Mesa Verde National Park

2003 Invasive Non-native Plant Inventory

Southern Colorado Plateau Inventory and Monitoring Network

Final Report

July 2005

Prepared by

Steven Dewey and Kimberly Andersen

Utah State University

Cover photo:

Senesced *Carduus nutans* on Chapin Mesa two years after the Long Mesa Fire. Photo by S. Dewey.

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FINAL REPORT

**Inventory of Invasive Non-native Plants
Conducted During 2003 in Portions of Mesa Verde National Park,
Southern 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 and Southern Colorado Plateau Networks 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 the results of the NPS inventory conducted in Mesa Verde National Park. Results from other Parks are documented in separate Park-specific project reports. Also, please note that this report updates and replaces the 2003 Mesa Verde National Park Inventory Annual Progress Report (Dewey et al. 2003).

BACKGROUND AND JUSTIFICATION

Numerous recent studies demonstrate that invasive non-native plant species pose one of the greatest threats to natural ecosystems regionally and globally by altering native plant communities, wildlife populations, fire regimes, nutrient cycling, hydrology, and energy budgets (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 Southern 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 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. Mesa Verde National Park is a member of the Southern Colorado Plateau Network. The Northern Colorado Plateau Network coordinated the project for Mesa Verde National Park in their behalf. A knowledge of current weed distribution, especially in or near riparian areas or areas disturbed by fire, was identified as an extremely high priority need by both the Northern and Southern Colorado Plateau Networks.

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 Mesa Verde National Park. It was anticipated that information from this inventory will be useful in the Park's ongoing efforts to improve strategic planning and to increase the effectiveness and efficiency of field operations associated with invasive plant management.

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

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

METHODS

The National Park Service supplied a four-person crew in 2003 to inventory designated areas within Mesa Verde National Park. Crew qualifications are documented in Appendix A.

SELECTION OF TARGET SPECIES AND INVENTORY AREAS

Twenty-seven species were identified as high-priority targets in the MEVE inventory (Table 1), and searched for systematically by all inventory crew members. Any other non-native species recognized as relatively new to MEVE 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 Mesa Verde National Park in the 2003 Non-native Plant Inventory.

Invasive species	Common Name
Ailanthus altissima	Tree of heaven
Alhagi pseudalhagi	Camelthorn
Arctium minus	Common burdock
Cardaria draba	Hoary cress
Carduus nutans	Musk thistle
Centaurea diffusa	Diffuse knapweed
Centaurea maculosa	Spotted knapweed
Centaurea repens	Russian knapweed
Centaurea virgata v. squarrosa	Squarrose knapweed
Cirsium arvense	Canada thistle
Cirsium vulgare	Bull thistle
Conium maculatum	Poison hemlock
Convolvulus arvensis	Field bindweed
Cynoglossum officinale	Houndstongue
Elaeagnus angustifolia	Russian olive
Halogeton glomeratus	Halogeton
Lepidium latifolium	Perennial pepperweed
Linaria Dalmatica	Dalmatian toadflax
Marrubium vulgare	Horehound
Melilotus officinalis	Yellow sweetclover
Onopordum acanthium	Scotch thistle
Rumex crispus	Curly dock
Salsola iberica	Russian thistle
Sorghum halepense	Johnsongrass
Tamarix ramosissima	Saltcedar
Tribulus terrestris	Puncturevine
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 Park development and high visitor use. Areas of likely weed seed introduction as well as sites identified as significant known or potential weed seed sources or "vector areas" were also given priority. Areas actually inventoried in Mesa Verde National Park in 2003 were determined in consultation with George San Miguel, Resource Management Specialist for the Park, and consisted primarily of two recently burned areas. Riparian areas, roads, hiking trails, and buildings associated with the burned areas were included.

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

DATA CATEGORIES

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

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

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

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

Table 2 continued.

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

Table 2 continued.

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

FIELD PROCEDURES

Some of the terms used in this and subsequent sections of the report have been created by the authors to describe new 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 Mesa Verde National Park was conducted between August 30 and September 28, 2003. For purposes of planning and data analysis the inventoried lands were divided into two areas (Table 3). 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. Areas such as burned mesa tops were open and visibility was generally good, allowing relatively broad EDSW's (typically 50 to 75 yards). In areas such as canyon bottoms or where non-burned vegetation cover was heavy, EDSW's were generally narrower, sometimes less than 25 yards. Whenever inventorying areas wider than a single swath width, multiple parallel passes of a lone crew member (or multiple crew members walking parallel transects or contours) were searched as contiguous or slightly overlapping strips to avoid coverage gaps. In situations of extremely steep or otherwise inaccessible terrain where vegetation could be identified clearly from a distance, crew members used binoculars to visually scan the area for suspected target species, and "offset" procedures were performed with the GPS units to map infestation points.   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 Mesa Verde National Park was assigned a detection confidence value based on the crew’s estimated ability to see infestations of 0.01 acre in size of the least visible target species, taking into account terrain, vegetation cover, and the size and growth stage of the targeted plant species. Detection confidence was broken into three categories: Low (1 to 50 %), Medium (51 to 89 %), and High (90 to 100%).

Table 3: Invasive plant inventory areas, inventory dates, crew members, and acres inventoried in 2003 in Mesa Verde National Park.

Area Number	Area Description	Dates Inventoried	Crew Members*	Acres Inventoried**	Corresponding Inset Map Names and Letter Codes***
1	Long Mesa Burn on Chapin Mesa, Headquarters area	Aug 30- Sept 4, 2003 and Sept 10- 15, 2003	LB, HR, CC, SS, V	2,133.38	Navajo Canyon (Inset A) Chapin Mesa (Inset B)
2	Burn in West Fork of School Section Canyon	Sep 25-28, 2003	LB, HR, V	131.27	School Section Canyon (Inset C)
	TOTAL			2264.65	

* Crew abbreviations: LZ = Liz Ballenger, HR = Heather Rickleff, SS= Stephanie Shoemaker, CC= Christine Craig, V = NPS volunteers

** An average of 34.8 acres inventoried per person per 10-hr day in 2003.

*** Indicates the key to mapped areas presented later in Figure 2.

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 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 under a dense tree canopy) 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 (or by using a laser rangefinder to measure patch dimensions) 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. Extensive weed infestations (greater than 5 acres in size) were to be mapped either as "actual" or "gross" area polygons (see 2003 NAWMA Weed Mapping Standards for definitions).

In deciding on the dominant vegetation cover, crews identified the two most prevalent or most dominant native species in the vicinity of the weed 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 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.

The crew was not consistent in designating the "dominant native species" in the two inventory areas. For the first 2/3 of the project (Area 1), they chose *Pinus edulis* and *Juniperus osteosperma* (code# 1412) as their dominants species (per instructions by George San Miguel), despite the fact that these species were burned and not yet regenerating. The crew thought the few living native species that were growing in the burned area were not abundant enough to be recorded as a dominant species. However, during a late-season project evaluation meeting in September it was decided to follow a different rational. Beginning on 9/25/03 (Area 2), they chose the dominant species from whatever was currently alive in the immediate vicinity of inventoried weed infestations. This information often was listed in the "notes" section simply as "weedy chenopods", "penstemon", and "asters". *Quercus gambelii* was often listed as a dominant (#20) in or near washes because it was already resprouting in the burned areas. If it is decided to change the dominant species designations from Area 1 to be consistent with the method used in Area 2, no changes need to be made when #20 was listed as dominant. However, when #1412 (or 1214) were listed as dominants, perhaps "weedy chenopods and asters" would be a better representation of what was actually regenerating there, since they were present throughout the majority of the burned areas.

