sisymbrium altissimum, Tamarix ramosissima, Tragopogon dubius,* and *Verbascum thapsus.* No infestations of *Centaurea repens* were discovered within the 11 inventoried areas. Non-target species found and mapped were *Conium maculatum, Halogeton glomeratus, Lactuca serriola, Melilotus officinalis,* and *Tribulus terrestris.*

The most abundant target species found in the Monument was *Erodium cicutarium*. The crew recorded 81.51 acres of this species during the project. *Erodium cicutarium* comprised 33.9 percent of the total infested acreage inventoried. Infestations of *Erodium cicutarium* ranged in size from 0.001 acres to 5 acres and were found most commonly along the eastern wildland/urban interface of the Monument. *Bromus tectorum* was the second most abundant target species found in the Monument, although the data represent only the inventoried area along the wildland/urban interface. It comprised approximately 28.3 percent of the total infested acreage. *Sisymbrium altissimum* was the third most common target species, making up 16.6 percent of the total infested acreage. The remaining infestations (21.2 percent of the total infested acreage) consisted of the other seven targeted species and the five 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. Crews were consistent in searching for and recording all infestations of *Conium maculatum, Melilotus officinalis, Tribulus terrestris, Lactuca serriola,* and *Halogeton glomeratus*.

Appendix H contains maps showing the overall distribution and relative abundance of all mapped weeds (no species distinction) within the boundaries of inventoried areas. Appendix I contains maps of individual species occurrences and weed-free areas within all inventoried

Table 4: Acres infested by invasive plant species within inventoried areas of Colorado National Monument in 2003.

Species	Infested Acres
Bromus tectorum	68
Conium maculatum	0.01
Convolvulus arvensis	0.64
Elaeagnus angustifolia	0.38
Erodium cicutarium	81.51
Halogeton glomeratus	1.24
Lactuca serriola	0.15
Melilotus officinalis	10.71
Rumex crispus	0.32
Salsola kali	13.60
Sisymbrium altissimum	39.77
Tamarix ramosissima	15.16
Tragopogon dubius	8.46
Tribulus terrestris	0.01
Verbascum thapsus	0.23
Totals	**240.19**

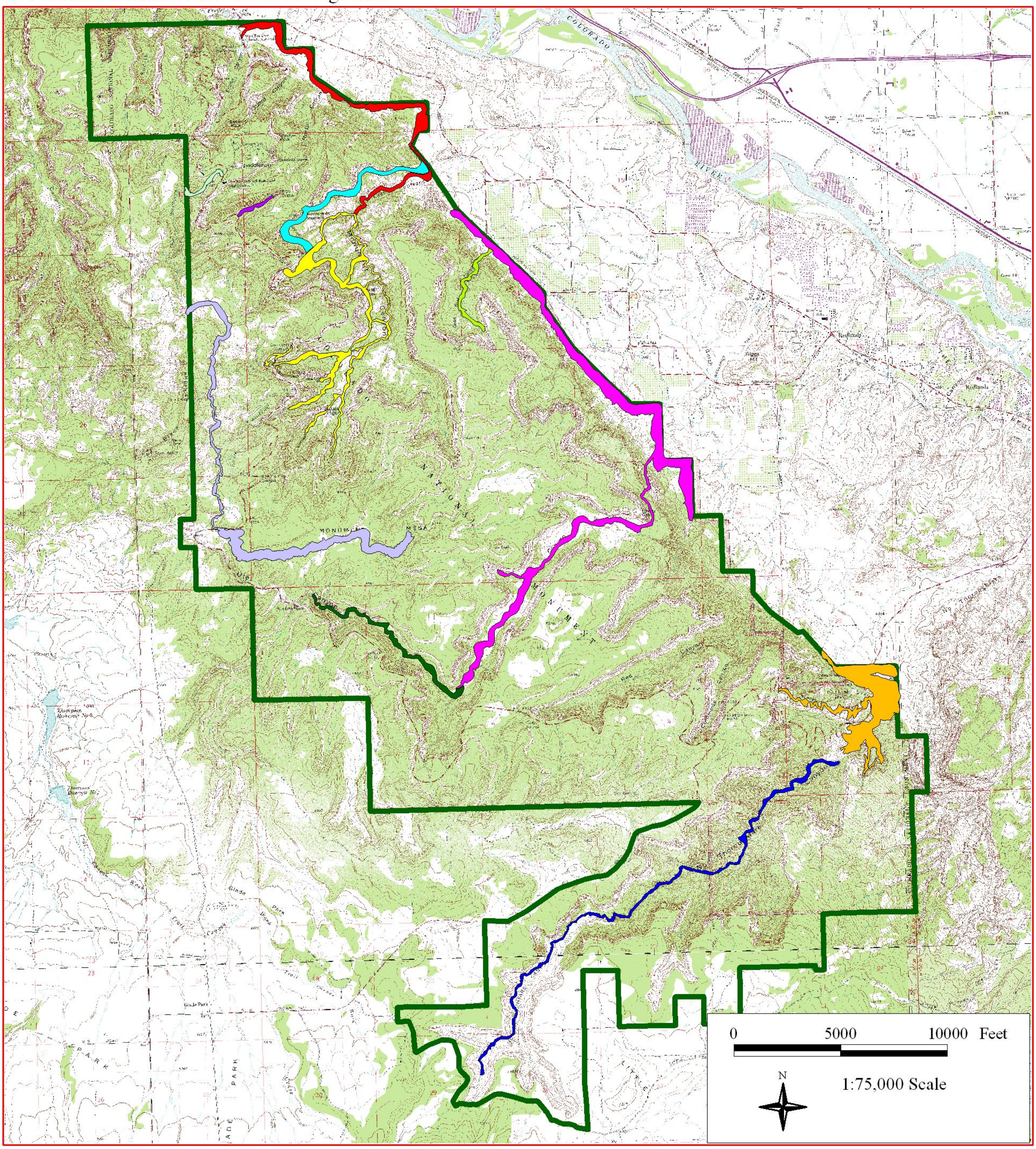
portions of Colorado National Monument. Following is a summary of the weed situation within individual inventory units of Colorado National Monument.

North Wildland/Urban Interface (Area Number 1; Inset Map A)
This inventory area includes the interface between Monument lands and urban lands along the eastern boundary of the Monument between the West Entrance gate and East Entrance Draw, as well as the lower portion of East Entrance Draw. This area contained several weedy species. Although *Bromus tectorum* was found throughout the entire Monument, it was only inventoried along the interface between wildlands and urban lands. The crew recorded 14 acres of this species occurring along this section of the eastern boundary. The crew also found several acres of *Erodium cicutarium* along the Monument border, as well as in the lower half of East Entrance Draw. Large amounts of *Sisymbrium altissimum* were discovered in this area.

Tamarix ramosissima was found frequently in the lower portion of East Entrance Draw. An acre of *Tamarix ramosissima* was recorded east of the West Entrance gate. Smaller amounts of *Tamarix* were found at the Monument boundary in North Entrance draw. *Tragopogon dubius* and *Salsola kali* were found scattered throughout the inventory area, as well as trace amounts of *Halogeton glomeratus*. *Convolvulus arvensis* was found at the West Entrance gate.

Although not target species, *Melilotus officinalis* and *Conium maculatum* were also mapped in this area. *Melilotus officinalis* was found scattered throughout the lower half of East Entrance

Figure 1. Identification number and acreage of individual areas inventoried for non-native invasive plant species in Colorado National Monument during 2003.



- Area 1 - Wildland/Urban Interface (104 acres)
- Area 2 - Black Ridge Trail (10 acres)
- Area 3 - Otto's Trail (7 acres)
- Area 4 - Black Ridge Trail, Monument Mesa (158 acres)
- Area 5 - Ute Canyon, Urban Interface (297 acres)
- Area 6 - East Entrance, Devil's Kitchen (177 acres)
- Area 7 - No Thoroughfare Canyon (80 acres)
- Area 8 - Independence Monument (60 acres)
- Area 9 - Gold Star Canyon (20 acres)
- Area 10 - Ute Canyon (44 acres)
- Area 11 - Monument Canyon (148 acres)
- Monument boundary

