

Capitol Reef National Park



2003-2004 Invasive Non-Native Plant Inventory

Northern Colorado Plateau Inventory and Monitoring Network

Final Report

August 2005

Prepared by

Steven Dewey and Kimberly Andersen

Utah State University

Cover photo:

Tamarix ramosissima invading a section of Deep Creek. Photo by K. A. Andersen.

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FINAL REPORT

Inventory of Invasive Non-native Plants Conducted During 2003 and 2004 in Portions of Capitol Reef National Park, Northern Colorado Plateau Network of the National Park Service.

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INTRODUCTION

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

BACKGROUND AND JUSTIFICATION

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

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

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

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

To meet this need, in 2001, the Intermountain Region Support Office in Denver prepared a successful Natural Resource Preservation Program (NRPP) proposal (USDI-NPS 2001) to conduct invasive plant mapping in high priority areas of Parks throughout the Intermountain Region, including six Parks within the Northern Colorado Plateau Inventory and Monitoring Network (NCPN). NCPN took the lead of coordinating this project and added network funding to increase the project scope to encompass work in 12 Park units. A cooperative agreement was negotiated between NCPN and Utah State University (USU) Extension to conduct inventory work during 2003 and 2004. Capitol Reef National Park is a member of the Northern Colorado Plateau Inventory and Monitoring Network. A knowledge of current weed distribution, especially in or near riparian areas, was identified as an extremely high priority need by Capitol Reef National Park and NCPN.

OBJECTIVES

- 1) The primary objective of this project was to document distribution and abundance of targeted invasive non-native plant species across the range of habitats and areas of management concern in Capitol Reef National Park. It was anticipated that information from this inventory will be useful in the Park's ongoing efforts to improve strategic planning and to increase the effectiveness and efficiency of field operations associated with invasive plant management.
- 2) Based on the inventory results, efforts were to be made to identify potential sources of weed introductions and significant vectors involved in weed spread in the Park.
- 3) Within the scope of this project, USU was to work with regional, network and Park staff to test and refine data collection and field inventory techniques that might be used by NCPN in future invasive plant inventories.

METHODS

Five NPS seasonal staff hired by Northern Colorado Plateau Network inventoried targeted invasive plants in portions of Capitol Reef National Park in 2003, and a three-person Utah State

University crew inventoried the remaining designated areas of CARE in 2004. Crew qualifications are documented in Appendix A.

SELECTION OF TARGET SPECIES AND INVENTORY AREAS

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

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

Invasive species	Common Name
<i>Ailanthus altissima</i>	Tree-of-Heaven
<i>Arctium minus</i>	Burdock
<i>Asparagus sp.</i>	Wild Asparagus
<i>Carduus nutans</i>	Musk thistle
<i>Centaurea diffusa</i>	Diffuse knapweed
<i>Centaurea maculosa</i>	Spotted knapweed
<i>Centaurea repens</i>	Russian knapweed
<i>Centaurea squarrosa</i>	Squarrose knapweed
<i>Cirsium arvense</i>	Canada thistle
<i>Cirsium vulgare</i>	Bull thistle
<i>Convolvulus arvensis</i>	Field bindweed
<i>Elaeagnus angustifolia</i>	Russian olive
<i>Euphorbia esula</i>	Leafy spurge
<i>Halogeton glomeratus</i>	Halogeton
<i>Marrubium vulgare</i>	Horehound
<i>Onopordum acanthium</i>	Scotch thistle
<i>Tamarix ramosissima</i>	Saltcedar

General categories of areas to be inventoried had been identified previously in the Intermountain Support Office Project Proposal and Implementation Plan (USDI-NPS 2001) based on what was considered to be the most likely invasive plant habitat, with priority given to areas of present or anticipated Park development and high visitor use. Areas of likely weed seed introduction as well as sites identified as significant known or potential weed seed sources or "vector areas" were also given priority. Areas actually inventoried in CARE in 2003-2004 included everything in the original Implementation Plan, plus additional areas added after consultation with Dave Worthington, CARE Biologist, and Tom Clark, CARE Chief of Resources. Lands inventoried in Capitol Reef National Park primarily consisted of riparian areas, roads and highways, hiking trails or slot canyon routes, campgrounds, buildings, and the historic farmstead / orchard areas.

The focus of this inventory project was NPS lands. However, in some cases a limited number of additional lands immediately adjacent to the CARE border were inventoried. This occurred if crew members found an infestation of a high-priority weed species straddling across the Park boundary and wanted to determine its full size. In other cases searches were extended if crew

members suspected a possible "contamination source" of one or more species immediately adjacent to the Park boundary. Non-NPS lands inventoried included portions of Burro Wash, Cottonwood Wash, and Fivemile Wash. Also inventoried was Miller's Creek Canyon, a remote portion of the Glen Canyon Recreation Area adjoining the southern CARE border. This area was inventoried as a matter of convenience and efficiency, as crew members were already working nearby.

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

DATA CATEGORIES

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

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

Table 2. Data fields used in 2003-2004 Inventory of Invasive Non-Native Plants in Capitol Reef National Park.

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

Table 2 continued.

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

Table 2 continued.

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

FIELD PROCEDURES

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

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

Minimum Detection Target Size (MDTS): The smallest infestation size (single plant or patch) of the least-visible targeted invasive species that searchers are confident of detecting and identifying at a stated level of probability under actual field conditions using their stated protocols. In this project the MDTs was set at 0.01-acre.

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

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

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

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

The 2003 invasive non-native plants inventory in Capitol Reef National Park was conducted by a five-person NPS crew between May 5 and September 12 (Table 3). Areas inventoried by the NPS crew included portions of Halls Creek, Miller's Creek Canyon, Upper and Lower Muley's Twist, Cohab Canyon, Grand Wash, Upper Fivemile Wash, Longleaf Flat, Twin Rocks, Capitol Gorge, Chimney Rock Canyon, Spring Canyon, Sheets Gulch, Fremont River, Pleasant Creek,

Oak Creek, Sleeping Rainbow Ranch, Frying Pan Trail, and a portion of Highway 24. The three-person USU crew inventoried additional portions of Fivemile Wash and Halls Creek, as well as South Draw, Burro Wash, Notom Road, Bitter Creek, Cottonwood Wash, Deep Creek, and various roads during June 2-21, 2004. The PI and crew leader returned to CARE on July 18-20, 2004, to conduct quality assurance inspections of areas surveyed previously by USU and NPS crews.

For purposes of planning and data analysis the inventoried lands were divided into 34 areas (Table 3). The order in which areas were inventoried in 2003 and 2004 was determined by the respective NPS and USU crew leaders. Potential invasive plant habitat within each targeted inventory area was considered prior to planning each day's travel route. Field crew members were expected to search along the planned inventory routes, spending more time in priority areas and areas of concentrated invasive plant habitat.

When arriving at a site, crews would determine the best search methods and GPS settings needed to achieve the required level of detection confidence for the established minimum target size. Terrain, vegetation cover, expected visibility of target weed species, and crew size were all factored into setting effective detection swath widths and other mapping techniques and standards used for each site.

Field searches were conducted at as fine of a scale as required to be confident that 90 to 100 percent of all invasive plant infestations 0.01 acre or larger within each inventory area were detected. Search swath widths were adjusted as needed based on variations in terrain, walking speed, associated vegetation, and target species. Areas such as Halls Creek and Lower Deep Creek were open and visibility was generally good, allowing relatively broad EDSW's (typically 50 to 100 yards). In areas such as slot canyons, or stream corridors in which vegetation cover was heavy, EDSW's were usually narrower, sometimes less than 25 yards. Whenever inventorying areas wider than a single swath width, multiple parallel passes of a lone crew member (or multiple crew members walking parallel transects or contours) were searched as contiguous or slightly overlapping strips to avoid coverage gaps. Daily inventory routes of each crew member were recorded and mapped using the BFP tracking function of the GeoExplorer GPS units. BFP tracking distance settings were adjusted as needed to correspond closely to the EDSW distance for each area.

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

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

Area Number	Area Description	Dates Inventoried	Crew Members *	Acres Inventoried **	Corresponding Inset Map Names and Letter Codes***
1	Chimney Rock Canyon Spring Canyon	May 26, Jul 19, Aug 19, 2003	GL, LB, HR, SS	601.91	Grand Wash – E Spring Canyon – F Sulphur Creek – G Chimney Rk Can – H Meeks Mesa – I
2	Twin Rocks	Jul 23, Sep 12, 2003	CC, SS, GL	436.93	Twin Rocks – J
3	Chimney Rock – drainage	May 28, 2003	GL	122.85	Sulphur Creek – G Chimney Rk Can – H Twin Rocks – J
4	Sulphur Ck, Mid-Fremont	May 26, 2003	LB, HR	359.42	Spring Canyon – F Sulphur Creek – G Twin Rocks – J Fruita – L
5	Longlead Flat, Corridors	May 23, Jul 2-3,10, Aug 8, 2003	CC, GL	392.83	Spring Canyon – F Fruita – L
6	Walker's Peak, Molly's Area	Jun 27, 2003	GL	184.80	Grand Wash – E Spring Canyon – F Fruita – L
7	Highway 24	Jul 17, 2003	SS, CC	204.69	Grand Wash – E Spring Canyon – F Fruita – L
8	Fremont River - West	May 5, 23, Jul 18, 20, 2003	LB, HR, SS, CC	169.99	Freemont River – K Fruita – L
9	Cohab Canyon, Frying Pan Trail	Jul 16, 20, 22, 2003	SS, CC	129.66	Fruita – L
10	Grand Wash	Jul 9, 22, 2003	SS, CC	100.95	Grand Wash – E Fruita – L
11	Capitol Wash	Jul 21, 30, Sep 5, 2003	SS, CC, GL	364.96	Golden Throne – M Capitol Wash – N
12	Pleasant Creek, Sleeping Rainbow Ranch	Jul 5-7, 10, 17, 20, 2003	SS, CC	279.31	Golden Throne – M Sleeping Rainbow Ranch – O Pleasant Creek – P Burro Wash – Q
13	Fivemile Wash – Upper	Jun 5, 2003	GL	33.54	South Draw – R
14	Sheets Gulch	May 29, Aug 29, 2003	GL	205.28	Oak Creek – T Sheets Gulch – U
15	Oak Creek	May 25, Jul 4, 2003	SS, CC, HR, LB	139.51	Oak Creek – T Sheets Gulch – U
16	Upper Muley Twist	Jul 31, Aug 1-2, 2003	SS, CC	566.92	Bitter Creek – W Upper Muley Twist – X Strike Valley Overlook – Y
17	Lower Muley Twist	Aug 2-3, 2003	SS, CC	612.35	Swap Canyon – AA Lower Muley Twist Canyon – BB The Post – CC Halls Creek – DD
18	Halls Creek – Halls Creek Overlook to Hall Divide	Aug 13, 16, 2003	SS, CC, LB, HR	240.84	Halls Creek Overlook – EE Red Slide – FF Hall Divide – GG

19	Halls Creek – Southern Park Boundary	Aug 15, 2003	SS, CC, LB, HR	64.70	Millers Creek – HH
20	Halls Creek – Miller’s Creek Canyon	Aug 14, 2003	SS, CC, LB, HR	127.27	Millers Creek – HH
21	NE Park	Jul 3, 2003	GL, CC	4.36	Jones Bench – II
22	Main Roads	Jun 8, 2004	KA, BA	650.25	Grand Wash – E Spring Canyon – F Sulphur Creek – G Twin Rocks – J Fruita – L
23	Deep Creek	Jun 14-15, 2004	KA, BA	2548.14	Polk Creek – A Jailhouse Rock – B The Notch – C Deep Creek – D
24	Rainbow Ranch Road	Jun 18, 2004	KA, BA	253.81	Fruita – L Golden Throne – M Sleeping Rainbow Ranch – O
25	South Draw	Jun 2-3, 2004	KA, BA, SD	1117.35	Sleeping Rainbow Ranch – O Pleasant Creek – P South Draw – R
26	Sandy Creek	Jun 7-8, 2004	KA, BA	809.70	Sandy Creek – V Bitter Creek – W
27	Halls Creek – Narrow to The Post	Jun 8-11, 2004	KA, BA, SD	2417.19	Bitter Creek – W Up. Muley Twist – X Bitter Spring – Z Swap Canyon – AA L. Muley Twist – BB The Post – CC
28	Notom Road - South	Jun 8, 2004	KA, BA	111.20	Up. Muley Twist – X Bitter Spring – Z Swap Canyon - AA
29	Notom Road – North	Jun 5, 8, 2004	KA, BA	115.88	Sandy Creek – V Bitter Creek - W
30	Burr Road	Jun 17	KA, BA	186.34	Strike V.Overlook – Y Swap Canyon – AA
31	Halls Creek – The Post to Fountain Tanks	Jun 10-11, 16, 2004	KA, BA	2138.30	The Post – CC Halls Creek – DD Halls Overlook – EE Red Slide - FF
32	Fivemile Wash – Lower	Jun 21, 2004	KA, BA	142.28	South Draw – R Fivemile Wash – S
33	Cottonwood Wash	Jun 9, 2004	KA, BA, SD	161.52	Burro Wash – Q South Draw – R
34	Burro Wash	Jun 4	KA, BA, SD	67.51	Pleasant Creek – P Burro Wash – Q
	TOTAL			16,062.54	

* Crew abbreviations: BA = Bridget Atkin, KA = Kim Andersen, SD = Steve Dewey, LZ = Liz Ballenger, HR = Heather Rickleff, SS = Stephanie Shoemaker, CC = Christine Craig, GL = Gary Lenhart.

** Year 2003 = 5,343 acres. Year 2004 = 10,719 acres. A 2-yr average of 83.9 acres inventoried per person per 10-hr day.

*** Indicates the key to mapped areas presented later in Figures 7, 8, and 9.

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

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

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

Extensive weed infestations (greater than 5 acres in size) were mapped either as “actual” or “gross” areas (see 2003 NAWMA Weed Mapping Standards for definitions). When mapping an actual area of this size, crew members either hand-drew the infestation perimeter on field maps or collected GPS “generic points” at key locations as they walked along the boundary of the infestation. This information then was used later to digitize the infestation as a polygon on the computer in the office. Generic points were deleted after such polygons were created, and are not included in the final report. This type of mapping was used only for large infestations of *Tamarix ramosissima* and *Elaeagnus angustifolia* along portions the Fremont River. Gross areas were used only in situations in which an invasive species was too abundant and widespread to fully inventory within the time and budget constraints of this project, and yet its general distribution was considered important to note in map form. To create a “gross” area, crew members drew on field maps and/or described in field notebooks the borders of an area observed to be infested. A sample survey then was conducted by walking through a portion of the area to estimate the percentage of land within the overall gross area boundary that was infested by the

weed, and also to estimate its average canopy cover within the infested portions. The gross area method was used in CARE only for infestations of *Salsola kali* in Halls Creek and Deep Creek. Gross area acreages are not included in the total number of acres inventoried in CARE because they represent only estimates based on limited sample surveys.