POINTS OF INTEREST AND RARE PLANT FINDINGS

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

GENERAL PHOTOGRAPHS

Representative photos are included in this report showing some of the species and habitats inventoried, as well as a sampling of photographs of field crews doing inventory work.

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

VOUCHER SPECIMENS

Specimens were to be collected to document new or otherwise unique occurrences of invasive species encountered within Mesa Verde National Park. No plant voucher specimens were collected 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, "B091913.ssf" would be the file name for raw GPS data collected by Liz Ballenger beginning in the thirteenth hour (24-hr local time) on September 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 Liz Ballenger on September 19 would be Sep19-B2.ssf.

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.

The data from edited GPS rover files were differentially corrected by Utah State University. 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: Sep19-B2.cor

Shapefiles were created by Utah State University by exporting the differentially corrected files from Pathfinder Office into ArcView GIS 3.3 for map-making and data analysis. 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

When shapefiles were imported into ArcView, additional data fields were added to comply with the task agreement. These fields include scientific name, ITIS code, life form of the species, county, state, country, and park code. Individual record numbers, including the four-letter Park code, were assigned to each weed infestation location entry. It was decided to enter this information after the field season to minimize the amount of time spent collecting non data in the field and maximize the acres inventoried. The data were checked again for any duplication of entries. Any gaps in the sequence of record numbers are due primarily to elimination of duplicated entries.

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

The shapefiles were used to create maps using ArcView software. A large-scale map was 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. The small-scale inset maps are identified by a letter, as well as the name of prominent feature found on that section of map. The distribution maps also illustrate weed-free areas within inventoried units and may help managers prioritize areas for weed prevention efforts. Queries and summations of the weed acreages were conducted in ArcView and are included in the Results and Discussion portion of this report.

Individual maps were exported and saved as .jpeg files. Any data tables were exported and saved as Microsoft Excel spreadsheets. Metadata was compiled for the final 2003 dataset by Utah State University using ArcGIS ArcCatalog software. The metadata was provided to the Southern 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 2,265 acres in Mesa Verde National Park during the summer of 2003 (Table 3), an amount representing approximately four percent of the entire 52,122-acre Park. An average of 34.8 acres was inventoried per person per 10-hr day in 2003 by NPS crews.

The location and size of the 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 1:20,000 scale weed-distribution "Inset" maps found in Appendices H and I. Inset maps are distinguished by letters A -C, 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.

Invasive plants infested a total of 221.67 acres within the mapped areas (Table 4), an amount equal to 9.8 percent of the land inventoried. Of the 27 initial targeted species, crews found only *Arctium minus, Carduus nutans, Centaurea repens, Cirsium arvense, Cirsium vulgare, Tamarix ramosissima* and *Verbascum thapsus* in the Park. The only non-target species found and mapped was *Alyssum incanum*. Other non-target weed species that were observed but not mapped include: *Bromus tectorum, Salsola kali, Lactuca serriola, Sisymbrium altissimum, Tragopogon dubius,* and *Chenopodium spp*.

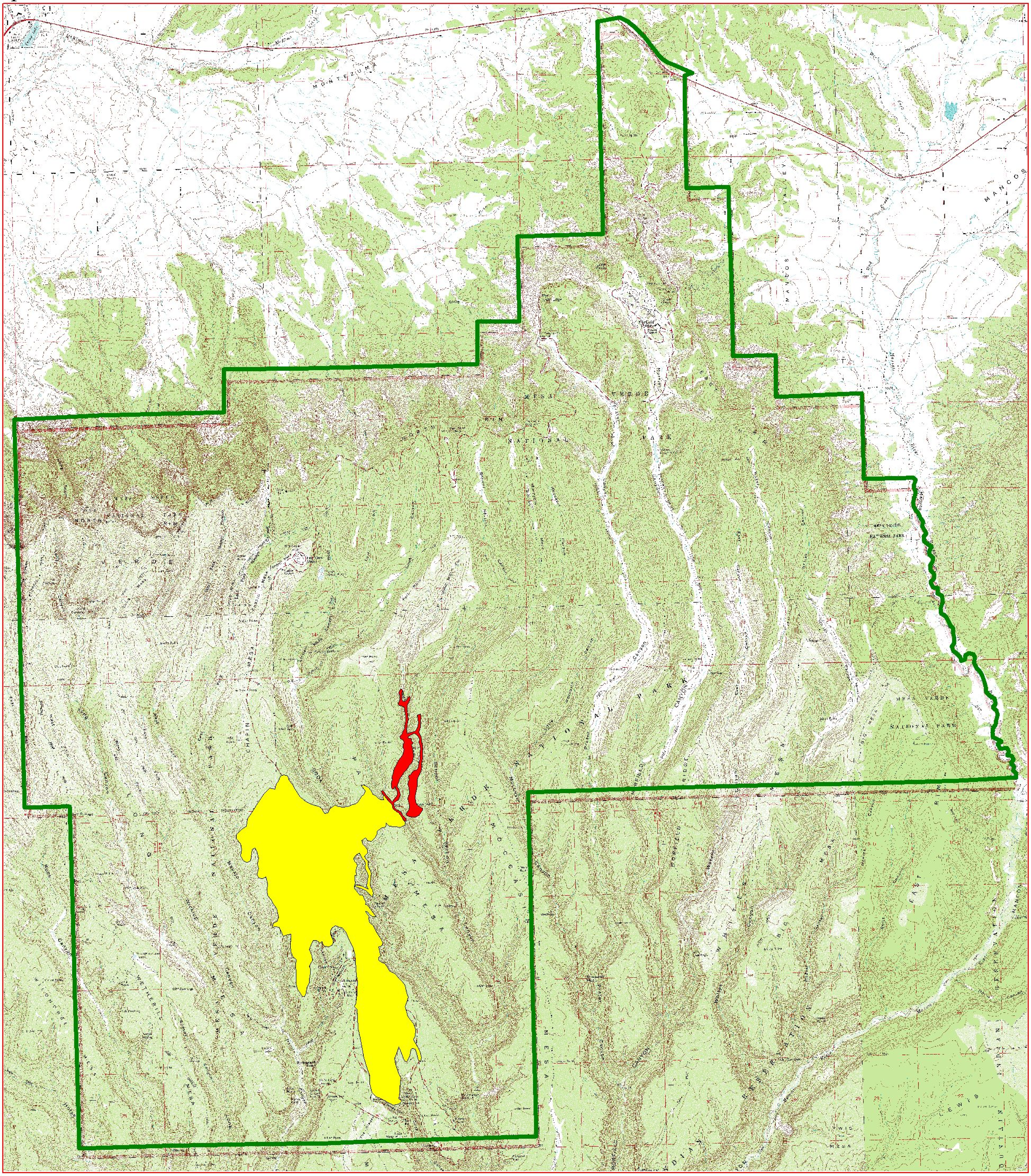
Table 4: Acres infested by invasive plant species within inventoried areas of Mesa Verde National Park in 2003.

Species	Total Acres *
Alyssum incanum	3.02
Arctium minus	0.01
Carduus nutans	207.98
Centaurea repens	0.01
Cirsium arvense	4.64
Cirsium vulgare	2.89
Convolvulus arvensis	0.01
Tamarix ramosissima	0.03
Verbascum thapsus	3.08
Totals	221.67

* Weed acreage values calculated from gross area polygons are included in the infestation totals presented in this table.