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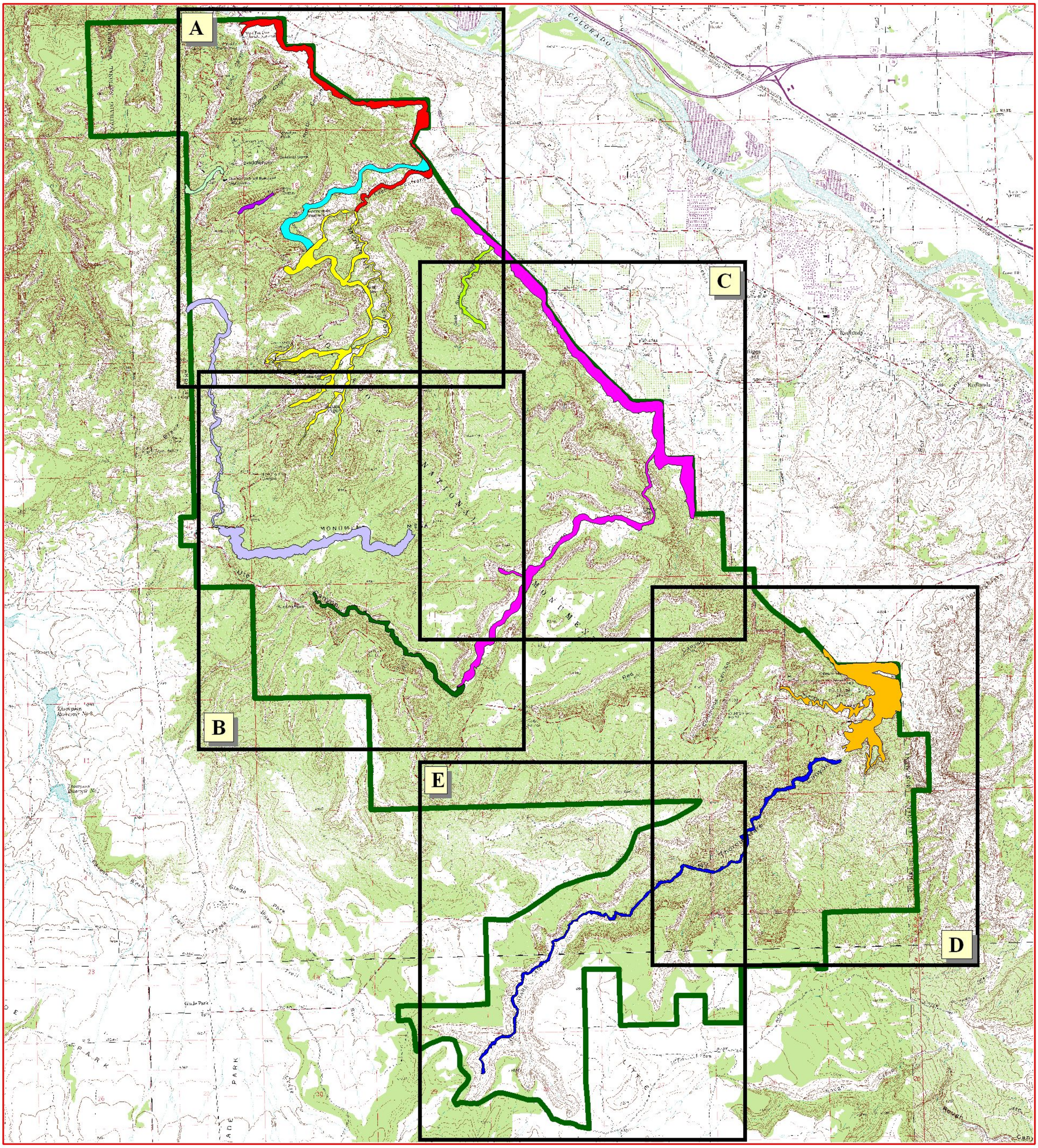
Figure 2. Insets indicating the location, letter code, and name of the five 1:24,000 scale maps used in Appendix tables to show weed distribution within individual inventoried areas.



Inset A - Monument Canyon (Areas 1, 2, 3, 4, 5, 8, 9, 11)

Inset B - Monument Mesa (Areas 4, 5, 10, 11)

Inset C - Ute Canyon (Areas 5, 9)

Inset D - Serpents Trail (Areas 6, 7)

Inset E - No Thoroughfare Canyon (Area 7)

Monument boundary

0 5000 10000 Feet

N

1:75,000 Scale

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Draw. A single patch of *Conium maculatum* was also reported in East Entrance Draw, although the crew was not positive of its identification.

Crews were confident of finding at least 90 percent of all 0.01-acre or larger infestations of the target species. No obvious disturbances were noted by the crew. An ecological status of three was assigned to the area.

Black Ridge Trail, Monument Mesa (Area Numbers 2, 4; Inset Maps A, B)
The Black Ridge hiking trail was inventoried from near the Visitor Center to the Monument boundary, and then from the Monument boundary to Monument Mesa. Although the trail contained some weeds, the top of Monument Mesa contained few weedy species. *Erodium cicutarium* was the primary target species recorded along the trail. Several small infestations were found near the Visitor Center. A 2.5 acre infestation and several other small infestations were found at the boundary where the Black Ridge Trail crossed back into the Monument.

Small patches of *Tragopogon dubius* were found at the Visitor Center as well as along the trail on Monument Mesa. A single patch of *Salsola kali* was also recorded near the Visitor Center. A patch of *Sisymbrium altissimum* was found at a point where the Black Ridge Trail crosses over the main road. Although not a target species, two small 0.01-acre infestations of *Melilotus officinalis* were mapped on the trail near the Highland View Overlook. *Bromus tectorum* was seen in this inventoried area, but was not mapped.

Crews were confident of having found at least 90 percent of all 0.01-acre or larger infestations of the target species. Disturbances include the foot traffic along the trail and around the Visitor Center. An ecological status of two was assigned to each inventory area.

Otto's Trail (Area Number 3; Inset Map A)
The crew inventoried Otto's Trail and the area around the trail until they were cliffed out. The crew did not discover any of the targeted species and did not record seeing any non-target species. The crew was confident of seeing all 0.01-acre or larger infestations of at least the targeted species. This area is considered clean and free of weedy species and was assigned an ecological status of one.

South Wildland/Urban Interface (Area Numbers 5; Inset Map B, C)
This inventory area is along the eastern Monument boundary between Gold Star Canyon and Ute Canyon. Large infestations of *Erodium cicutarium* and *Bromus tectorum* were found consistently throughout the entire inventory area. Several patches of *Sisymbrium altissimum* were also found, but they were most common along a section where the Hinderlider Lift Canal and South Broadway road run parallel the Monument boundary. *Salsola kali* and *Tragopogon dubius* had similar distributions. A single dense 0.01-acre patch of *Tamarix ramosissima* was found near the Hinderlider Lift Canal.

Non-target species mapped include *Tribulus terrestris* and *Halogeton glomeratus*. A single infestation of *Tribulus terrestris* was found below the mouth of Gold Star Canyon. A single infestation of *Halogeton glomeratus* was found in a small draw along the Monument's boundary. No obvious disturbances were noted by the crew and the crew was confident of seeing all 0.01-

acre and larger infestations of the targeted species. An ecological status level four was assigned to the inventory area.

Ute Canyon (Area Numbers 5, 10; Inset Maps B, C)

Ute Canyon was inventoried from the Monument boundary to Suction Point. Overall Ute Canyon was heavily infested with several non-native species. *Tamarix ramosissima* was the primary target species recorded in the Canyon. Infestations ranged in size from 0.01-acre to 0.5-acres and contained mostly mature and sapling trees. The frequency of infestations was highest approximately 3 miles up the canyon from the eastern Monument boundary. *Sisymbrium altissimum* and *Tragopogon dubius* were also found widely scattered throughout the canyon.

Several infestations of *Salsola kali* were found in Ute Canyon, although they occurred more frequently in the lower half of Ute Canyon. One small patch was found at the top of the canyon, below Suction Point. Small patches of *Erodium cicutarium* were also found throughout the Canyon, and often occurred in proximity to those of *Salsola kali*.

Infestations of *Elaeagnus angustifolia* were found approximately 3 miles up the canyon from the Monument boundary. Patch size ranged from 0.01 to 0.1 acres and patch density was high (26-50 %) in all cases. Three small patches of *Convolvulus arvensis* were found in Ute Canyon as well. One large 0.25-acre patch was found approximately one mile from the Monument's eastern boundary, while the other two 0.01-acre patches were found near the top of the canyon, below Suction Point.

The only infestations of *Verbascum thapsus* and *Rumex crispus* recorded during this inventory occurred in Ute Canyon. Five small infestations were found in the upper portions of Ute Canyon. Two of those patches were located directly below Suction Point. The remaining three infestations were approximately a mile down-canyon from Suction Point. Infestations of *Rumex crispus* were also found below Suction Point, stretching approximately one mile down the canyon.

Non-target species mapped in Ute Canyon include *Melilotus officinalis* and *Lactuca serriola*. Infestations of *Melilotus officinalis* were found along the entire inventory area in Ute Canyon, ranging in size from 0.01 to 0.5 acres. Three separate patches of *Lactuca serriola* were found in the upper half of Ute Canyon. One patch was found below Suction Point, and the remaining two patches were found approximately a mile down canyon.

Although it was not mapped, the crew reported heavy amounts of *Bromus tectorum* throughout Ute Canyon. No obvious disturbances were noted aside from seasonal flash flooding down the canyon. The crew was confident of finding all 0.01-acre or larger infestations of the targeted species. The area was assigned an ecological status level of three to the upper portion of Ute Canyon and a level four to the lower portion of the canyon.

East Entrance, Devil's Kitchen (Area Number 6; Inset Map D)

The inventory of this area includes the east entrance gate of the Monument, the Serpent's Trail, and the wildland/urban interface. The primary target species found in the area was *Erodium cicutarium*. This species was found scattered along the wildland/urban interface, along the

Serpent's Trail, and at the mouth of Thoroughfare Canyon. Salsola kali was also found widely scattered throughout the wildland/urban interface and east entrance gate but only a small amount was found at the beginning of the Serpent's Trail.