In deciding on the dominant vegetation cover, crews identified the two most prevalent or most dominant native species in the immediate vicinity of the weedy infestation. The full list was not a part of the data dictionary due to its size, but a paper copy (Appendix F) was carried and referred to by each crew member while working in the field. The vegetation list was compiled by Tamara Naumann, Botanist at Dinosaur National Monument, for an inventory conducted by USU in 2002-2003, and it was decided to use the same list for this project. Native species were coded with a 2-digit number and these codes were entered into the data dictionary. The list was not a complete list and crews had the option to add additional native species if they encountered them in the field.

POINTS OF INTEREST

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

GENERAL PHOTOGRAPHS

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

VOUCHER SPECIMENS

Specimens were to be collected to document new or otherwise unique occurrences of invasive species encountered within Capitol Reef National Park. Voucher specimens of *Ailanthus altissima*, *Asparagus* sp., *Arctium minus*, *Centaurea repens*, *Convolvulus arvensis*, *Elaeagnus angustifolia*, *Halogeton glomeratus*, *Marrubium vulgare*, *Salsola kali*, *Tamarix ramosissima*, and *Tragopogon dubius* were collected in 2004. The voucher specimen of *Convolvulus arvensis* was collected from an infestation on the east shoulder of the Notom Road. A voucher of *Centaurea*

repens was collected on the shoulder of Highway 24 near Chimney Rock. Voucher specimens of *Elaeagnus angustifolia* and *Ailanthus altissima* were also collected from infestations on the shoulder of Highway 24 near Fruita's historic district. Voucher specimens of *Marrubium vulgare* and *Halogeton glomeratus* were collected from the group site in the campground. Vouchers of *Arctium minus*, *Asparagus* sp., *Tamarix ramosissima*, *Tragopogon dubius*, and *Salsola kali* were collected near the Amphitheatre in the campground. Duplicate voucher specimens were processed for deposit in herbaria at USU and Capitol Reef National Park. The specimen deposited at USU is considered "on loan" from NPS and documented in a loan agreement. Specimens were curated and managed following NPS service-wide protocols. The specimens collected as part of this project are affixed with labels containing information on species, collector, collection date, collection site, and NPS record number. Specimen data also is provided in electronic format.

FIELD DATA PROCESSING

At the end of each day, field crews marked and dated all inventoried areas on USGS 7.5' topographic maps to assist in determining project progress and thoroughness of coverage. The GPS between-feature positions recorded automatically each day were used for reference when marking the topographic maps. Each crew member kept a daily log of where they searched, what species they encountered, disturbances noted, thoroughness of coverage, and any additional information that they felt might be of importance to the project. Data were downloaded from GPS units onto a laptop computer each day using Pathfinder Office GIS software. Edits (such as eliminating any duplicate features) were made to the data, and any additional information (such as infestations drawn by hand on field maps or other data not recorded with a GPS unit) were added at this time. Four sub-folders were created within the main project folder on the computer hard drive. These were for: 1) unedited raw GPS rover files, 2) edited GPS rover files, 3) differentially corrected edited GPS rover files, and 4) GIS shapefiles created from the differentially corrected rover files (for export and use in ArcView). Separate disks were used for raw and edited rover files.

Raw data consisted of rover files transferred directly from GPS units to the computer, and stored without any editing or modification. They were named using a 6-digit code (month-day-hour) preceded by a single letter (corresponding to the first letter in the crew member's last name), and ending in ".ssf." For example, "C071013.ssf" would be the file name for raw GPS data collected by Christine Craig beginning in the thirteenth hour (24-hr local time) on July 10.

Edited data files were created from raw files that were viewed in Pathfinder Office and checked for accuracy. Features were added or deleted in the process of editing to eliminate any duplicate reporting (two crew members finding the same infestation), and to add locations drawn on field maps (as when satellite signals could not be obtained). Any locations added in the editing process were noted as "hand mapped" in the notes section and are denoted as "Non-GPS" under the differential correction section. Notes were sometimes expanded during the editing process to include more detailed information about the surrounding habitat. Gross area features also were created during this process. File names were changed after editing to avoid confusion with the raw files. Edited files were named as a 3-letter month and 2-digit day abbreviation, followed by

a dash and the first letter of the crew member's last name. If a crew member collected more than one file for that day, a number would follow the crew identification letter. For example, the edited version of the second file of GPS data collected by Christine Craig on July 10 would be July10-C2.ssf.

The data from edited GPS rover files were then differentially corrected. Features that were added or deleted in the editing process were not differentially corrected; nor were points for which corresponding base station data were not available. Generally, the closest base station to the inventory area was used. However, if use of a slightly more distant base station resulted in a higher percentage of successfully corrected points, it was used in preference to a closer station. Corrected files retained the same name as their edited counterparts, but used the file extension "cor" rather than "ssf". Example: Jul10-C2.cor.

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

POST-SEASON DATA PROCESSING

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

Polygons of areas inventoried within the various drainages of the Park were created in ArcView 3.3 using the between-feature positions that tracked each crew member's daily route. Individual areas represent the units used in planning and executing inventories. Each inventory unit is identified by a unique area number, and is described using names of associated canyons or other geographical features. Information provided for each inventory area includes area size (acres), dates of the inventory, the persons involved, Park code, county, state, and country. In addition,

each area was assigned a detection confidence level indicating the crew's estimated ability to detect 0.01-acre patches of targeted weed species based on the vegetation types and the terrain. Each area also was given an ecological status rating which is a qualitative estimate of the ability of a site to recover to a natural state once the weeds have been removed. The levels of ecological status are defined in Table 2. The crew leader assigned this number based on crew field notes and/or personal on-site inspections of the areas.

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

Individual maps were exported and saved as .jpeg files. Any data tables were exported and saved as Microsoft Excel spreadsheets. Metadata was compiled for the final 2003-2004 dataset by Utah State University using ArcGIS ArcCatalog software. The metadata was provided to the Northern Colorado Plateau Network in an electronic format as part of the final project deliverables. All shapefiles, spreadsheets, raw, edited, and differentially corrected data files as well as digital photographs were also provided to NCPN as part of the final deliverables.

QUALITY ASSURANCE

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

During the first few weeks of the 2004 field season, and periodically thereafter, the Crew Supervisor (CS) and/or the Principal Investigator (PI) worked individually with each crew member to ensure that all skills had been mastered and that procedures were consistent among all crew members. The CS reviewed the crew's downloaded data and project log entries at the end of each day. Any gaps in search patterns that were significantly wider than the effective detection swath width were identified, revisited, and inventoried.

Periodically during the 2004 field season, the CS and/or PI conducted inservice training for the USU crew in the form of weed I.D. quizzes or demonstrations, reviewing the key identifying characteristics of targeted and other invasive weed species at various stages of growth. Each time any new weed species was found during an inventory, the identity was verified by the CS

and/or PI. At the end of the 2004 season the PI and CS conducted random field inspections of areas previously inventoried by individual crew members. Data collected by the PL and CS were compared with data collected by individual crew members to evaluate detection thoroughness and data accuracy (species, location, size, canopy cover, stage of growth, associated vegetation, etc.). At the end of the season both the CS and PI reviewed the data again.

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

RESULTS and DISCUSSION

Field crews inventoried 16,063 acres in Capitol Reef National Park during the summers of 2003 and 2004 (Table 3), an amount representing approximately 6.6 percent of the entire 241,904 - acre Park. The general location and relative size of areas inventoried in 2003 and 2004 are represented in Figures 1, 2, and 3. Lands inventoried in 2003 are shown in orange and those inventoried in 2004 are in red. An average of 83.9 acres was inventoried per person per 10-hr day during the two seasons.

Figures 4, 5, and 6 show the thirty-four inventory areas used in planning and field operations. The identification number, drainage description, and acreage of each inventory area are listed in the legend. Each inventory area is also color-coded for ease in identification. Figures 7, 8, and 9 serve as orientation maps for the smaller 1:24,000 scale weed-distribution “inset” maps found in Appendices H and I. Inset maps are distinguished by letters A - II, plus the name of a distinct geographic feature found within its boundaries. The corresponding inventory area numbers from Figures 4, 5, and 6 are included in the legend in parentheses behind each inset map name. Thirty-five inset maps are required to cover all 34 of the inventory areas, and large inventory areas may span over several inset maps. For example, different sections of Deep Creek (Inventory Area 23) appear on Polk Creek, Jailhouse Rock, The Notch, and Deep Creek (Insets A, B, C, D).

Invasive plants infested a total of 1,199.6 acres (Table 4), an amount equal to 7.5 percent of the land inventoried. Of the 17 targeted species, only *Asparagus* sp., *Ailanthus altissima*, *Arctium minus*, *Centaurea repens*, *Cirsium vulgare*, *Convolvulus arvensis*, *Elaeagnus angustifolia*, *Halogeton glomeratus*, *Marrubium vulgare*, and *Tamarix ramosissima* were found in the Park. No infestations of *Carduus nutans*, *Centaurea diffusa*, *Centaurea maculosa*, *Centaurea squarrosa*, *Cirsium arvense*, *Euphorbia esula* or *Onopordum acanthium* were discovered. Non-target species mapped were *Salsola kali*, *Sisymbrium altissimum*, *Tragopogon dubius*, *Ulmus pumila*, and *Verbascum thapsus*.

The most abundant target species found in the Park was *Tamarix ramosissima*. This species, which was especially common along much of the Fremont River and Halls Creek drainages, comprised more than 68 percent of the total infested acreage inventoried. *Elaeagnus angustifolia* made up 21.9 percent of the infested acres. The remaining infestations (10.1 % of the total infested acreage) were comprised of the other eight targeted species and the four additional non-native species that were mapped.

Deciding which non-target weeds to map was left to the discretion of individual crew members, based on their assessment of the potential threat and relative abundance of each species. Species such as *Bromus tectorum*, *Bromus inermis*, *Lactuca serriola*, *Erodium cicutarium*, *Sonchus oleraceus*, *Melilotus officinalis*, *Dactylis glomeratus*, and *Chenopodium album* were present in most areas but were ignored due to their previously recognized abundance in the Park. Species such as *Salsola kali*, *Sisymbrium altissimum*, and *Tragopogon dubius* were mapped by some but not all crew members; and those who chose to map them often did so only in locations of unusually low abundance. As a result, the acreage values and corresponding distribution maps for these non-target species should be considered less than complete inventories.

Figure 1. Total area inventoried for non-native plant species in the Fruita region of Capitol Reef National Park during 2003 and 2004.

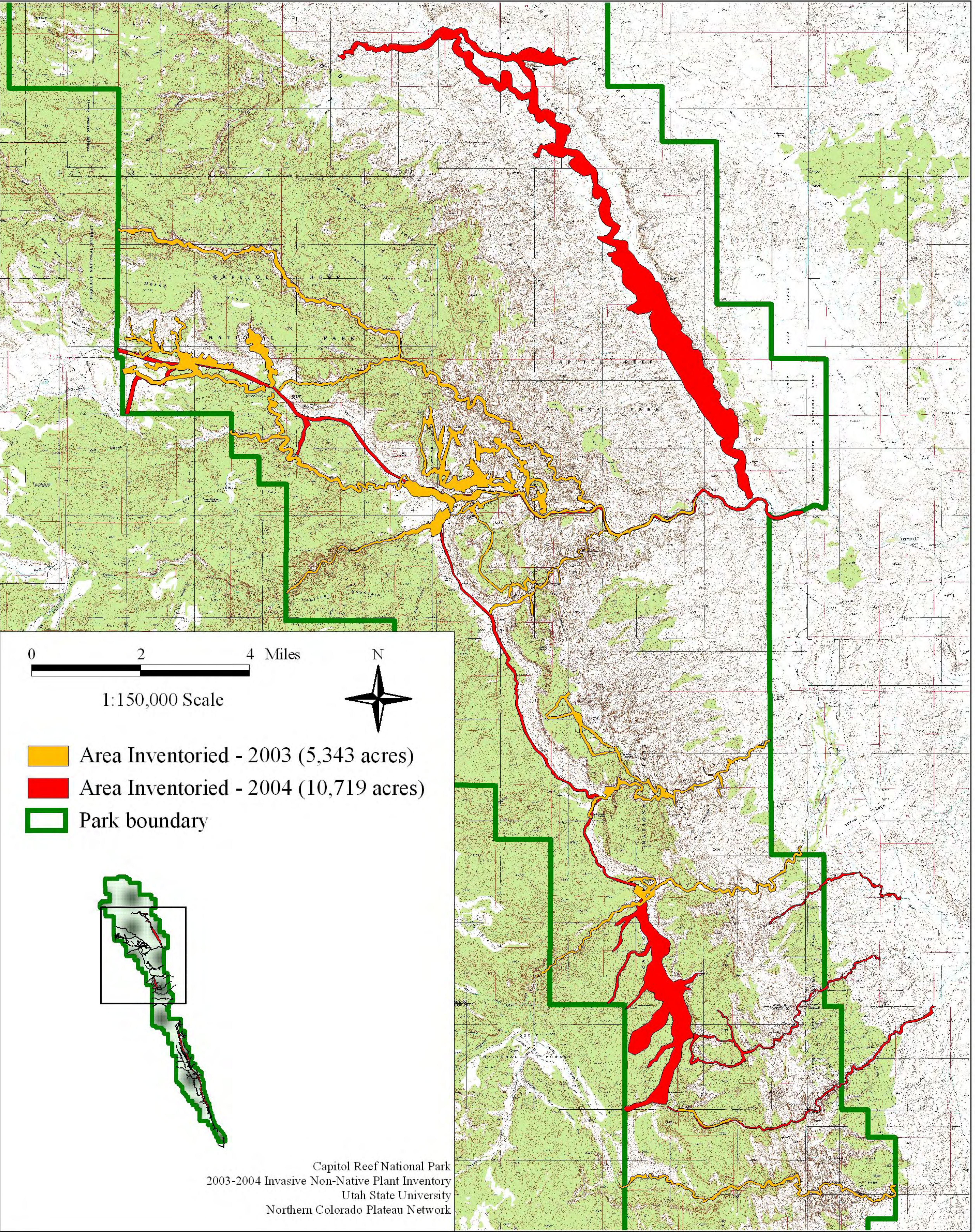


Figure 2. Total area inventoried for non-native plant species in the Upper Halls Creek region of Capitol Reef National Park during 2003 and 2004.

