

# Zion National Park



## **2006 Inventory of Invasive Non-Native Plants and Endemic Plants**

Northern Colorado Plateau Inventory and Monitoring Network

### **Addendum Report**

November 2006

Prepared by  
**Steven Dewey and Kimberly Andersen**  
Utah State University

Cover photo:

NPS employees Alexia Savold and Fleur Nicklen search for targeted invasive plants and rare endemic plants in a field on Horse Ranch Mountain. Photo by R. Richards.

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Report prepared for: Northern Colorado Inventory and Monitoring Network, National Park Service, 2282 S. West Resource Blvd., Moab UT 84532 by Utah State University.

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**ADDENDUM REPORT**

**An Inventory of Invasive Non-native Plants and Rare Endemic Plants  
Conducted During 2006 in Portions of Zion National Park,  
Northern Colorado Plateau Network of the National Park Service.**

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## **INTRODUCTION**

During the summers of 2003 and 2004 Utah State University conducted an invasive plant inventory project for twelve Parks and Monuments associated with the National Park Service's Northern Colorado Plateau Network, including Zion National Park, (ZION). Funding became available to continue the work on a limited basis in some Parks and Monuments during the 2006 field season. This report documents the results of the 2006 invasive non-native plant inventory at Zion National Park. This report also includes the results of an endemic rare plant inventory conducted in portions of the Park. The document serves as an addendum to the Final Report for the Zion National Park 2003-2004 Invasive Non-native Plant Inventory (Dewey and Andersen 2005). Methods are documented fully in the original report and only summarized in the current report.

## **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 in designated areas of management concern in Zion 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) The second objective of this project was to document the distribution of rare and endemic plants along the Park boundary in areas targeted for future fire treatments. It was anticipated that the information collected to meet this objective will be useful in planning operations relating to fire management.

## **METHODS**

### SELECTION OF TARGET SPECIES AND INVENTORY AREAS

Four members of the Utah State University weed mapping crew and three National Park Service employees participated in an inventory of targeted invasive plants and rare plants in portions of Zion National Park in August and September of 2006. Crew qualifications are documented in Appendix A. All field and office methods used in 2006 were identical to those described in the 2003-2004 Final Report. Six species were identified as high-priority targets in the ZION invasive plant inventory (Table 1). Any other non-native species recognized as relatively new to ZION 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 earlier projects, plus some additional species of regional or national concern. In addition, the Park designated twenty-five rare plant species as primary targets for inventory (Table 2). Both sets of plants were searched for systematically by all inventory crew members.

The location and size of the areas inventoried in 2003, 2004, and 2006 are represented in Figure 1. Lands inventoried in 2003 are shown in yellow, lands inventoried in 2004 are shown in orange, and those inventoried in 2006 are shown in red. The acreage of each year's inventoried area is listed in the legend. Areas inventoried in 2006 were selected in consultation with Cheryl Decker, Horticulturist for Zion National Park. They included primarily lands that had been treated with prescribed burned in 2004 and were considered most likely to contain invasive plant habitat. Emphasis was given to areas of designated management priority. 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 during the planning process. Additional areas were selected based on potential future fire management and the associated risk to rare and endemic plant populations within the Park. Potential areas to be treated with prescribed fire were identified by the Park's Fire Management Officer.

**Table 1. List of invasive plant species targeted in Zion National Park in the 2006 Non-native Plant Inventory.**

Invasive species	Common Name
<i>Bromus diandrus</i>	Ripgut Brome
<i>Bromus inermis</i>	Smooth Brome
<i>Bromus tectorum</i>	Downy Brome
<i>Dactylis glomerata</i>	Orchardgrass
<i>Elymus repens</i>	Quackgrass
<i>Sorghastrum nutans</i>	Indiangrass