By far, the most abundant target species found in the Park was *Carduus nutans*. The crew recorded 207.98 acres of this species; a value representing 93.8 percent of the total weed-infested acres.

Figure 1. Identification number and acreage of individual areas inventoried for non-native invasive plant species in Mesa Verde National Park durin 2003.



Areas Inventoried (2003)

Area 1 - Long Mesa Burn on Chapin Mesa, Headquarters region (2,133 acres)

Area 2 - Burn in West Fork of School Section Canyon (131 acres)

Park boundary

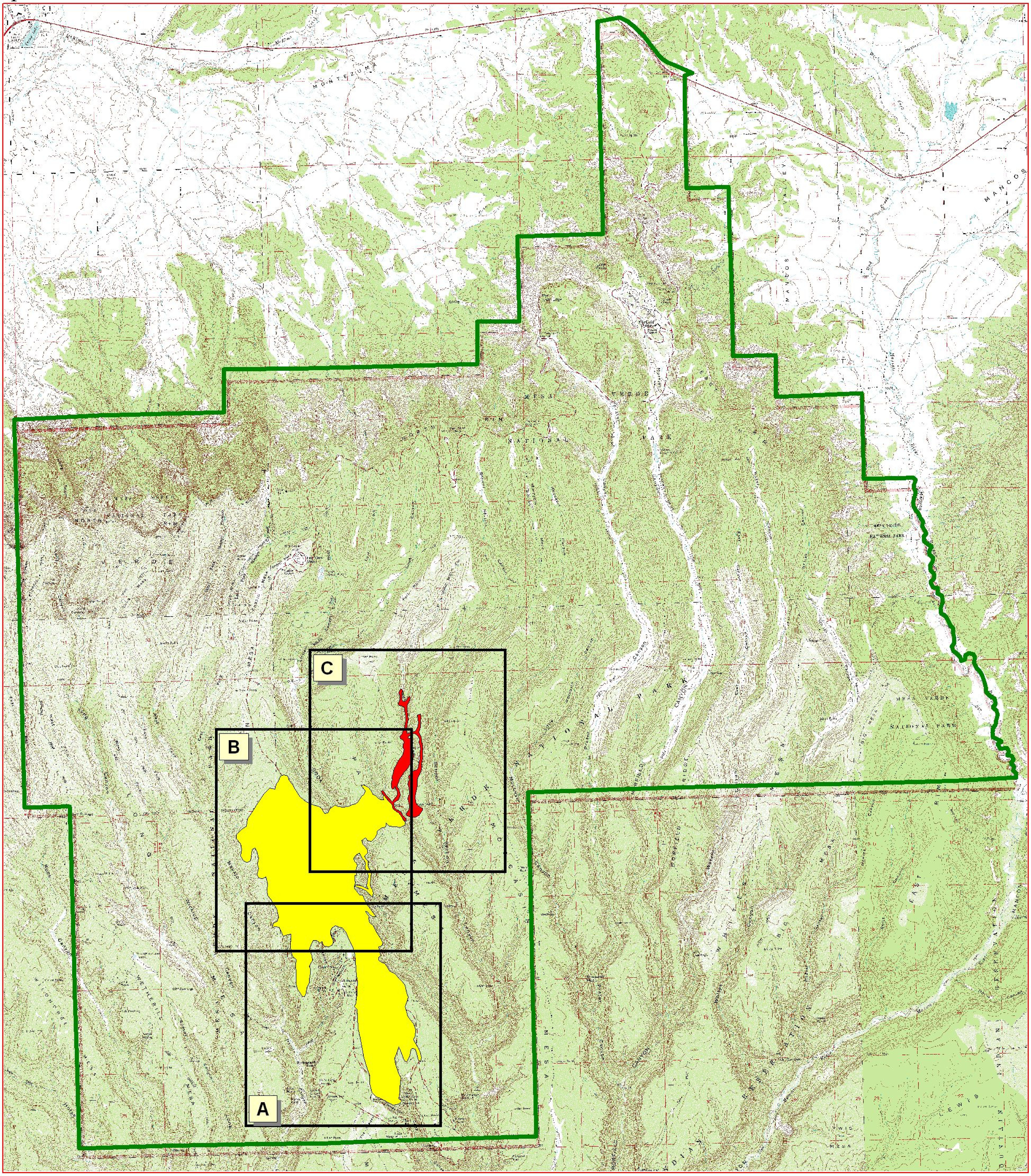
0 5000 10000 15000 Feet

1:100,000 Scale

N

Utah State University
Mesa Verde National Park
2003 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

Figure 2. Identification number and acreage of individual areas inventoried for non-native invasive plant species in Mesa Verde National Park durin 2003.



0 5000 10000 15000 Feet

1:100,000 Scale

N

Inset A - Navajo Canyon (Area 1)

Inset B - Chapin Mesa (Areas 1, 2)

Inset C - School Section Canyon (Areas 1, 2)

Park boundary

Utah State University
Mesa Verde National Park
2003 Invasive Non-Native Plant Inventory
Northern Colorado Plateau Network

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 portions of Mesa Verde National Park. Following is a summary of the weed situation within the individual inventory areas of Mesa Verde National Park.

<u>Long Mesa Burn on Chapin Mesa, Headquarters Area (Area Number 1, Inset Maps A and B)</u>

The Long Mesa wildfire occurred in the summer of 2002. By the time this inventory was conducted just 1 year later, *Carduus nutans* was the predominant plant species growing on the majority of the burned area. Other weeds that were observed and mapped in the burned area, in order of abundance, were: *Cirsium arvense, Verbascum thapsus, Alyssum incanum,* and *Cirsium vulgare*. *Alyssum incanum* was confined primarily to the road shoulder near the Park headquarters. *Cirsium arvense* was found more frequently along a small stretch of Soda Canyon up-canyon from the Painted Kiva House, although it was found in patches along Spruce Canyon and in a side drainage of Navajo Canyon. *Verbascum thapsus* and *Cirsium vulgare* were found scattered in several side drainages of Spruce Canyon and along the mesa top between Spruce Canyon and the road.
Weeds encountered least frequently were *Arctium minus, Tamarix ramosissima*, and *Centaurea repens*. Three small patches of *Tamarix ramosissima* were found in the burned area. Two 0.01-acre infestations were found in Spruce Canyon, and a third 0.01-acre infestation was found in a side drainage of Navajo Canyon. A single patch of *Arctium minus* was recorded in the mouth of a side drainage of Spruce Canyon. A single 0.01-acre infestation of *Centaurea repens* was found along the road shoulder past the turnoff to the Cedar Tree Tower.

Bromus tectorum, Tragopogon dubius, Chenopodium spp.*, Lactuca serriola,* and *Sisymbrium altissimum* were found throughout the inventoried area but were not mapped.

Rhus glabra was searched for throughout the burned area (at the request of Marilyn Colyer) because it is considered a rare native plant at this Park. Three populations of *Rhus glabra* were recorded but no size information was included with the locations. As stated earlier, the information on *Rhus glabra* locations was provided to the Park, but is not included in this report.

Visibility in the burned area was usually good, and crews were confident of finding at least 90 percent of all 0.01-acre infestations of all targeted species within the inventoried areas. Crew members were often able to spread as much as 50-75 yards apart and still inventory the areas thoroughly. However, they did not remember to change the between-feature points in the setup menu of the GPS units to reflect this. Therefore, it may appear that the distance between their inventory transects were too wide, when they actually covered the area adequately. On a few days there were not enough GPS units for everyone, so the volunteers walked transects between the crew members and alerted them when weeds needed to be mapped. Between-feature positions are also missing whenever the GPS units malfunctioned.