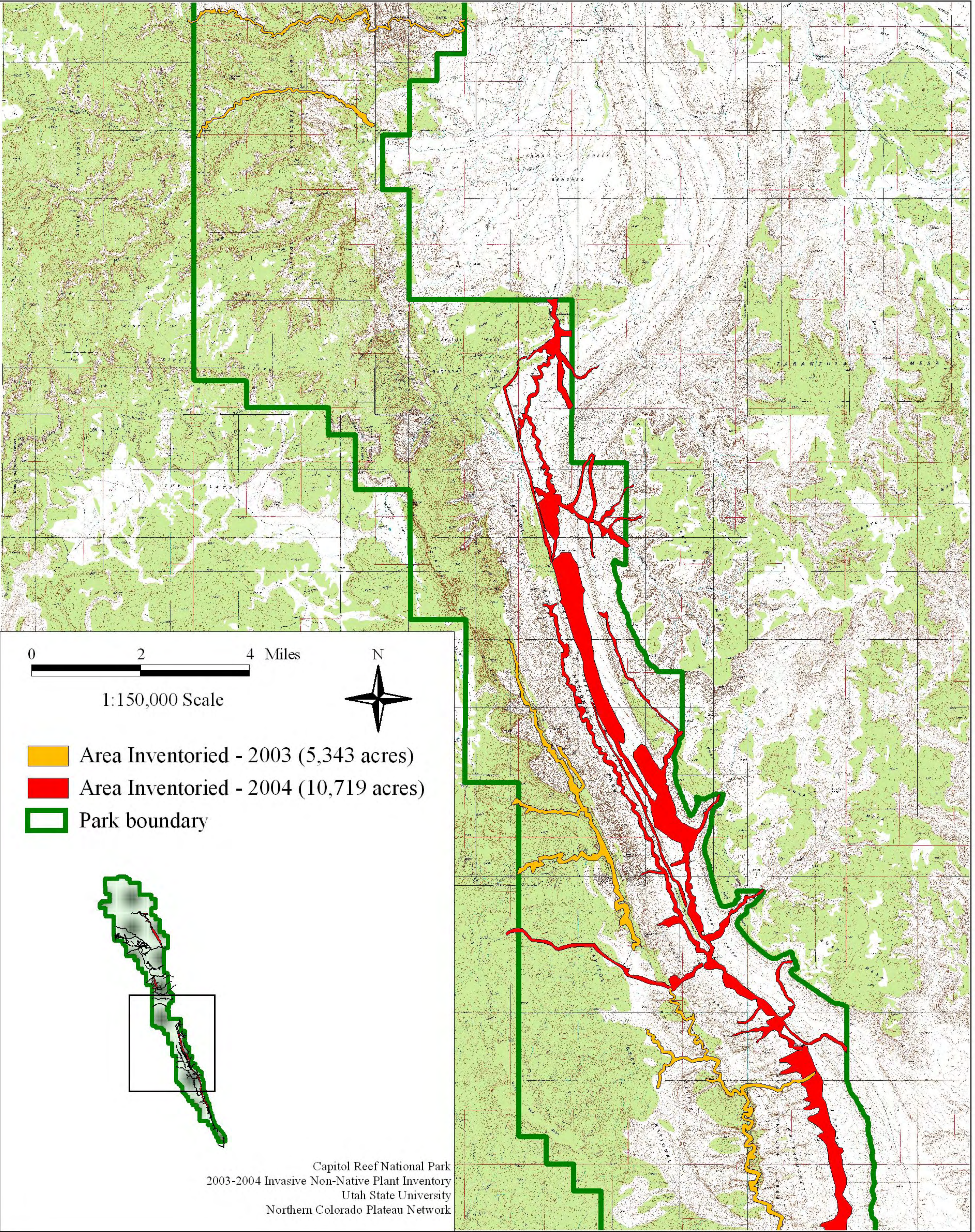


Figure 3. Total area inventoried for non-native plant species in the Lower Halls Creek region of Capitol Reef National Park during 2003 and 2004.

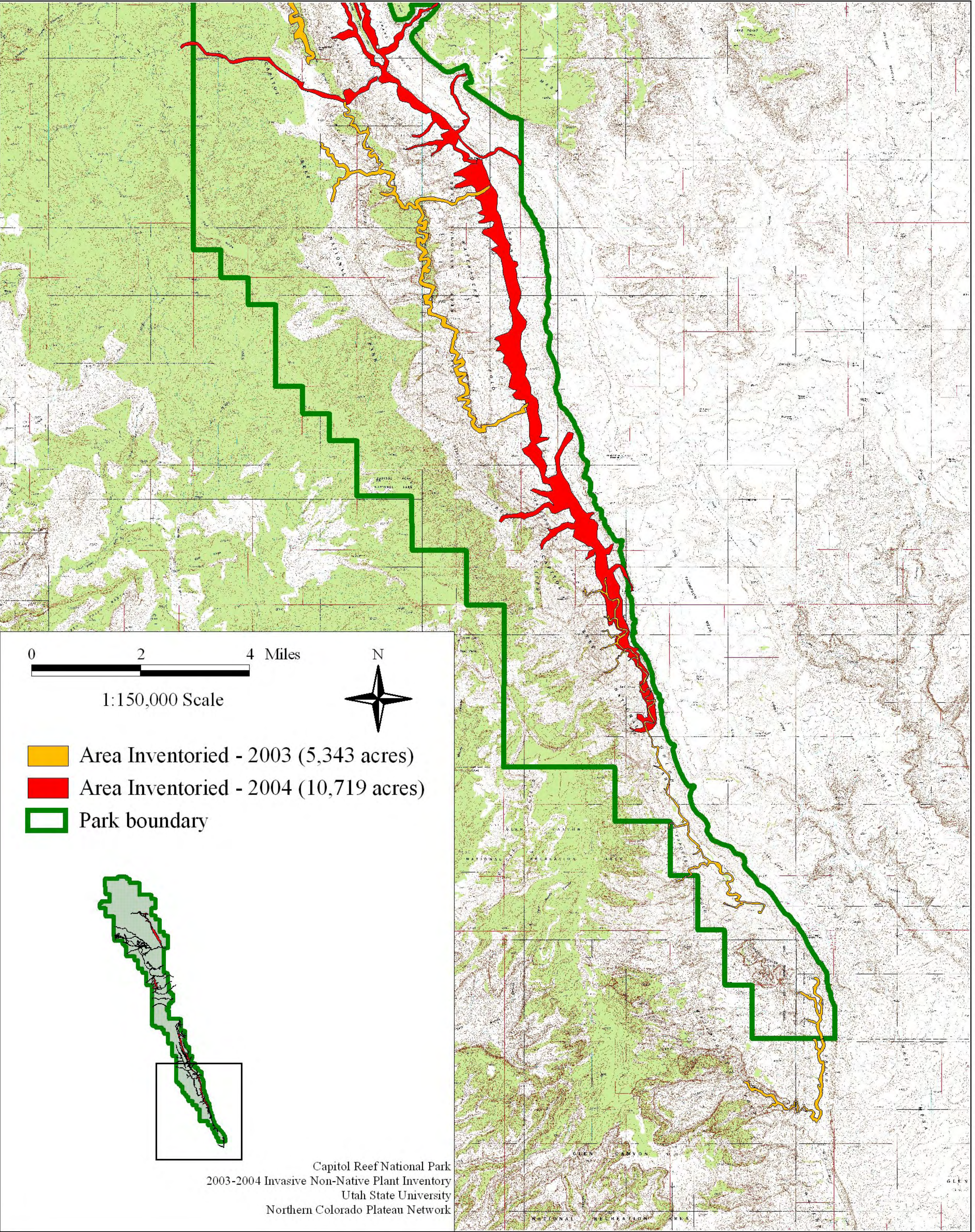


Figure 4. Identification number and acreage of individual areas inventoried for non-native invasive plant species in the Fruita region of Capitol Reef National Park during 2003 and 2004.

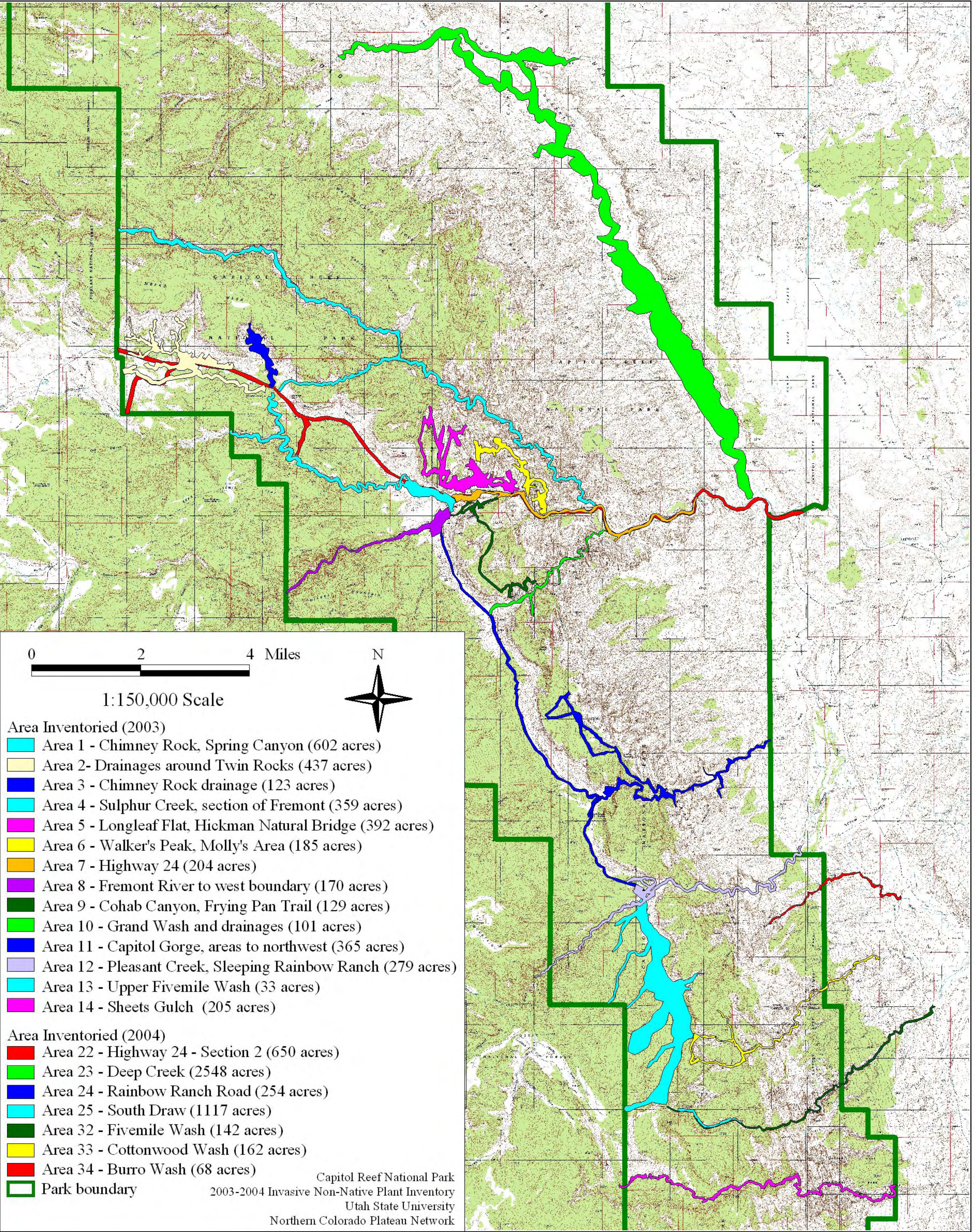


Figure 5. Identification number and acreage of individual areas inventoried for non-native invasive plant species in the Upper Halls Creek region of Capitol Reef National Park during 2003 and 2004.

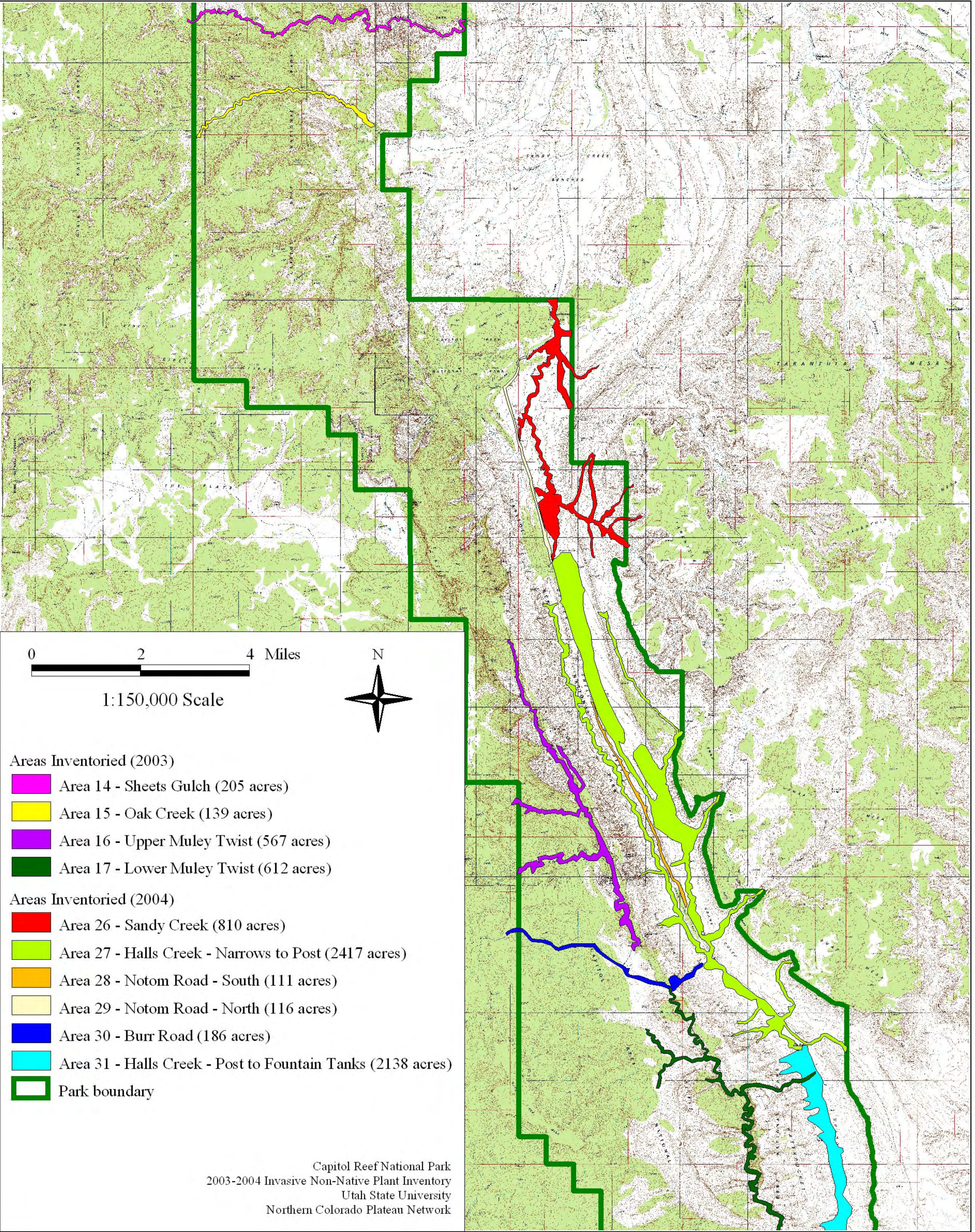


Figure 6. Identification number and acreage of individual areas inventoried for non-native invasive plant species in the Lower Halls Creek region of Capitol Reef National Park during 2003 and 2004.

