

2003-2004 Invasive Non-Native Plant Inventory

**Conducted in Portions of Arches, Canyonlands, Hovenweep, Natural Bridges,
Black Canyon of the Gunnison, and Zion National Parks within the Northern
Colorado Plateau Network of the National Park Service**

2003 Annual Progress Report

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Section 1: Introduction, Methods, Results Summary, and Appendices

I. Introduction

Utah State University completed its first year of a 2-year project to inventory and map invasive species for the Northern Colorado Plateau Network in the summer of 2003. The project included Arches National Park (ARCH), Black Canyon of the Gunnison National Monument (BLCA), Canyonlands National Park (CANY), Hovenweep National Monument (HOVE), Natural Bridges National Park (NABR), and Zion National Park (ZION). The survey crew was comprised of six members from Utah State University. They were joined by two members from the National Park Service weed mapping crew in the months of June and July.

II. Background and Justification:

Invasive, nonnative plants represent the greatest collective threat to the natural (and cultural resources) in parks throughout the National Park System. Throughout the Intermountain West, invasive plants distinctly jeopardize the integrity of natural ecosystems. Threats to biological diversity through the displacement of native plant and wildlife species and subsequent changes to natural processes, such as alterations to fire frequency and intensity and natural hydrological conditions, are risking significant impairment to park resources.

The management and control of invasive non-native species has been identified as a high priority issue within the National Park Service (NPS) and is specifically, under the Government Performance and Results Act of 1993, identified as an accountable goal for all national park units. Executive Order 13112 signed on February 3, 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 (1999). The Natural Resource Challenge specifically states, "Identifying, mapping and evaluating nonnative species are critical for effective management". Similarly, the development of the Exotic Plant Management Team (EPMT) initiative has further confirmed the dedication of the NPS to the management and control of invasive plant species. However, the EPMT program has a primary funding focus on the actual treatment and control of weed infestations and has not been established as a funding source for the actual inventory and mapping of invasive weed populations. Although the Natural Resources Challenge identifies the need for obtaining "accurate data about nonnative species distributions" as critical to meeting the goal of effective and efficient management, a specific funding source to accomplish this goal was not identified.

To meet this need, in 2001, the Intermountain Region Support Office in Denver took on the task of preparing a Natural Resource Preservation Program (NRPP) proposal to secure funding to conduct invasive plant mapping in high priority areas of parks throughout the Intermountain Region (NPS 2001). The project was selected for funding by the NPS Washington Office, with Northern Colorado Plateau Network (NCPN) parks scheduled for inventory in FY 2003 and FY2004. NCPN took the lead of coordinating this project and added network funding to increase the scope of work.

In this project Utah State University supplied a 5- to 6-person field crew, which traveled to and mapped invasive plants in specified portions of six NCPN parks (ARCH, BLCA, CANY, HOVE, NABR, and ZION) during FY 2003. NCPN complemented the USU effort by hiring two additional field crews which were stationed at CARE and CANY during the 2003 field season. USU conducted initial field-based training for the NPS crews, and is also providing data management support for the data collected by NPS crews. Data collected by the NPS crews working in ARCH and CANY are included in this report.

III. Objectives

The overall objective of this project was to document distribution and abundance of targeted invasive non-native plant species across the range of habitats represented in the designated areas of the 6 parks, providing park weed management specialists with information essential to the development and implementation of effective vegetation control strategies. Park natural resource staff and the NCPN Vegetation Ecologist worked closely with the USU to provide existing information and advice that was helpful in planning field surveys 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.

IV. Methods

Approximately 10,000 acres were identified as priority units in 6 National Parks or Monuments within the Northern Colorado Plateau Network. The projected schedule included approximately 4500 acres for survey and inventory in 2003, with the remaining acres to be completed in 2004 (Table 2 A-B). Survey areas were identified in the Intermountain Support Office Project Proposal and Implementation Plan (NPS 2002). Surveys targeted the most likely invasive plant habitat, with priority given to areas most likely to be impacted by park development and visitor use activities. Specific survey requests received from each park include:

Arches NP (ARCH), Canyonlands NP (CANY), Hovenweep NM (HOVE), and Natural Bridges NM (NABR) – Map priority canyon bottoms, riparian zones, and roadsides. Weed distributions, especially in riparian areas, were identified as extremely high priority needs for planning efforts in both prototype monitoring and network vital signs monitoring.

Black Canyon of the Gunnison NP (BLCA) – Map the inner canyon river corridor. BLCA has filed a claim for a federal reserved water right in Colorado Water Court (January, 2001). Knowledge of information on weed issues within the inner canyon is needed to determine the relationship of weed species and proposed new flow regimes. The project will be used to augment on-going and planned BLM activities to inventory, map and manage weed species within the Gunnison Gorge NCA.

Zion NP (ZION) – Map priority riparian habitats, high visitation zones, and areas with fire and past land use disturbances. Inventory and mapping will enhance the park's effectiveness in addressing non-native plant issues as well as augment already documented weed distributions in the park.

Basic field survey, mapping, and data processing procedures used by Utah State University are summarized below. Additional details can be found in Appendix Table A. These methods meet the minimum mapping standards established by NAWMA and most of the core elements contained in the NPS Intermountain Region Weed Mapping Guidelines (Benjamin 2001). Appendix B provides a table indicating 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.

Weed mapping was performed by the USU crew using Trimble GeoExplorer 3 global positioning system (GPS) units with 2 to 5-meter accuracy. NPS crews used GeoExplorer XM GPS units with 2 to 5-meter accuracy. Field locations were determined as UTM coordinates, which were differentially corrected in the production of final digital products. The crews recorded invasive plant occurrence data on hard copy (USGS 7.5' topographical maps) in any case where GPS satellite reception failed or in case of equipment malfunction. All data from field maps were converted to digital format.

Invasive plant infestations 1 acre or less in size were typically recorded as point features. Infestations between 1 and 5 acres were usually recorded as areas, gross-areas, or line features in the field. Some area or line features were converted to point features to facilitate viewing on maps.

The size of each infestation recorded as a point feature was estimated visually (using a laser rangefinder) and placed in the size category most closely matched to its actual area: 1) 0.01 acre, 2) 0.1 acre, 3) 0.25 acre, 4) 0.5 acre, 5) 1 acre, 6) 2.5 acres, or 7) 5 acres. Canopy cover of all infestations was estimated visually and placed in categories of: 1) trace = less than 1 percent, 2) low = 1 to 5 percent, 3) moderate = 6 to 25 percent, and 4) high = 26 to 50, or majority = 51 to 100 percent.

Points of interest were also collected throughout the survey. These points denoted additional information not specifically weed-related. These points include springs, seeps, and archeological finds. They were also used to mark the edges of widespread infestations and later converted to polygons. Points of interest were collected at the discretion of the individual surveyor.

Mapping activities were conducted at as fine a scale as required to achieve 90 percent or greater confidence that all invasive plant infestations (0.01 acre or larger) within each survey area were detected. The term “effective detection swath width” is used to describe the maximum width of a visual search pattern in which a walking surveyor is confident of detecting at least 90 percent of all target species of the minimum specified infestation detection size. When surveying areas wider than a single swath width, multiple parallel passes of a lone surveyor (or multiple surveyors walking parallel transects or contours) were searched as contiguous or slightly overlapping strips to avoid coverage gaps.

The width of survey swaths required to obtain at least a 90 percent infestation detection confidence level was determined and adjusted as needed by each surveyor based on variations in terrain, walking speed, associated vegetation, and target species. In heavy cover and/or for very

difficult-to-see species this may have required slowly walking detection swath widths as narrow as 25 yards or less. In very open terrain and/or for highly visible species such as saltcedar, effective swath widths could have been greater than 100 yards.

At the end of each day field crews marked and dated surveyed areas on USGS 7.5' topographic maps to assist in determining thoroughness of coverage. Daily survey routes of each crew member were recorded and mapped using the “between feature” position tracking option of the GeoExplorer GPS units. The interval for collecting “between-feature” positions was adjusted to correspond to the average effective detection swath width for each area surveyed. Data dictionary categories for swath width were 25, 50, 100, 150, 200, 250, and 300 yards.

Survey team members systematically searched for high priority invasive plants requested by the individual parks. Any other new non-native species recognized as potentially invasive on wildlands in the West were noted if found. Target invasive non-native plant species for each park were determined in consultation with park botanists and other knowledgeable sources. A total of 35 species were included on the various target lists of the 6 Parks Table 1. Field crews planned survey dates and routes to maximize chances of encountering the target species.

The initial project budget and schedule were based on the assumption that an average of 50 acres per day could be surveyed by a crew of 3 people in the rugged terrain of the specified parks. This estimate included daily travel time, daily downloading of data from GPS to computer, and daily review and verification of field data for accuracy and completeness. Because of the advanced experience and skill level of this particular crew, as well as an increase in the USU crew size to as many as 6 individuals, it was possible to survey considerably more acres per day than anticipated. The combined average for USU and NPS crews in the 6 parks was 95 acres surveyed per person per day (Tables 4 A-G).

Table 1. List of invasive plant species targeted in each of the 6 parks surveyed in 2003.

	ARCH	BLCA	CANY	HOVE	NABR	ZION
Alhagi pseudalhagi	X					X
Alianthus altissima						X
Anthemis sp.		X				
Arctium minus		X				
Arundo donax						X
Brassica tournefortii						X
Bromus tectorum		X				
Cardaria draba		X				X
Carduus nutans	X	X	X	X	X	X
Centaurea diffusa	X	X	X	X	X	X
Centaurea maculosa	X	X	X	X	X	X
Centaurea repens	X	X	X	X	X	X
Centaurea solstitialis						X
Centaurea virgata v. squarrosa						X
Cirsium arvense	X	X	X	X	X	X
Cirsium vulgare		X				X
Convolvulus arvensis		X			X	X
Cynodon dactylon						
Cynoglossum officinale		X				
Elaeagnus angustifolia	X	X	X	X	X	X
Elytrigia repens						
Euphorbia esula		X				X
Hyoscyamus niger		X				
Isatis tinctoria						
Iva xanthifolia		X				
Lepidium latifolium	X	X	X			X
Linaria dalmatica		X				X
Linaria vulgare		X				X
Lythrum salicaria						X
Marrubium vulgare				X	X	
Onopordum acanthium	X	X	X	X	X	X
Rubus discolor						X
Rumex crispus		X				
Salsola kali						X
Sorghum halepense	X					X
Taeniatherum caput-medusae						
Tamarix ramosissima	X	X	X	X	X	X
Tribulus terrestris						X
Ulmus pumila	X	X	X	X	X	
Verbascum thapsus		X				X

Potential habitat within each section was reviewed prior to planning each day's travel route by studying aerial photographs, and/or topographic maps. Field crew members then walked the planned survey route, spending more time in priority areas and areas of concentrated invasive plant habitat. Planned survey routes also included areas of likely weed seed introduction and other areas identified as significant known or potential source or vector areas. The park natural resource staff provided assistance in identifying important areas to include.

At the end of each day data were downloaded from GPS units onto a laptop computer using Pathfinder Office GIS software. Edits (such as eliminating 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) was 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 the rover files directly transferred from the GPS units. They were named by using a 6-digit code (month-day-hour) preceded by a single letter (corresponding to the first letter in the surveyor's last name), and ending in ".ssf." For example, "A051913.ssf" would be the file name for raw GPS data collected by Kim Andersen beginning in the thirteenth hour (24-hr local time) on May 19. No changes were made to this data after it was downloaded onto the computer.