**Table 2. List of rare and endemic plant species targeted in Zion National Park in the 2006 Rare Plant Inventory.**

Rare species	Common Name
<i>Aquilegia formosa v. fosteri</i>	Foster Columbine
<i>Asplenium adiantum-nigrum</i>	Black Spleenwort
<i>Aster welshii</i>	Welsh Aster
<i>Astragalus concordius</i>	Harmony milkvetch
<i>Calochortus ambiguus</i>	Doubting Mariposa Lily
<i>Carex haysii</i>	Hays Sedge
<i>Chimaphila menziesii</i>	Little prince's pine
<i>Draba asprella</i>	Rough whitlowgrass
<i>Epilobium nevadense</i>	Nevada Willowherb
<i>Erigeron canaani</i>	Canaan daisy
<i>Erigeron jonesii</i>	Jone's fleabane
<i>Erigeron religiosus</i>	Clear Creek fleabane



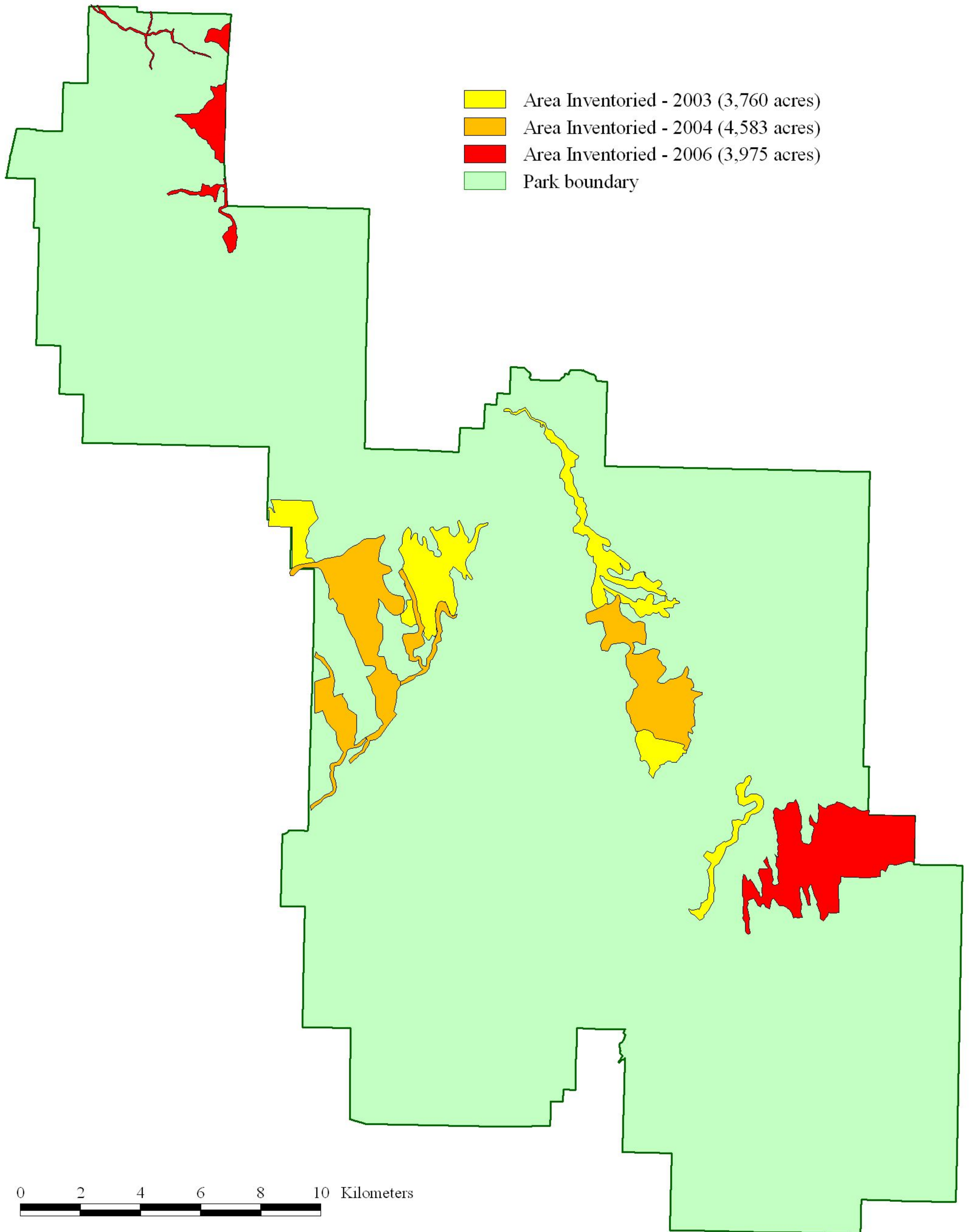
<i>Erigeron sionis</i>	Zion fleabane
<i>Erigonum jamesii</i>	Higgins buckwheat
<i>Erigonum panguinense</i>	Panguitch buckwheat
<i>Erigonum racemosum v. zionis</i>	Zion buckwheat
<i>Heterotheca jonesii</i>	Jones goldenaster
<i>Jamesia americana var. zionis</i>	Zion Jamesia
<i>Lomatium graveolens</i>	Clark's Lomatium
<i>Penstemon higginsii</i>	Higgins beardstongue
<i>Penstemon humilus v. obtusifolia</i>	Low beardstongue, lowly penstemon
<i>Selaginella utahensis</i>	Utah Spikemoss
<i>Sphaeromeria ruthiae</i>	Ruth's Sphaeromeria
<i>Viola charlestonensis</i>	Charleston Mountain Violet
<i>Viola clauseniana</i>	Clausen's Violet