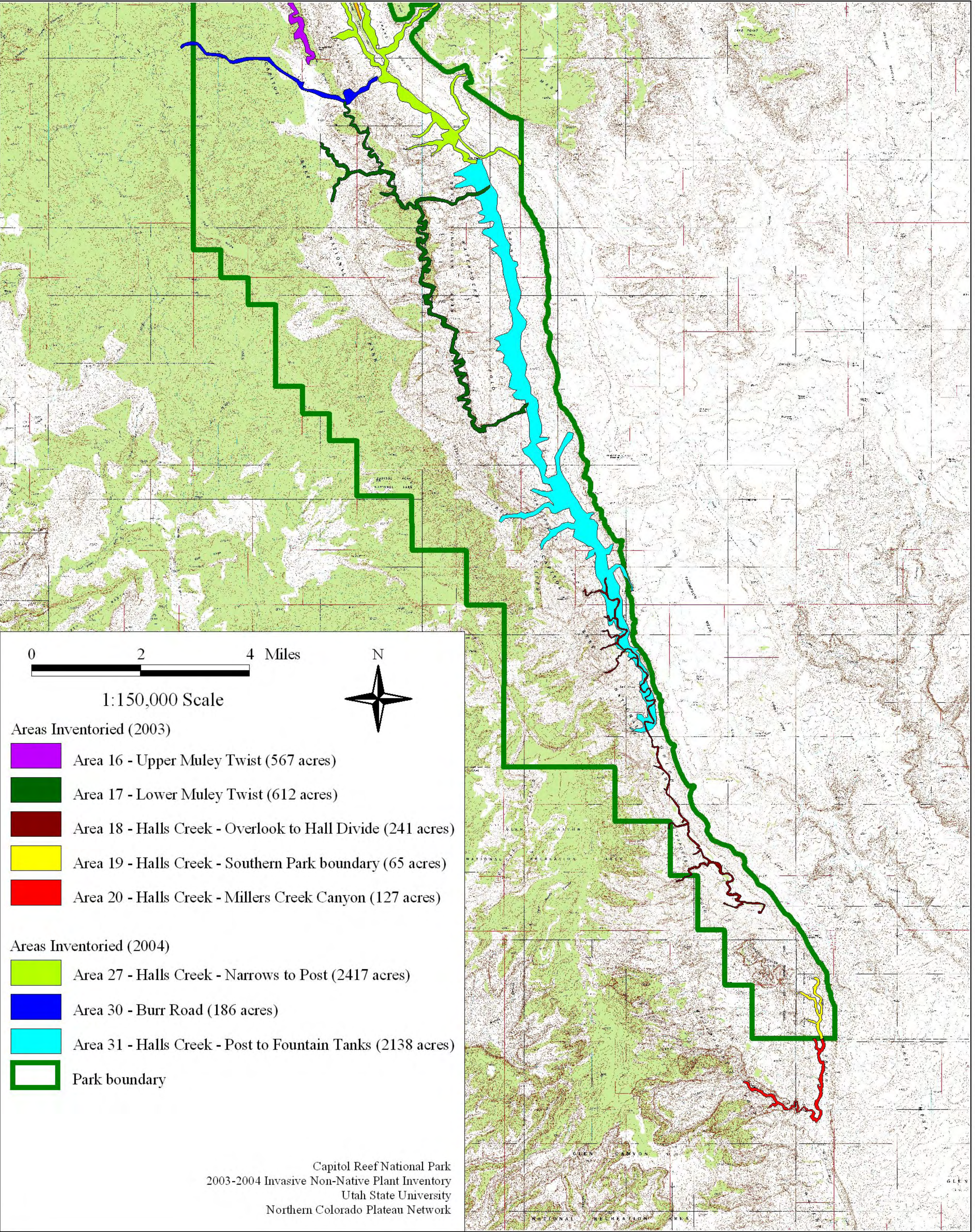


Figure 7. Insets indicating the location, letter code, and name of the twenty-one 1:24,000 scale maps used in Appendix tables to show weed distribution within individual inventoried areas in the Fruita region of Capitol Reef National Park during 2003 and 2004.

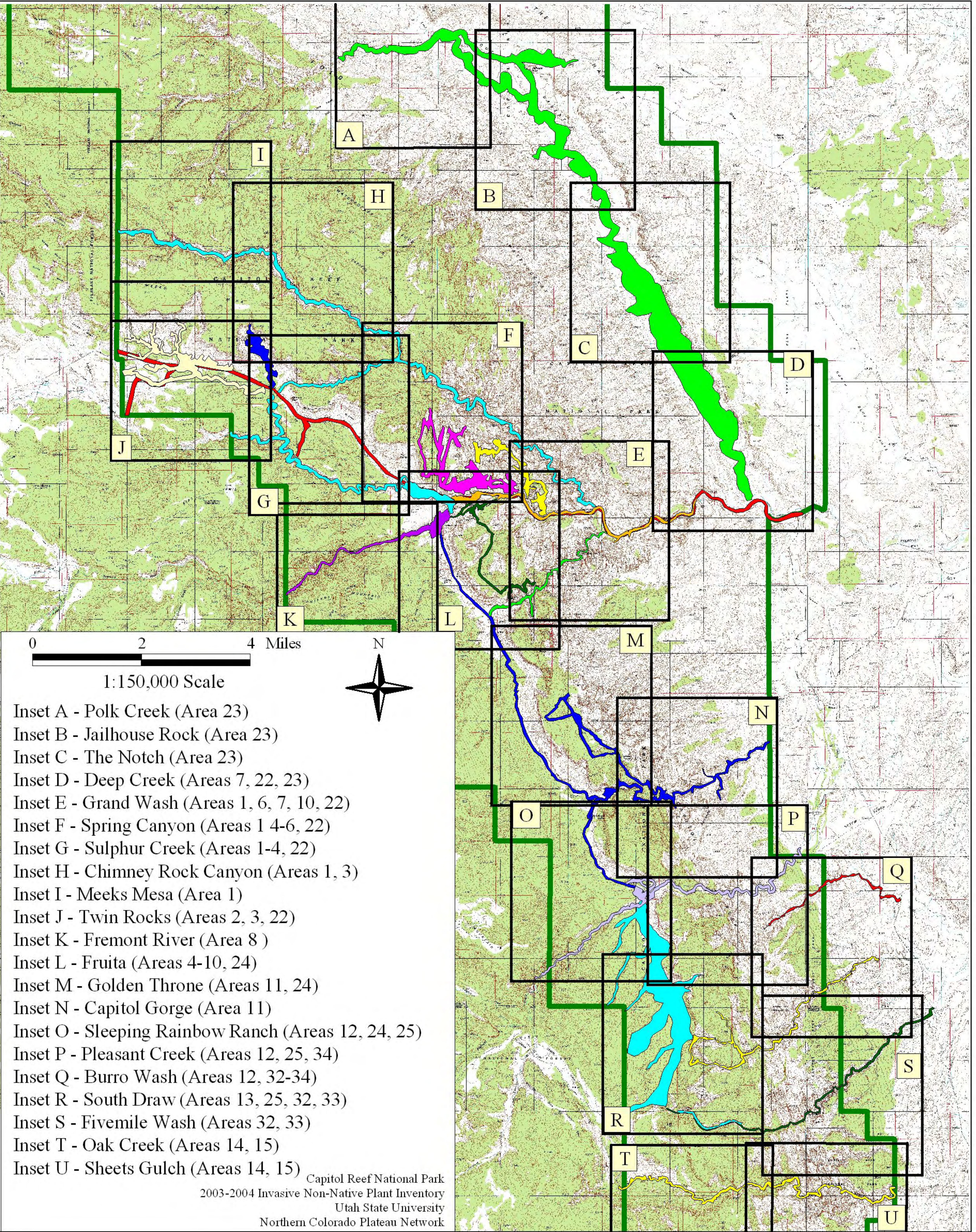


Figure 8. Insets indicating the location, letter code, and name of the ten 1:24,000 scale maps used in Appendix tables to show weed distribution within individual inventoried areas in the Upper Halls Creek region of Capitol Reef National Park during 2003 and 2004.

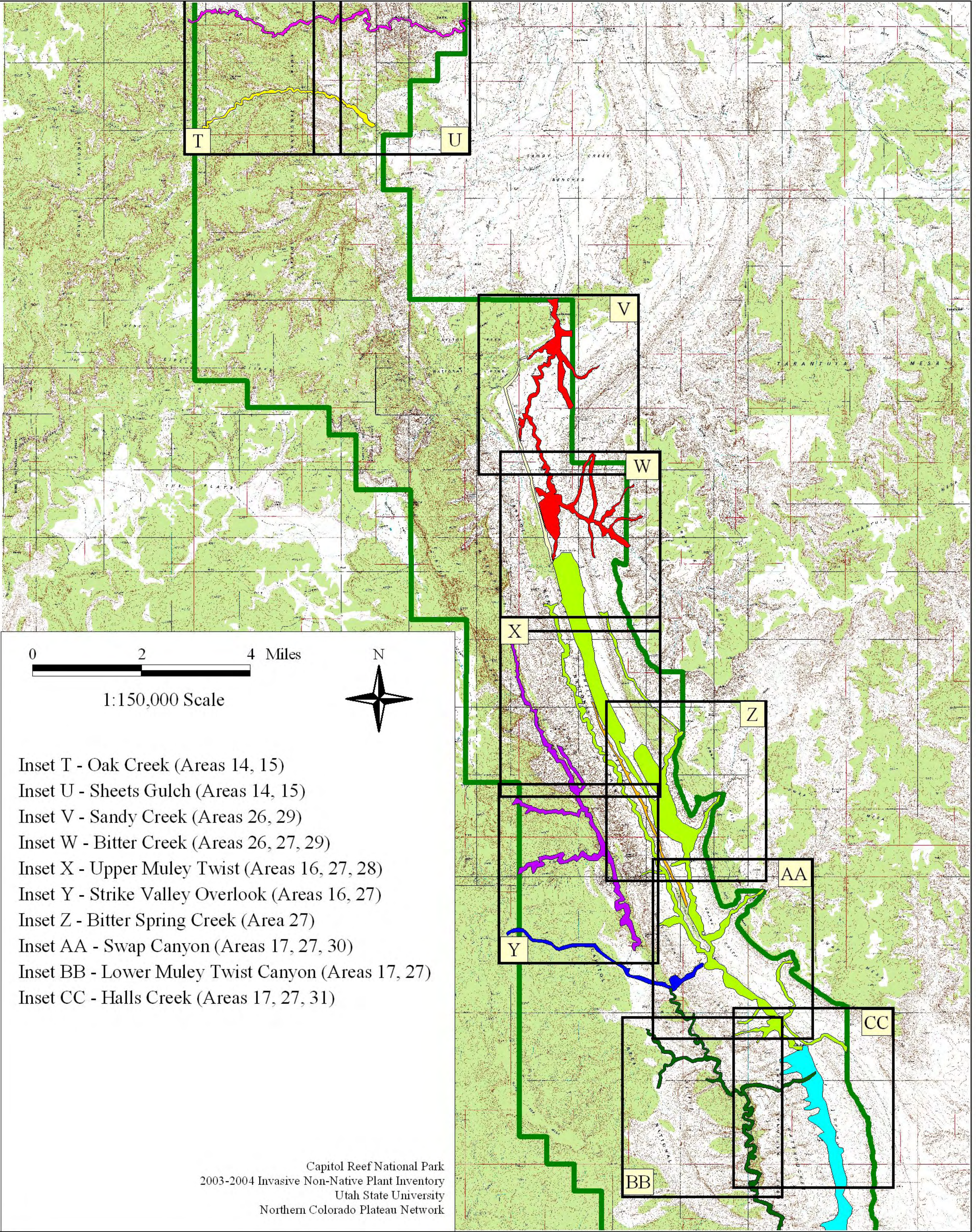


Figure 9. Insets indicating the location, letter code, and name of the nine 1:24,000 scale maps used in Appendix tables to show weed distribution within individual inventoried areas in the Lower Halls Creek region of Capitol Reef National Park during 2003 and 2004.