The recent fire was the most obvious disturbance occurring in the inventory unit. Other disturbances include the annual flooding of the canyon bottoms and the constant disturbance from vehicles along the road. The inventoried area was assigned an ecological status level four due to the large abundance of *Carduus nutans* and the heavy disturbance from the fire.

Burn in West Fork of School Section Canyon (Area Number 2, Inset Map A)

This inventory unit includes a portion of the West Fork of the School Section Canyon as well as the mesa top between the West Fork and East Fork of School Section Canyon. *Carduus nutans* was again the predominant plant species growing on the mesa top and along the West Fork. Large patches between 0.5 to 2.5 acres were recorded consistently in the West Fork of School Section Canyon as well as along the mesa above. *Cirsium arvense* was also found in the upper portion of the West Fork. Smaller patches of *Cirsium arvense* were found on the mesa top. Two 0.01-acre infestations of *Verbascum thapsus* were also found in the West Fork.

Although not mapped, the crew noted the presence of *Bromus tectorum, Salsola kali, Tragopogon dubius,* and *Chenopodium spp.* in the inventory area. Visibility in the burned area was usually good, and crews were confident of finding at least 90 percent of all 0.01-acre infestations of all targeted species within the inventoried areas. Again fire appeared to be the factor causing the most disturbance. However, the crew also noted obvious disturbance from wild horses in the East Fork section of School Section Canyon within the burned area. The inventoried area was assigned an ecological status level 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 Mesa Verde National Park. It is anticipated that the information obtained from this inventory will be useful in the Park's ongoing efforts to improve strategic planning and to increase the efficiency and effectiveness of all field operations associated with invasive plant management.

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

Regularly scheduled weed inventories of all managed lands should be an ongoing part of any weed management plan 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 Mesa Verde National Park to inventory a portion of their land each year, so that within a reasonable number of years all of the Park could be inspected. The key is to schedule inventories often enough to detect all new weed infestations before they exceed a size considered feasible for eradication. Early detection of invasive weeds through regular searches and mapping is just as essential to successful weed management as the early detection of wildfires is to effective fire management.

Tied to an ongoing inventory effort, Mesa Verde National Park 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, Mesa Verde National Park is encouraged to become an active member of a local Cooperative Weed Management Area. Weed management goals can be achieved more effectively when managed in cooperation with partner organizations also trying to achieve the same goals. The following excerpt taken from the National Park Service's own 2002 publication "Inventory and Monitoring for Invasive Plants Guidelines" further emphasizes the importance of this concept, particularly as it relates to invasive weed inventories:

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

Dinosaur National Monument is currently a member of a Cooperative Weed Management Area, as are some other NCPN Parks. If interested in more information and advice, we suggest contacting Tamara Naumann, Park Botanist at DINO.

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

Applying this strategy to Mesa Verde National Park would mean that species such as *Alyssum incanum, Arctium minus, Centaurea repens, Cirsium arvense, Cirsium vulgare, Convolvulus arvensis, Tamarix ramosissima,* and *Verbascum thapsus* should be the highest control priority of the species mapped, and should be targeted for prompt Park-wide eradication. Infestations of *Convolvulus arvensis*, *Centaurea repens*, and *Arctium minus* were especially small (0.01 acres) and often consisted of a single patch. *Carduus nutans* fits best into the second priority category of "contain and reduce" in some portions of the Park, but also a candidate for eradication in other areas. It is likely that *C. nutans* occurs in other portions of the Park not included in this inventory in much smaller concentrations. Those patches should be identified and eradicated if possible. Infestations were also much less dense and less frequent along the West Fork of School Section Canyon. These areas should also be targeted for eradication.

On September 20, 2004, Dr. Steve Dewey and Kim Andersen of Utah State University met with Pam Benjamin, George San Miguel, the Park Superintendent, and other NPS personnel at Mesa Verde to tour the Park and discuss weed management progress. It was noted that, although the biological control agent *Rhinocyllus conicus* is widespread throughout much of the West, none could be found infesting *Carduus nutans* within the Park. It is our understanding that current policies or regulations prohibit new intentional introductions of *Rhinocyllus conicus* onto NPS lands. If not for the ban, it would be our suggestion that the Park consider distributing this weevil into some of the most severely infested areas, such as inside the Long Mesa Burn site on Chapin Mesa. The risk to native thistles posed by uncontrolled *Carduus nutans* populations appears to us to be much greater and more certain than the risk associated with potential damage to natives by *Rhinocyllus conicus*.

The Park will likely need additional inventory information before deciding in which management category to place *Bromus tectorum, Salsola kali, Lactuca serriola, Sisymbrium, altissimum, Tragopogon dubius*, and *Chenopodium* spp. These non-native species appeared scattered throughout the two burn sites, but the assessment is based on an incomplete survey rather than a full inventory of these species. If further study reveals that these species are truly relatively scarce in the Park, we suggest that they be targeted for eradication, even though they were not originally considered high-priority species.

The second objective of this project was to identify potential sources of weed introduction and significant vectors involved in weed spread in the Park. Humans are the most likely vectors for new introductions of invasive plant species into Mesa Verde National Park and all other Parks of the Northern and Southern Colorado Plateau Networks, 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 and Southern Colorado Plateau region, and over 400,000 per year visit Mesa Verde National Park. Every person potentially brings with them errant seeds of an exotic invasive plant lodged in the tread of a tire or hidden in the dried mud of a hiking boot. The ever-increasing number of visitors, combined with the distant and diverse geographical areas from which they come, all combine to make National Parks highly and uniquely vulnerable to exotic plant invasions. Frequent inspection of high-visitation sites within each Park is essential to the “early detection and rapid response” strategy of invasive plant management. Roadways, parking areas, visitor centers, picnic sites, campgrounds, view points, trails, and all other high-visitation sites should be searched regularly (at least yearly) at a time when new plants would be visible. Park visitors should be informed of the potential damage caused by invasive plants, and ways they can help minimize the chances of introduction and spread. This might be done in the form of written information distributed at the Park's Visitor Center, through displays or a video program, and evening fireside presentations to visitors made by NPS personnel.

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

Natural vectors such as wind, water, and wildlife do play a role in weed seed dissemination within the National Parks, and cannot be overlooked. However, they probably play a much less significant role overall, compared to human-related vectors. Control of isolated new weed infestations at the heads of otherwise non-infested drainages could prevent rapid spread associated with flowing streams or flash flood events. Traditional annual migration routes of deer, elk, 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 Mesa Verde National Park, 90.2percent 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 MEVE 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 twenty-three targeted species of great concern to the region (Appendix K).

An important new trend in weed management is the concept of identifying areas that are currently free of one or more species of invasive plants, and officially designating them as “Weed Prevention Areas” (WPA). Land units designated as WPA's are given a higher priority for prevention efforts, early detection, and rapid control (eradication) of any new invaders. In our opinion, all areas within Mesa Verde National Park that are currently "clean" should be identified as WPAs, and Park management should take all appropriate measures to keep invasives from spreading into them. Protecting and preserving lands in this weed-free condition is much more cost-effective than restoring extensive areas already badly infested by invasives, and therefore should be the highest weed management priority for the all Parks in the Northern and Southern Colorado Plateau Networks. 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 could help to justify increased budgets for prevention practices. Increasing the number of weed-free acres in a Park should be recognized as a highly significant accomplishment, and 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 Mesa Verde National Park.