Edited data 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 surveyors finding the same infestation), and to add locations drawn on field maps (as for when satellite signals could not be obtained). Any added locations were noted as "hand mapped" in the notes section. Notes were sometimes expanded. Gross area features 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 surveyor's last name. If a surveyor collected more than one file for that day, a number would follow the surveyor identification letter. For example: May19-A2.ssf

Next, the data from edited GPS rover files were differentially corrected. Features that were added or deleted in the editing process were not differentially corrected; nor were points for which corresponding base station data were not available. Generally, the closest base station to the survey area was used. However, if use of a 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 have the file extension ".cor." Example: May19-A2.cor

Shapefiles were created from exported data by sending the differentially corrected files from Pathfinder Office into ArcView. ArcView created shapefiles 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

At the end of the field season, the project crew leader again reviewed the data to ensure all were accounted for and present. The field notebook and maps served to ensure that all species were included in the data set and survey areas were complete. The data were then exported from Pathfinder Office into ArcView for data analysis and map making. Additional data fields were added to comply with the task agreement. These fields include species code, species scientific name, country, state, county, and life form. Record numbers were assigned to each data entry that includes a unique number and the four-letter park. The data were also checked for any duplication in entries. Any gaps in the sequence of record numbers are due primarily to elimination of duplicated entries.

Polygons of surveyed areas were created using the between-feature positions collected during each surveyor’s daily route. Information provided for each survey area polygon included dates of the inventory, the persons involved, the names of the areas inventoried, and the size of the survey area. Each polygon was also assigned a detection confidence level indicating the surveyor’s perceived ability to detect 0.01-acre patches of targeted weed species based on the vegetation types and the terrain. The detection confidence was broken into three categories, low (0-25%), medium (25-50%), and high (50-100%). Each polygon was also assigned an ecological status representing the overall level of weed infestation within that surveyed area. This is intended to help managers predict a site’s ability to recover to its natural state when the weeds are removed. The crew leader assigned this number based on crew field notes and a personal on-site impression of the area.

Polygons of extensive weed infestations were sometimes created in the office from a series of GPS points taken in the field. This was done by collecting GPS “Points of Interest” at key locations along the boundary of an infestation, and then using those points to later draw the polygon on the computer.

The shapefiles were used to create maps using ArcView software. Maps were produced at various scales to provide land managers with as much visual information as possible. Large-scale maps were created to show the overall level of infestations in each park as well as identifying the greatest problem areas for each park. Smaller scale maps were created to show individual species occurrences as well as provide detailed maps of early-stage invaders. Point infestations were shown to scale on each single-species map to reflect the true size of the infestation. Record numbers were also included on some maps to help direct the reader to the appropriate data table to facilitate rapid control of early-stage invaders. Individual maps were exported and saved as .jpeg files. The data tables were exported and saved as Microsoft Excel spreadsheets. It was decided that the Northern Colorado Plateau Network would prepare Metadata for the 2003 progress reports and Utah State University would provide metadata for the final reports for 2003-2004.

V. Crew Qualifications and Project Quality Assurance

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

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

Kim Andersen (crew leader) and Melanie Ballard (assistant crew leader) have considerable experience working on the USU crew in past years. Kim has a Bachelor of Science degree in Fisheries and Wildlife from the College of Natural Resources, and 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 BS degree from USU in Environmental Studies. Eric Lamalfa and Ruth Richards are upper division students at USU in the Plant Science department.

All USU weed survey crew members were required to pass a written exam in weed identification and mapping skills before being hired. Each also had passed an upper-division university course in weed identification, biology, and management, and/or has extensive practical experience in wildland plant identification. Once hired, USU and NPS crew members also attended a 3-week classroom and outdoor training course in late April and early May in wildland weed mapping techniques taught by Dr. Dewey at Logan and Zion National Park. Crew members were provided with weed identification field guide book, taxonomic keys, and pressed reference specimens of all targeted weeds. During the course of the summer USU crew members were quizzed periodically with fresh plant specimens provided by the crew leader and/or Dr. Dewey. Dr. Dewey also spent several days in the parks working with individual crew members under field conditions. To further authenticate findings, Dr. Dewey and/or the crew leader re-visited representative areas in each park that had been previously mapped by the USU crew, using the most recent crew-generated weed infestation maps to compare them against their own field observations.

VI. Project Schedule

Table 2A. The Projected 2003 Schedule of Field Work (USU crew – 22 weeks)

Location	Description	Acres to Survey	Dates
Logan	USU Crew and NPS Crew-Leader Training		April 21 – May 2 (2 weeks)
ZION	NPS Crew Training		May 5-9
	Map high visitation areas	75	May 11 – May 30 (3 weeks)
	Map high priority areas of fire and past land use disturbance areas	1000	
ARCH	Map “Salt Wash” from the Colorado River north to park boundary	1000	Jun 2 – Jun 27 (4 weeks)
CANY	Map Salt Creek: lower half of Cathedral Butte to Colorado River	1200	Jun 30 – Aug1 (5 weeks)
NABR	Map major canyon bottoms and 20 linear miles of roadside	1000	Aug 4 – Aug 29 (4 weeks)
BLCA	Map inner canyon river corridor	290	Sept 1 – Sept 19 (3 weeks)

Table 2B. Projected 2004 Schedule of Field Work (USU crew – 22 weeks)

Location	Description	Acres to Survey	Dates
Logan	USU Crew and NPS Crew-Leader Training		April 19 – April 30 (2 weeks)
ZION	Map high priority riparian zones	1500	May 3 – Jun 4 (5 weeks)
ARCH	Map Courthouse Wash from the Colorado River to park boundary	680	Jun 7 – Jun 25 (3 weeks)
CANY	Map Salt Creek: upper half of Cathedral Butte to Colorado River	1300	Jun 28 – Aug 6 (5 weeks)
HOVE	Map canyon bottoms and spring sites throughout the monument	785	Aug 9 – Aug 27 (3 weeks)
BLCA	Map inner canyon river corridor	390	Aug 30 – Sept 17 (3 weeks)

VII. Other Information Gathered

Voucher Specimens

No plant voucher specimens were collected in 2003. All voucher specimens to be collected in 2004 will be processed for deposit in herbaria at USU and individual park collections. Specimens deposited at USU will be considered 'on loan' from NPS and documented in a loan agreement. All specimens will be curated and managed following NPS service-wide protocols. Specimens collected as part of this project will be affixed with National Park Service issue labels containing information on species, collector, date of collection, collection site and NPS record number. Specimen data also will be provided in electronic format.

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 each 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 follow up. The location of each photo documenting a weed infestation 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 position of the photographer, and the direction that the camera was facing is noted as a compass bearing (magnetic north reference). Additional photos were taken showing the general types of terrain and habitat encountered during the inventory. Representative photos were also taken of the crews doing inventory work in each park. The locations of general terrain and crew photographs were generally not documented with GPS points.

VIII. RESULTS

During the summer of 2003, USU field crews surveyed 23,424 acres and the NPS crew surveyed 5,436 acres for a total of 28,866 acres mapped in priority units of the designated 6 parks. The field component of this project occurred between May 12 and September 12, 2003. The two crews (USU and NPS) worked a combined total of 304 person-days (8 hour basis). The parks surveyed, weed species detected, and their relative abundance in each park are included in Table 3. The location, dates, and personnel involved in field surveys in each Park are listed in Table 4 (A-G). Occasionally targeted species were seen outside park boundaries but within relative proximity to the survey areas. These species were often recorded due to their potential to spread into park boundaries in the near future. The acreage is not included in the total presented in Table 3 but is noted within each individual park discussion.

The parks surveyed for invasive species during 2003 are relatively weed free at this time. Areas selected for inventories were locations considered most likely to contain weeds and to serve as vectors for spread, and likely represent where the majority of weeds within the park would be found. Areas were surveyed as thoroughly as possible based on the terrain and vegetative cover. Less than 11 percent of total acreage surveyed in 2003 was infested by targeted invasive species. Three of the parks surveyed were less than 2 percent infested. Parks with higher percentages were typically infested with a single widespread species that had been well established prior to this survey. For example, saltcedar (*Tamarix ramosissima*) was the primary species documented in Canyonlands National Park and accounted for 99.5 % of the total acres of weeds found. Saltcedar and Russian olive (*Elaeagnus angustifolia*) comprised 87 % of the total acres of invasive weeds found in Arches National Park. Common mullein (*Verbascum thapsus*) made up 81% of the total acres of weeds found in Zion National Park; and downy brome (*Bromus tectorum*) represented 68% of total weeds recorded in Black Canyon of the Gunnison National Park. Most infestations of the remaining species found in these and other surveyed parks were typically small in size and would be deemed early invaders. Emphasis should be placed on these small infestations, as they could be eradicated with relative ease at this early stage of invasion. Most surveyed areas still contained substantial populations of native vegetation. Most riparian areas in ARCH, CANY, BLCA, HOVE, NABR, and ZION still contained fair amounts of willows and cottonwoods. Even in the case of large dense stands of such species as saltcedar, native plants were often prevalent around the perimeter and within the outer edges of these infestations. Control of the invasives would allow for native vegetation to re-populate these areas.

A discussion of the situation in each park is presented below. A separate volume was created for each park containing maps and spreadsheets of the weeds. The first maps in each volume orient the reader to the areas surveyed within the entire park. Maps of a finer scale were produced to provide greater detail for each surveyed area. Maps of individual species were also produced, primarily to assist local land managers in relocating infestations of early-stage invaders for the purpose of eradication. Maps are arranged according to drainages within the survey area and typically follow the drainage either south or north. Individual maps are named by a prominent feature within the viewed area of the map. Metadata will be provided for the 2003 Progress Reports by the Northern Colorado Plateau Network and will be attached to these reports.

Table 3. 2003 Total Acres of Weeds Found in 6 Units of the Northern Colorado Plateau Network

Species	ARCH	BLCA	CANY	HOVE	NABR	ZION
Barley, foxtail	4.6	0	---	0	---	0
Bindweed, field	0	0.58	0.6	0.23	0	0.01
Blackberry, Himalayan	0	1.0	0	0	0	0
Brome, downy	---	36.18	---	---	---	---
Burdock	0	2.43	0.03	0.73	0	0
Chamomile	---	0	--	---	---	---
Cocklebur	1.14	---	---	---	---	0.02
Dock, curly	1.3	0	0	0	0	1.31
Elm, Siberian	0	0	0	0	0	0
Halogeton	14.76	0	0.83	0	0	0
Henbane, black	0	0	0	0	0	0
Horehound	0	0.01	0	0.77	0.05	0.21
Johnsongrass	0	0	0	0	0	0.01
Knapweed, diffuse	0	0	0.27	0	0	0
Knapweed, Russian	70.81	0		0	0	0
Marshelder	---	0	---	---	---	---
Milkweed, showy	---	---	0.01	---	---	---
Mullein, common	0	5.38	0	0.53	0	58.8
Mustard, tumble	0.01	---	---	---	---	---
Nightshade, Cutleaf	0	0	0	1.02	0.01	0
Olive, Russian	34.15	0	0.09	0	0	0.04
Pepperweed, perennial	0	0	0	0	0	0
Pigweed, tumble	0.01	---	---	---	---	---
Reed, common	---	0	0.11	---	---	0
Saltcedar	610.64	0.11	1433.5	0.86	1.82	4.28
Sweetclover	0	0.15	---	---	---	---
Sowthistle, annual (spiny)	0.28	0	0.02	0	0.01	0
Thistle, bull	0	0.69	0.03	0	0	0.87
Thistle, Canada	0	4.80	0.6	6.7	0.01	0
Thistle, musk	0	2.70	0.01	3.48	0	0.1
Thistle, Russian	---	---	---	---	---	6.73
Thistle, Scotch	0	0	0	0	0	0.35
Toadflax, Dalmatian	0	0	0	0.12	0.04	0
Toadflax, yellow	0	0.46	0	0	0	0
Total Acres Infested	737.7	53.49	1436.1	14.44	1.94	72.73
Total Acres Surveyed	7442.07	544.18	14088.1	966.42	2069.56	3759.65
Percent Infested	9.91	9.83	10.19	1.49	0.09	1.93

"---" Indicates species possibly present but not mapped

"0" Indicates species searched for but not found

Arches National Park

Table 4A: 2003 Field Work Schedule - ARCH

LOCATIONS	DATES SURVEYED	SURVEYORS	AREA (acres)
Courthouse Wash (from east park boundary)	Jun 13	B, J, R	234.2
Lower Courthouse Wash	Jun 14	B, J, R	178.7
Salt Wash, Cache Valley Wash	Jun 13	A, M	331.6
Eagle Park	Jun 20	A, B, H, J, M, R, Z	920.0
Courthouse Wash (from west park boundary)	Jun 14,16,18,23	A, B, J, M, R	1853.2
Lower Salt Wash	Jun 16	A, M	201.0
Winter Camp Wash	Jun 23	A, R	185.0
Salt Wash & associated side canyons	Jun 14,16-19,22-23	A, B, D, H, J, M, R, Z	2756.9
Fin Canyon	Jun 21	H, Z	240.0
Upper Clover Canyon, campground	Jun 23	D, J, M	541.6

[78 person-days, 7442 Acres (5909 USU, 1533 NPS), 95.4 acres / person / day]

* Surveyor abbreviations: A = Andersen, B = Ballard, D = Dewey, H = Rickleff, J = Simonsen, M = Lamalfa, R = Richards, Z = Ballenger

** Person-days converted from 10-hour (actual average work day) to 8-hour basis.

The survey in Arches National Park was completed in June and involved both the USU and NPS crews. Areas to be surveyed and weed species to be mapped were determined by Ian Torrence, Vegetation Manager for the NPS-Southeast Utah Group. The USU and NPS crews surveyed a total of 7442 acres in 2003. Targeted survey areas for USU for both 2003 and 2004 were completed this summer (Table 2A-B). Approximately 737.7 acres of weeds were recorded, infesting 9.9 % of the surveyed area. Saltcedar comprises more than 85% of the total weeds recorded for this park.