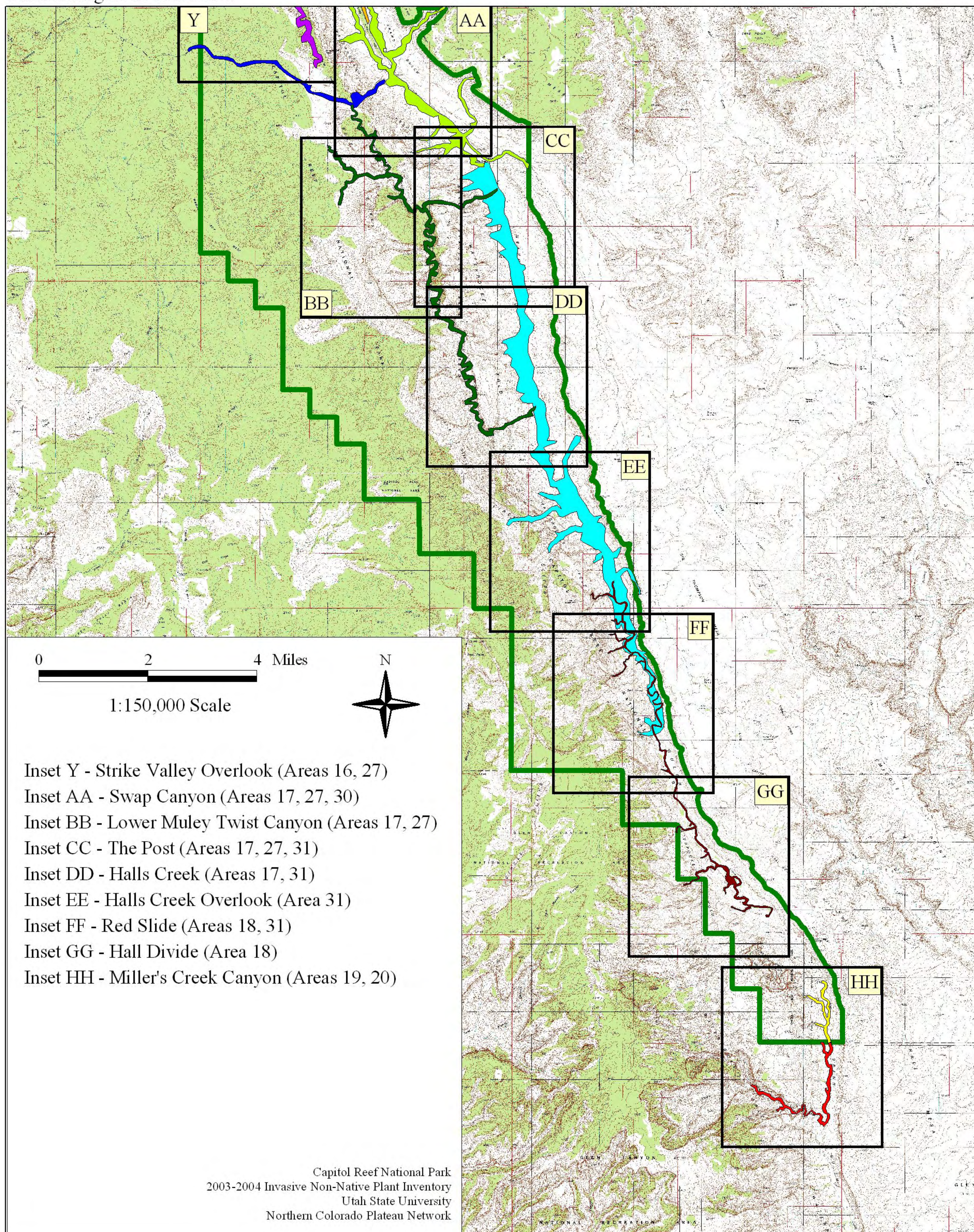


Table 4: Acres infested by invasive plant species within inventoried areas of Capitol Reef National Park and adjacent lands in 2003-2004.

Species	2003	2004	Acres (Inside Park)	Acres (Outside Park)	Total Acres Infested
<i>Ailanthus altissima</i>	8.33	0.371	8.701	---	8.701
<i>Arctium minus</i>	0.33	---	0.33	---	0.33
<i>Asparagus sp.</i>	0.08	---	0.08	---	0.08
<i>Centaurea repens</i>	---	0.01	0.01	---	0.01
<i>Cirsium vulgare</i>	0.04	---	0.04	---	0.04
<i>Convolvulus arvensis</i>	37.18	0.031	37.211	---	37.211
<i>Elaeagnus angustifolia</i>	9.83	240.278	250.088	0.02	250.108
<i>Halogeton glomeratus</i>	4.80	17.682	22.482	---	22.482
<i>Marrubium vulgare</i>	0.23	---	0.23	---	0.23
<i>Salsola kali</i>	3.390	64.034	64.432	2.992	67.424
<i>Sisymbrium altissimum</i>	---	0.005	0.005	---	0.005
<i>Tamarix ramosissima</i>	130.196	682.755	808.415	4.536	812.951
<i>Tragopogon dubius</i>	---	0.035	0.035	---	0.035
<i>Ulmus pumila</i>	0.02	---	0.02	---	0.02
<i>Verbascum thapsus</i>	---	0.001	0.001	---	0.001
Totals	194.426	1,005.202	1,192.08	7.548	1,199.628

Appendix H contains maps showing the overall distribution and relative abundance of all mapped weeds (no species distinction) within the boundaries of inventoried areas. Appendix I contains maps of individual species occurrences and weed-free areas within all inventoried portions of Capitol Reef National Park. Following is a summary of the weed situation in individual drainages and other inventory units within Capitol Reef National Park.

Twin Rocks (Area Number 2; Inset Map J)

Several drainages around the Twin Rocks were inventoried by the NPS in 2003. Targeted species found by the crew include *Tamarix ramosissima* and *Halogeton glomeratus*. The patches of *Tamarix ramosissima* were found in many of the small drainages formed by the runoff of water from the cliffs to the north. *Halogeton glomeratus* was found more commonly along the road shoulder of Highway 24. *Salsola kali* was also found and mapped along the road shoulder of Highway 24. Small patches of it were also discovered in a small wash directly behind Twin Rocks. *Bromus tectorum* was seen but not mapped in this area.

Visibility was generally very good and the area was very open. It is assumed the crew inventoried the area in a way to ensure at least 90 percent of all 0.01-acre or larger infestations of the targeted species could be found. No obvious disturbance aside from seasonal flooding was noted by the crew. The area was assigned an ecological status level three.

Chimney Rock Canyon / Spring Canyon (Area Number 1; Inset Maps E, F, G, H, I)

Chimney Rock Canyon and Spring Canyon from the Park boundary to the Fremont River were inventoried by four NPS crew members in 2003. The only targeted species found were *Tamarix ramosissima*, and *Elaeagnus angustifolia*. *Tamarix ramosissima* was scattered sporadically throughout the entire length of the drainage. Five of the six occurrences of *Elaeagnus angustifolia* occurred near the mouth of Spring Canyon within 1 kilometer or less of its confluence with the Fremont River. The sixth infestation of *Elaeagnus* was a 0.01-acre patch located approximately 3 kilometers from the Fremont River. Several infestations of *Salsola kali* were mapped in the section of canyon where the drainage name changes from Chimney Rock Canyon to Spring Canyon.

Visibility was generally very good and it is assumed the NPS crew inventoried the area in a manner that ensured detection of at least 90 percent of all 0.01-acre or larger infestations of the targeted species. No obvious disturbance aside from seasonal flooding was noted. The area was assigned an ecological status level of three.

Chimney Rock Drainage (Area Number 3; Inset Maps G, H, J)

This small drainage was inventoried by one NPS crew member in 2003. The inventory area includes the washes formed from water runoff from the cliffs to the northwest of Chimney Rock. The inventory area is from the base of the cliffs to Highway 24. The only target species found was *Halogeton glomeratus*. The infestations were found primarily at the base of the cliffs and the head of the wash. *Bromus tectorum* was also seen in trace amounts but not mapped.

Visibility was excellent and it is unlikely that any 0.01-acre or larger infestations of the targeted species were missed during the inventory of this area. No disturbances were noted by the person mapping this area. The area was assigned an ecological status of two.

Sulphur Creek, Mid-Fremont (Area Number 4; Inset Maps F, G, J, L)

Sulphur Creek was inventoried from the Park boundary to its confluence with the Fremont River by two NPS crew members in 2003. Targeted species encountered were *Ailanthus altissima*, *Arctium minus*, *Convolvulus arvensis*, *Elaeagnus angustifolia*, *Halogeton glomeratus*, and *Tamarix ramosissima*. Based on numbers of infestations recorded, *Convolvulus arvensis* was the most abundant target species found in Area 4. *Convolvulus arvensis* was scattered throughout the area between the Visitor Center and the Fremont River, but was not found upstream from the Center. The general distribution pattern of *Convolvulus arvensis* appeared to correlate closely with previously cultivated lands associated with earlier farming operations. *Elaeagnus angustifolia* and *Tamarix ramosissima* were common along the entire length of Sulphur Creek above the Visitor Center, but were noticeably absent between the Visitor Center and the Fremont River – presumably because of the Park's aggressive efforts to control these two species in such high-visibility sites. *Ailanthus altissima* was relatively abundant at the east edge of this inventory area within 400 yards or less of the Fremont River. No *Ailanthus* was found upstream from the Visitor Center. Scattered *Halogeton glomeratus* was observed along the shoulder of the road running through the historic district from the Visitor Center to the campground, and some *Arctium minus* was found in the associated orchard and picnic areas. A single patch each

of *Halogeton* and *Arctium* were found upstream from the Visitor Center at the canyon fork above the Goosenecks. The crew pulled all *Halogeton* plants at that location.

Visibility was excellent and it is unlikely that any 0.01-acre or larger infestations of the targeted species were missed during the inventory of this area. No obvious disturbance aside from seasonal flooding was noted above the Visitor Center. The primary disturbance in the lower portion of this inventory area was the result of past agricultural developments and current visitor-related facilities and improvements. The area was assigned an ecological status level of three.

Longleaf Flat, Hickman Natural Bridge Hiking Trail (Area Number 5; Inset Maps F, L)

This area was inventoried by three members of the NPS crew in 2003. The inventory unit includes the hiking trail to Hickman Natural Bridge as well as areas around Longleaf Flat. *Tamarix ramosissima* was the most common species found in the inventory unit. The majority of *Tamarix ramosissima* was found around or below the Natural Bridge. Four infestations of *Ailanthus altissima* were also found below the Bridge in various small side drainages. An additional patch of *Ailanthus altissima* was found east of Longleaf Flat. An acre patch of *Halogeton glomeratus* was also inventoried on Longleaf Flat. Although not mapped, *Bromus tectorum* was seen along the Hickman Natural Bridge trail.

Visibility was very good throughout this inventory area and it is assumed that the crew conducted the inventory in a way making it possible to see 90 percent of all 0.01-acre or larger patches of the targeted species. This trail is probably the most popular trail in the Park and receives continual disturbance from people. The only other obvious disturbance is from seasonal flooding throughout the year. The area was assigned an ecological status of two.

Walker's Peak, Molly's Area (Area Number 6; Inset Maps E, F, L)

This area was inventoried by one NPS crew member in 2003. Species found include 1 patch of *Tamarix ramosissima*, two infestations of *Ailanthus altissima*, two patches of *Asparagus* sp., and two patches of *Ulmus pumila*. No notes indicating obvious disturbances could be found. It is assumed that the crew was confident of finding 90 percent of all 0.01-acre or larger infestations of the targeted species. The area was assigned an ecological status level two.

Fremont River - West (Area Number 8; Inset Maps K, L)

The Fremont River was inventoried by four NPS crew members in 2003 from the Park boundary to the bridge just above the river's confluence with Sulphur Creek. Targeted species encountered were *Arctium minus*, *Asparagus* sp., *Cirsium vulgare*, *Convolvulus arvensis*, *Elaeagnus angustifolia*, *Halogeton glomeratus*, *Marrubium vulgare*, and *Tamarix ramosissima*. As was the case in the Sulphur Creek inventory area, the most abundant target species was *Convolvulus arvensis*, and its distribution appeared to correlate closely with the once-farmed eastern portion of this area. *Halogeton glomeratus* was the second most common target species, and its distribution was likewise restricted to the eastern portion. Other less-abundant species associated with the previously cultivated lands were *Marrubium vulgare*, *Cirsium vulgare*, and *Arctium minus*. A single *Asparagus* plant was found approximately 1 mile from the west Park boundary, and a single *Cirsium vulgare* was found near the midpoint between the west and east ends of this inventory area. *Tamarix ramosissima* was distributed from one end of the area to the other, although somewhat less abundant than in the Sulphur Creek area. Only 5 individual

trees or small patches of *Elaeagnus angustifolia* were found within this inventoried section of the Fremont River.

Visibility was excellent and it is unlikely that any 0.01-acre or larger infestations of the targeted species were missed during the inventory of this area. No obvious disturbance aside from seasonal flooding was noted outside the developed or previously cultivated lands. The area was assigned an ecological status level of three.

Cohab Canyon, Frying Pan Trail (Area Number 9; Inset Map L)

The trail through Cohab Canyon and the Frying Pan Trail were inventoried in 2003 by a crew of two. The canyon and the Frying Pan Trail were both clean of targeted species. Two small plants of *Halogeton glomeratus* were found on the trail up to Cohab Canyon next to the road and campground. Otherwise no other target species were discovered. The crew also did not note the presence of any other non-native species in the area. It is assumed the crew could see at least 90 percent of all 0.01-acre infestations in this inventory unit. The trail likely serves as the only disturbance through this area. The area was assigned an ecological status level one.

Grand Wash (Area Number 10; Inset Maps E, L)

Grand Wash was inventoried by two NPS crew in 2003. The wash was inventoried from the South Draw road to Highway 24 during this inventory. Portions of two small side canyons were also included in this unit. *Tamarix ramosissima* was the most common species found in Grand Wash and it was only found in the first mile stretch from the scenic drive. Three patches of *Halogeton glomeratus*, one patch of *Asparagus* sp., and two patches of *Salsola kali* were also recorded along this stretch of Grand Wash. Species seen but not mapped include *Bromus tectorum* and *Melilotus officinalis*.

Visibility was generally good in this inventory unit and the crew was confident of finding 90 percent of the 0.01-acre or larger infestations of the targeted species. Grand Wash is a popular hiking trail in Capitol Reef National Park. Disturbances include vehicle traffic in the upper portion of Grand Wash and foot traffic in the lower portion as well as regular flash flooding. The area was assigned an ecological status level two.