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 MEVE 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 Mesa Verde National Park.

NPS-2003
Inventory of invasive weeds in SCPN

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) Menu, Required, Normal, % weed cover in typical infestations
Trace: < 1 %
Low: 1 to 5 %
Mod: 6 to 25 %
High: 26 to 50 %
Majority: 51 to 100 %

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 <u>pt-weed</u>.

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 <u>pt-weed</u>.

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 Mesa Verde National Park.

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

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

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

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

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

System / Setup

Configurations

Data

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

GPS

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

Real Time

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

Coordinates

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

Units

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

Formats

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

Appendix D . GPS Settings using in 2003 Invasive Non-native Plant Inventory in Mesa Verde National Park. (cont)

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

Data Dictionaries

(Select NCPN-04)

Feature Settings

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

About

(Nothing to set here)

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

Appendix E. Photograph and list of equipment used in 2003 Invasive Non-Native Plant Inventory in Mesa Verde National Park.

Equipment

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

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

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

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

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

Appendix G. Project Photographs of Weed Species and Rare Plants Detected, Inventoried Landscapes, and Crew Working in Mesa Verde National Park During the 2003 Invasive Non-native Plant Inventory.

Weeds Detected

Figure 1. A mixed stand of *Carduus nutans* and asters on Chapin Mesa in the Long Mesa Burn, (MEVE PR-03).

Figure 2. *Carduus nutans* spread throughout the landscape of the Long Mesa Burn on Chapin Mesa, (MEVE PR-12).

Figure 3. *Carduus nutans* in the Long Mesa Burn on Chapin Mesa (MEVE PR-11).

Figure 4. Senesced *Carduus nutans* in the Long Mesa Burn area on Chapin Mesa a year after the inventory and two years after the fire.

Weeds Detected

Figure 5. *Cirsium vulgare*, found in the Long Mesa Burn area on Chapin Mesa, (MEVE PR-07).

Figure 6. *Cirsium vulgare* mixed with asters on Chapin Mesa a year after the Long Mesa Fire, (MEVE PR-08).

Figure 7. *Cirsium arvense* in the Long Mesa Burn area on Chapin Mesa, (MEVE PR-09).

Figure 8. Area infested with *Cirsium arvense* on Chapin Mesa, (MEVE PR-10).

Weeds Detected

Figure 9. *Alyssum incanum* found near the Resource Management Building on Chapin Mesa, (MEVE PR-05).

Figure 10. Heather Rickleff mapping *Alyssum incanum* in the Long Mesa Burn area near the Resource Manage-ment Building, (MEVE PR-06).

Figure 11. Large infestations of *Chenopodium* spp. in the Long Mesa Burn area on Chapin Mesa, (MEVE PR-04).

Figure 12. *Chenopodium* spp. on Chapin Mesa, (MEVE PR-04).

Weeds and Rare Plants Detected

Figure 13. *Verbascum thapsus* found on Chapin Mesa in the Long Mesa Burn area, (MEVE PR-13).

Figure 14. *Verbascum thapsus* on the side of a drainage on Chapin Mesa, (MEVE PR-14).

Figure 15. *Verbascum thapsus* in the West Fork of School Section Canyon, (MEVE PR-18).

Figure 16. The rare plant *Rhus glabra* in the Long Mesa Burn on Chapin Mesa, (MEVE PR-15).

Mesa Verde Landscapes

Figure 17. Inventoried areas on Chapin Mesa within the boundaries of the Long Mesa Burn, (MEVE PR-01).

Figure 18. Inventoried site in the West Fork of School Section Canyon, (MEVE PR-16).

Figure 19. Looking downstream in the West Fork of School Section Canyon, (MEVE PR-19)

Figure 20. Looking upstream in the West Fork of School Section Canyon, (MEVE PR-18).

Crew

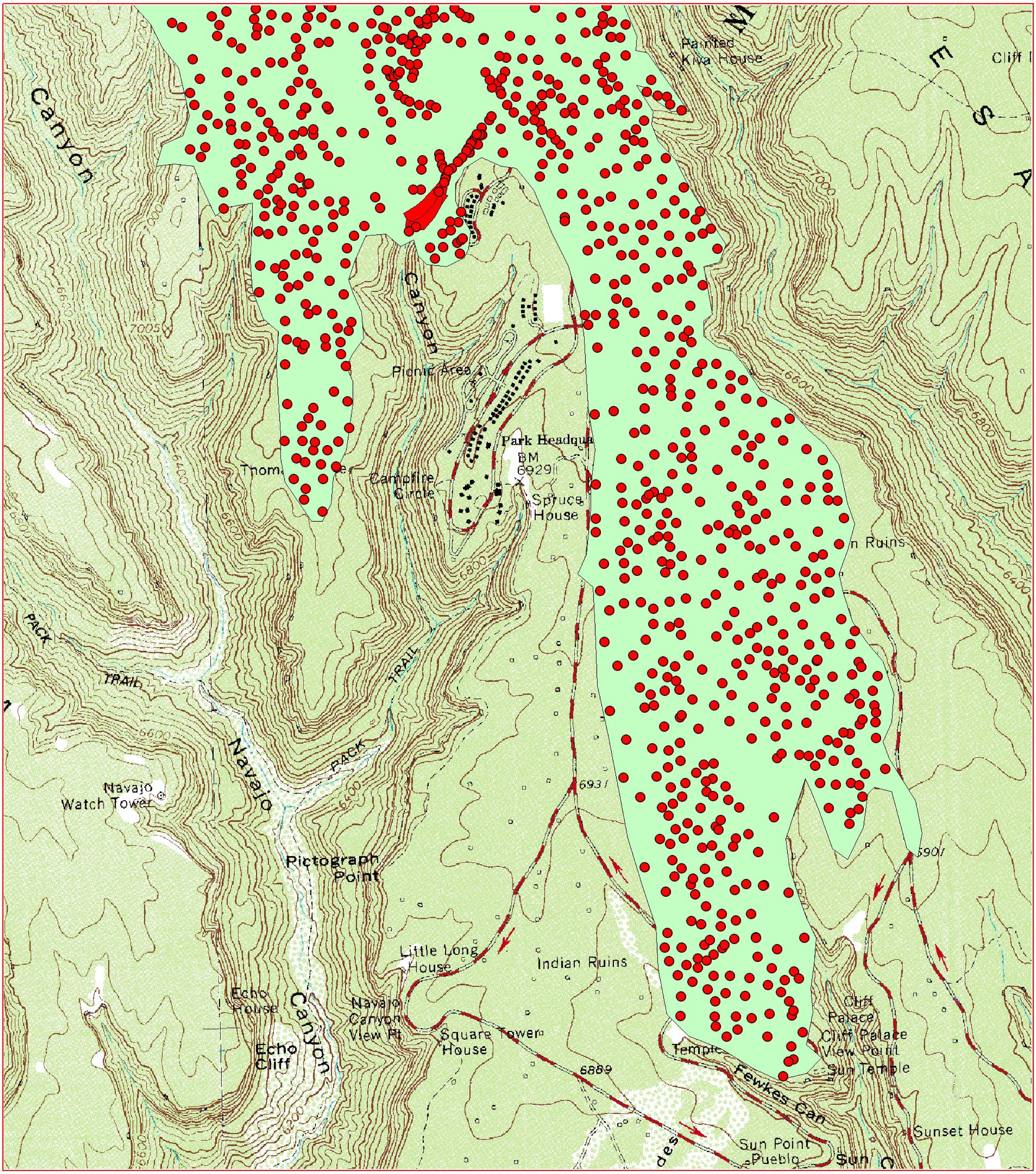
Figure 21. Heather Rickleff in the West Fork of School Section Canyon.