The USU crew surveyed Salt Creek Wash, Courthouse Wash, Winter Camp Wash, and portions of Eagle Park. The survey areas were mapped from park boundary to park boundary in Salt Wash and Courthouse Wash. The NPS crew surveyed mainly side-canyons branching from Salt Wash, including Lost Spring Canyon, Clover Canyon, and Cottonwood Wash. Several additional side canyons branching from main drainages of these canyons were also surveyed. Russian knapweed (*Centaurea repens*), saltcedar (*Tamarix ramosissima*), and Russian olive (*Elaeagnus angustifolia*) were the only targeted species found in Salt Wash and its associated side canyons. Due to the large extent of saltcedar's distribution, it was mapped as large area polygons created from boundary points taken in the field. Halogeton (*Halogeton glomeratus*), foxtail barley (*Hordeum jubatum*), curly dock (*Rumex crispus*), cocklebur (*Xanthium strumarium*), and annual sowthistle (*Sonchus oleraceus*) were mapped but were not targeted species of concern at Arches. It is likely that some species were missed due to the dense brush throughout Salt Wash. Saltcedar and willows were extremely thick throughout the length of wash between the northern park boundary and Wolfe Ranch. Many times the brush was well

over ten feet tall with a dense canopy. The crew covered as much of the inner wash as was possible. The crew walked the canyon rims and surveyed with binoculars in places where the brush was too thick to penetrate. Little recent disturbance was noted. Some disturbance by cattle was evident in Salt Wash and its associated side canyons although the disturbances appeared old.

Of the targeted species, only saltcedar and Russian olive were found in Courthouse Wash. Halogeton and cocklebur were also found there and mapped, although they were not targeted species, and the confidence level for detecting these species is likely below 90 percent. A trail running through the lower portion of Courthouse Wash was the only obvious disturbance noted in that area.

Both crews spent a day surveying in Eagle Park. Approximately two-thirds of Eagle Park was surveyed but no noxious weeds were found and future efforts to finish surveying the area may not be worthwhile. Disturbance by cattle was evident in Eagle Park.

The NPS crew surveyed Fin Canyon, which appeared to be a very undisturbed area. Scattered saltcedar plants were found throughout the lower canyon, and one tumble mustard (*Sisymbrium altissimum*) was found and pulled.

Other non-native species observed in the various surveyed areas of the park, but which were not mapped, were downy brome (*Bromus tectorum*), Russian thistle (*Salsola iberica*), salsify (*Tragopogon dubius*), lambsquarters (*Chenopodium berlandieri*), filaree (*Erodium cicutarium*), and sweetclover (*Melilotus officinalis*). The crews also mapped some species found at or outside park boundaries. These species include field bindweed (*Convolvulus arvensis*) at 0.010 acre, halogeton (0.25 acres), Russian knapweed (1.12 acres), Russian olive (0.5 acres), and saltcedar (15.57 acres). All targeted weed species that were mapped were relatively widely distributed and could not be considered as new invaders to the park. Thus no new invading weed species were found during the 2003 season. It should be noted that although Salt Wash and Courthouse Wash were heavily infested with saltcedar, there were still many cottonwoods and willows as well as many native forbs in those drainages. Salt Wash also contained several small marshes with abundant wildlife species such as ducks, herons, and amphibians. If these weeds are allowed to spread, additional native plant and wildlife species will be crowded out.

There is some additional work scheduled for 2004 in Arches National Park. The park manager will be asked to designate the specific areas for surveying.

Black Canyon of the Gunnison National Park

Table 4B: 2003 Field Work Schedule – BLCA

LOCATIONS	DATES SURVEYED	SURVEYORS	AREA (acres)
Red Rocks Canyon	Sep 12	A, J, R	68.4
East Portal	Sep 11	A, J, R	107.7
Inner canyon from Tomichi route	Sep 9	A, J, R	21.1
Inner canyon from Gunnison route	Aug 5	A, D	17.7
Main roads of west canyon rim, East Portal Rd	Sep 10	A, J, R	329.2

[18 person-days, 544 Acres, 30.2 acres / person / day]

* Surveyor abbreviations: A = Andersen, D = Dewey, J = Simonsen, R = Richards

** Person-days converted from 10-hour (actual average work day) to 8-hour basis.

The survey of Black Canyon of the Gunnison National Park was conducted during two separate visits. Areas to be surveyed and weed species to be mapped were determined by Dangoule Bockus, Ecologist for Black Canyon National Park. A total of 544 acres were surveyed in 2003, which included canyon bottoms accessed via the Gunnison Route, Tomichi Route, and East Portal area. Other areas surveyed include Red Rock Canyon, the East Portal Road, and all main roads and campgrounds on the south rim of the canyon. Most survey areas were along the Gunnison River where access was normally not possible to both banks of the river. Binoculars were used to observe opposite shorelines and the GPS offset feature was used when weedy species were visible. Approximately 54 acres of weeds were discovered and mapped, representing 9.8% of the surveyed area. Downy brome was the most abundant species, comprising 68% of the total acres recorded.

Weed species found on the river below the Gunnison Route include downy brome (*Bromus tectorum*), common mullein (*Verbascum thapsus*), bull thistle (*Cirsium vulgare*), Canada thistle (*Cirsium arvense*), musk thistle (*Carduus nutans*), and yellow toadflax (*Linaria vulgare*). Sweetclover was mapped also, although it was not a targeted species of concern for Black Canyon.

Weed species discovered from the Tomichi Route access included downy brome, burdock, common mullein, bull thistle, Canada thistle, and sweetclover. Inclement weather hampered efforts to map all possible areas along the Gunnison River at this access point, and this area will need to be revisited next summer. Red Rock Canyon was surveyed in September. However, due to high water levels, only one crew member was able to make it down the entire length of canyon. Though the majority of the targeted areas were inspected, it is recommended that Red Rock Canyon be revisited next summer. Weed species found in Red Rock Canyon include field bindweed, downy brome, burdock, common mullein, saltcedar, bull thistle, Canada thistle, and musk thistle. Points features were used to map all species found in Red Rock Canyon, except for downy brome, which was widespread. An area feature for downy brome was created later in the office from points taken in the field.

Roads were surveyed from a slow moving vehicle, and each side of the road was surveyed separately. The campground was surveyed on foot. Weed species found in the campground and along the main roads and East Portal Road include field bindweed, downy brome, horehound, common mullein, bull thistle, Canada thistle, and musk thistle.

The Gunnison River along East Portal was surveyed in September as well. Portions of the east riverbank were accessible by a cable car and thus both shores of the Gunnison River were surveyed below the spillway at East Portal. Inaccessible portions of the east bank were surveyed using binoculars and weed species found were recorded as offset points. Weed species found at East Portal include field bindweed, Himalayan blackberry (tentative identification to be verified next season), downy brome, burdock, common mullein, saltcedar, bull thistle, Canada thistle, musk thistle, and yellow toadflax. Much of East Portal is outside the Park boundary but was mapped because it was infested with several significant species and lies upstream of the Park. It is very probable that East Portal serves as a seed source for many of the species found within the canyon downstream. Invasive species mapped outside the Park boundary include field bindweed (0.23 acres), Himalayan blackberry (0.15 acres), downy brome (3.33 acres), burdock (0.12 acres), common mullein (4.06 acres), bull thistle (0.94 acres), Canada thistle (0.98 acres), and musk thistle (0.99 acres). Portions of the Gunnison River accessed by steep hiking routes did not appear to have any additional obvious disturbance other than that caused by the river itself. Cattle have disturbed upper portions of Red Rock Canyon and cattle were present at the time of the survey. East Portal was extremely weedy and heavily disturbed by both vehicular and human activities.

Other weedy species noted in Black Canyon, but not mapped, include filaree, lambsquarters, cocklebur, and wild asparagus. Common mullein, bull thistle, Canada thistle, musk thistle, and downy brome were common and found essentially throughout all survey areas. Downy brome also was found throughout all survey areas and seen throughout many other portions of the Park. Our figures under estimate the total number of acres infested by downy brome within surveyed areas because many infestations were observed on ledges of canyon walls and were not accessible by surveyors. Due to its extensive distribution, it may not be productive to map downy brome next year.

The new invading weed species found at Black Canyon are yellow toadflax and horehound. The inner canyon is not heavily infested with these species, and eradication is possible. The inner canyon is mostly comprised of native plant species, and willows were abundant along the river of the Tomichi and Gunnison routes. It likely the native species will naturally revegetate those areas after the invasives are controlled. Areas scheduled for the 2004 season include the remaining 4 access routes into the inner canyon and the road along the north rim of the canyon.