Tragopogon dubius was found frequently in the inventory unit but was found primarily along the interface near the Monument entrance and near the Devil's Kitchen. Only small patches were found along the Serpent's Trail. *Sisymbrium altissimum* and *Bromus tectorum* were found along the wildland/urban interface near the Monument's entrance and along the boundary. Patches of *Sisymbrium altissimum* inventoried by the crew ranged from 0.01 to 0.5 acres in size. Patches of *Bromus tectorum* ranged in size of 1 to 5 acres.

Several infestations of *Convolvulus arvensis* were found near the east entrance to the Monument. These patches, ranging in size from 0.01 to 0.1 acres, were found directly on the road shoulder, within a mile of the Monument's boundary. A single 0.1-acre patch of *Elaeagnus angustifolia* was found in Thoroughfare Canyon, below Devil's Kitchen at the Monument boundary. A 0.01-acre patch of Tamarix ramosissima was found in the same area. A second patch of *Tamarix ramosissima* was found in the Devil's Kitchen. Both patches of *Tamarix ramosissima* were comprised of sapling trees.

Although not target species, the crew also recorded infestations of *Melilotus officinalis* and *Halogeton glomeratus* occurring in the inventory unit. *Melilotus officinalis* was found on the road shoulder near the east entrance gate as well as widely scattered along the Serpent's Trail. Moderate amounts of *M. officinalis* were also found in the Devil's Kitchen area. *Halogeton glomeratus* was found along the wildland/urban interface near the east entrance gate.

The crew was confident of finding at least 90 percent of all 0.01-acre or larger infestations of the target species within this inventory unit. No obvious disturbances were noted aside from vehicle and foot traffic along the road shoulder and hiking trails. The area was assigned an ecological status level three.

<u>No Thoroughfare Canyon (Area Number 7; Inset Maps D, E)</u>
The inventory unit contains the area searched for the target species from the head of No Thoroughfare Canyon to the Devil's Kitchen. The primary species detected in No Thoroughfare Canyon was *Tragopogon dubious*. This species was widely scattered throughout the entire length of the canyon. *Tamarix ramosissima* was also found scattered throughout much of the canyon, although it was found only in the lower three miles of the inventory unit. No *Tamarix* was found in the top three miles of the canyon.

Small infestations of several other target species were detected in this canyon. Three infestations of *Sisymbrium altissimum* were found less than a mile up canyon from the Devil's Kitchen. Several small infestations of *Salsola kali* were also found approximately 3 miles down from the head of No Thoroughfare Canyon. A single 0.1-acre patch of *Erodium cicutarium* was found approximately a mile from the head of the canyon. A single 0.01-acre patch of *Convolvulus arvensis* was also found a little more than a mile up the canyon from the Devil's Kitchen. Two infestations of *Elaeagnus angustifolia* were also found approximately two miles from the head of the canyon as well.

Although not a target species, crews also recorded occurrences of *Melilotus officinalis*. *Melilotus officinalis* was widely spread throughout much of the lower half of No Thoroughfare Canyon. The crew noted the presence of *Bromus tectorum* but did not map it during the inventory. No obvious disturbances were noted by the crew during the inventory aside from seasonal flooding. The crew was not able to access the bottom of the canyon in some sections due to large pour-offs. They were able to inventory the canyon with binoculars from the sides of the canyon when this occurred, but it is possible they missed some species using this method. However, the crew was confident of seeing 90 percent or more of all 0.01-acre and larger infestations of the target species when they were able to walk the canyon floor. Their confidence was only 60-75 percent for seeing all 0.01-acre infestations when inventorying from the sides of the canyon with binoculars. No Thoroughfare Canyon was assigned an ecological status level three.

Independence Monument (Area Number 8; Inset Map A)

The area inventoried near Independence Monument stretches across the tops of the mesa from Independence Monument to the eastern Monument boundary. The only target species the crew found in this area was *Erodium cicutarium*. The crew reported finding two small patches, totaling 0.11 acres, near the eastern boundary of the Monument. No other target species were discovered in this area and no non-target species were mentioned in the field notes.

No obvious disturbances were noted and the crew was confident of finding all 0.01-acre or larger infestations of the target species. The area was assigned an ecological status of two.

Gold Star Canyon (Area Number 9; Inset Maps A, C)

Gold Star Canyon was inventoried from the head of the Canyon to the Monument boundary. The primary target species found was *Tamarix ramosissima*. The infestations were found in the upper half of the Canyon and were comprised of mostly 0.01-acre patches of saplings. A small amount of *Tragopogon dubius* was discovered in the middle section of Gold Star Canyon. Two small patches each of *Salsola kali* and *Sisymbrium altissimum* were found near the boundary and head of the Canyon as well. Although not inventoried, *Bromus tectorum* was present in Gold Star Canyon.

No obvious disturbances were noted by the crew and the crew was confident of seeing at least 90 percent of all 0.01-acre infestations of the targeted species. An ecological status level three was assigned to the inventory area.

Monument Canyon (Area Number 11, Inset Maps A, B)

This inventory unit includes the areas of Monument Canyon, Coke Oven, and Squaw Fingers. The primary species found in Monument Canyon includes *Tamarix ramosissima* and *Tragopogon dubius*. These two species were found scattered throughout the canyon as well as in the areas of Coke Oven and Squaw Fingers. *Erodium cicutarium* and *Salsola kali* were also found moderately scattered throughout the inventory unit although these two species occurred more frequently in the lower portion of Monument Canyon.

Target species occurring less frequently in this area include *Sisymbrium altissimum*, *Elaeagnus angustifolia*, and *Convolvulus arvensis*. *Sisymbrium altissimum* was found in the areas of Coke Oven and Squaw Fingers. Two patches of *Elaeagnus angustifolia* were discovered below Squaw Fingers. A single patch of *Convolvulus arvensis* was also mapped near the Kissing Couple in Monument Canyon.

Non-target species mapped in Monument Canyon include *Melilotus officinalis*, *Lactuca serriola*, and *Halogeton glomeratus*. *Melilotus officinalis* was found widely scattered throughout the entire inventory unit. Small patches of *Lactuca serriola* were inventoried in Monument Canyon, between Independence Monument and the Kissing Couple. *Halogeton glomeratus* was found on the road shoulder at Coke Oven Overlook as well as in Monument Canyon approximately a mile down canyon from the Kissing Couple.

Although not mapped, the crew also noted the presence of Bromus tectorum in Monument Canyon. The crew was confident of finding at least 90 percent of all 0.01-acre infestations of the target species and did not note any obvious disturbances aside from seasonal flooding. The area was assigned an ecological status level of four.

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 Colorado National Monument. It is anticipated that the information obtained from this inventory will be useful in the Monument's ongoing efforts to improve strategic planning and to increase the efficiency and effectiveness of all field operations associated with invasive plant management.

If it does not already exist, the Monument is urged to develop a comprehensive written management plan for invasive plant species in COLM, similar to the plan currently being finalized by Utah State University for Dinosaur National Monument. If there currently is a written plan, the Monument is encouraged to review and improve it on a regular basis. An excellent reference that will aid the Monument 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 emphasizing early detection and rapid response. 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 Colorado National Monument to inventory portions of their land each year, so that within a reasonable number of years all of the Monument 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, Colorado National Monument also should consider establishing permanent monitoring sites (if it hasn't already done so) 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, Colorado National Monument 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 highly invasive species should be given highest priority, with the ultimate objective being their 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, 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 this strategy to Colorado National Monument would mean that species such as *Conium maculatum, Tribulus terrestris, Rumex crispus, Verbascum thapsus, Lactuca serriola, Elaeagnus angustifolia, Halogeton glomeratus,* and *Convolvulus arvensis,* and should be given the highest control priority of the species mapped, and should be targeted for prompt Monument-wide eradication. *Tamarix ramosissima* and *Salsola kali* probably fit best into the second priority category of "contain and reduce" in some portions of the Monument, but also could be candidates for eradication in other areas. For example, *Tamarix ramosissima* could be eradicated from the wildland/urban interface as well as in Gold Star Canyon. Likewise, the small infestations of *Salsola kali* in Ute Canyon and Gold Star Canyon could also be targeted for eradication. Plants that we would place in the third management category (lowest priority) include *Bromus tectorum, Erodium cicutarium, Tragopogon dubius, Sisymbrium altissimum,* and *Melilotus officinalis,* which were widespread throughout the Monument.

The Monument will likely need additional inventory information before deciding in which management category to place *Halogeton glomeratus* and *Lactuca serriola*. These non-native species appeared infrequently scattered throughout the inventory areas in the Monument, but our assessment is based on an incomplete survey rather than a full inventory of these species. If further study reveals that these species truly are relatively scarce in the Monument, 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 Monument. Humans are the most likely vectors for new introductions of invasive plant species into Colorado National Monument 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 355,200 per year visit Colorado National Monument alone. 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. For example, several of weed species inventoried in Colorado National Monument were found along roadways. The single infestation of *Tribulus terrestris* inventoried in the Monument was found along South Broadway road along the wildland/urban interface. Likewise, several infestations of *Convolvulus arvensis* were found directly on the road shoulder near the east entrance to the Monument. 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. Monument 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 Monument's Visitor Center, through displays or a video program, and evening fireside presentations to visitors made by NPS personnel.