Capitol Wash (Area Number 11; Inset Maps M, N)

Capitol Wash was inventoried by three persons from the NPS crew in 2003. Included in this inventory unit is the section of Capitol Wash from Eph Hanks Tower to the Park boundary and the trail leading to the base of the Golden Throne. *Tamarix ramosissima* was the most common targeted species found in Capitol Wash. It was mostly found below the Pioneer Register, although a small patch was found in the mouth of Waterpocket Canyon. An additional patch was found in a small wash at the base of the Golden Throne. *Halogeton glomeratus* was also found scattered along the wash in Capitol Wash and it was also more common between Eph Hanks Tower and the Pioneer Register. Only a handful of small infestations of *Salsola kali* were discovered in Capitol Wash along the wash. One patch of *Elaeagnus angustifolia*, comprised of saplings, was found in the wash below Golden Throne. Species seen but not mapped include *Bromus tectorum* and *Melilotus officinalis*.

Visibility was generally very good and the crew was confident in finding at least 90 percent of all 0.01-acre or larger infestations of the targeted species. The trail through Capitol Wash receives a heavy amount of foot and vehicle traffic on a regular basis and is one of the more heavily used trails in the Park. The area is also subject to seasonal flooding. The area was assigned an ecological status level two.

Pleasant Creek, Sleeping Rainbow Ranch (Area Number 12; Inset Maps M, O, P, Q)

Pleasant Creek was inventoried from its western Park boundary to the eastern Park boundary by the NPS crew in 2003. The Sleeping Rainbow Ranch was also included in this inventory unit. Pleasant Creek is one of the few perennial streams in the Park, and as might be expected, an abundance of non-native species were found here. The most common targeted species encountered was *Tamarix ramosissima*. *Tamarix ramosissima* was found along the entire length of Pleasant Creek inventoried and it likely continues along the Creek outside the Park. *Tamarix* stands consisted of a mixture of mature trees and saplings. The crew also found several patches of *Elaeagnus angustifolia* at and upstream from the Sleeping Rainbow Ranch. Two patches were also mapped near the western Park boundary.

Other targeted species found include *Halogeton glomeratus*, *Ailanthus altissima*, and *Asparagus* sp. The four patches of *Asparagus* sp., two patches of *Ailanthus altissima*, and one patch of *Halogeton glomeratus* were found at the Ranch site. Although not a target species, *Salsola kali* was mapped and inventoried in this area. Small patches of *Salsola kali* were along Pleasant Creek near the western Park boundary. However, it was found heavily invading the Ranch site as well in the lower portion of Pleasant Creek below the Ranch. Other non-target species seen but not mapped include *Erodium cicutarium*, *Bromus tectorum*, *Lactuca serriola*, and *Chenopodium album*. Although apparently no GPS data was collected showing the location of *Convolvulus arvensis* in Pleasant Creek, the crew did make mention in their field notes of its presence.

Visibility was generally good along Pleasant Creek and it is unlikely the crew missed any 0.01-acre or larger patches of the targeted species. No obvious disturbances were noted in the area, although the Ranch site appears heavily disturbance from past use. Vehicle traffic and foot traffic are common in the vicinity of the Ranch. The area was assigned an ecological status level four.

Rainbow Ranch Road (Area Number 24; Inset Maps L, M, O)

The Rainbow Ranch road (out to approximately 35 yards on both sides of the road) were inventoried by the USU crew in 2004 between the campground near the Visitor Center to the point where the road crosses Pleasant Creek. *Halogeton glomeratus* was the most common target species encountered, with a total of 9 infestations reported. The crew also found 1 *Convolvulus arvensis* infestation and 1 *Elaeagnus angustifolia* sapling. No other target species were observed. Five patches of *Salsola kali*, a non-targeted species, were mapped along the road.

The crew noted several occurrences of a plant somewhat resembling *Alhagi pseudalhagi* growing along the road, but was unsure of its identity. During a quality-assurance visit by the PI and crew leader later in the summer (after the species in question had bloomed) a specimen was

inspected and photographed for identification by the Intermountain Herbarium at Utah State University. It was determined to be *Stephanomeria spinosa* (Thorn Wirelettuce), a native plant found throughout much of western North America.

Visibility was excellent and the crew was confident of having found all 0.01-acre or larger infestations of all targeted species during the inventory of this area. No obvious disturbance aside from seasonal flooding was noted beyond the graded road shoulders. The area was assigned an ecological status level of two.

South Draw (Area Number 25; Inset Maps O, P, R)

South Draw is a large area containing a mixture of juniper and sagebrush with some cottonwoods and willow along the wash. *Tamarix ramosissima* was found scattered along the wash. Most of the trees were moderately sized saplings in the budding stage at the time of the inventory. Trace amounts of *Tamarix ramosissima* were also detected in several of the small side drainages to the west of South Draw. Small amounts of *Salsola kali* were also found along the wash although it was much more common near the Ranch. A single patch of *Halogeton glomeratus* was also found out in the hills near the head of Burros Wash.

Visibility was generally good and the crew was confident of finding 90 percent of all 0.01-acre or larger infestations of the targeted species. The plant community was relatively intact away from the wash. No weeds were found away from the wash and it is not believed that any weeds would exist outside the wash due to the dry conditions and shale covered ground. The region near the Sleeping Rainbow Ranch was weedier and the crew noted the presence of *Bromus tectorum* and *Chenopodium album*. Disturbances include vehicle and foot traffic along the wash and road and historical grazing. The area was assigned an ecological status level two.

Burro Wash (Area Number 34; Inset Maps P, Q)

Portions of Burro Wash were inventoried by a crew of two in 2004. The crew was able to inventory the wash from the Notom Road to the first large pouroff, approximately three miles from the road. The crew also inventoried the top portion of the wash but inclement weather prevented them from continuing down the slot canyon. The lower half of Burro Wash was infested with *Tamarix ramosissima* and *Salsola kali*. Thirteen infestations of *Tamarix ramosissima* and nine patches of *Salsola kali* were found between the Notom Road and the Park boundary. No target species were observed inside the Park between the Park boundary and the pouroff, nor in the head of the canyon. The crew noted *Bromus tectorum* lightly scattered along the lower portion of Burro Wash but none inside the Park boundary.

The middle section of Burro Wash was not inventoried but it is unlikely that any of the target species will be found there. Visibility was very good throughout this inventory area and the crew was confident of finding all 0.01-acre or larger infestations of the targeted species. Heavy seasonal flooding is an obvious disturbance in this area as well as vehicle traffic along the first two miles of the wash. The overall area was assigned an ecological status level two due to the presence of weeds outside the Park boundary. However, the section of Burro Wash inside the Park boundary could have an ecological status of one.

Cottonwood Wash (Area Number 33; Inset Maps Q, R)

Cottonwood Wash was inventoried in 2004 by a USU crew of three persons. This wash was a mixture of slot canyons and narrow pockets of boxelders, juniper, native grasses and forbs. *Tamarix ramosissima* was the only target species found in this inventory unit and all were discovered outside the Park boundary. These three small patches of mature trees were inventoried approximately a mile from the Notom Road. The crew did see *Bromus tectorum* in scattered pockets along the wash but did not map it.

Visibility was excellent in the canyon and the crew was confident of finding all 0.01-acre or larger infestations of the targeted species. Heavy seasonal flooding appeared the only disturbance to this area. An ecological status level two was assigned due to the presence of non-native species in the section of wash outside the Park boundary. However, the section of Cottonwood Wash inside the Park boundary could have an ecological status of one.

Fivemile Wash (Area Number 13, 32; Inset Maps R, S)

Fivemile Wash is a slot canyon inventoried by two USU crew members in 2004. Sections of Fivemile Wash contain cottonwoods, boxelders, junipers, virgin's bower, native grasses and forbs, while other sections are comprised of bare rock and sand. One *Tamarix ramosissima* was found approximately 2 miles from the head of the wash and approximately a quarter-mile from the point where the canyon narrows to a slot. This single tree was mature and in a seed dispersing stage at the time of its discovery. *Tamarix ramosissima* was also found along Fivemile Wash below the slot canyon section. These trees were found in the last mile of Fivemile Wash before the Notom Road. However, they were not mapped at the time due to technical difficulties with the GPS and maps. A small patch of *Salsola kali* was also found near the first patch of *Tamarix ramosissima*.

Other non-native species seen but not mapped include *Bromus tectorum*, *Melilotus officinalis* and *Tragopogon dubius*. Visibility was excellent throughout the canyon and the crew was confident of having seen all 0.01-acre or larger infestations of the targeted species. Flash flooding is the major disturbance in this inventory unit. An ecological status level of two was assigned.

Sheets Gulch (Area Number 14; Inset Maps T, U)

Sheets Gulch was inventoried by one of the NPS crew in 2003. *Tamarix ramosissima* was the only target species recorded in this drainage. The infestations of *Tamarix ramosissima* were particularly common in the upper half of the Gulch and only three small patches were found in the lower half. This suggests that the remaining half of the Gulch could be invaded by *Tamarix ramosissima* if it is not controlled. No notes were made by the crew pertaining to this site but it is likely that seasonal flooding would be the primary disturbance in the area. It is assumed that the crew was confident of finding more than 90 percent of all 0.01-acre infestations of the targeted species. The area was assigned an ecological status level of three by the USU crew leader.

Oak Creek (Area Number 15; Inset Maps T, U)

Oak Creek was inventoried by the NPS crew in 2003. Oak Creek was found to be heavily infested with *Tamarix ramosissima*. The crew recorded a total of 89 separate infestations of

Tamarix ramosissima throughout the portion of Oak Creek found inside the Park boundary. The crew also found 3 patches of *Elaeagnus angustifolia* and 1 patch of *Salsola kali* near the western Park boundary. The crew searched for *Euphorbia esula* reported to be in the area but was not able to locate any plants.

The primary disturbance appears to be a pack trail that follows the creek, and normal seasonal flooding. The crew was confident of finding at least 90 percent of the 0.01-acre or larger infestations of the targeted species. The area was assigned an ecological status level of four.

Notom Road (Area Numbers 28, 29; Inset Maps V, X, X, Z, AA)

The Notom Road was inventoried from the cab of a truck by two persons in 2004. The entire length of road was inventoried from the Narrows to the Post, but this discussion will only include the section of road from the Narrows to Peek-a-boo Rock. The remaining sections of road are included in other inventory units and are discussed in other sections of this report. The crew inventoried the road corridor from the road shoulder to approximately 50 yards out on either side. *Tamarix ramosissima* was the most common target species, with infestations typically 25 yards or more from the road. Infestations were found in stock ponds and water catchment areas that appeared to be spaced every quarter mile along the road. Each of these stock ponds usually contained some *Tamarix* as well as several other non-native species. A single 0.01-acre patch of *Convolvulus arvensis* was also found on the east shoulder of the road approximately 3 miles south of the Narrows (and the Park boundary).

Salsola kali was widespread along the road shoulder but was not inventoried. Instead, its abundance was estimated as a gross area encompassing much of the Halls Creek region (discussed later). Other species seen but not mapped along the road shoulder include *Bromus tectorum*, *Melilotus officinalis*, *Lactuca serriola*, *Chenopodium album*, and *Erodium cicutarium*.

Visibility was generally good and it is unlikely the crew found at least 90 percent of all 0.01-acre patches of the targeted species. The road shoulders appeared heavily disturbed due to the lack of abundant native species. This is likely due to vehicle traffic and the effects of past grazing. Both sections of road were assigned an ecological status level three due to the presence of mapped and unmapped non-natives.

Sandy Creek (Area Number 26; Inset Maps V, W)

The Sandy Creek area was inventoried by a crew of two in 2004. Included in this inventory area is the section of Sandy Creek between the Park boundary and Bitter Creek Divide as well as a section of Bitter Creek from the Notom Road to Sandy Creek. The wash in Sandy Creek was dry at the time of the inventory and appeared to only flow during seasonal flood periods. Although not a targeted species, *Salsola kali* was the most common non-native species encountered in this inventory unit, and was so extensive that the crew decided to map it as a gross area (discussed later). Additional infestations of *Salsola kali* were inventoried in the finger canyons of the upper portion of Sandy Creek near the Bitter Creek Divide. *Tamarix ramosissima* was also found in scattered sections of Sandy Creek and relatively infrequent in this drainage system. It was found in small patches at the Park boundary near The Narrows as well as in the finger canyons east of Bitter Creek Divide. Most infestations in these finger canyons were on the Park boundary or outside the Park and comprised of mature stands. A single patch of *Halogeton glomeratus* was

also found near The Narrows along a road to Spring Canyon from the Notom Road. The patch was directly on the road and only 0.01-acres in size. Although not mapped, *Bromus tectorum* and *Tragopogon dubius* were also present in the area.

Visibility was excellent in this area as the shrubs were generally small. The crew was confident of finding at least 90 percent of all 0.01-acre or larger patches of the targeted species. The Sandy Creek inventory unit was heavily disturbed at some point due to livestock grazing. Several stock ponds were still present in the area and could potentially be sites for new invasive species. Other disturbances include seasonal flooding and vehicle traffic along the Notom Road. A dirt bike trail also was found along the top of Divide Canyon near the Bitter Creek Divide. It appeared the trail crossed over the Park boundary and then followed Sandy Creek back out of the Park. The overall area was so heavily infested with *Salsola kali* that it was assigned an ecological status level four.

Halls Creek – Bitter Creek Divide to The Post (Area Number 27; Inset Maps W, X, Z, AA, BB, CC)

The north section of Halls Creek from its headwaters to the Post was inventoried by two crew persons in 2004. The inventory area begins at the headwaters of Halls Creek on the Bitter Creek Divide and extends south along Halls Creek to the Post. Included in this inventory unit are sections of Bitter Creek, Swap Canyon, Bitter Creek Reservoir, and several long side canyons of Halls Creek. The area was very dry at the time of the inventory and heavily infested with *Salsola kali*. The gross area of *Salsola kali* discussed later applies to this inventory unit as well. *Salsola kali* was also found continuously along Bitter Creek and Swap Canyon and inventoried to the Park boundary in both canyons, although infestations likely extend beyond the boundary.

Tamarix ramosissima was also widespread throughout this inventory unit. The headwaters of Halls Creek were only lightly infested with *Tamarix ramosissima* but infestations became more frequent further south. The Bitter Creek Reservoir was heavily invaded and infestations of *Tamarix* also were found continuously up both side canyons of Bitter Creek. Infestations of *Tamarix* continued steadily along Halls Creek to the Burr Road. Infestations were also continuous along the side drainage of Halls Creek to the west of the Notom Road. Patches of it were less frequent along Halls Creek between the Burr Road and the Post. Patches were also found invading many of the stock ponds and collection ponds dotted across the landscape. Interestingly, only two small patches were found in Swap Canyon at the Park boundary.