Canyonlands National Park

Table 4C: 2003 Field Work Schedule – CANY (Island in the Sky District)

LOCATIONS	DATES SURVEYED	SURVEYORS	AREA (acres)
Upheaval Dome, Syncline Valley	Jun 24	A, B, J, M, R	403.6
Upheaval Canyon	Jun 25	B, J, M	384.9
Taylor Canyon, Trail Canyon	Jun 25, Jun 27	A, B, J, M, R	1699.6
Main roads, Upheaval Dome Trail	Aug 8	A, D	476.8
Lathrop Canyon	Jun 26	A, B, J, M, R	879.4

[26 person-days, 3844 acres, 147.8 acres / person / day]

Table 4D: 2003 Field Work Schedule – CANY (Needles District)

LOCATIONS	DATES SURVEYED	SURVEYORS	AREA (acres)
Cyclone Canyon, Devil's Lane, Devil's Pocket, Red Lake Canyon, Butler Wash, Lower Red Lake Canyon	Jul 16-18, 20-21	H, Z	1441.0
Big Spring Canyon, Little Spring Canyon	Jul 30, Aug 2, Aug 4	H, Z	214.5
Lower Salt Creek between the main road and the Lower Jump	Jul 8-11, Aug 7	A, B, D, J, M R	1708.2
Horse Canyon, Upper Salt Creek	Jul 01-11, 14-16, 22, Aug 1	A, B, D, H, J, M, R, Z	6540.1
Lost Canyon	Aug 3, Oct 8	H, Z, V	340.0

[95 person-days, 10,244 acres (6341USU, 3903 NPS), 107.8 acres / person / day]

* Surveyor abbreviations: A = Andersen, B = Ballard, D = Dewey, H = Rickleff, J = Simonsen, M = Lamalfa, R = Richards, Z = Ballenger, V = volunteers

** Person-days converted from 10-hour (actual average work day) to 8-hour basis.

Canyonlands National Park was surveyed according to districts. A five-member Utah State University crew surveyed the Island-in-the-Sky district in June, covering 3844 acres. Areas to search and weed species to map were determined by Ian Torrence, Vegetation Manager for the NPS-Southeast Utah Group. Areas surveyed include Upheaval Dome, Syncline Valley, Upheaval Canyon, Lathrop Canyon, Taylor Canyon, Trail Canyon, and the main roads through the district. The surveyed areas were generally open and visibility was very good, thus it is unlikely that any 0.01-acre or larger patches of targeted weeds were missed. Weed infestations found within Island in the Sky total 48.8 acres. Weed species included diffuse knapweed, Siberian elm, halogeton, and saltcedar. Saltcedar was found extensively throughout all canyons and was most often the only weedy targeted species in the surveyed areas. A single saltcedar was also found on the road shoulder outside the park boundary. Saltcedar comprised 99% of the total infestations recorded for this district. Diffuse knapweed was on the road shoulder by Willow Flat and is identified as a new invader. Halogeton was mapped in Lathrop Canyon although it was not designated as a species of concern in Canyonlands. Siberian elm (0.03 acres)

was found on the road shoulder just outside of the Park boundary but was mapped due to its potential for spread into the Park. Old evidence of disturbance from mining was evident in Taylor Canyon, Trail Canyon, and Lathrop Canyon. Little or no disturbance was noted in other surveyed areas aside from effects of flash flooding. Most areas surveyed were in canyon bottoms and did not contain much native vegetation. Saltcedar was often the only species found within these areas. Due to harsh conditions, abundant natural revegetation by native species does not appear likely in many of the drainages even if the weedy species were removed.

A six-member USU crew and a two-member NPS crew surveyed portions of the Needles district in July. Approximately 10,244 areas were surveyed in the Needles district in 2003. The primary target area for USU was Salt Creek and its associated side canyons. Additional areas designated by Ian Torrence and surveyed by the NPS crew include Horse Canyon (and all of its side-canyons), the Grabens (including Devil's Lane, Devil's Pocket, Cyclone Canyon, Red Lake Canyon, Lower Red Lake Canyon, and a small portion of Butler Wash), Big Spring Canyon, Little Spring Canyon, and Lost Canyon. Portions of Salt Creek between the Lower Jump and Angel Arch as well as the southern headwaters of Salt Creek, including side canyons, were surveyed thoroughly. Sections of Salt Creek between Angel Arch and Big Pocket were surveyed less intensively and will be looked at more thoroughly in 2004. Discussion is still open as to whether the remaining side canyons of Salt Creek should be surveyed in 2004. Crews recorded 1387.4 acres of weeds, infesting 13.5% of the surveyed area. Saltcedar was the main species recorded, making up 99.8 % of the infested acres.

The main Salt Creek canyon is heavily infested with saltcedar and willow, making it significantly more difficult to survey than areas in the Island-in-the-Sky District. Some sections of Salt Creek were nearly impossible to penetrate on foot due to the size and density of the saltcedar. The trail through the middle portion of Salt Creek was also hard to follow in many places, and essentially nonexistent in other portions. Polygons of saltcedar were created from points taken in the field of infestation boundaries. Other weed species of concern encountered in Salt Creek were Russian olive, bull thistle, Canada thistle, and musk thistle. Weed species mapped but not targeted for concern include field bindweed, burdock, common reed, showy milkweed, spiny sowthistle, and halogeton. Non-native species observed, but not mapped, were downy brome, cocklebur, Russian thistle, salsify, lambsquarters, filaree, sweetclover, and redroot pigweed.

The Grabens did not have any targeted weed species (except for some saltcedar in Lower Red Canyon Lake). Upper Red Lake Canyon was not surveyed this year. However, since no noxious weeds were found in other areas of the Grabens, it may not be worthwhile to survey Upper Red Lake at this time.

Disturbance in many parts of Horse Canyon was heavy due to the road corridor. There was also some evidence of cattle grazing in this area. The Grabens appeared relatively undisturbed, aside from the roads and trails. Big Spring, Little Spring, and Lost Canyons contained little or no disturbance aside from hiking trails. Salt Creek also did not have any obvious recent soil disturbances besides the road and seasonal flooding events.

Saltcedar heavily infests most of Salt Creek; but infestations of new invaders such as bull thistle, musk thistle, burdock, Canada thistle, and perhaps Russian olive, were relatively small in size

and could be eradicated. Native vegetation such as willows are still abundant through most portions of Salt Creek. Cottonwoods are also scattered throughout the drainage. It is likely that populations of these and other native species would be reduced or even lost if control strategies are not put in place to slow the spread of saltcedar. The scope of work for 2004 will include mapping additional portions of upper Salt Creek as well as the lower half of Salt Creek between the Lower Jump and the Colorado River.

Hovenweep National Monument

Table 5E: 2003 Field Work Schedule – HOVE

LOCATIONS	DATES SURVEYED	SURVEYORS	AREA (acres)
Goodman Point Group	Jul 17, Aug 6	A, D	141.3
Square Tower Group	Jul 16-17, Aug 6	A , D	398.6
Holly Group	Jul 15, 17, Aug 6	A, D	63.2
Horseshoe & Hackberry Group	Jul 15, Aug 6	A, D	143.9
Cutthroat Castle Group	Jul 15	A	23.8
Cajon Group	Jul 16, Aug 6	A, D	39.2
Roads between Units	Aug 6	A, D	156.4

[8 person-days, 966 acres, 120.8 acres / person / day]

* Surveyor abbreviations: A = Andersen, D = Dewey

** Person-days converted from 10-hour (actual average work day) to 8-hour basis.

Two people surveyed Hovenweep National Monument in July. The entire monument was surveyed, covering 966 acres in the 6 units and the main road connecting 4 of the units. Ian Torrence, Vegetation Manager of the NPS-Southeast Utah Group, determined the weed species to be mapped and the areas to be surveyed. Targeted survey areas for both 2003 and 2004 were completed in 2003. A total of 14.44 acres of weeds were recorded within the Monument. The entire Monument is 1.5% infested with invasive weeds. Visibility was generally good in all units and it is unlikely that any patches greater than 0.01 acres in size were missed.

The Goodman Point Group was the weediest of the six units, probably because the surrounding lands are used for agricultural purposes. Targeted weed species mapped there include Dalmatian toadflax, Russian knapweed, musk thistle, Canada thistle, and saltcedar. Non-target species that were mapped include field bindweed, burdock, common mullein, cutleaf nightshade, and . Weedy species observed but not mapped include lambsquarters, tumble pigweed, redroot pigweed, prickly lettuce, sweetclover, downy brome, purslane, and Russian thistle. The Russian knapweed was actually not on Park Service land, but across the street on private land. It was mapped due to its proximity and potential to spread into the Park. Musk thistle and Canada

thistle were found extensively through the unit, while most other species were concentrated on the eastern end below a spring. Only three small infestations of Dalmatian toadflax and a single saltcedar sapling were found in the entire monument. These species are at an extremely early stage of invasion and should be controlled immediately to prevent their spread.

Weeds found in the Hackberry and Horseshoe Unit include horehound, saltcedar, Canada thistle, and musk thistle, and common mullein. Most of these species were concentrated in Hackberry Canyon while saltcedar was found in both canyons. Only saltcedar and horehound were found in the Cajon Unit and the Square Tower Group. Only a few saltcedar saplings were found in the Cutthroat Castle Group. No weeds were found in the Holly Group Unit but a large group of saltcedar was noted outside the Park boundary. The roads between the Square Tower Group, Hackberry and Horseshoe Unit, Holly Unit, and Cutthroat Castle Group were mapped for several invasive and aggressive weedy species. Horehound (2.06 acres), Russian knapweed (0.34 acres), and perennial pepperweed (0.02 acres) were mapped along the main road connecting 4 of the units due to their proximity to the Park and their potential to spread into the units. Horehound was found heaviest near the Square Tower Group and most plants were found near the park boundary closest to the road entering the Monument. Infestations within this unit are most likely parented by infestations along the road. The potential is high for this to occur with Russian knapweed and perennial pepperweed if nearby infestations outside the Park boundaries are not controlled.

Excluding the Goodman Point Group, units were relatively clean and weeds were concentrated along canyon bottoms. Control of saltcedar was evident in the Square Tower Group and the Hackberry Unit, and saltcedar found there was often re-sprouting from previously controlled stumps. Little or no recent human-caused disturbance was visible in any of the units away from trails, parking areas, or other structures.

Eradication of the weedy species is probably very feasible in the Cajon Unit, Cutthroat Castle Group, and Square Tower Group; and significant effort should be devoted to preventing weedy species from invading the Holly Group. Eradication of the early-stage invaders (Dalmatian toadflax and horehound) in the Goodman Point Group Unit and Hackberry Horseshoe Unit is also possible. Despite the abundance of weeds in some of the units, there is a good diversity of native vegetation throughout the area. Willows were abundant at the springs in the Square Tower Group and cottonwoods were found at the heads of several springs in the other units. However, these will likely be displaced if current infestations of weedy species are allowed to spread. Almost all infestations of invasive species were concentrated in the canyon bottoms and were relatively small in size. Only 1.5% of the entire monument is infested and every effort should be taken to eradicate as many invasive species as possible.

No surveying is planned for the 2004 season.

Natural Bridges National Monument

Table 4F: 2003 Field Work Schedule – NABR

LOCATIONS	DATES SURVEYED	SURVEYORS	AREA (acres)
White Canyon	Jul 18	M, R	191.3
Uplands north of headquarters & sewage ponds	Jul 21, Aug 7	A, D, M, R	496.7
Tuwa Canyon	Jul 19, 21	A, M	185.7
Armstrong, Deer, Tokochi, and White Canyons	Jul 18-19	A, M, R	480.7
Main roads and upland trail, upland drainages	Jul 17-18, 21	A, M, R	715.0

[16 person-days, 2070 acres, 129.4 acres / person / day]

* Surveyor abbreviations: A = Andersen, D = Dewey, M = Lamalfa, R = Richards

** Person-days converted from 10-hour (actual average work day) to 8-hour basis.

Natural Bridges National Monument was surveyed by three people in July. The survey area and weed species to be mapped were designated by Ian Torrence, Vegetation Manager for the NPS-Southeast Utah Group. A total of 2070 acres were surveyed. A total of 1.94 acres of weeds were recorded for all survey areas. Survey areas included all canyon bottoms of Deer Canyon, White Canyon, To-ko-chi Canyon, Armstrong Canyon, and Tuwa Canyon. Upland trails and some of the upland washes also were searched. Most areas were relatively open and visibility was fair to good.

Targeted weed species found at Natural Bridges were horehound, saltcedar, Canada thistle, and Dalmatian toadflax. Additional species mapped but not of significant concern to the Park include annual sowthistle and cutleaf nightshade. Weedy species seen but not mapped include sweetclover, cocklebur, downy brome, tumble pigweed, Russian thistle, and prickly lettuce.

Saltcedar was found scattered along all canyon bottoms and along upland washed, but most plants were saplings. Efforts to control saltcedar were evident throughout the survey area, but in many cases new shoots were re-sprouting from previously controlled stumps. Some saltcedar was mapped outside of the park boundary (0.5 acres) in canyons leading into the Monument. Coordinated efforts with the BLM in controlling these infestations would prevent present infestations from serving as a seed bank.

Other than along roadsides and in developed sites, no weeds were found in the upland areas. Little or no disturbance was noted at Natural Bridges, aside from effects of periodic flash flooding in the canyon bottoms.