Routine Monument 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 Monument employees and/or the creation of unprotected disturbed sites that can be ideal for weed establishment. An excellent example of effective weed prevention methods can be seen in protocols developed for the recent multi-crew EPMT deployment exercise conducted at Arches National Park (USDI-NPS 2004) (Appendix J). Additional weed prevention protocols have been developed by the Forest Service (USDA-Forest Service 2001).

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

All NCPN Parks that were inventoried in 2003 and 2004 are in the enviable situation of still having the majority of their lands free of invasive weeds. In Colorado National Monument, 78.2 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 COLM 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 25 invasive weed species of great concern to the region (Appendix K).

An important new trend in weed management is the concept of identifying areas that are currently free of one or more species of invasive plants, and officially designating them as “Weed Prevention Areas” (WPA). Land units designated as WPA's are given a higher priority for prevention efforts, early detection, and rapid control (eradication) of any new invaders. In our opinion, all areas within Colorado National Monument that are currently "clean" should be identified as WPAs, and Monument management should take all appropriate measures to keep invasive weeds 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 invasive weeds 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 with a Park or Monument could help to justify increased budgets for prevention practices. Increasing the number of weed-free acres in a Park or Monument 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 "weed free"). WPA's also present an opportunity for Parks to help the general public feel more involved as visitors see more clearly the focus of the preventive measures they are being asked to adopt.

The final objective of this project was to test and refine data collection and field inventory techniques that might be used by NCPN in future invasive plant inventories. 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, Dewey and Andersen 2005c).

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Appendix Tables and Figures

Appendix A. NPS Crew Qualifications for the 2003 Invasive Non-native Plant Inventory in Colorado National Monument.

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. Stephanie Shoemaker and Christine Craig also have Bachelor's degrees in Natural Resource related fields. All four of the NPS crew members were hired by the Northern Colorado Plateau Network, having met all criteria described in the National Park Service job announcement.

NPS crew leaders (Liz and Stephanie) completed an intensive 2-week pre-season training course conducted at Utah State University by Dr. Dewey (USU project leader) and Kim Andersen (USU crew leader). The course consisted of classroom presentations and field exercises to familiarize participants with all inventory procedures and policies, and to improve all skills related to the job. Each crew leader was provided with a copy of the training manual and a weed identification field guide. The remaining 2 NPS crew members participated with their crew leaders in an additional 1-week field training exercise held at the beginning of the season in Zion National Park. Training at Zion was conducted by Dr. Dewey, Kim, and Melanie Ballard (Assistant USU crew leader).

During the first few weeks of the field season, and periodically thereafter, NPS crew leaders worked individually with each crew member to ensure that all skills had been mastered and that procedures were consistent among all crew members.

Data collected by the NPS crew were compiled, analyzed, and summarized as a COLM annual progress report and final report by Kim Andersen and other members of the USU mapping crew (Melanie Ballard and Janna Simonsen) under the supervision of Dr. Dewey. The Utah State University wildland weed mapping crew has considerable experience conducting the type of survey required in this NPS project and in preparing summary reports. 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 and Melanie Ballard have considerable experience working on the USU invasive weed mapping 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). 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 Bachelor of Science degree from USU in Environmental Studies.

Appendix B. Standard GPS Data Dictionary used in the 2003 Invasive Non-native Plant Inventory in Colorado National Monument.

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 Invasive Non-native Plant Inventory in Colorado National Monument.

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

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

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

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

Appendix D. GPS Settings using in 2003 Invasive Non-native Plant Inventory in Colorado National Monument.

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 D . GPS Settings using in 2003 Invasive Non-native Plant Inventory in Colorado National Monument. (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 E. Photograph and list of equipment used in 2003 Invasive Non-Native Plant Inventory in Colorado National Monument.

Equipment

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

Appendix F. Dominant Vegetation Types Key used in 2003 Invasive Non-native Plant Inventory, Colorado National Monument.

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

Appendix F. Dominant Vegetation Types Key used in 2003 Invasive Non-native Plant Inventory, Colorado National Monument.

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

Appendix G. Project Photographs of Weed Species Detected in Colorado National Monument During the 2003 Invasive Non-native Plant Inventory.

Weeds Detected

Figure 1. *Erodium cicutarium* along the wildland/urban interface.

Figure 2. *Erodium cicutarium* along the wildland/urban interface.

Figure 3. *Tragopogon dubius* along the wildland/urban interface.

Figure 4. *Tragopogon dubius* infestations along the wildland/urban interface.

Weeds Detected

Figure 5. *Sisymbrium altissimum* found growing next to the Resource Office.

Figure 6. *Sisymbrium altissimum* found near the Resource Office.

Figure 7. *Salsola kali* found in the wildland/urban interface.

Figure 8. *Salsola kali* found in the wildland/urban interface.

Weeds Detected

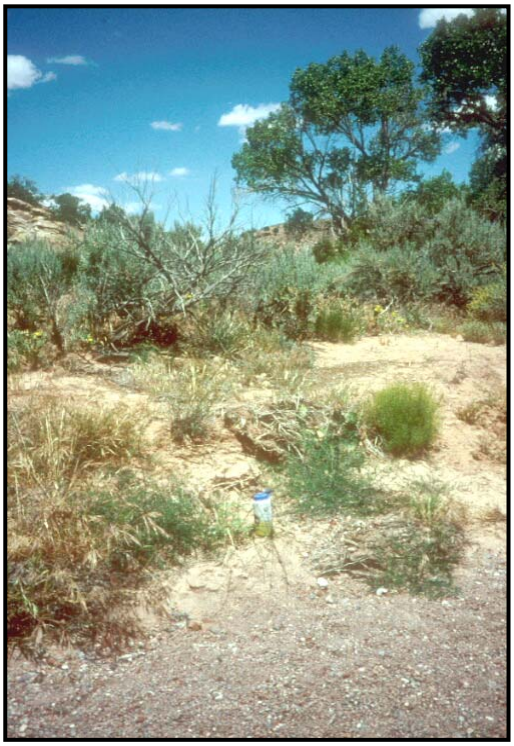


Figure 9. *Salsola kali* found in the wildland/urban interface.

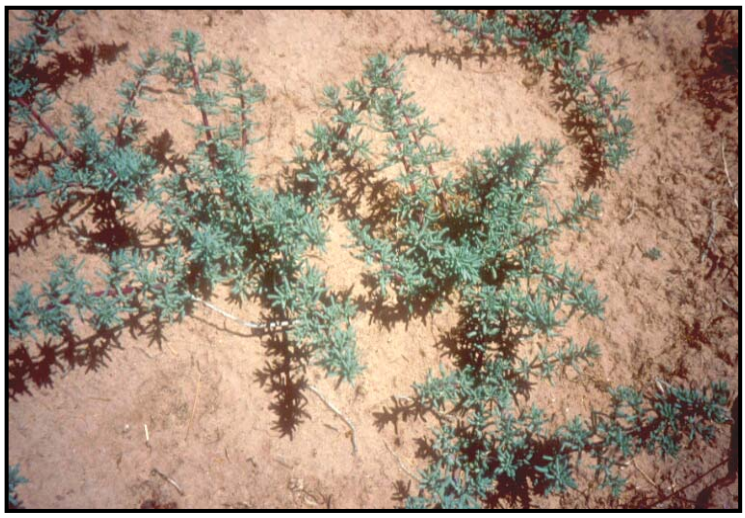


Figure 10. *Halogeton glomeratus* along the wildland/urban interface.

Figure 11. *Halogeton glomeratus* along the wildland/urban interface.

Figure 12. *Halogeton glomeratus* (landscape) along the wildland/urban interface.