## 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 3. Data collection categories and definitions comply with the minimum mapping data standards established by the 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).

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). GPS-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, life form 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.

Figure 1. Total area inventoried for non-native invasive plant species in Zion National Park in 2003, 2004, and 2006.



**Table 3. Description of data fields used in 2006 Inventory of Invasive Non-Native Plants and Designated Rare Endemic Plants in Zion 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	ZION	Required	Office
Country	Name of country (e.g. USA)		Required	Office
State	Two-letter state abbreviation		Required	Office
County	County name		Required	Office
UTMN	UTM northing coordinate for population		Required	GPS
UTME	UTM easting coordinate for population		Required	GPS
Elevation	Elevation in meters (and feet)	Meters (or feet)	Required	GPS
Size of Infested Area	Size of population (if a point feature). Based on average diameter of plant population.	- 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 (for invasive plants)	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
Density of inhabited area (for rare and endemic plants)	Estimated number of rare plants within an occupied area	1-10 11-100 101-1000 >1000	Required	GPS
Distribution	Characterization of density	To be determined by PI		GPS

**Table 3 continued.**

Data Field	Description	Options / Values	Priority	Entry
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
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 3 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) -hanging gardens	Required	GPS
Disturbance	Evaluate disturbance at population site	1 - no disturbance apparent 2 - light to moderate disturbance 3 - site heavily disturbed	Required	GPS
Treatment	Comment on obvious control treatments at the field collection site.	-Yes (additional notes then to be placed under the "Notes" section identifying treatment type) -No	Optional	GPS
Program Name	Name of the Park's Program involved in the project's coordination of data collection and analysis	Veg	Required	Office
Project Name	Name of the park project name	-IM_Monitoring -PreTreat Endemic Survey	Required	Office
Data Dictionary Name	Identifies the name of the data dictionary utilized for field data collection	ncpn06-G3	Required	Office
DataFile Name	Name of the Trimble ".ssf" data file containing the original field data collected		Required	Office
Receiver Type	Type of GPS used to collect data	-GeoExplorer3 -GeoExplorer XM	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

Data Field	Description	Options / Values	Priority	Entry
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

The 2006 inventory of invasive non-native plants and designated rare and endemic plants in Zion National Park was conducted from August 28 – September 17 and involved a seven-person crew (Table 4). The area inventoried for invasive non-native plants was the 2004 prescribed fire known as the ClearTrap Burn. The ClearTrap Burn encompassed the plateaus along the East Entrance Trail, Cable Mountain Trail, and Deertrap Trail. The Park boundary along Horse Ranch Mountain as well as the Camp Creek drainage were selected for inventory of rare and endemic plants. For purposes of planning and data analysis the inventoried lands were divided into five areas. The order in which areas were inventoried in 2006 was determined by the USU crew leader, and potential plant habitat within each targeted inventory area was considered prior to planning each day's travel route.