The patches of Dalmatian toadflax found in Deer Canyon and White Canyon consisted of just a few individual plants. A small patch of Canada thistle was found in White Canyon near Sipapu Bridge. Scattered plants of horehound were found along road shoulders. All of these new invaders and could be easily eradicated at this point. All weed infestations found in the Monument are currently small enough for eradication to be feasible. A total of approximately 2

acres of weeds were found, infesting less than 0.10% of the survey area. Saltcedar, the most abundant species, was found mostly as small to large saplings and very rarely in patches larger than 0.1 acre in size. Native vegetation was abundant in canyon bottoms and several areas contained thick stands of willow, large cottonwoods, and rabbitbrush. These species as well as other riparian species are currently not being heavily impacted by invasives. However if no control strategies are put in place, they will almost certainly be impacted and eventually replaced by the invasives.

No work is scheduled for the 2004 season.

Zion National Park

Table 4G: 2003 Field Work Schedule – ZION

LOCATIONS	DATES SURVEYED	SURVEYORS	AREA (acres)
Firepit Knoll	May 12-13	A, B, J, M, R	511.1
Northgate Peaks, Pine Valley	May 14-16	A, B, J, M, R	1380.7
West Rim/Horse Pasture Plateau	May 16, 20-22	A, B, J, M, R	1086.0
West Rim Trail by Telephone Canyon	May 19	A, B, J, M, R	405.8
Zion Canyon	May 17, 22	A, B, J, M, R	376.1

[63 person-days, 3760 acres, 59.7 acres / person / day]

* Surveyor abbreviations: A = Andersen, B = Ballard, J = Simonsen, M = Lamalfa, R = Richards

** Person-days converted from 10-hour (actual average work day) to 8-hour basis.

Zion National Park was surveyed in May. Sean Haile, Exotic Plant Specialist, and Denise Louie, Vegetation Program Manager of Zion National Park determined 4 areas to be surveyed and the weed species to be mapped. The five-person crew covered 3759 acres. A total of 72.73 acres of weeds were recorded, infesting less than 2 % of the total surveyed area. Common mullein was the most abundant species found and represents 81% of the total weeds recorded for Zion National Park.

Firepit Knoll was a fairly open survey area with some mixed stands of oak and juniper. Visibility was generally good and it is unlikely that any 0.01-acre infestations would be missed in the open fields. Surveying within the stands of oak and juniper was more difficult, but again it is unlikely that the crew would have missed patches at least 0.01 acres in size. Weed species found were common mullein, Russian thistle, and Scotch thistle. Curly dock was also mapped but not of concern to Zion.

The Northgate Peaks area was a mix of open ground with great visibility, and heavy brush with low visibility. Weed species found there were common mullein, Russian thistle, Scotch thistle, and curly dock.

Horse Pasture Plateau was the largest area, and only portions of it were surveyed in the 2003 season. The surveyed area contains heavy amounts of oak and visibility was often extremely limited, making progress slow. Access to the Plateau was along the West Rim Trail, and the trail was surveyed along the northern and southern portions of the Plateau. The crew focused its attention on the northern portion of the Plateau and in Corral Hollow in the 2003 season. Weeds found include musk thistle, bull thistle, common mullein, and Russian thistle.

The area between the main road and the Virgin River in Zion Canyon was also surveyed. The area was covered with Ripgut brome and the visibility of other weeds was difficult in some places. Weed species found are field bindweed, curly dock, horehound, Johnsongrass, common mullein, Russian olive, saltcedar, bull thistle, Russian thistle, Scotch thistle. Although not a priority species, cocklebur was also found.

Zion Canyon has been historically disturbed and continues to be disturbed by foot traffic, horse pack trails, roads, and natural erosion associated with the Virgin River. Fire disturbance was evident in the areas of Firepit Knoll, Northgate Peaks, and Horse Pasture Plateau. Other disturbance was minimal in those areas. Some evidence of cattle was seen in the Firepit Knoll region.

Common mullein and Russian thistle were fairly prevalent throughout all survey areas. Saltcedar was found frequently along the Virgin River in Zion Canyon but most infestations were small saplings and previous control efforts were evident in those areas. During training exercises in early May for NPS and USU crew members, infestations of Johnsongrass, Himalayan blackberry, Scotch thistle, giant reed, and other invasive species were found in the Watchman campground. These infestations were not mapped because Sean Haile was already aware of them. Infestations of new invaders not previously reported in our survey areas include musk thistle, Scotch thistle, horehound, and Johnsongrass.

It is noted that many of the species found at Zion were in a very small rosette stage and it is possible that due to the early time of year, other infestations and/or other species were missed. This will be taken into account in next year's planning. However, it should be noted that if any other infestations of mullein or other invasive species 0.01 acres in size or larger had been present in the surveyed areas, their standing dead vegetation from last year's growth almost certainly would have been observed and recognizable.

No areas were found to be heavily infested with invasives beyond Zion Canyon. The upland areas were relatively free of weeds, and native vegetation did not appear to be impacted by existing infestations. The most prominent infestations were typically found in areas of heavy burning. Areas showing little sign of fire disturbance contained very few infestations. Zion Canyon, despite the heavy disturbance by park visitors and an abundance of invasive bromes, still contained some native vegetation.

The scope of work for the 2004 season will primarily consist of finishing the inventory of Horse Pasture Plateau.

IX. CONCLUSIONS / RECOMMENDATIONS

Humans are the most likely vectors for new invasive weed introductions into parks of the Northern Colorado Plateau Network. Millions of visitors come from all over the world to enjoy the unique beauty of this region, and each person potentially brings with them errant seeds of an exotic invasive plant lodged in the tread of a tire or hidden in the dried mud of a hiking boot. The huge numbers 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 monitoring of high-visitation sites within each park is essential to the "early detection and rapid response" strategy of invasive plant management. Roadways, parking areas, visitor centers, picnic sites, campgrounds, view points, boat ramps, trails, and all other high-visitation sites should be inspected regularly (at least yearly) at a time when new plants would be visible. Park visitors should be informed of the potential damage caused by invasive plants, and ways they can help minimize the chances of it occurring.

Routine park operations represent a second 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 conducted at Arches National Park (Appendix D). Additional 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 surveyed are in the enviable situation of having the majority of their lands free of invasive weeds. Protecting and preserving lands in this weed-free condition is much more cost-effective than restoring extensive areas already badly infested by invasives, and therefore should be the highest weed management priority for the Northern Colorado Plateau Network. Programs based on prevention, early detection, and rapid response to control all new invaders on presently weed-free lands will be needed to accomplish this objective. Regularly scheduled weed surveys of all park lands should be an ongoing part of all weed management plans. Inspections of all high-visitation areas should be performed at least annually, whereas surveys of the most remote sites or habitats least suitable for weed establishment might need to be performed only once every 5 to 10 years. A rotating schedule should be developed by each park to survey a portion of their land each year, so that within a set number of years all of the park could be inspected. The key is to schedule surveys often enough to detect all new weed infestations before they exceed a size considered feasible for eradication.

Literature Cited

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Appendices

Field Operations Manual

Utah State University GPS Weed Mapping Methods

Introduction:

The first and most crucial step in any weed survey / mapping project is to establish a clear set of mapping objectives. The simple yet critical questions which must be answered are “what is the primary purpose of this project?” and “how will the data be used?” It is our observation that without clear objectives, the tendency of planners as well as surveyors is to collect far more information than will be needed or used, thus greatly reducing overall project efficiency. The types of data that could be collected are nearly limitless, as also are the number of potential field methods if objectives aren’t narrowed as much as possible.

The purpose of this manual is to describe a specific set of field procedures and equipment suited to invasive weed surveys and/or inventories conducted on wildlands or other non-crop areas at a landscape scale in support of weed management planning and control efforts. Our primary mapping objective is to find and record infestations of newly established invasive weed species in support of “early detection and rapid response” efforts. Widespread infestations of other targeted weed species may be mapped, but generally not at an equally high level of resolution. It is our primary goal to search as many acres as possible within the time and budget constraints of a project. Our objective is not to provide site-specific data for monitoring purposes, although managers should be able to use this data to identify areas where monitoring plots might be established.

Survey Area Coverage:

In most types of hilly terrain it is more energy and time efficient to search along parallel topographic contours than it is to hike up and down draws and ridges, or to follow straight transect or grid lines.

When two or more people are surveying an area together, there can be confusion and associated inefficiencies resulting from not knowing exactly where each person has searched and which features each other has mapped. If searches performed by multiple surveyors are not properly coordinated, some infestations or patches could be mapped twice, and others might be missed entirely. To minimize this problem it is suggested that:

- 1) Crew members remain in sight of each other if walking parallel transects or contours, communicating (by radio if necessary) to verify who is mapping specific infestations in question.

Or

2) Each crew member is assigned sole responsibility to map specific drainages, canyons, or other large areas that can be easily defined and recognized to prevent overlap by multiple crew members. For safety and efficiency reasons these areas should be adjacent to one another, or at least close enough so that all crew members can remain in radio contact with each other.

Effective Detection Swath Width (EDSW) - Definition and Calibration

Standard weed inventory and mapping activities should be conducted at as fine of a scale as required to achieve 90 percent or greater confidence that all invasive plant infestations of the minimum specified size (single plants, 0.01 acre, 0.1 acre, or larger) for each targeted species within each survey area are detected (90 percent detection efficiency). In heavy cover and/or for very difficult-to-see species this may mean slowly walking on consecutive parallel search lines or routes as narrow as 25 yards or less apart. In very open terrain and/or for highly visible species such as saltcedar, it might be possible to widen search routes to as much as 300 yards or more and still achieve the necessary level of detection confidence.

The width of search swaths needed to detect at least 90 percent of targeted infestations is called the Effective Detection Swath Width (EDSW). Effective swath widths are to be determined and adjusted as needed by each surveyor based on the minimum infestation detection size (set at beginning of project), variations in terrain, walking speed, associated vegetation, target species. Another term used is “effective detection distance” or EDD. This is the maximum distance from which a surveyor can consistently detect (see and recognize) the minimum infestation size of the targeted species with at least 90 percent detection efficiency. An effective detection swath width is equal to 2 times the EDD, because the surveyor is able to effectively detect weeds 1 EDD on either side of his/her search route.

From years of experience we’ve concluded that it is generally unrealistic to expect detection of every individual invasive plant in field-scale surveys. For example, Montana State University researchers conducting intensive weed surveys in Yellowstone National Park are unable to detect every target plant even though their search swaths are never more than 10 yards wide. In most cases, the cost associated with large-scale field surveys requiring 10-yard or narrower survey swath widths would be completely prohibitive.

Surveyors should calibrate themselves in such a way that single plants of all likely targeted species would be recognizable anywhere within a detection swath width. By so doing they can be confident of finding a high percentage of single plants. However, we prefer to be more conservative by claiming that our surveyors will find 90 percent or more of all patches 0.01 acre in size (approximately 20 x 20 ft) or larger, rather than guarantee that all individual plants were discovered.

One justification for this approach is the argument that eradication of a new weed infestation can be achieved with virtual certainty and minimal effort if detected and treated before the patch exceeds approximately 0.25 acre in size. From the standpoint of eradication it takes nearly as much time and effort to control a few individual plants (0.01 acres) at an isolated remote location

as it does to control a 0.25 acre patch; and the chances of success are essentially the same for both situations. However, once weed patches get much larger than 0.5 acre in size, eradication can become considerably more difficult. If weed surveys are conducted on a regular basis, perhaps once every 5 to 10 years, it is likely that any single plants missed in a previous survey will be detected during the next survey before they have become an infestation greater than 0.5 acre in size.