Weeds Detected

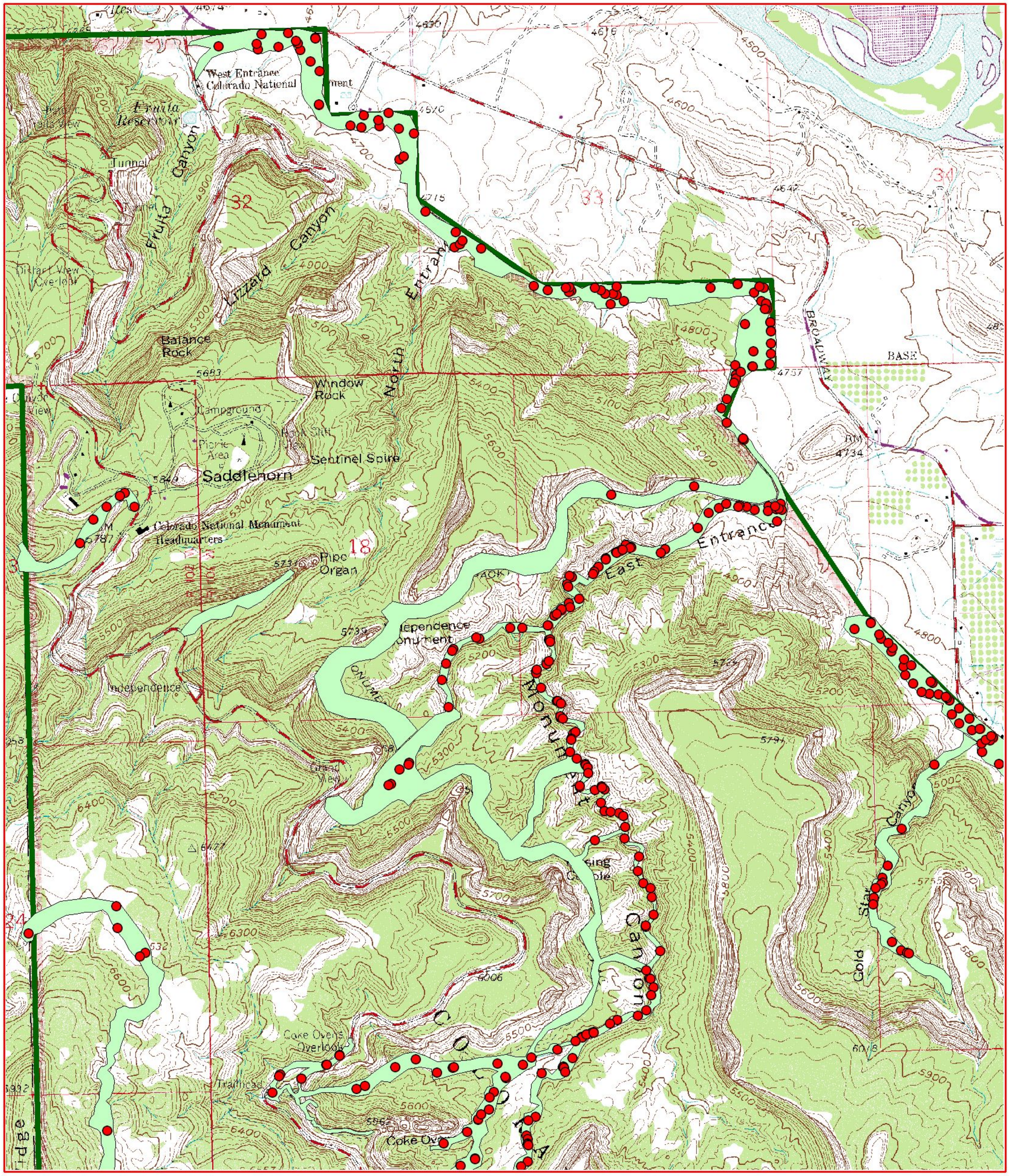
Figure 13. *Bromus tectorum* along the wildland/urban interface.

Figure 14. *Bromus tectorum* along the wildland/urban interface.

Figure 15. *Bromus tectorum* along the wildland/urban interface.

Figure 16. Liberty Trail landscape.

Appendix H. Overall Weed Distribution in Inventoried Areas - Monument Canyon (Inset A)



Weed Points

Areas Inventoried

Monument boundary

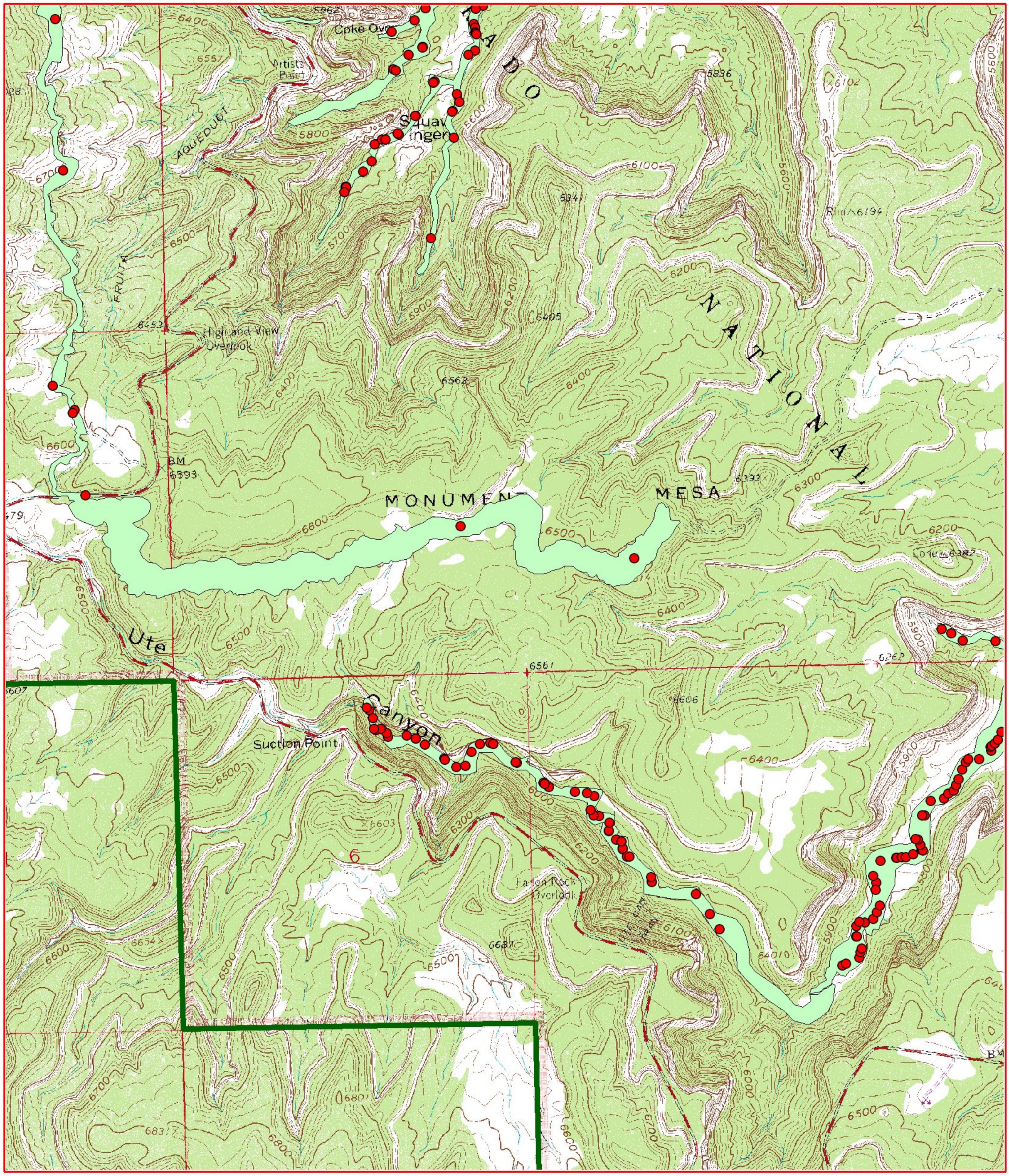
0 2000 4000 Feet

1:24,000 Scale

N

Inset A
Utah State University
Colorado National Monument
2003 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix H. Overall Weed Distribution in Inventoried Areas - Monument Mesa (Inset B)