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 heavily burned portions of the ClearTrap Burn were generally open with good visibility, allowing relatively broad EDSW's (typically 75 yards). In stream corridors or where vegetation cover was heavy, such as in portions of Camp Creek and on Horse Ranch Mountain, EDSW's were usually narrower, sometimes less than 25 yards. Whenever inventorying areas wider than a single swath width, such as on the plateaus of Horse Ranch Mountain and the ClearTrap Burn, multiple parallel passes of a lone crew member (or multiple crew members walking parallel transects or contours) were searched as contiguous or slightly overlapping strips to avoid coverage gaps. In situations of extremely steep or otherwise inaccessible terrain where vegetation could be identified clearly from a distance, crew members sometimes used binoculars to visually scan the area for suspected target weed species. Daily inventory routes of each crew member were recorded and mapped using the BFP tracking function of their Trimble GPS units. BFP tracking distance settings were adjusted as needed to correspond closely to the EDSW distance for each area.

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

The locations of all target species were documented by the USU crew using Trimble GeoExplorer 3 global positioning system (GPS) units or GeoExplorer XM GPS units with 2- to 5-meter accuracy. Crews also recorded the location and documented the identity of any other non-target plant species they encountered if that species has a known history of invasiveness in other regions in the West. Field locations were recorded as UTM coordinates, and were later differentially corrected in the production of final digital products.

At the end of each day, field crews marked and dated all inventoried areas on standard USGS 7.5' topographic maps to assist in determining project progress and thoroughness of coverage. 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

**Table 4: Invasive plant and rare endemic inventory areas, inventory dates, crew members, and acres inventoried during 2006 in Zion National Park.**

Area Number	Area Description	Dates Inventoried	Crew Members*	Acres Inventoried**	Corresponding Inset Map Names and Letter Codes ***
10	ClearTrap Burn	Aug. 28 – Sept. 1 Sept. 7, 13-17	SD, KA, RR, ASc, ASa, KD, FN	3,113.1	Inset A – ClearTrap I Inset B – ClearTrap II Inset C – ClearTrap III Inset D – ClearTrap IV
11	Horse Ranch Mountain	Sept. 4 – 6	KA, RR, ASa, FN	456.7	Inset F – Horse Ranch Mountain
12	Plateau north of Horse Ranch Mountain	Sept. 5	ASa, FN	110.2	Inset G – Upper Camp Creek
13	Buck Pasture Mountain, Beatty Point, Death Point	Sept. 6	RR	198.3	Inset E – Buck Pasture Mountain
14	Camp Creek	Sept. 8, 12	KA, RR, ASa, FN	97.1	Inset G – Upper Camp Creek Inset H – Lower Camp Creek
TOTALS				3,975.4	

\* Crew abbreviations: SD = Steve Dewey, KA = Kim Andersen, RR = Ruth Richards, ASc = Anna Schmidt, KD = Kathy Davidson, ASa = Alexia Savold, and FN = Fleur Nicklen.

\*\* An average of 77.7 acres inventoried per person per 10-hr day in 2006.

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

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. The data was then processed and managed following the protocols described in the original report (Dewey and Andersen 2005).

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



## RESULTS and DISCUSSION

Field crews inventoried 3,975.4 acres Zion National Park during August and September of 2006 (Table 4), an amount representing approximately 2.7 percent of the entire 146,598-acre Park. An average of 77.7 acres was inventoried per person per 10-hr day in 2006.