Figure 22. Liz Ballenger in the West Fork of School Section Canyon.

Figure 23. Liz Ballenger mapping C*arduus nutans* on Chapin Mesa in the Long Mesa Burn.

Figure 24. Liz Ballenger and Christine Craig planning at the Resource Office in MEVE.

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



0 1000 2000 3000 Feet

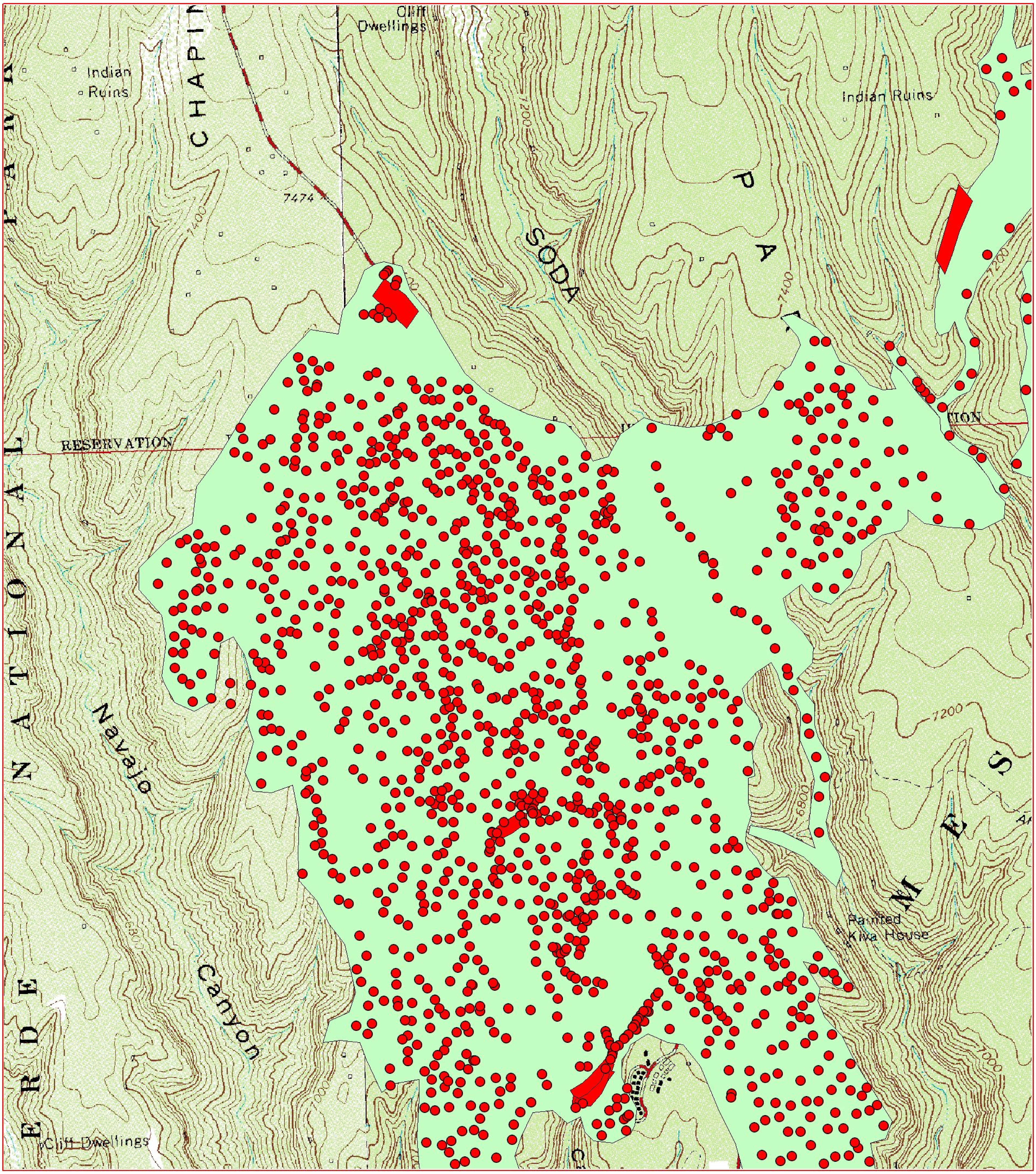
1:20,000 Scale

N

- Weed Points
- Weed Areas (gross)
- Areas Inventoried (2003)
- Park boundary

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

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



Weed Points

Weed Areas (gross)

Areas Inventoried (2003)

0 1000 2000 3000 Feet

1:20,000 Scale

N

Inset B
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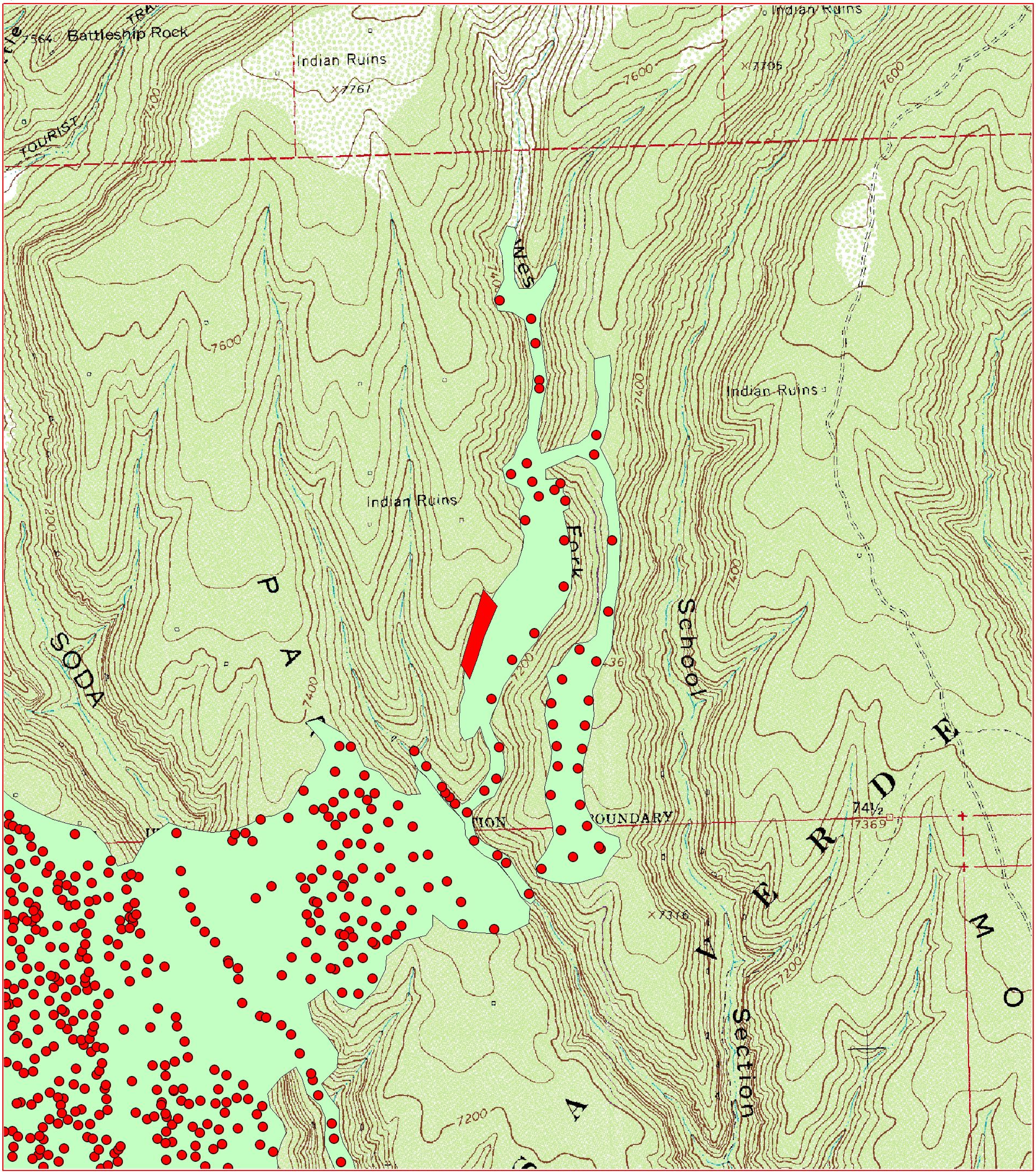
Appendix H. Overall Weed Distribution in Inventoried Areas - School Section Canyon (Inset C)