Weed Points

Areas Inventoried

Monument boundary

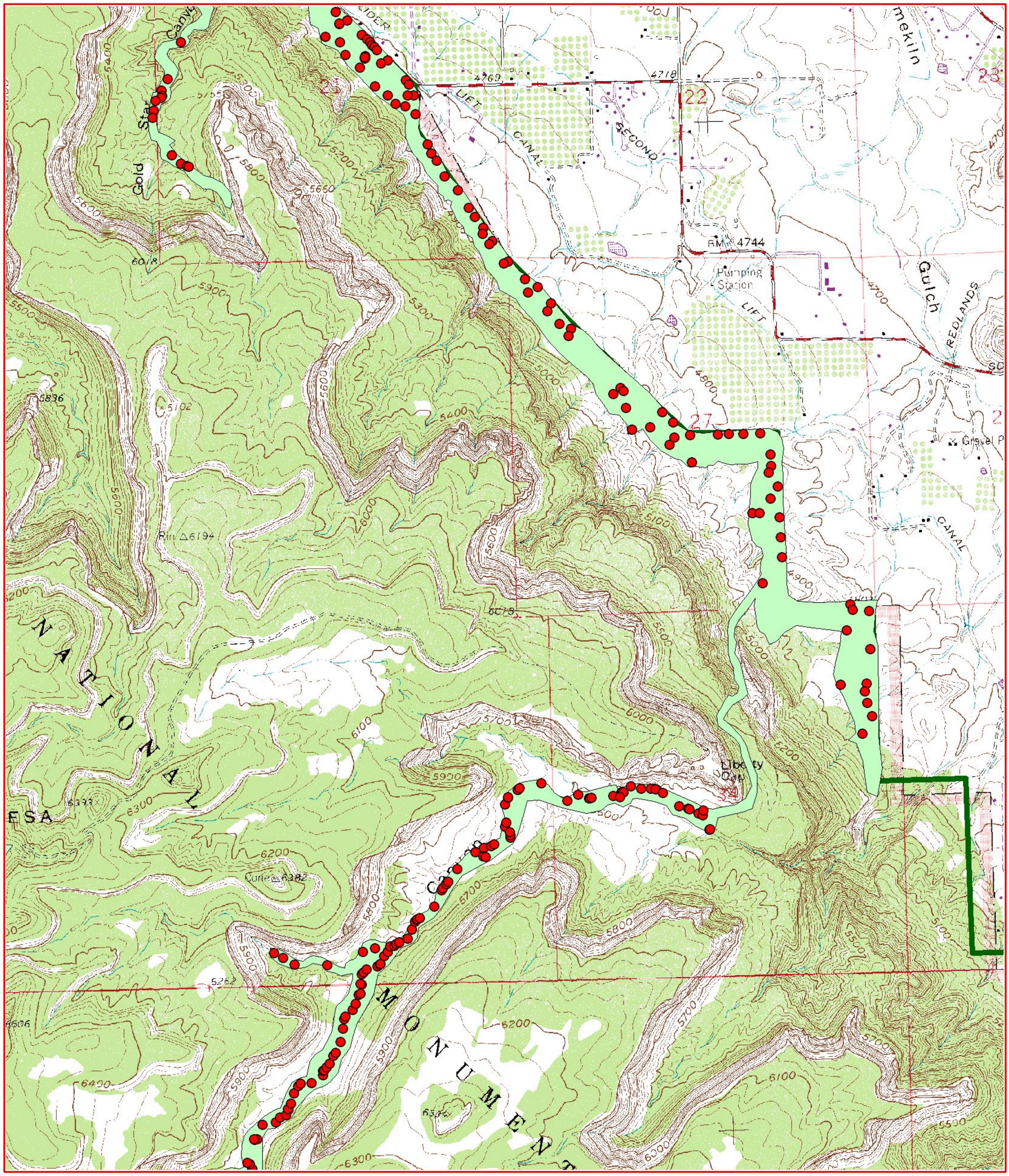
0 2000 4000 Feet

1:24,000 Scale

N

Inset B
Utah State University
Colorado National Monument
2003 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix H. Overall Weed Distribution in Inventoried Areas - Ute Canyon (Inset C)



Weed Points

Areas Inventoried

Monument boundary

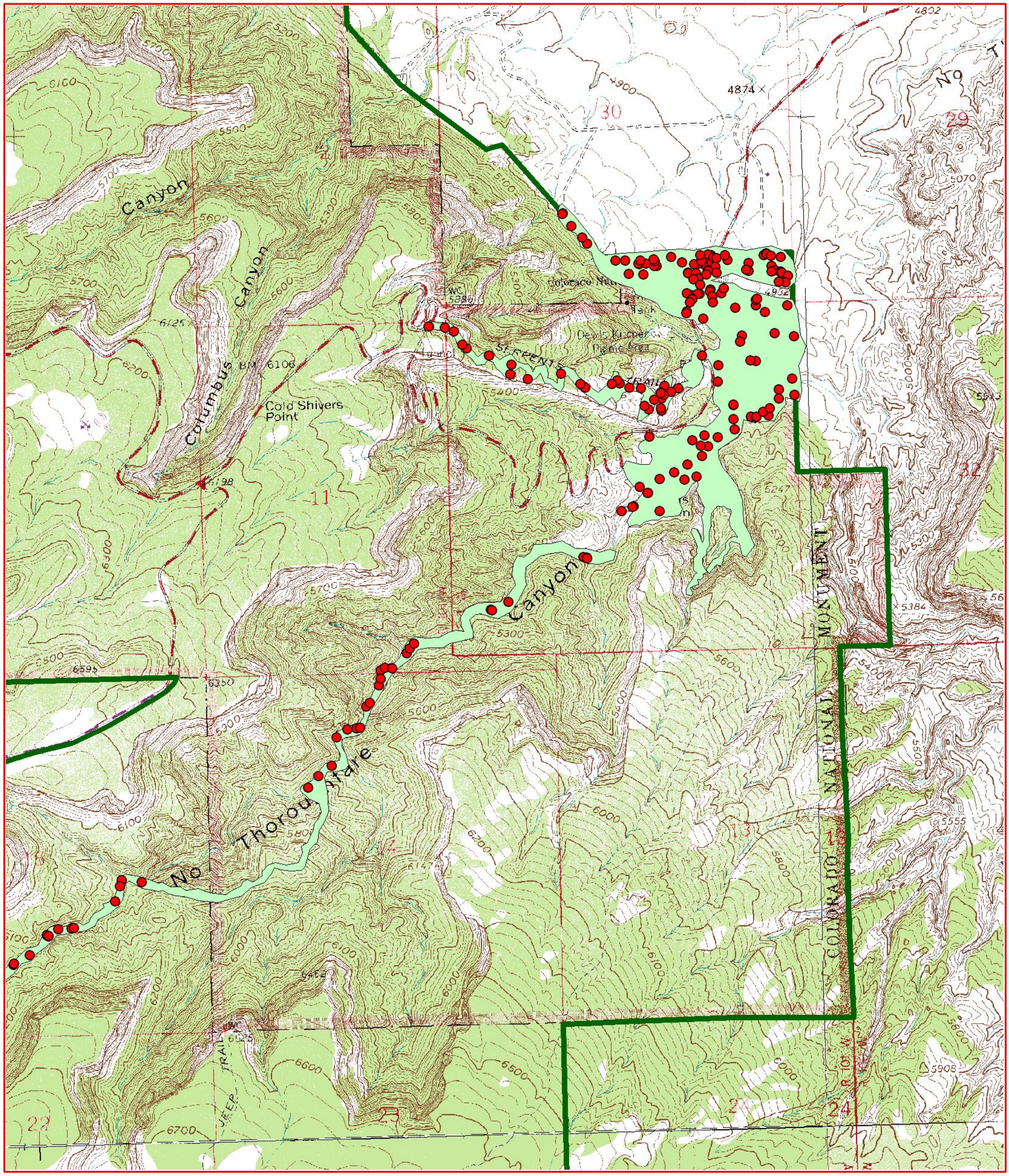
0 2000 4000 Feet

1:24,000 Scale

N

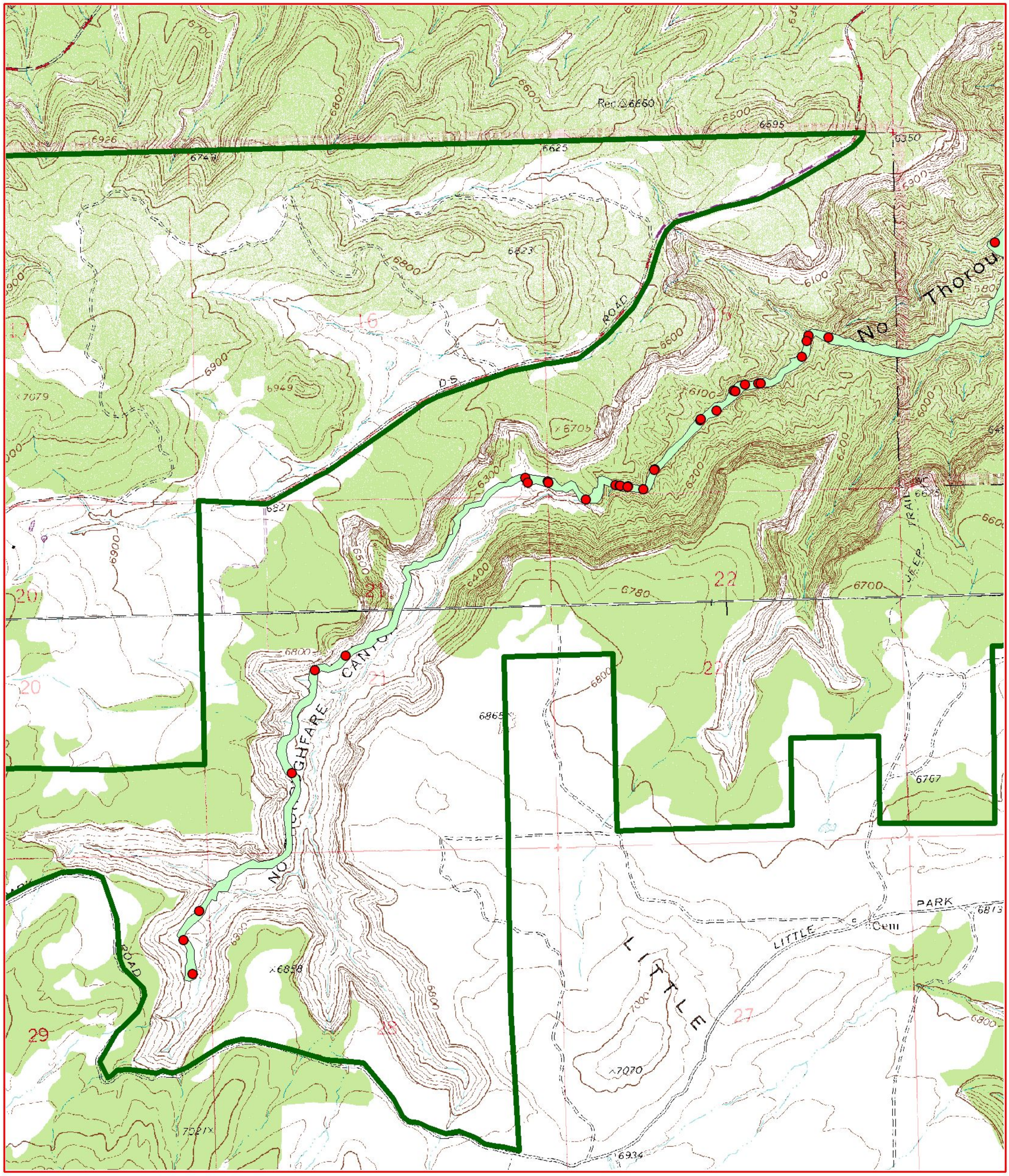
Inset C
Utah State University
Colorado National Monument
2003 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix H. Overall Weed Distribution in Inventoried Areas - Serpent's Trail (Inset D)