The location and size of just the five areas inventoried in 2006 are represented in Figure 2. The identification number, name, and acreage of each inventory area are listed in the legend. Each inventory area is also color-coded for ease in identification. Figure 3 serves as an orientation map for the smaller 1:14,000 scale distribution “Inset” maps found in Appendices C, D and E. Inset maps are distinguished by letters A –H, plus the name of a distinct geographic feature found within its boundaries. The corresponding inventory area numbers from Figure 2 are included in the legend in parentheses behind each inset map name. Six inset maps are required to cover all five inventory areas, and large inventory areas may span over several insets. For example, different sections of the ClearTrap Burn (Inventory Area 10) appear on ClearTrap I, ClearTrap II, ClearTrap III, and ClearTrap IV (Inset maps A, B, C, and D).

Invasive plants infested a total of 534.612 acres within the mapped areas (Table 5), an amount equal to 13.4 percent of the land inventoried. Of the six initial targeted weed species, crews found *Bromus inermis*, *Bromus tectorum*, *Dactylis glomerata*, and *Elymus repens*. No infestations of *Sorghastrum nutans* or *Bromus diandrus* were discovered within the five inventoried areas. Non-target invasive plant species found and mapped were *Cirsium vulgare*, *Elaeagnus angustifolia*, *Melilotus officinalis*, *Onopordum acanthium*, *Salsola iberica*, *Tamarix ramosissima*, and *Verbascum thapsus*.

The most abundant target weed species found in the inventoried areas in 2006 was *Bromus tectorum*. The crew recorded 412.692 acres of this species, comprising 77.2 percent of the total infested acreage inventoried. Infestations of *Bromus tectorum* were generally less than 0.1 acre in size, often consisting of dense patches found scattered in open disturbed meadows or at the base of juniper trees. *Bromus inermis* was the second most abundant target species found in the Park and comprised approximately 13.6 percent of the total infested acreage. *Bromus inermis* was typically found along drainages or wet meadows. *Verbascum thapsus* was the third most common target species, making up 6.7 percent of the total infested acreage. The remaining infestations (2.5 percent of the total infested acreage) consisted of the other two targeted species and the seven additional non-native species that were mapped.

Not all non-native species that were found were mapped. For example, species such as *Descuraina pinnata*, *Epilobium* sp., *Erodium cicutarium*, *Lactuca serriola*, *Lepidium perfoliatum*, *Malva neglecta*, *Phleum pretense*, *Sisymbrium altissimum*, *Taraxacum officinale*, and *Thlaspi arvense* were observed in some areas but were ignored due to their previously recognized presence in the Park. *Agropyron cristatum* was also present in many areas but ignored.

Deciding which non-target weeds to map was left to the discretion of individual crew members, based on their assessment of the potential threat and relative abundance of each species. Crews were consistent in searching for and recording all infestations of *Cirsium vulgare*, *Elaeagnus angustifolia*, *Onopordum acanthium*, *Tamarix ramosissima*, and *Verbascum thapsus*.

Figure 2. Identification number and acreage of the area inventoried for non-native invasive plant species and rare plant species in Zion National Park in 2006.