Weed Points

Weed Areas (gross)

Areas Inventoried (2003)

0 1000 2000 3000 Feet

1:20,000 Scale

N

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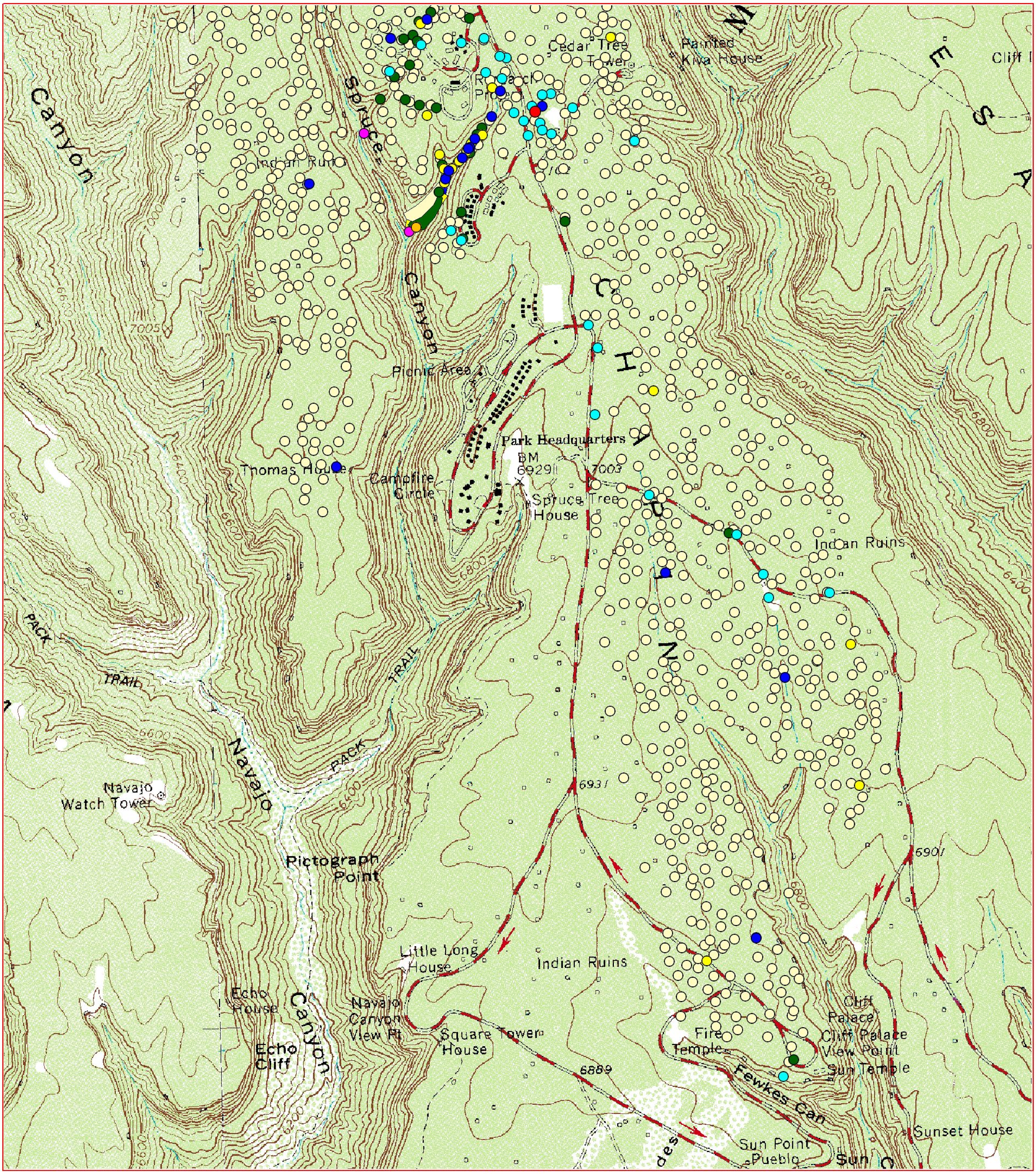
Appendix I. Weed Species Detected in Inventoried Areas - Navajo Canyon (Inset A)



Arctium minus
Alyssum incanum
Carduus nutans
Centaurea repens
Cirsium arvense
Cirsium vulgare
Tamarix ramosissima
Verbascum thapsus
Weed Areas (gross)
Carduus nutans
Cirsium arvense
Cirsium vulgare
Verbascum thapsus