EDSW Calibration:

- (Supervisor) In typical terrain and vegetative cover, establish a calibration area of 1 to 5 acres. Place 10 or more individual plastic weed specimens (or specimens of actual targeted weeds) within the area and GPS their locations.
- (Surveyor) Outside of the calibration area place a similar specimen. Walk away from it as far as possible while still being at least 90 percent confident of your ability to recognize and detect it.
- Measure distance to the plant (with both laser and by pacing). Note this distance as half of a swath width
- Multiply this value by 2, and then select the most representative full swath width from the list of choices (25, 50, 100, 150, 200, 250, or 300 yards)
- Set GPS Between-Feature option to “distance”, and enter the value chosen from the swath width categories.
- Be sure GPS unit is set to make audible “beep” at each between-feature distance interval
- Search the calibration area by walking a serpentine pattern, maintaining average swath widths equal to the between-feature distance entered in the GPS (visually searching $\frac{1}{2}$ swath width on either side of your line of travel).
- Stop each time the GPS beeps. Slowly turn 360 degrees while visually scanning the area out to at least 1 swath width before proceeding.
- Record the number of specimens detected in the calibration plot and calculate the percentage.
- If fewer than 90 percent of specimens were detected, repeat the calibration process using narrower swath widths until detection ability equals or exceeds 90 percent.
- Practice selecting effective detection swath widths by calibrating under a variety of terrains and vegetative cover types with a range of target species.

[The example above is for single-plant detection confidence. In cases where the minimum detection confidence size is 0.01 or 0.1 acre infestations, the exercise would use weed patches of corresponding size]

Daily Application:

At the beginning of each day, and whenever moving to terrain or vegetative cover with potentially different EDSW's, each surveyor should:

- Identify a typical single target weed, then walk away from it as far as possible while still being at least 90 percent confident of its detection and recognition..
- Measure distance to the plant (with both laser and by pacing), noting this distance as half of a swath width
- Multiply this value by 2, and select the most representative full swath width from the list of choices (25, 50, 100, 150, 200, 250, or 300 yards)
- Set GPS Between-Feature option to “distance”, and enter the value chosen from the swath width categories.
- Be sure GPS unit is set to make audible “beep” at each between-feature distance interval
- Search the calibration area by walking a serpentine pattern, maintaining average swath widths equal to the between-feature distance entered in the GPS (visually searching $\frac{1}{2}$ swath width on either side of your line of travel).
- Stop each time the GPS beeps. Slowly turn 360 degrees while visually scanning the area out to at least 1 swath width before proceeding.

Maintaining thorough coverage when multiple parallel search swaths are required can be challenging. It is recommended that surveyors use some method of marking or recording their routes of travel, and that they periodically measure the distance between passes. Noting a few objects that are approximately one swath width to your right or left side that can serve as guiding landmarks for your return pass on the next swath. Using colored biodegradable surveyor ribbon (where allowed) is an effective method of marking a search route, and periodic use of the laser range finder can keep the surveyor within the appropriate minimum distance of the center of his/her previous search swath. Or, the surveyor can use a tracking feature in the Geo Explorer to display his/her route on the GPS screen in real time. This latter method also allows the surveyor to see how far apart his/her search routes are by noting the map scale displayed on the screen. This method is particularly valuable in conditions where surveyors might become disoriented, such as in featureless flat timbered terrain where visibility is limited

It is recommended, especially in rugged terrain, that surveyors use a hiking staff to increase safety and improve weed detection probability. Using a hiking staff reduces the chances of stumbling or falling, and the associated injuries that are possible. Use of a hiking staff also can allow surveyors to spend a little higher percentage of their walking time looking for weeds rather than at their feet.

Point, Line, and Area Features

Normally, weed “infestations” (or rare plant “patches”) 5 acres in size or less should be recorded as point features. Infestations 5.5 acres or larger may be recorded as area features, or as multiple contiguous 5-acre point features. It is recommended, however, that area features (polygons) should only be used for high-priority infestations that will be monitored over time for specific changes in perimeter shape and size. Unless there is a compelling reason to do otherwise, linear infestations should be mapped as a series of appropriately-sized point features. Line features should be reserved for long linear infestations that are relatively uniform in width and density, and that do not require frequent interruptions for “nesting” of points of other target species.

Unless otherwise noted, individual weeds or weed patches separated from each other by 50 yards or more will be considered as separate infestations. (This is also true for line and area features.). Weeds separated by less than 50 yards may be mapped as separate infestations if a surveyor feels it could be of significant benefit to the end-use of the information.

Patch Location:

Surveyor should stand in the middle of the targeted weed infestation when recording the GPS location.

Patch/Infestation Size:

Surveyors estimate the size of a point infestation as follows:

- 1- While standing in the middle of the infestation, envision it as a circle, square, or rectangle (whichever most accurately represents its overall shape). If circular, determine its average radius by visual estimate, pacing, or laser range finder. If rectangular or

square, determine its average length and width by visual estimate, pacing, or laser range finder.

- 2- For rectangular or square patches, determine the average length and width, then multiply to obtain the total area (square feet or square yards).
- 3- For a circular infestation measure the distance to the furthest edge and the distance to the closest edge. Then average the two readings to obtain an average radius.
- 4- Select closest patch size category from GPS menu (using midpoint values in Table 1).
The patch size categories we normally use are 0.01, 0.1, 0.25, 0.5, 1.0, 2.5, and 5.0 acres. In some cases a smaller category called “1 to few plants” is requested. We interpret this category to represent occurrences of single plants, or very small patches (fewer than a dozen plants) covering less than 50 square feet (0.001 acre or less).

Example: An oblong weed infestation is discovered. Surveyor estimates its average radius to be 25 yards (greatest radius = 30 yards, and shortest radius = 20 yards). Looking at the 5th column in Table 1, the surveyor notes that a 25-yd radius falls between the bold-face values of 24 and 34 yards, which bracket the size category of 0.5 acres (28 yard radius). The surveyor therefore selects 0.5 acres as the size for this infestation.

In some specialized surveys the actual dimensions or size of each weed patch may be recorded, rather than placing patches into pre-determined size categories. This may be a more accurate method, but it takes more time to enter the data into the GPS, and also requires more time when summarizing and analyzing the data. In the majority of mapping projects (where many patches of a species are anticipated) it is felt that size categories can provide an adequate representation of overall weed abundance, while minimizing data-entry time for surveyors. If one assumes that within each size category there will be as many weed patches of actual sizes greater and smaller than the average, then the overall total acreage for that species will still be relatively accurate.

Percent Cover (surface cover / canopy cover):

Surveyor envisions a polygon defined by the outermost plants of an infestation, and then estimates the percentage of that polygon's surface area covered by the weed (in terms of canopy or surface cover). Surveyor then will select the closest % cover category from the GPS menu.

Note: the actual infested polygon may be somewhat larger or smaller than the point category selected to represent the infestation size. Percent cover is estimated for the actual infested area, not the area of the infestation size category. In other words, if a weed patch is actually 0.39 acres, it would be considered a 0.5-acre infestation. However, the canopy cover estimate is to be made for the actual 0.39-acre polygon rather than an envisioned 0.5-acre circle. To minimize possible confusion it is recommended that “percent cover” appear in the data dictionary before “infestation size”, and that surveyors estimate percent cover before selecting an infestation size category.

Example: The oblong infestation noted above is fairly dense, with the targeted weed's canopy representing approximately 45 percent of the surface area within the actual perimeter of the infestation (within the equivalent of the 25-yard actual infestation radius, not the 28-yard radius of the 0.5 acre size category). Therefore, the best GPS menu choice for % cover would be "high" (26 to 50%).

For infestations in the size category of "1 to few plants" (or 0.001 acre) the canopy cover will usually be high (essentially 100 percent in the case of single plants). In some projects it may be appropriate to design the data dictionary to omit "cover" as a required data field for size categories of 1/1000 acre or less.

Linear areas:

If a weed infestation is much more linear than circular, and if the surveyor wishes to record it as a point rather than a line feature, the following procedure should be followed:

Size and Location:

Surveyor will estimate the size of "linear" point infestations as follows:

- 1- Envision the infestation as an elongated rectangle
- 2- Estimate the average width and approximate length of the infestation (in feet).
- 3- Determine square footage by multiplying length by width
- 4- Select closest size category from GPS menu (using midpoint values in table)
- 5- Stand in the middle of the infestation to record the GPS location

Example: A dense weed infestation is growing along one side of a stream bank for approximately 400 feet. The average width of the infestation is estimated to be 20 feet. The calculated size of this infested area would be 8000 square feet [400 x 20]. The surveyor notes in column 2 of Table 1 that 8000 square feet falls between the values for 0.1 and 0.25 acres, and is slightly greater than the midpoint value of 7,623 square feet. The surveyor therefore chooses 0.25 acres as the infestation size.

Normally, if a linear infestation is greater than 0.25 acre, and if the surveyor wishes to record it as a point rather than a line feature, the infestation should be visually divided into 2 or more contiguous segments, with a separate point feature recorded for each segment. This provides an advantage over the line feature option because the surveyor can record differences in density that may vary along the linear feature.

Example: A weed species is found abundantly along a road side for several miles. It is estimated that the average infestation width is about 8 feet. A quarter-acre is equal to 10,890 square feet. A quarter-acre rectangle that is 8 feet wide would be 1361 feet long [10,890 / 8 = 1361], or approximately 0.25 miles long [1361 / 5280 = 0.258 miles]. To record this infestation as a series of point features the surveyor could enter a new point about every quarter mile while traveling down the infested length of road. Weed density would be estimated within each quarter-mile (8 x 1361 foot) area.

Percent Cover (surface cover / canopy cover):

Surveyor will estimate the percentage of the area within the envisioned elongated rectangle that is actually occupied by the weed (in terms of surface cover or ground cover), and then estimate the “percent cover” within the actual infestation. Surveyor selects the closest cover/density category from the GPS menu.

Note: as for the point feature option, the actual infested polygon may be somewhat larger or smaller than the size category selected to represent the infestation. Percent cover is estimated for the actual infested area, not the area of the size category. In other words, if a weed patch is actually 0.78 acres, it would be considered a 1-acre infestation. However, the canopy cover estimate is to be made for the actual 0.78-acre polygon rather than an envisioned 1-acre circle. To minimize possible confusion it is recommended that “percent cover” appear in the data dictionary before “infestation size”, and that surveyors estimate percent cover before selecting an infestation size category.

Note: Density refers to a “count” of the number of individual plants or stems per unit of area (such as weeds / square meter), and should only be used when a consistent counting unit can be recognized.. The term “canopy over” refers to a visual estimate of the amount or “percentage” of ground covered by the vertical projection of plant matter as visualized from a bird’s-eye view of the vegetation. The percentage of ground obscured by the vegetation of a particular weed species when viewed from above is the canopy (or aerial) cover of that species.

PDOP:

PDOP values of 6 or less are generally preferred for weed surveys, but that does not mean that data obtained at higher PDOP values is worthless, or that the PDOP mask must be set at 6. When it is not possible to consistently obtain GPS locations at PDOP 6, it may be desirable to raise the value to 8 (or even higher). This does not change the PDOP of most readings, but allows collection of additional points that otherwise might be impossible. The GPS unit will collect data at the best possible PDOP value obtainable at any given time and location. The difference in non-differentially-corrected horizontal accuracy between points obtained at PDOP 8 vs. 6 is generally less than a couple of meters. The difference is significantly less once the data are differentially corrected. (Horizontal precision can be viewed using the “Position Properties” window in Pathfinder.) For most weed surveys (when the objective is to be able to relocate an infestation), a difference of 2 meters is insignificant.

Another reason for elevating the PDOP mask has to do with recording between-feature positions. (Between feature positions are used to show where the surveyor went but did not find any weeds.) Normally the surveyor would prefer to put the GPS unit in a belt pouch, shoulder holster, or pocket in order to have their hands free when hiking. Even if placed in an open pouch so that the internal antenna is oriented upward and away from the body, conditions for obtaining adequate satellite configurations can be hampered. Without an external antenna, this means that the GPS unit may have difficulty obtaining points at a PDOP of 6. By setting the PDOP mask higher, the surveyor will be able to obtain usable between-feature positions (which don’t need to be very accurate).