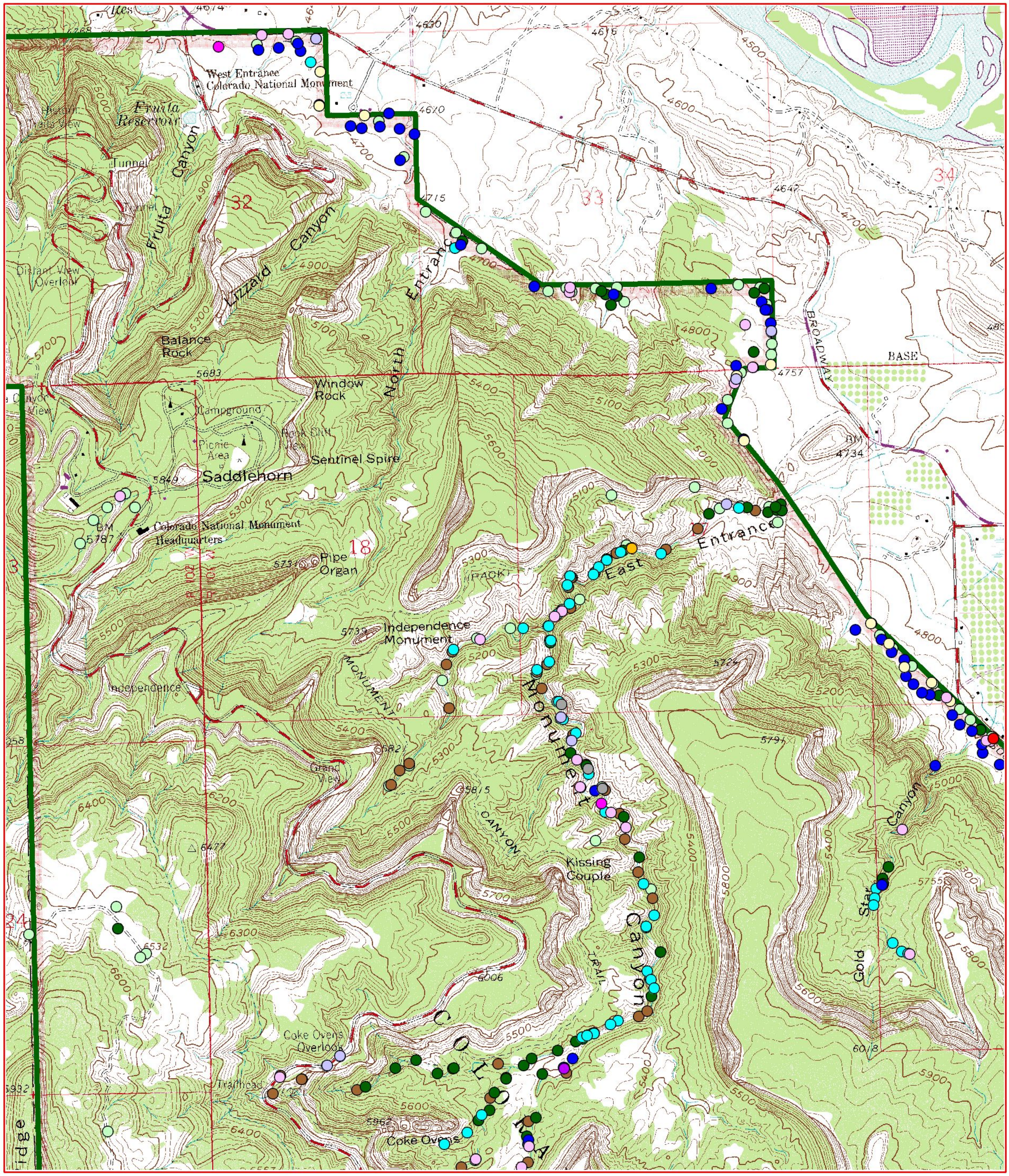


Inset D
Utah State University
Colorado National Monument
2003 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix H. Overall Weed Distribution in Inventoried Areas - No Thoroughfare Canyon (Inset E)



Appendix I. Weed Species Detected in Inventoried Areas - Monument Canyon (Inset A)



- *Bromus tectorum*
- *Conium maculatum*
- *Convolvulus arvensis*
- *Elaeagnus angustifolia*
- *Erodium cicutarium*
- *Halogeton glomeratus*
- *Lactuca serriola*
- *Melilotus officinalis*
- *Salsola kali*
- *Sisymbrium altissimum*
- *Tamarix ramosissima*
- *Tragopogon dubius*
- *Tribulus terrestris*
- Monument boundary

0 2000 4000 Feet

1:24,000 Scale

N

Inset A
Utah State University
Colorado National Monument
2003 Invasive Non-Native Plant Inventory
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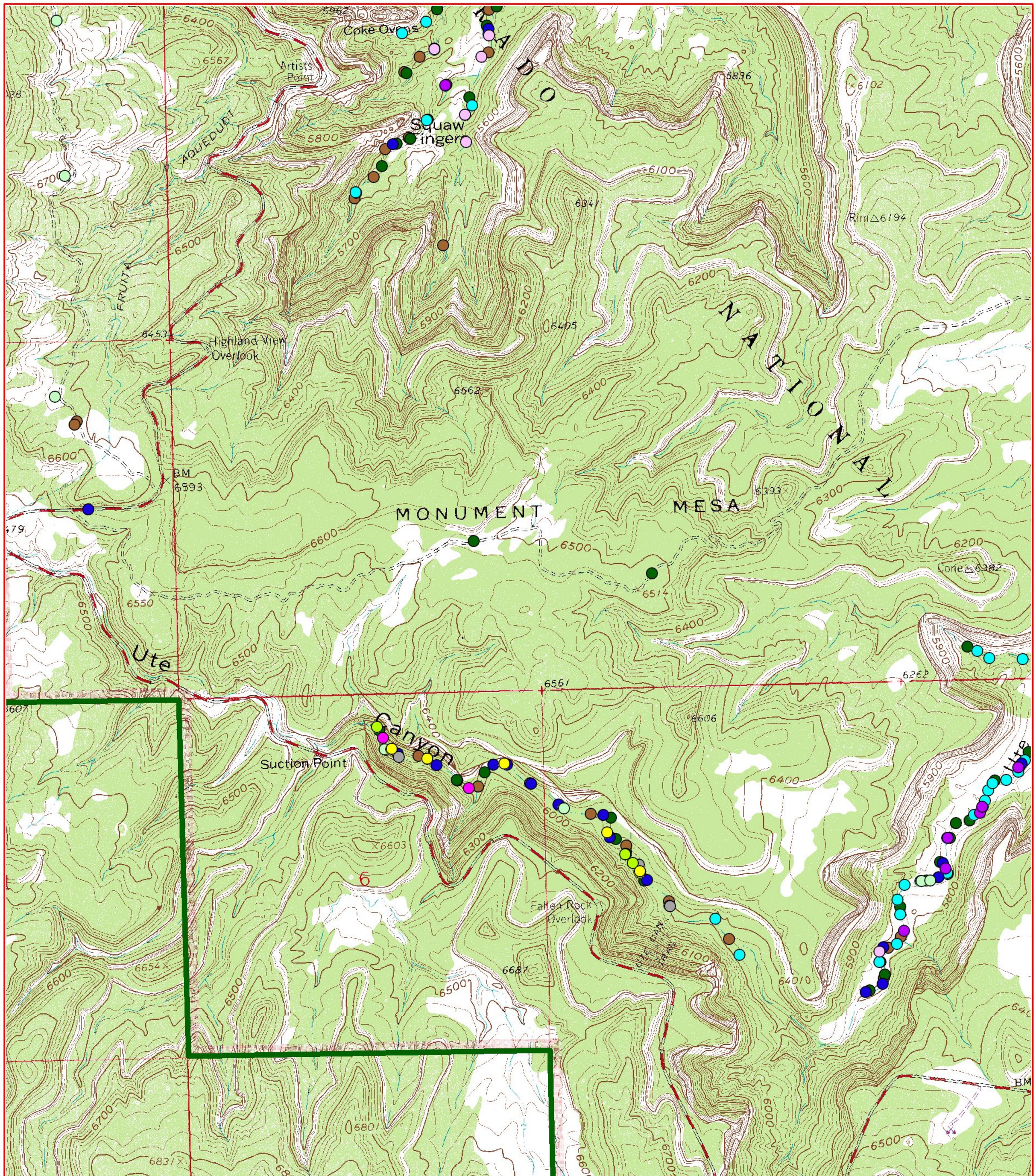
Appendix I. Weed Species Detected in Inventoried Areas - Monument Mesa (Inset B)



- *Convolvulus arvensis*
- *Elaeagnus angustifolia*
- *Erodium cicutarium*
- *Lactuca serriola*
- *Melilotus officinalis*
- *Rumex crispus*
- *Salsola kali*
- *Sisymbrium altissimum*
- *Tamarix ramosissima*
- *Tragopogon dubius*
- *Verbascum thapsus*
- Monument boundary