0 1000 2000 3000 Feet

1:20,000 Scale

N

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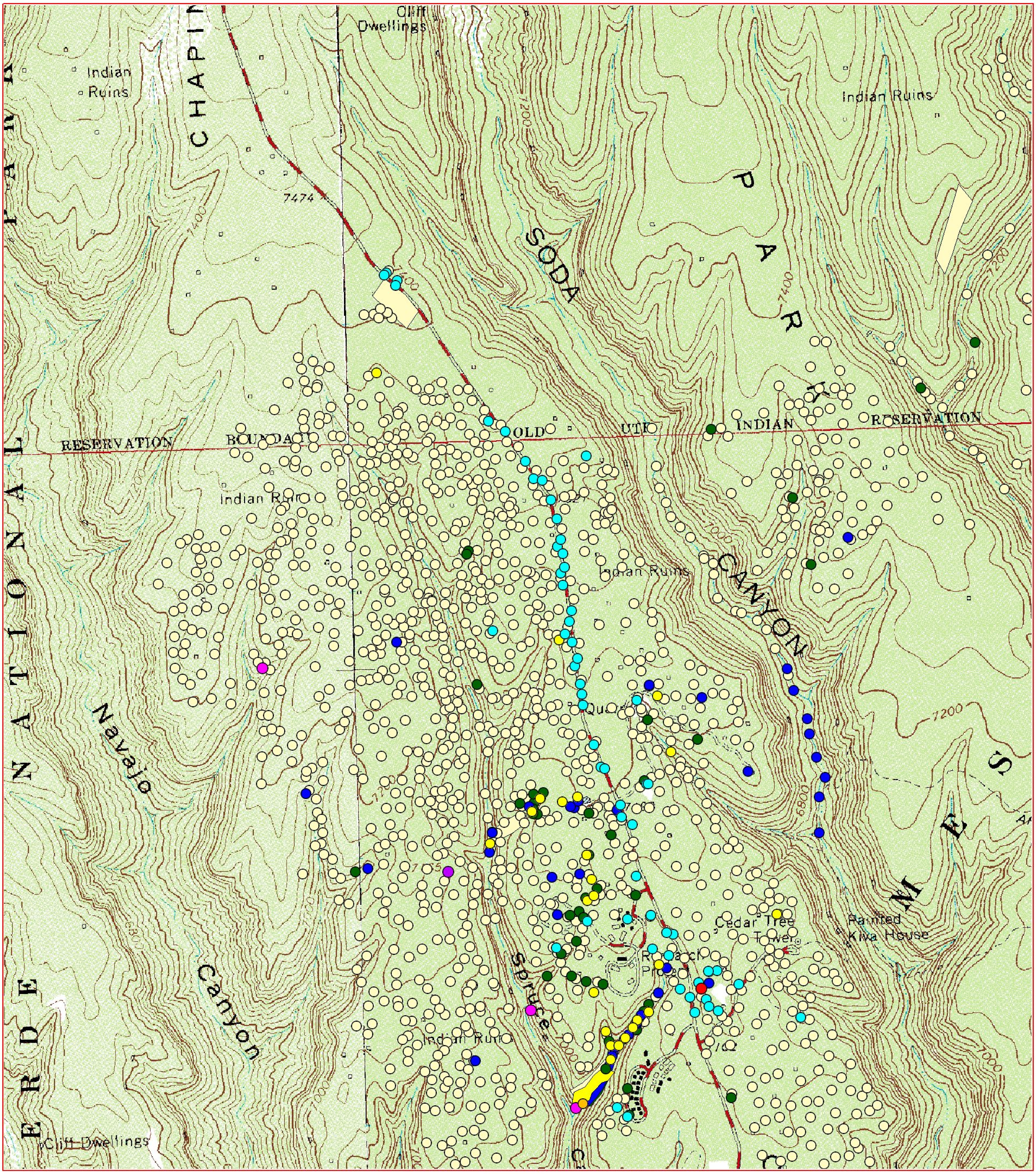
Appendix I. Weed Species Detected in Inventoried Areas - Chapin Mesa (Inset B)



- *Alyssum incanum*
- *Arctium minus*
- *Carduus nutans*
- *Centaurea repens*
- *Cirsium arvense*
- *Cirsium vulgare*
- *Convolvulus arvensis*
- *Tamarix ramosissima*
- *Verbascum thapsus*

Weed Areas (gross)

- *Carduus nutans*
- *Cirsium arvense*
- *Cirsium vulgare*
- *Verbascum thapsus*

0 1000 2000 3000 Feet

1:20,000 Scale

N

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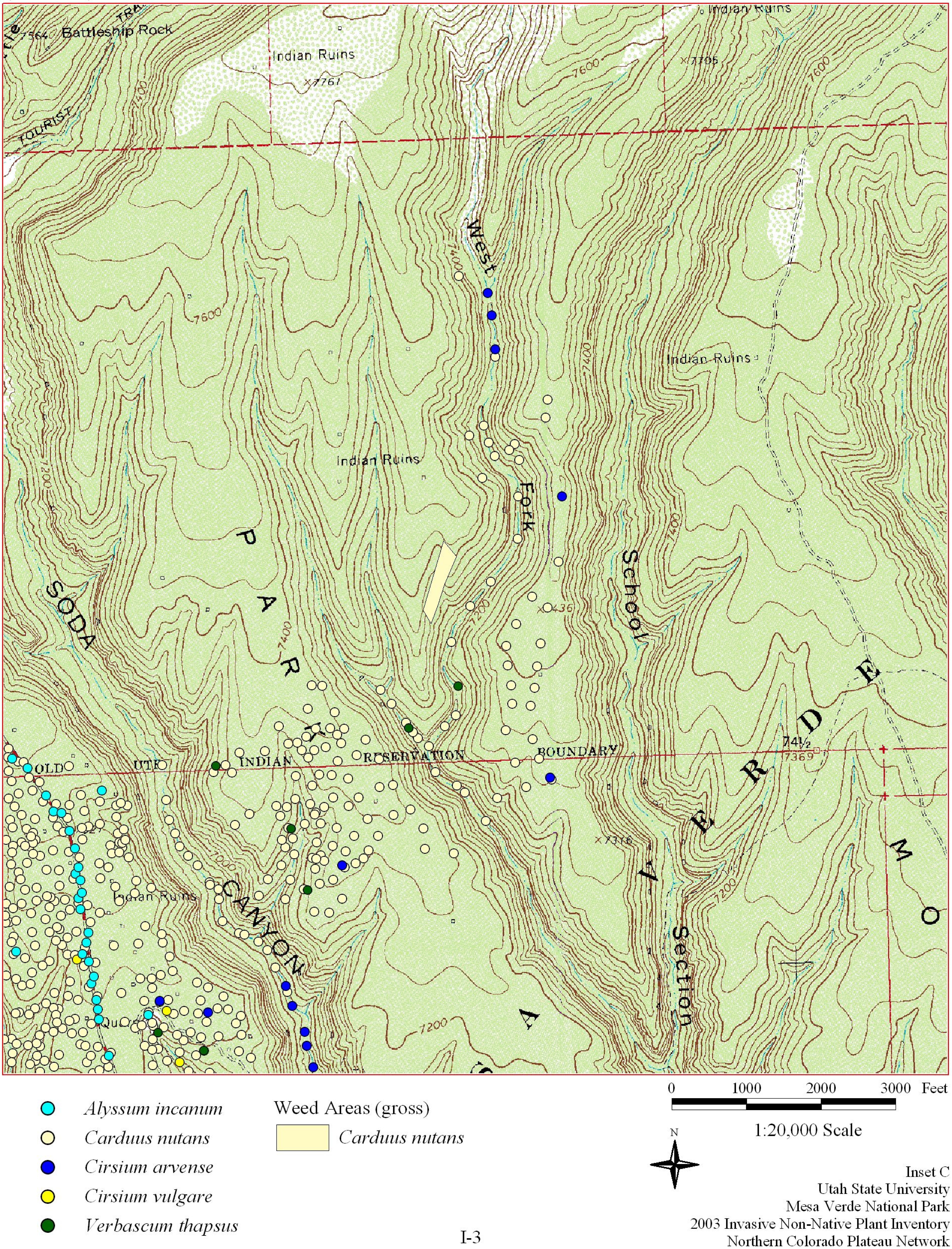
Appendix I. Weed Species Detected in Inventoried Areas - School Section Canyon (Inset C)



Inset C
Utah State University
Mesa Verde National Park
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 Mesa Verde National Park.

GPS Species	**A**	**B**	**C**	**D**	**E**	**GPS Species**	**A**	**B**	**C**	**D**	**E**
Agropyron cristatum					X	*Lepidium latifolium*				X	
Ailanthus altissima				X		*Linaria dalmatica*				X	
Alhagi pseudalhagi				X		*Linaria 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					*Alyssum incanum*	X				
Conium maculatum				X		*Lactuca serriola*			X		
Convolvulus arvensis	X					*Sisymbrium altissimum*			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