Other species recorded in this inventory area include *Halogeton glomeratus*, *Tragopogon dubius*, and *Sisymbrium altissimum*. *Sisymbrium altissimum* was found approximately a mile north of the Bitter Creek Reservoir. *Tragopogon dubius* was found in the side canyon west of the Notom Road. A single patch of *Halogeton glomeratus* was found near the headwaters of Hall Creek. It is very likely the amounts of these three species do not represent a complete inventory in this area and that other infestations exist. For example, it was noted by the crew that *Tragopogon dubius* was present in the headwaters of Halls Creek but not mapped.

The crew also noted the presence of *Bromus tectorum*, *Lactuca serriola*, *Sonchus oleraceus*, *Erodium cicutarium*, *Melilotus officinalis* and *Chenopodium album*. Visibility was generally very good throughout the inventory unit. The crew was confident of finding all 0.01-acre or

larger infestations of the targeted species. It was obvious the area had been heavily grazed at some point due to the lack of native grasses in most of the area. *Salsola kali* and *Bromus tectorum* covered much of the ground. In areas where those two species were absent, it was often bare ground. Other disturbances include some seasonal flooding. The area was assigned an ecological status level four due to the heavy amounts of *Salsola kali*, *Tamarix ramosissima*, and *Bromus tectorum*.

Halls Creek – The Post to Fountain Tanks (Area Number 31; Inset Maps CC, DD, EE, FF)

This section of Halls Creek was inventoried by three people in 2004. The area included in this inventory is the section of Halls Creek between the Post and the Fountain Tanks as well as several of the smaller side canyons. The section of Halls Creek between the Halls Creek Overlook and Fountain Tanks inventoried this year overlaps previous inventory work conducted in 2003. However, some sections were remapped after careful study of the information collected in the previous year and it was determined that the data did not truly reflect the extent of the infestations in this section of Halls Creek. The area was open, containing occasional cottonwoods and willows along the creek. *Tamarix ramosissima* was the only targeted species found. *Tamarix ramosissima* was spread almost continuously along Halls Creek, in low to moderately dense stands of mixed mature and sapling stands. It was also found encroaching upon the Cottonwood Tanks and Willow Tanks, although it wasn't found at the Muley Tanks. It also did not appear to be spreading into the numerous side canyons to the east and west of Halls Creek. *Tamarix* was only found in a handful of side canyons during the inventory. Although there were native cottonwoods and willows in sections of Halls Creek, *Tamarix* most certainly will crowd out these and other native species if left unchecked.

Although not a target species, *Salsola kali* was also widespread throughout the area (see discussion of *Salsola kali* gross areas). Species seen but not mapped include *Bromus tectorum*, *Erodium cicutarium*, *Melilotus officinalis*, *Chenopodium album*, *Sonchus oleraceus*, and *Lactuca serriola*.

Visibility was generally very good along this stretch of Halls Creek and the crew felt confident in its ability to see 90 percent of all 0.01-acre infestations of the targeted species. Several stretches of Halls Creek contained large stands of willows and cottonwoods but a greater part of the benches contained moderate to little native vegetation. The cover of *Salsola kali* and *Bromus tectorum* was as high as 100 percent in some places in Halls Creek and along the benches. Disturbance from previous grazing was evident in the broad extent of *Salsola kali* and *Bromus tectorum*. Other disturbances included seasonal flooding. The area was assigned an ecological status level four.

Halls Creek – Halls Creek Overlook to Hall Divide (Area Number 18; Inset Maps EE, FF, GG)

This section of Halls Creek was inventoried by four NPS crew members in 2003. This area extends from Halls Creek Overlook to approximately a half mile north of Hall Divide. A portion of Halls Creek between Halls Creek Overlook and the Fountain Tanks was re-inventoried in 2004 by the USU crew. This discussion will only include the data from the Fountain Tanks to Hall Divide. The primary target species found in this area was *Tamarix ramosissima*, which generally occurred in relatively small patches scattered along the entire length of Halls Creek between the Fountain Tanks and Hall Divide. The crew decided to map three relatively large

infested areas as area features instead of point features. The acreage of the three polygons was 1.8 acres, 8.5 acres, and 40.8 acres. These polygons represent actual areas rather than gross area features. It was noted that *Tamarix* was absent from the side canyons inventoried. Although the crew did not map it, *Salsola kali* was reported to be throughout much of the inventoried area (see upcoming gross area discussion). A single patch of *Elaeagnus angustifolia* was found approximately a mile upstream from Hall Divide. It is assumed that *Bromus tectorum* was also present in some areas of this inventory unit.

Visibility was generally good along this stretch of Halls Creek and it is assumed that the crew inventoried the area in such a way as to ensure 90 percent of all 0.01-acre infestations of the targeted species are found. No disturbances were noted by the crew. Based on their findings, an ecological status level three was assigned to this inventory unit.

Halls Creek – Southern Park Boundary (Area Number 19; Inset Map HH)

A portion of Halls Creek along the southern Park boundary was inventoried by four persons from the NPS crew in 2003. Included in this inventory unit are approximately a mile and half stretch of Halls Creek and two side canyons. *Tamarix ramosissima* was the only target species found in this inventory unit. Infestations were almost continuous along this stretch of Halls Creek and continued beyond the Park boundary. No other target species were found, nor was the presence of any non-target species specifically mentioned.

It is assumed the crew searched in a way that enabled them to find at least 90 percent of the targeted species in this inventory unit. The crew did not note any obvious disturbances. Based on the species inventoried, the area was assigned an ecological status level of three.

Halls Creek, Millers Creek Canyon (Area Number 20; Inset Map HH)

Sections of Halls Creek and Millers Creek Canyon were inventoried by four persons from the NPS crew in 2003. This inventory area falls outside the Park boundary, in Glenn Canyon National Recreation Area, but it was inventoried due to its proximity to the Park. The crew found *Elaeagnus angustifolia* and *Tamarix ramosissima* in the section of Halls Creek below the Park boundary and *Tamarix ramosissima* in Millers Creek Canyon. *Tamarix ramosissima* was fairly continuous in its distribution along Halls Creek as well as its spread along Millers Creek. Infestations were typically between 0.01 and 0.1 acres in size, with several in the category of 0.25 acres, and one 1-acre patch.

Two patches of *Elaeagnus angustifolia* were discovered approximately a half mile south of the Park boundary. These two infestations were 0.01-acre in size and at a mature stage of growth. No other target species was found in this area, nor were any non-target species noted.

It is assumed that the crew inventoried this area in a way to ensure that at least 90 percent of the targeted species a 0.01-acre or larger in size could be found. No disturbances were noted and the area was assigned an ecological status level three based on the abundance of species present.

Burr Road (Area Number 30; Inset Maps Y, AA)

The Burr Road from its junction with the Halls Creek Road to just west of the Park boundary was inventoried in 2004 by the 2-person USU crew. The only targeted species found was *Tamarix ramosissima* which occurred as 2 infestations totaling 2.75 acres in size.

The average width of the inventoried area was approximately 75 to 80 meters. Visibility was excellent and the crew was confident of seeing all 0.01-acre or larger infestations of all targeted species in this area. No obvious disturbance aside from seasonal flooding was noted beyond the road shoulders. The area was assigned an ecological status level of two.

Upper Muley Twist (Area Number 16; Inset Maps W, X, Y)

The upper portion of Muley Twist was inventoried by two members of the NPS crew in 2003. The area in this unit began near the Onion Beds and ended at Peek-a-boo Rock. Very few invasive species were found in this area and *Tamarix ramosissima* and *Salsola kali* were the only two species mapped. The crew recorded 18 patches of *Tamarix*, of which were comprised of mixed stands of mature trees and saplings. Two-thirds of the infestations were 0.01 acre in size, while the remaining one-third averaged 0.1 acre each. The majority of the patches were also found in a side canyon across from the Strike Valley Overlook and a side canyon directly north rather than in the main draw. The crew also recorded three infestations of *Salsola kali*, all in a vegetative state of growth and 0.01-acres in size. No other target or non-target species were noted by the crew.

It is assumed that the crew inventoried this area in a way to ensure that at least 90 percent of the targeted species a 0.01-acre or larger in size could be found. It was noted that the area had flash flooded during the time of the inventory. The area was assigned an ecological status level two.

Lower Muley Twist (Area Number 17; Inset Maps AA, BB, CC, DD)

Lower Muley Twist was inventoried by two members of the NPS crew in 2003. This inventory unit began at the top of Burr Canyon and continued down to approximately a mile above the Muley Tanks. As is the case for much of this area, *Tamarix ramosissima* was the only targeted species found and mapped. A total of fifty-seven infestations 0.01-acre in size and twelve infestations 0.1-acre in size were recorded along the lower half of Muley Twist. Infestations were mainly comprised of mature trees in moderately dense (6 to 25%) stands. Patches were scattered lightly but consistently along this stretch of canyon. The crew also recorded several infestations of *Salsola kali*. These infestations were found primarily in the first mile of the inventory unit, although one patch was recorded near the Muley Tanks.

It is assumed that the crew inventoried this area in a way to ensure that at least 90 percent of the targeted species a 0.01-acre or larger in size could be found. A portion of this inventory area was searched from the cab of a truck. No obvious disturbances were noted by the crew and the area was assigned an ecological status level three.

Deep Creek (Area Number 23; Inset Maps A, B, C, D)

Deep Creek is a large drainage that converges with the Fremont River near the eastern Park boundary. This site was inventoried by a crew of two persons in 2004. The drainage itself is a dry area consisting of mostly sagebrush, native grasses, and *Salsola kali*. *Salsola kali* was so

extensive across the valley that the crew decided to map it as a gross area. A 2,967 acre area was included in this gross area polygon, of which approximately 60 percent was infested with *Salsola kali* (1780 acres). The canopy cover within the infested portion of the gross area was estimated to be moderate (6-25 percent). *Tamarix ramosissima* was also frequently encountered in the creek bed. *Tamarix ramosissima* was found almost continuously along Deep Creek between the Fremont River and Polk Creek. However, it was noticeably less frequent above the junction of Deep Creek and Polk Creek. All of the small stock ponds encountered across the landscape were also found infested with *Tamarix ramosissima*. The crew also found lightly scattered patches of *Halogeton glomeratus* in the wash as well as scattered across the alkali fields at Jailhouse Rock. It was more frequently encountered above Polk Creek's junction with Deep Creek. Species seen but not mapped include *Tragopogon dubius*, *Erodium cicutarium*, and *Bromus tectorum*.

Visibility was excellent throughout the inventoried area and the crew was confident of having seen all 0.01-acre or larger infestations of the targeted species. No obvious disturbances were seen in this inventory area. Because of the widespread weed infestations, the area was assigned an ecological status of three. The remaining unmapped sections of Deep Creek will be inventoried in 2005.

Highway 24 Corridor – 2003 and 2004 (Area Numbers 7 and 22; Inset Maps E, F, G, J, L)

A section of the Highway 24 canyon corridor from Fruita east to the falls on the Fremont River (Area 7) was inventoried, primarily for species other than *Tamarix ramosissima* and *Elaeagnus angustifolia*, by 2 members of the NPS crew in 2003. In 2004 the USU crew was asked to re-inventory that same area for all target species, and to expand their inventory to include the entire Highway 24 corridor from the west boundary of the Park to the Halls Creek Road junction (Area 22). The USU crew also inventoried 2 spur roads on the south side of Highway 24 between the Visitor Center and the west Park boundary and included them in this area.

The most common species within these two overlapping inventory areas were *Tamarix ramosissima* and *Elaeagnus angustifolia*. Both species were mapped as continuous infestations covering essentially all of Area 7. Additional *Tamarix ramosissima* was found scattered along Highway 24 and/or the river corridor extending east and west of Area 7. Additional *Elaeagnus angustifolia* infestations were observed only east of inventory Area 7. The third most common target species in this unit was *Ailanthus altissima*. Numerous infestations, ranging in size from 0.01 to 1 acre, were found downstream from the Visitor Center. No *Ailanthus* was found west of the Center. Other target species found in this unit in relatively low numbers were *Arctium minus*, *Convolvulus arvensis*, and *Halogeton glomeratus*. Although not a target species, 7 infestations of *Salsola kali* were mapped.

A single infestation of *Centaurea repens* was found on the north shoulder of Highway 24 approximately 100 yards east of the turnoff to the Chimney Rock trailhead parking area. To our knowledge, this is the only infestation of this highly invasive species anywhere within the Park boundary.

Vegetative cover was relatively tall and dense along the Fremont River, limiting the visibility of small infestations of most non-woody target species. However, search coverage was intensified to compensate, and crews were confident of seeing at least 90 percent of all 0.01-acre or larger

infestations of all targeted species in this area. Disturbance factors included seasonal flooding, grading of road shoulders, vehicle and foot traffic, and other human activities in visitor-usage areas. Area 7 was assigned an ecological status level of four, and Area 22 (excluding the overlap with Area 7) was rated as a level two. Overall, the combined areas were given an ecological status rating of three.

Mesa 7176 (Area Number 21; Inset Map II)

This small area was inventoried by one person on the NPS crew in 2003 in conjunction with another study in the Park. The inventoried area is along a ridgeline near a mesa top designated as Mesa 7176, southeast of Jones Bench. A single 0.1-acre patch of *Halogeton glomeratus* was recorded in this small area. No other targeted or non-targeted species were noted to occur in this area. No disturbances were noted and the area was assigned an ecological status level of two.

Salsola kali Gross Areas (Appendices J and K)

Although not a target species *Salsola kali* was found extensively throughout the Park. It was generally so widespread that trying to precisely quantify its abundance and map its exact distribution seemed pointless. Instead, gross-area acreage estimates were made to illustrate its relative abundance in typical infested landscapes within the Park at Halls Creek (Appendix J) and Deep Creek (Appendix K). It was estimated that an average of 70 percent of the 10,773-acre Halls Creek gross area was infested with *Salsola kali*, with an average canopy cover of 26 to 50 percent (high category) within the infested portions. Therefore, the Halls Creek gross area is calculated to be infested with approximately 7,541 acres of *Salsola kali*. It was estimated that an average of 60 percent of the 2,967-acre Deep Creek gross area was infested with *Salsola kali*, with an average canopy cover of 6 to 25 percent (moderate category) within the infested portions. Therefore, the Deep Creek gross area is calculated to be infested with approximately 1,780 acres of *Salsola kali*. As stated earlier, gross area values were not included in the Park totals of acres inventoried or acres infested because the areas were not searched thoroughly in their entirety, and the numbers are based on estimates and projected calculations rather than on actual field inventory measurements. They are provided solely for the purpose of illustrating the relative abundance of this well-established invasive species in the Park.