0 2000 4000 Feet

1:24,000 Scale

N

Inset B
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Appendix I. Weed Species Detected in Inventoried Areas - Ute Canyon (Inset C)

Bromus tectorum
Convolvulus arvensis
Elaeagnus angustifolia
Erodium cicutarium
Halogeton glomeratus
Melilotus officinalis
Salsola kali
Sisymbrium altissimum
Tamarix ramosissima
Tragopogon dubius
Monument boundary

0 2000 4000 Feet

1:24,000 Scale

N

Inset C
Utah State University
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2003 Invasive Non-Native Plant Inventory
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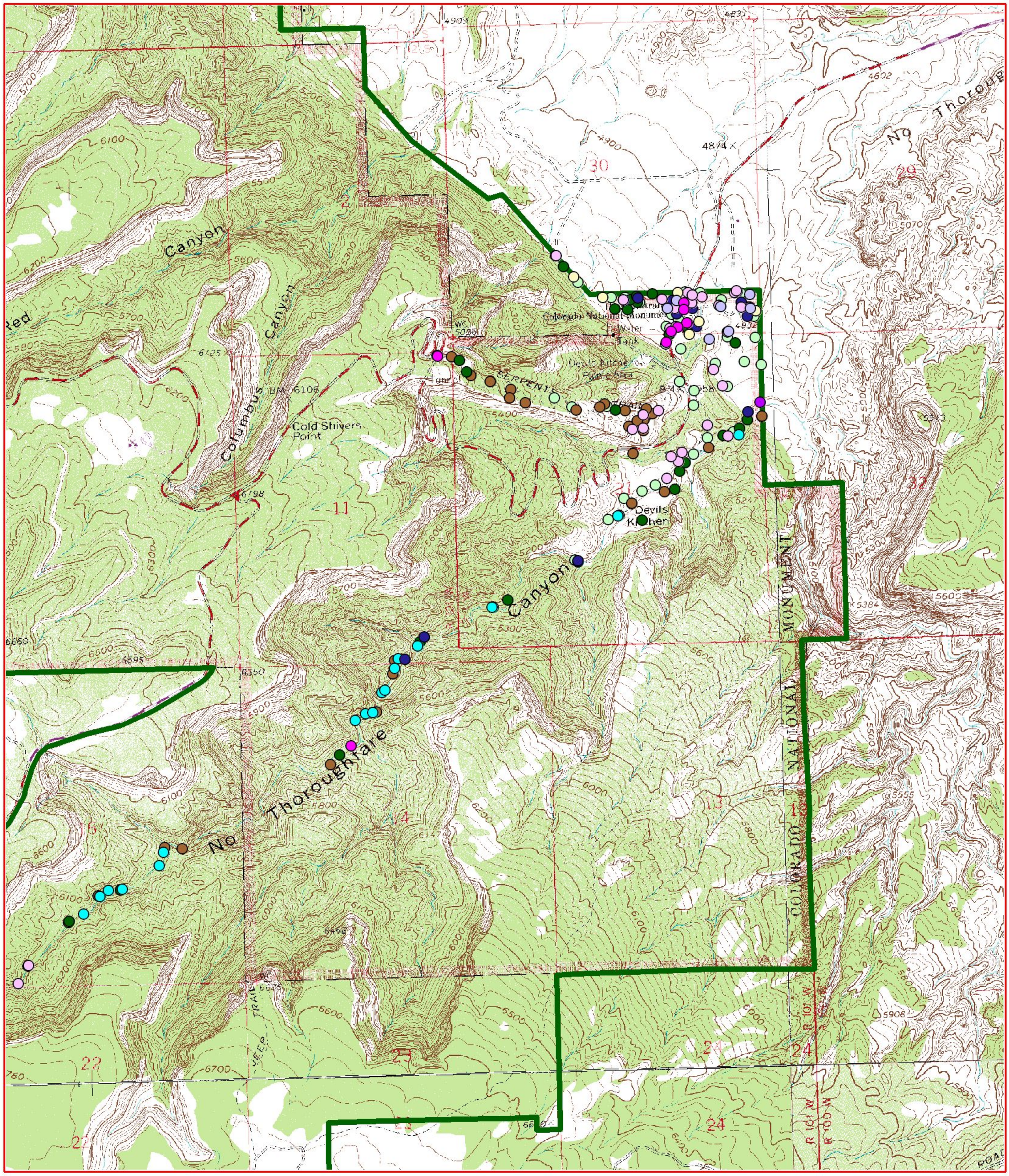
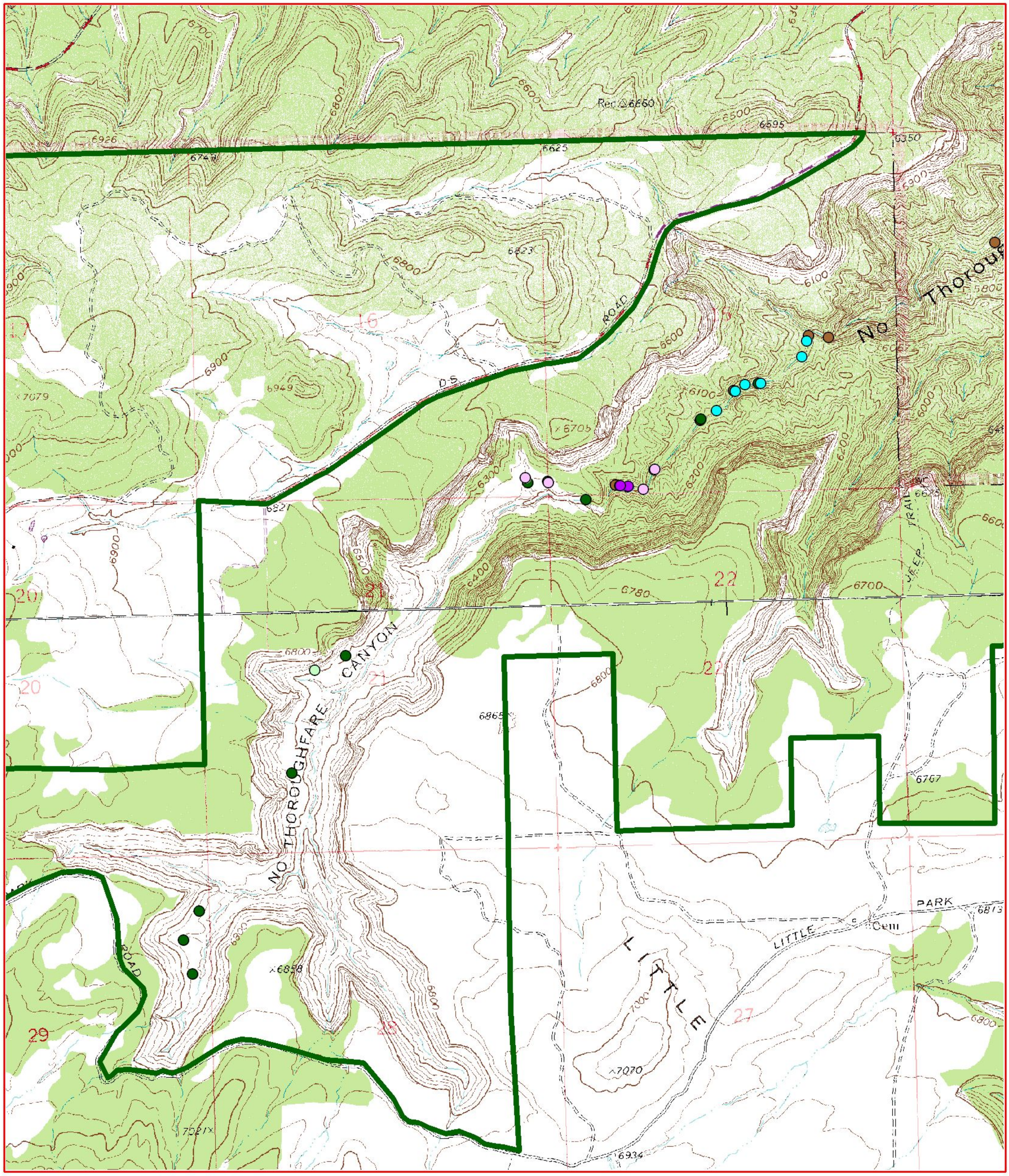
Appendix I. Weed Species Detected in Inventoried Areas - Serpent's Trail (Inset D)



I-4

Inset D
Utah State University
Colorado National Monument
2003 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Appendix I. Weed Species Detected in Inventoried Areas - No Thoroughfare Canyon (Inset E)



- *Convolvulus arvensis*
- *Elaeagnus angustifolia*
- *Erodium cicutarium*
- *Melilotus officinalis*
- *Salsola kali*
- *Tamarix ramosissima*
- *Tragopogon dubius*
- Monument boundary

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

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

EPMT COURTHOUSE WASH PROJECT

Arches National Park
March 9 – 14, 2004

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

Weed Seed/Propagule Decontamination Procedures:

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

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

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

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

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

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

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

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 vulgare*				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		*Lactuca serriola*		X			
Conium maculatum	X					*Melilotus officinalis*		X			
Convolvulus arvensis	X										
Cynoglossum officinale				X							
Dactylis glomerata					X						
Elaeagnus angustifolia	X										
Euphorbia esula				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