Then, when the GPS is removed from the pouch and oriented correctly toward the sky it will obtain a much lower PDOP for recording actual feature locations.

Note: The factory pouch for the Geo3 can work very well as a shoulder holster if mounted on the surveyor's backpack shoulder strap. Left unzipped, the pouch allows the GPS to ride face-up with its antenna in a near-horizontal position. To mount the pouch, run the backpack shoulder strap through the black belt loop on the GPS pouch, then clip the ring at the top of the pouch to a position higher on the should strap using a small carabineer. Be sure to clip the GPS neck cord into the carabineer too so that the GPS can't hit the ground if it falls out of the open pouch.

Rover Files:

Rover files should be labeled in the GPS by using the first letter of the surveyor's last name as the file prefix. Normally each surveyor should open a new rover file at the beginning of each day, and a second rover file should be created immediately after the lunch break. That way if a file is lost or corrupted, only ½ day's work will have to be repeated.

Data Handling/Processing:

At the end of each day all rover files from each GPS unit should be downloaded to the project computer's hard drive and backed up twice on 2 sets of zip disks. At least 4 data sub-folders should be created within the main project folder on the hard drive. These are: 1) Raw 2) Edited, 3) Corrected, and 4) Exported. In large projects, separate zip disks should be used for raw, edited, corrected, and exported files. In other words, as many as 8 zip disks may be needed to maintain 2 full sets of backup data.

Raw data consist of rover files transferred directly from the GPS units. They should be named using a 6-digit code (month-day-hour) preceded by a single letter (R, or the first letter in surveyor's last name) and ending with an ".ssf" ending. Example: R071518.ssf

Edited data are created from raw data files that have been viewed in Pathfinder Office and checked for accuracy. Editing of a raw data file normally should take place on the same day in which the data were collected. Features may be deleted from or added to raw files in the process of editing. Notes may be added or expanded. Gross area features should be created (polygon drawn) when editing raw files. It is suggested that the file name be changed after editing, so as not to confuse it with the corresponding raw data file. Edited files are named as a 3-letter month and 2-digit day abbreviation, followed by a dash and the first letter of the surveyor's last name. If the surveyor collected more than 1 file for that day, a number will follow the letter. Example: JUL15-R2.ssf

Corrected data consist of edited files that have been differentially corrected. Differential correction is to take place after all editing is completed. Features added or deleted in the editing process can not be differentially corrected; nor can points or features for which corresponding base station data are not available. Though preferred, it is not necessary to have 100 percent of all points differentially corrected. Corrected files retain the same name

as their edited counterpart, but have a “.cor” instead of “.ssf” ending. Example: JUL15-R2.cor

Exported data are shape files (.shp) that are created by exporting from the Pathfinder Office program into ArcView. Actually, 3 kinds of files are created from each “.cor” file. These are “.shp”, “.shx”, and “.dbf” files. All 3 file types must be created and stored together for use in ArcView.

Special Situations:

Can't stand in center of infestation to record point feature:

Surveyor should collect half (5) of the minimum required points on one edge of the infestation, pause the GPS, walk to the opposite side of the infestation, then resume the GPS to take the remaining (5) required points. The GPS unit will average these 2 clusters of points and place the location of the feature half-way between the 2 clusters.

Steep canyon terrain. Difficult to see weed infestations above and below you on hillside:

For spot infestations of highly visible weeds such as leafy spurge, hoary cress, or dyer's woad it is often more effective to survey canyons as teams of at least 2 individuals. One person hikes up or down one side of the canyon while the other person hikes on the other side of the canyon directly across from each other. Each surveyor inspects the opposite hillside where their partner is walking, then radios instructions to their partner on where to go to record observed infestations.

Can't reach a weed infestation that is clearly visible from your present location:

If in terrain where reaching a visible weed infestation is difficult or impossible, it is still possible to accurately record the location as a point feature using the “offset” command in the Geo 3. While standing in your present position, collect GPS position points and record all of the required feature information as you were standing in the middle of the target infestation. Before closing the feature press the OPTIONS key. The word OFFSET will appear. Press the enter key to see the information that is required to perform the offset procedure.

Bearing: Use your compass to determine the bearing to the center of the targeted weed infestation. (Be sure your GPS is configured to request magnetic north rather than true north, or you will have to adjust your compass reading to include declination.)

Horizontal Distance: Use a laser rangefinder to determine the exact distance from your location to the center of the targeted infestation. (Note: this is most accurate if

the targeted infestation is at approximately the same elevation as the surveyor. If the infestation is higher or lower than your present infestation the distance determined by the rangefinder will be somewhat greater than the true horizontal distance. To determine the true horizontal distance requires use of a little basic trigonometry as per the following equation:

$$(\text{Cosine of vertical angle}) \times (\text{laser distance}) = \text{horizontal distance}$$

The vertical angle can be determined by any of several methods. A clinometer is the most accurate tool, but is relatively expensive. A compass dial can be used to estimate the vertical angle by tipping the compass on its side with the orienting lines held horizontally level. Hold the compass dial stationary while turning the base plate up or down until the direction-of-travel arrow points to the infestation. The difference between the degree reading noted at the index line and 360 is equal to the vertical angle.

The tool used by our crew is modified protractor (0 to 90 degrees in both directions) attached to the back of a clipboard or calculator case so that the edge of the protractor is parallel to a clipboard or case edge. A string with a small pendulum weight (paper clip) is attached at the center point of the protractor. With the clipboard or calculator case on its side, sight along the top edge to the center of the target infestation. Allow the pendulum to stabilize, then slowly tilt the clipboard or calculator case flat so that the pendulum string rests against the protractor. The point where the string crosses the protractor scale is the approximate vertical angle in degrees.

Vertical Distance: To determine the difference in vertical distance (elevation) between yourself and the targeted infestation use the following equation:

$$(\text{Sine of vertical angle}) \times (\text{laser distance}) = \text{vertical distance}$$

Be sure to change the value to the appropriate + or – in the GPS field before entering the vertical distance number

Infestation Size: To estimate the width of a distant weed infestation, determine the compass bearings of its right and left edges, and then compute its width in degrees. Use the equation for vertical distance (above) to determine infestation width, then look on the size category chart to select the most appropriate infestation size.

Range finder doesn't acquire its target:

At distances greater than 100 yards the rangefinder sometimes has difficulty, particularly when the target is not a flat, smooth, or highly reflective surface. This problem often can be solved by holding down the activator button for 2 to 3 seconds while holding the crosshair site steady on the target. If this still does not work, aim the rangefinder at more reflective surface estimated to be approximately the same distance away as the target weed infestation.

Large data dictionary and many similar features to record:

One of the important options of the Geo 3 that can help compensate for large data dictionaries (where there is much repetition of information from feature to feature) is called “Repeating Features”. Instructions are found on page 11-14 of the Operation Guide. It allows the user to record sequences of similar features more efficiently by automatically copying all attribute values recorded for the previous feature of that type. The operator simply has to check to make sure the attribute choices are correct, and then can edit only those that need to be changed.

Mapping an area twice - early and late in season:

As a general rule, plants are more easily surveyed when in full bloom. Therefore it may be necessary to map the same area twice during a single season in instances where multiple species with considerably different blooming dates are targeted. For example dyer’s woad in northern Utah typically blooms in late May through early June. After mid-July it becomes senescent and is very difficult to see. Canada thistle or bull thistle, which can grow in many of the same areas as dyer’s woad, typically does not even begin to bloom until mid-July. Ideally, an area infested with both early- and late-blooming weeds should be surveyed once in late spring or early summer, and again in mid- to late summer. When surveying an area twice there is always the potential for information duplication. Some procedures to help minimize this problem include:

- 1) Have the same person survey the same areas both times.
- 2) Generate infestation maps from the first survey, and send them with the field crews on their second survey of the area.
- 3) Restrict each survey to specific species, mapping only those species normally in bloom at the time of each survey.

Species typically targeted in the second survey might be weedy members of the Asteraceae family (thistles and knapweeds) as well as any other species not found in the first survey. In the second survey, crew members normally should ignore infestations of the common weed species found in the first survey. For example, in the second survey at Dry Canyon we ignored most infestations of leafy spurge, burdock, and houndstongue. These species were mapped only in cases where an infestation definitely did not appear on the first survey map, or in cases where the current growth stage made it obvious that the infestation could not have been visible at the time of the first survey.

Crew member disoriented. Not sure of location:

[Note: It is important for crew members always to carry full-sized 7½ minute quad maps (rather than just copies of portions of maps) so that margin UTM grid marks can be seen.

It's also important that all field quad maps have UTM grid lines penciled on them to make it easier to estimate the coordinates of map features.]

To find where you are on a quad map, use your GPS unit to show the UTM coordinates of your present location. Look on map margins to find the box formed by the UTM grid lines (north/south and east/west) that bracket the coordinates of your present location. Then estimate where you are in that grid box by referring to the last 3 digits of the northing and easting values on the GPS.

Example:

The UTM coordinates of your present location are 4479750 (N) x 641500 (E). Look on either the right or left margin of the quad map until you find grid marks corresponding to the first 4 digits of your northing value (4479). Next, look on the top or bottom margin of the map until you find the grid marks corresponding to the first 3 digits of your easting value (641). Follow these 2 grid lines to the point on the map where they intersect. Your present location is somewhere within the 1 square kilometer (1000 meters x 1000 meters) grid box formed by the 4479 and 4480 northing grid lines, and the 641 and 642 easting grid lines. To estimate your exact location within the box, use the last 3 digits of the GPS northing value to estimate what fraction of a kilometer you are north of the bottom line in the box. Then do the same with the last 3 digits of the easting value to estimate what fraction of a kilometer you are east of the left line in the box. In this example the northing reading is 4479**750**, so you are 750/1000's or 3/4 of the way from the bottom to the top grid line in the box. The easting reading is 641**500**, indicating that you are exactly halfway from the west to the east border of the grid box.

The same technique can be used to determine the approximate UTM coordinates of any feature on the map to which you might wish to navigate.

Crew in radio contact, but unable to locate each other:

Radio your current UTM coordinates to other party, who enters them into their GPS as a waypoint. Then they navigate to the new waypoint (you). If it's sunny and likely that your location is visible to each other, use mirrors to reveal your present location.

Table 1. Values used to assign weed infestation to specified size categories.

Acres	LxW (ft)	Sq Feet	LxW (yd)	Sq Yards	Radius (ft)	Radius (yds)	Diameter (ft)	Diameter (yds)
0.01	21 x 21	436	7 x 7	48	11.75	4	23.5	8
(midpoint)	49 x 49	2,396	16 x 16	266	28	9	56.1	19
0.1	66 x 66	4,356	22 x 22	484	37.25	12	74.5	25
(midpoint)	87 x 87	7,623	29 x 29	847	49.25	16	98.5	33
0.25	104 x 104	10,890	35 x 35	1,210	59	20	117.8	39
(midpoint)	128 x 128	16,335	43 x 43	1,815	72	24	144.3	48
0.5	148 x 148	21,780	49 x 49	2,420	83.25	28	166.6	56
(midpoint)	181 x 181	32,670	60 x 60	3,630	102	34	204	68
1	209 x 209	43,560	70 x 70	4,840	117.75	39	235.6	79
(midpoint)	276 x 276	76,230	92 x 92	8,470	156	52	311.6	104
2.5	330 x 330	108,900	110 x 110	12,100	186.25	62	372.5	124
(midpoint)	404 x 404	163,350	135 x 135	18,150	228	76	456.2	152
5	467 x 467	217,800	156 x 156	24,200	263.5	88	526.7	176
5.5	489 x 489	239,580	163 x 163	26,620	276.25	92	552.4	184

[Simplified version of Table 1 – taped on back of range finders]

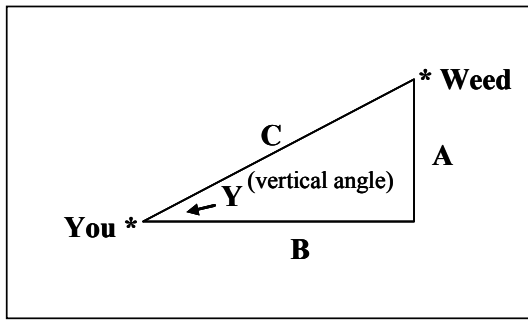
<i>Acres</i>	<i>Sq Yards</i>	<i>Radius (yds)</i>
0.01	48	4
(midpoint)	266 (16x16)	9
0.1	484	12
(midpoint)	847 (29x29)	16
0.25	1,210	20
(midpoint)	1,815 (43x43)	24
0.5	2,420	28
(midpoint)	3,630 (60x60)	34
1	4,840	39
(midpoint)	8,470 (92x92)	52
2.5	12,100	62
(midpoint)	18,150	76
5	24,200	88
5.5	26,620	92

Table 2. Point sizes for circle symbols on ArcView maps, which represent approximate infestation sizes of point features at various map scales.