CONCLUSIONS / RECOMMENDATIONS

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

It is acknowledged that Capitol Reef National Park is already implementing many effective weed control strategies and practices, for which they are to be commended. For example, the Utah Conservation Corp was seen cutting and treating *Elaeagnus angustifolia* and *Tamarix*

ramosissima along the Fremont River in Fruita during 2004. The Lake Mead EPMT team was also seen in the Park controlling *Tamarix ramosissima* and *Elaeagnus angustifolia* in 2004. They were able to rapidly control the only known *Centaurea repens* infestation in the Park within a week of its discovery. It was also evident that several sites containing *Ailanthus altissima* along Highway 24 had recently been controlled.

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

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

Tied to an ongoing inventory effort, Capitol Reef National Park also should consider establishing permanent monitoring sites to evaluate the impact and spread of weeds, and to evaluate the effectiveness of its weed management approaches. Long-term studies provide valuable insight into the effectiveness of current management techniques and quantify whether management goals have been accomplished. Monitoring standards and protocols exist in the federal agencies and provide guidelines as to selecting appropriate sites and proper techniques for gathering information. Several excellent publications on monitoring methods and standards are currently available for reference (Coulloudon et al. 1999, Elzinga et al. 1998, Kuchler et al. 1988, Silsbee et al. 1991, USDI-USGS 1994, Winward 2000).

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

“Although the Park’s primary responsibility is to itself and to upholding the mission for which it was established, Parks have a role and responsibility in promoting and supporting collaborative information exchange among local weed and natural resource management professionals. It is in the self-interest of the Park (in fulfilling its mission)

and the agency (as a cooperating federal land management agency) to do more than simply share data passively or opportunistically. To the extent a Park can place the distribution and abundance of its invasive plants in the context of a larger landscape, the Park's efforts to identify management objectives and allocate resources efficiently will be improved as the scale of that landscape grows in size."

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

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

Applying that strategy to CARE would mean that species such as *Centaurea repens*, *Ulmus pumila*, *Verbascum thapsus*, *Arctium minus*, *Halogeton glomeratus*, *Marrubium vulgare*, *Ailanthus altissima*, *Cirsium vulgare*, and possibly *Convolvulus arvensis* should be given the highest control priority of the species mapped, and should be targeted for prompt Park-wide eradication. We would place *Elaeagnus angustifolia* and *Tamarix ramosissima* in the second priority category, recommending containment of existing infestations, complemented by effective prevention, early detection, and rapid response (eradication) strategies on the non-infested and lightly infested portions of the Park. For example, *Elaeagnus angustifolia* was prevalent along the eastern half of the Fremont River and probably beyond feasibility of eradication there, at least in the near term. But it was relatively rare in Oak Creek, Pleasant Creek, Halls Creek, Sulphur Creek, and the western half of the Fremont River, and could be eliminated quite easily from those portions of the Park. *Tamarix ramosissima* could be eliminated in areas such as Grand Wash, Capitol Gorge, Fivemile Wash, the Hickman Natural Bridge drainage, the drainages around Twin Rocks, and Upper Muley's Twist. Plants that we would place in the third management category (lowest priority) include *Bromus tectorum* and *Salsola kali* which were widespread throughout the Park and too abundant for meaningful mapping.

The Park will likely need additional inventory information before deciding in which management category to place *Bromus inermis*, *Sisymbrium altissimum*, *Tragopogon dubius*, *Asparagus* sp., *Chenopodium album*, *Erodium cicutarium*, *Melilotus officinalis*, *Sonchus oleraceus*, *Dactylis glomeratus*, and *Bromus inermis*. These non-natives appeared scattered throughout the inventory

areas in the Park, but our assessment is based on an incomplete survey rather than a full inventory of these species. If further studies reveal that these species are truly infrequent in the Park, we suggest that they be targeted for eradication even though they were not originally considered high-priority species.

The second objective of this project was to identify potential sources of weed introduction and significant vectors involved in weed spread in the Park. Humans are the most likely vectors for new introductions of invasive plant species into Capitol Reef National Park and all other Parks of the Northern Colorado Plateau Network, and areas of highest human visitation are also the areas where new invaders might be expected to appear first. Millions of visitors come from all over the world to enjoy the unique beauty of the Northern Colorado Plateau region, and over 500,000 per year visit Capitol Reef National Park. Every person potentially brings with them errant seeds of an exotic invasive plant lodged in the tread of a tire or hidden in the dried mud of a hiking boot. The ever-increasing number of visitors, combined with the distant and diverse geographical areas from which they come, all combine to make National Parks highly and uniquely vulnerable to exotic plant invasions. Frequent inspection of high-visitation sites within each Park is essential to the “early detection and rapid response” strategy of invasive plant management. Roadways, parking areas, visitor centers, picnic sites, campgrounds, view points, trails, and all other high-visitation sites should be searched regularly (at least yearly) at a time when new plants would be visible. Park visitors should be informed of the potential damage caused by invasive plants, and ways they can help minimize the chances of introduction and spread. This might be done in the form of written information distributed at the Park's Visitor Center, through displays or a video program, and evening fireside presentations to visitors made by NPS personnel.

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

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

All NCPN Parks that were inventoried in 2003 and 2004 are in the enviable situation of still having the majority of their lands free of targeted invasive weeds. In Capitol Reef National Park 85.9 percent of the inventoried acres were free of all targeted species. And, because areas

selected for this inventory were generally considered the sites most likely to be infested, it can be assumed that those CARE lands not inventoried have an even higher proportion of weed-free acres. Furthermore, 100 percent of all inventoried lands were completely free of at least 21 species of great concern to the region (Appendix M).

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

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

The final objective of this project was to test and refine data collection and field inventory techniques that might be used by NCPN in future invasive plant inventories. As part of our effort to meet that objective, USU provided training in weed mapping techniques at several state weed conferences as well as at the regional Western Society of Weed Science Weed Management Short Course held in Montana annually. An overview of the USU weed mapping program was also presented to over 60 EPMT personnel from around the country during a week-long field training exercise held in Arches National Park in 2004. In addition, several documents were published containing detailed information about USU inventory procedures and techniques (Andersen et al. 2003, Andersen and Dewey 2005, Ballard et al. 2003, Dewey and Andersen 2004a, Dewey and Andersen 2004b, Dewey and Andersen 2005a; Dewey and Andersen 2005b, Dewey and Andersen 2005c).

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References Cited

- Andersen, K., S. Dewey, and M. Ballard. 2003. Field Techniques for Improving Accuracy and Efficiency of GPS Wildland Weed Surveys. *Proc., Western Society of Weed Science*, 56:87.
- Andersen, K. and S. Dewey. 2005. Do's and Don'ts of Wildland Weed Mapping - The USU Experience. *Proc., Idaho Weed Control Association Conf., Nampa, ID.*
- Asher, J. E. and D. W. Harmon. 1995. Invasive exotic plants are destroying the naturalness of U.S. wilderness areas. *International Journal of Wilderness*, Vol 1, No.4, p. 35-37.
- Ballard, M., S. Dewey, and K. Andersen. 2003. Using GPS Point Features to Describe Spot, Line, and Area Infestations in Wildland Weed Surveys. *Proc., Western Society of Weed Science*, 56:86.
- Benjamin, Pamela K. 2001. Weed Mapping and Database Development Guidelines for the National Park Service Intermountain Region (IMR). Intermountain Support Office, Denver, CO. 22pp. plus appendices.
- Clinton, William. 1999. "Invasive Species." Executive Order 13112 of February 3, 1999 (as amended by E.O. 13286 on February 28, 2003). (64 F.R. 6183, February 8, 1999).
- Coulloudon, B, K. Eshelman, J. Gianola, N. Habich, L. Hughes, C. Johnson, M. Pellant, P. Podborny, A. Rasmussen, B. Robles, P. Shaver, J. Spehar, and J. Willoughby. 1999. Sampling Vegetation Attributes. *Interagency Tech. Ref.* 1734-4. p. 31-130.
- D'Antonio, C. and N. Jackson. 2003. Invasive plants in natural and managed systems: linking science and policy. *Abstr., 7th International Conference on the Ecology and Management of Alien Plant Invasions*, Ft. Lauderdale, FL., 104 pp.
- Dewey, S., K. Andersen, M. Ballard, J. Simonsen, R. Richards, and E. Lamalfa. 2003. Invasive non-native plant inventory conducted in portions of Arches, Canyonlands, Hovenweep, Natural Bridges, Black Canyon, and Zion National Parks. *Ann Prog Report* (8 volumes), submitted to the Intermountain Regional Office of the National Park Service, Denver, CO, and the Northern Colorado Plateau Network, Moab, UT.
- Dewey, S.A. and K.A. Andersen. 2004a. Strategies for Early Detection - Using the Wildfire Model. *Weed Technol.* 18:1396-1399.
- Dewey, S.A. and K.A. Andersen. 2004b. Distinct Roles of Surveys, Inventories, and Monitoring in Adaptive Weed Management. *Weed Technol.* 18:1449-1452.
- Dewey, S.A. and K.A. Andersen. 2005a. Determining Effective Search Swath Widths for Wildland Weed Surveys. *Proc., Western Society of Weed Science Conf., Vancouver, BC.*

- Dewey, S.A. and K.A. Andersen. 2005b. Quality Assurance Measures for Invasive Weed Surveys on Wildlands. Abstr., Weed Science Society of America Conf., No. 121, p. 37.
- Dewey, S.A. and K.A. Andersen. 2005c. Strategies for Early Detection – Using the Wildfire Model. *Weed Technology* 18: 1396-1399.
- Duncan, C. L., and J. K. Clark (eds.). 2005. *Invasive Plants of Range and Wildlands and Their Environmental, Economic, and Societal Impacts*. Weed Science Society of America, 222 pp.
- Elzinga, C. L., D. W. Salzer, and J. W. Willoughby. 1998. Measuring and Monitoring Plant Populations. USDI-BLM Tech. Ref. 1730-1 BLM/RS/ST-98/005+1730. p. 1-10.
- [GPRA] Government Performance and Results Act of 1993. P.L. 103-62 (2003).
- Kuchler, A. W. and I. S. Zonneveld (eds.). 1988. *Vegetation Mapping. Handbook of Vegetation Science*, Vol. 10. Kluwer Academic Publishers, Boston, MA. p. 193-202.
- Layden, P. C. and M. J. Manfredo. 1994. *National Park conditions: a survey of Park superintendents*. National Parks and Conservation Association, Washington, D.C.
- [NAWMA] North America Weed Management Association. 2003. *North American Invasive Plant Mapping Standards*. (Web page: <http://www.nawma.org>).
- Mack, R. N., D. Simberloff, W. M. Lonsdale, H. Evans, M. Clout, and F. Bazzaz. 2000. Biotic invasions: causes, epidemiology, global consequences, and control. *Issues in Ecology*, 5:1-20.
- Mullin, B. H., L. W. J. Anderson, J. M. DiTomoso, R. E. Eplee, and K. D. Getsinger. 2000. *Invasive plant species*. Council for Agricultural Science and Technology, Issue Paper No. 13, 17 pp.
- Randall, J. M. 1995. Assessment of the invasive weed problem on preserves across the United States. *Endangered Species Update* 12 (4&5): 4-6
- Sakai, A. K., F. W. Allendorf, J. S. Holt, D. M. Lodge, J. Molofsky, K. A. With, S. Baughman, R. J. Cabin, J. E. Cohen, N. C. Ellstrand, D. E. McCauley, P. O'Neil, I. M. Parker, J. N. Thompson, and S. G. Weller. 2001. The Population Biology of Invasive Species. *Ann. Rev. Ecol. Syst.*, 32:305-332.
- Silsbee, D.G. and D.L. Peterson. 1991. *Designing and implementing comprehensive long-term inventory and monitoring programs in the National Parks*. NPS Natural Resources Rept. NPS/NRUW/NRR-95/16.
- Tu, M., Hurd, C., & J.M. Randall, 2001. *Weed Control Methods Handbook*, The Nature Conservancy. Web page: <http://tncweeds.ucdavis.edu/handbook.html>, Version: April 2001.

[USDA-FS] United States Department of Agriculture, Forest Service. 2001. Guide to Noxious Weed Preventive Practices. Version 1, July 5, 2001. 25 pp. (Web page: <http://www.fs.fed.us/rangeland/ecology/invasives>)

[USDI-NPS] United States Department of Interior, National Park Service. 1995. Natural resource inventory and monitoring guidelines. NPS-75.

[USDI-NPS] United States Department of Interior, National Park Service. 1996. Preserving Our National Heritage - a Strategic Plan for Managing Invasive Nonnative Plants on National Park System Lands. Natural Resources Stewardship and Science, National Park Service, Washington, D.C. 16 pp.

[USDI-NPS] United States Department of Interior, National Park Service. 1999. Natural Resource Challenge: The National Park Service's Action Plan for Preserving Natural Resources. U.S.D.I. National Park Service, Washington, D.C. 21 pp. (Web page: <http://nature.nps.gov/challengedoc>)

[USDI-NPS] United States Department of Interior, National Park Service. 2001. Initiate an Intermountain Region Noxious Weed Inventory and Mapping Program. Implementation Plan prepared by Intermountain Support Office PMIS #72973. January 2001. 77 pp. plus appendices.

[USDI-NPS] United States Department of Interior, National Park Service. 2002. Inventory and Monitoring for Invasive Plant Guidelines. Workshop report held in Fort Collins, CO, June 4-6, 2002. 60 pp.

[USDI-NPS] United States Department of Interior, National Park Service. 2004. Weed Seed/Propagule Decontamination Procedures. Arches National Park EPMT Strike Team Incident Action Plan, Courthouse Wash Project, March 9-14, 2004.

[USDI-USGS] United States Department of Interior, U. S. Geological Survey. 1994. USGS-NPS Vegetation Mapping Program Documents and Standards. Web page: <http://biology.usgs.gov/npsveg/standards.html>.

Westbrooks, R. 1998. Invasive plants, changing the landscape of America: Fact book. Federal Interagency Committee for the Management of Noxious and Exotic Weeds, Washington, D. C. 109 pp.

Winward, A. 2000. Monitoring the Vegetation Resources in Riparian Areas. USDA Forest Service General Technical Report RMRS-GTR-47. p. 10-32.