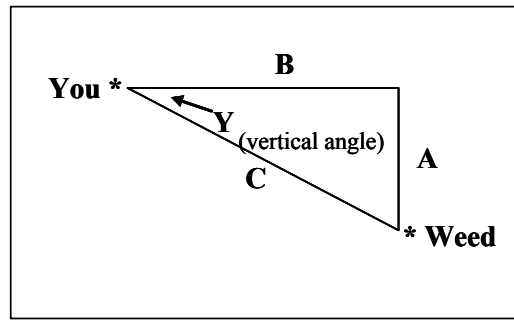
Infestation Size	Map Scale					
	1:5,000	1 : 12,000	1:15,000	1 : 18,000	1 : 24,000	1 : 48,000
0.01 acre	10	6	5	5	5	5
0.1 acre	18	9	8	7	5	5
0.25 acre	30	13	11	9	7	5
0.50 acre	45	18	15	11	10	5
1.0 acre	60	24	21	18	14	8
2.5 acres	90	40	34	28	20	10
5.0 acres	130	56	48	39	29	16

Effective Detection Swath Width (EDSW) Categories:

Avg EDSW (Yds)	BFP Setting (ft)
<i>17 (10-21)</i>	<i>50</i>
<i>25 (21-29)</i>	<i>75</i>
<i>33 (29-41)</i>	<i>100</i>
<i>50 (42-62)</i>	<i>150</i>
<i>75 (63-87)</i>	<i>225</i>
<i>100 (88-125)</i>	<i>300</i>
<i>150 (125-175)</i>	<i>450</i>
<i>200 (175-225)</i>	<i>600</i>
<i>250 (225-275)</i>	<i>750</i>
<i>300 (275-325)</i>	<i>900</i>



Weed Higher



Weed Lower

A = Vertical Distance (calculated or estimated frontopo map)

B = Horizontal Distance (calculated)

C = Laser Distance (determined by rangefinder)

Y = Vertical Angle (estimated using clinometer, protractor, or compass dial)

Determining B (horizontal distance) :

$$B = (\cosine \text{ of angle } Y) \times (C)$$

Determining A (vertical distance) :

$$A = (\sin \text{ of angle } Y) \times (C)$$

Offset Function Formulas

Horizontal Distance (ft):

[cosine of vertical angle] x [laser distance yds] x 3

Vertical Distance (ft):

[sine of vertical angle] x [laser distance yds] x 3

Offset Function Formulas

Horizontal Distance (ft):

[cosine of vertical angle] x [laser distance yds] x 3

Vertical Distance (ft):

[sine of vertical angle] x [laser distance yds] x 3

Note: Laser rangefinder determines distance in yards. Must convert yards to feet for use in Trimble GeoExplorer III GPS offset function

APPENDIX B. Relationship of NCPN Project Data Elements to IMR and NAWMA Weed Mapping Standards

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	Included in metadata only
	2. Source of Data (contact of individual who manages data)	Required	Required	YES	Office	
	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	This will be done but not entered as a data field. Included in metadata only
	6. Site ID (Name or Number)	Optional	Optional	YES	Field	
	7. Quality Control Assessment (Yes/No)	Optional	N/A	(yes)	Office	
	8. Methodology Used For Inventory (casual observation/formal survey/remote)	Optional	Optional	YES	Office	
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)	1. Country (USA/Canada/Mexico)	Required	Required	YES	Office	
	2. State (2-Letter Code)	Required	Required	YES	Office	
	3. County	Required	Required	YES	Office	

CHANGES IN SPECIES POPULATION OVER TIME		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	
		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
SITE ENVIRONMENTAL	ABIOTIC DATA	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		
		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	Relationship of weed occurrences to resource values can be derived through GIS analysis as needed.
		2. Ecological Status	Required	N/A	YES	Field and Office	
		3. Values At Risk	Required	N/A	NO		
		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 C. Definitions of Data Fields

The following table describes data elements collected (or yet to be collected) in this project. An appropriate record was completed for each area where a survey was conducted, and for each location where a targeted species was observed or photographed. Maps of “areas surveyed” were generated from a combination of between-feature GPS positions, field notes, and field maps.

Data elements were collected in one of several methods: automatically recorded by GPS units or entered into units using a data dictionary (GPS); transcribed from field notes (field notes); derived from GIS in post-processing (GIS-derived), or added in office during post-processing (office).

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).

Data	Description	Field Value(s)	Comments	Data Collection Method
Species and location data				
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		Required	GPS
Location ID	Unique identifier for species population ("Record #")		Required	GPS
Park Code	Four-letter abbreviation of park	ARCH, CANY, HOVE, NABR, BLCA or ZION	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 (feet)	Required	GPS

Data	Description	Field Value(s)	Comments	Data Collection Method
Size of Infested Area	Size of population if point feature	- 1 to few plants - 0.1 acre - 0.25 acre - 1 acre - 2.5 acres - 5 acres	Required only for points. Based on average diameter of weed infestation	GPS
Gross Area		Gross area reflects an area of land 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	- vegetative - bud - flower - immature fruit - mature fruit - seed dispersing - dormant	Required. Use most progressive life stage if population appears evenly split	GPS
Woody Growth	Predominant growth stage of species	- seedling - sapling - mature - old-growth	<u>Optional.</u> Use for woody weed species only (elm, tamarisk, Russian olive, etc.) If stages are mixed, use most advanced stage. (valuable for planning control efforts)	GPS
Lifeform	Lifeform of species.	-tree -shrub -graminoid -forb	Required	office

Data	Description	Field Value(s)	Comments	Data Collection Method
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. There may be more than 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

Data	Description	Field Value(s)	Comments	Data Collection Method
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 to field crews by park)	Required. If single or few plants, use dominant species in 1/10-acre area	GPS
Buffer	Buffer needed to encompass population if GPSed as a line or polygon feature	Enter number in feet	Required only for lines and optional for polygons	GPS
Hydrology	General hydrologic setting of site	- upland (above and away from floodplains riparian categories (along rivers or stream channels) - riparian - perennial: stream flows continuously in time. - riparian - intermittent: stream flows only at certain times of the year (typically on seasonal basis) when it receives water from springs or from some surface source (melting snow). - riparian - ephemeral: stream flows only in direct response to precipitation. Ephemeral streams generally lack obligate riparian vegetation. - wetland (saturated for extended periods during the growing season) - playa lakebed (poorly drained depressions)	Required. If further specificity is needed in park, add items as subcategories to existing terms (e.g., wetland - seep)	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

Data	Description	Field Value(s)	Comments	Data Collection Method
Survey Area Data				
Survey Area ID	Unique identifier for survey area		Required	GPS
Disturbance Comments	Comments on type and extent of disturbance noted in <u>survey area</u> . 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

Appendix D. Weed Seed/Propagule Decontamination Procedures

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, maleleuca, 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 E. Standard GPS Data Dictionary

NPS-2003

Survey of invasive weeds in NCPN

pt-weed	Point Feature, Label 1 = Species	Code 1 = IT IS code	Code 2 = Plant Code
Species	Menu, Required, Normal		
Bindweed, field	[30705]	[COAR4]	
Blackberry, Himalayan	[24852]	[RUDI2]	
Brome, downy	[40524]	[BRTE]	
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]	
Loosestrife, purple	[27079]	[LYSA2]	
Marshelder	[36041]	[IVA]	
Mullein, common	[33394]	[VETH]	
Mustard, Sahara	[23064]	[BRTO]	
Olive, Russian	[27770]	[ELAN]	
Pepperweed, perennial	[503379]	[LELA2]	
Puncturevine	[29057]	[TRTE]	
Reed, giant	[41450]	[ARDO4]	
Saltcedar	[22310]	[TARA]	
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]	
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
Bindweed, field	[30705] [COAR4]
Blackberry, Himalayan	[24852] [RUDI2]
Brome, downy	[40524] [BRTE]
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]
Loosestrife, purple	[27079] [LYSA2]
Marshelder	[36041] [IVA]
Mullein, common	[33394] [VETH]
Mustard, Sahara	[23064] [BRTO]
Olive, Russian	[27770] [ELAN]
Pepperweed, perennial	[503379] [LELA2]
Puncturevine	[29057] [TRTE]
Reed, giant	[41450] [ARDO4]
Saltcedar	[22310] [TARA]
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]
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]

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 Menu, Required, Normal	
Species		
Bindweed, field	[30705]	[COAR4]
Blackberry, Himalayan	[24852]	[RUDI2]
Brome, downy	[40524]	[BRTE]
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]
Loosestrife, purple	[27079]	[LYSA2]
Marshelder	[36041]	[IVA]
Mullein, common	[33394]	[VETH]
Mustard, Sahara	[23064]	[BRTO]
Olive, Russian	[27770]	[ELAN]
Pepperweed, perennial	[503379]	[LELA2]
Puncturevine	[29057]	[TRTE]
Reed, giant	[41450]	[ARDO4]
Saltcedar	[22310]	[TARA]
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]

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]

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
Menu, Required, Normal

Species		
Bindweed, field	[30705]	[COAR4]
Blackberry, Himalayan	[24852]	[RUDI2]
Brome, downy	[40524]	[BRTE]
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]
Loosestrife, purple	[27079]	[LYSA2]
Marshelder	[36041]	[IVA]
Mullein, common	[33394]	[VETH]
Mustard, Sahara	[23064]	[BRTO]
Olive, Russian	[27770]	[ELAN]
Pepperweed, perennial	[503379]	[LELA2]
Puncturevine	[29057]	[TRTE]
Reed, giant	[41450]	[ARDO4]
Saltcedar	[22310]	[TARA]
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]
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]
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	
Bindweed, field	[30705]	[COAR4]
Blackberry, Himalayan	[24852]	[RUDI2]
Brome, downy	[40524]	[BRTE]
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]
Loosestrife, purple	[27079]	[LYSA2]
Marshelder	[36041]	[IVA]
Mullein, common	[33394]	[VETH]
Mustard, Sahara	[23064]	[BRTO]
Olive, Russian	[27770]	[ELAN]
Pepperweed, perennial	[503379]	[LELA2]
Puncturevine	[29057]	[TRTE]
Reed, giant	[41450]	[ARDO4]
Saltcedar	[22310]	[TARA]
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]
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]

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	
Bindweed, field	[30705]	[COAR4]
Blackberry, Himalayan	[24852]	[RUDI2]
Brome, downy	[40524]	[BRTE]
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]
Loosestrife, purple	[27079]	[LYSA2]
Marshelder	[36041]	[IVA]
Mullein, common	[33394]	[VETH]
Mustard, Sahara	[23064]	[BRTO]
Olive, Russian	[27770]	[ELAN]
Pepperweed, perennial	[503379]	[LELA2]
Puncturevine	[29057]	[TRTE]
Reed, giant	[41450]	[ARDO4]
Saltcedar	[22310]	[TARA]
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]
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]

Notes Text, Maximum Length = 50
Normal, Normal

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