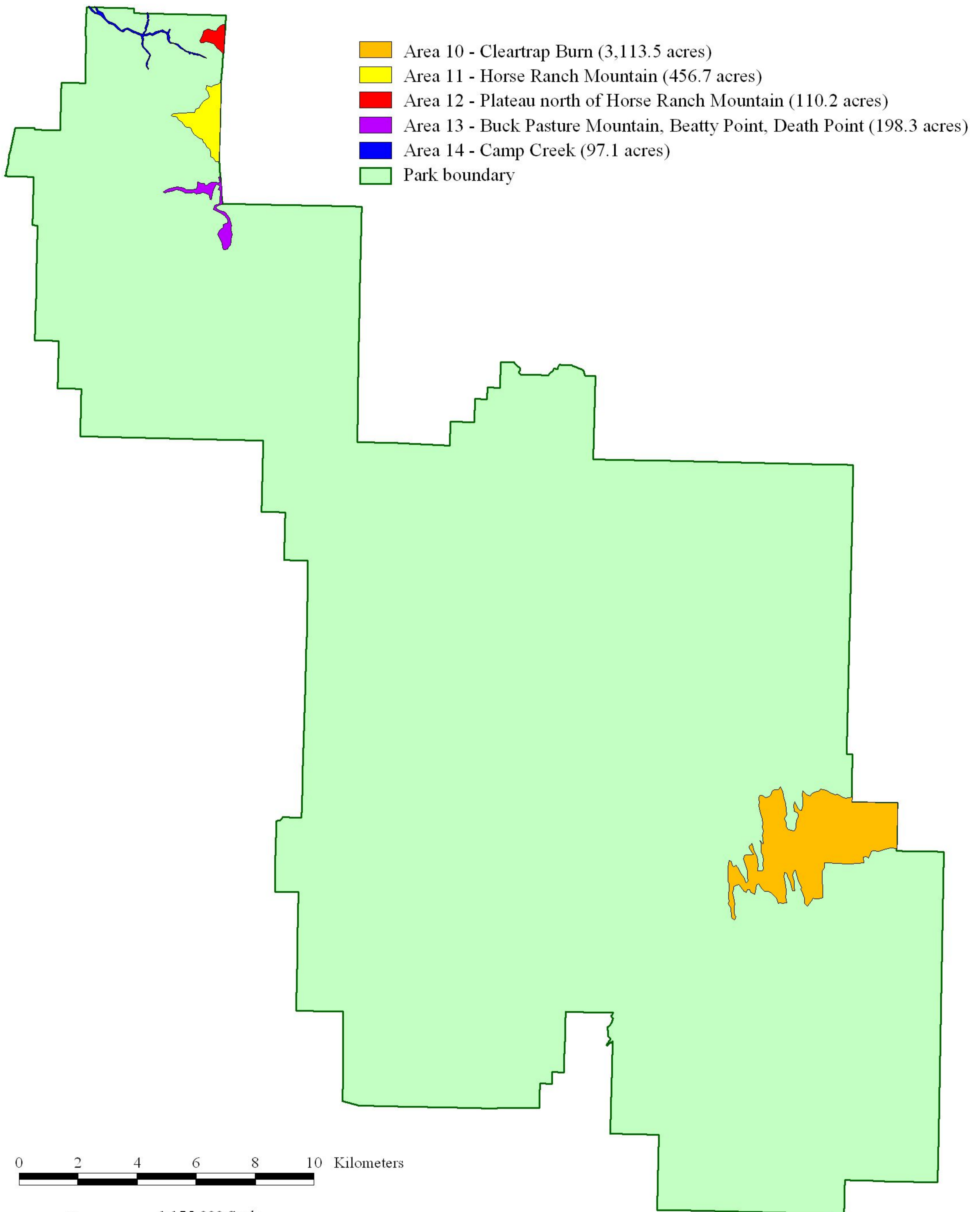
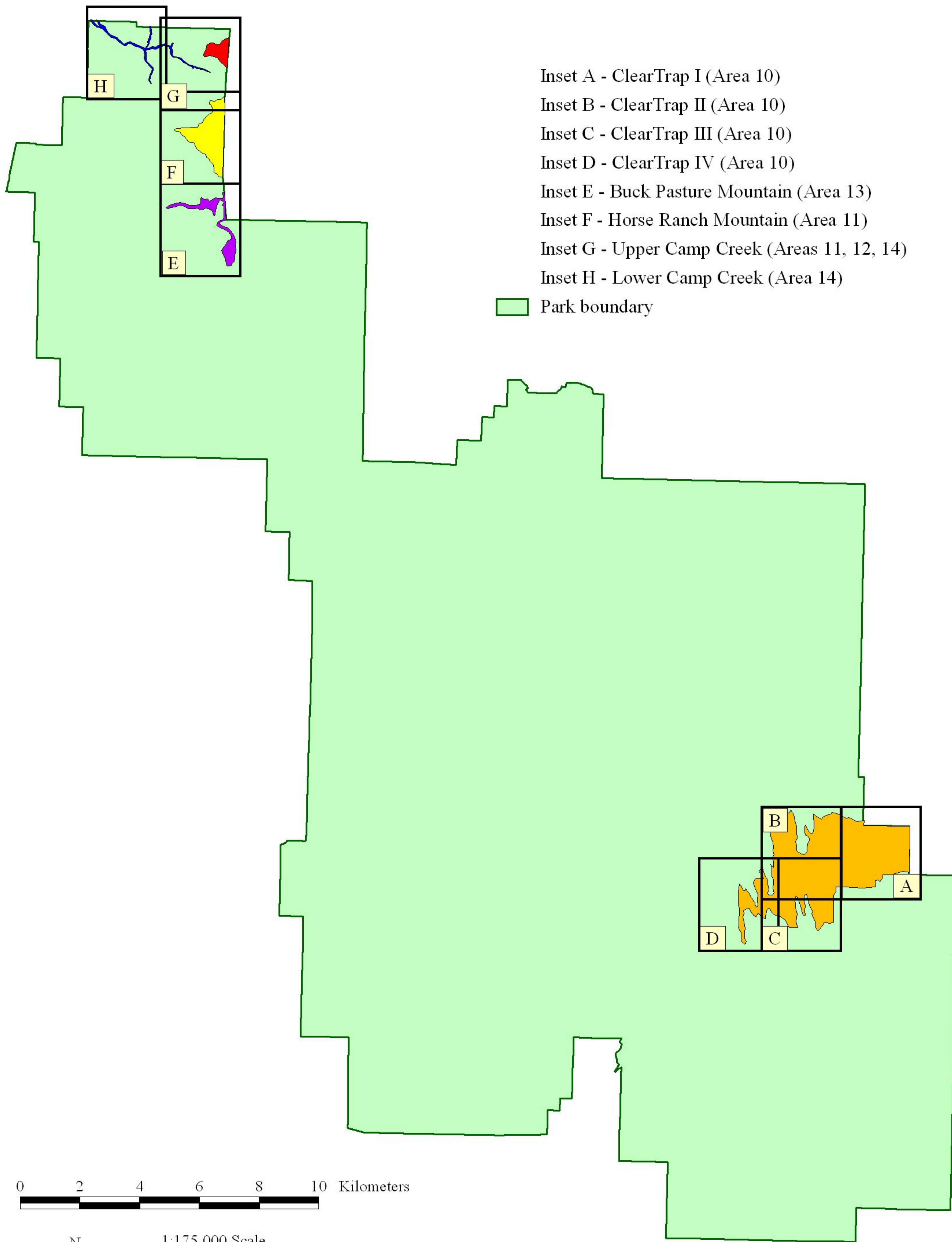


Figure 3. Insets indicating the location, letter code, and name of the 1:14,000 scale maps used in Appendix tables to show weed and rare plant distributions within individual inventoried areas in Zion National Park.



**Table 5: Acres infested by invasive plant species within inventoried areas of Zion National Park in 2006.**

Species	Point Features	Line Features	Area Features	Total
<i>Bromus inermis</i>	27.232	0.970	44.659	72.861
<i>Bromus tectorum</i>	311.640	---	101.052	412.692
<i>Cirsium vulgare</i>	2.174	---	---	2.174
<i>Dactylis glomerata</i>	3.863	---	---	3.863
<i>Elaeagnus angustifolia</i>	0.004	---	---	0.004
<i>Elymus repens</i>	1.001	---	---	1.001
<i>Melilotus officinalis</i>	0.900	---	---	0.900
<i>Onopordum acanthium</i>	2.085	---	---	2.085
<i>Salsola iberica</i>	1.213	---	---	1.213
<i>Tamarix ramosissima</i>	2.045	---	---	2.045
<i>Verbascum thapsus</i>	35.774	---	---	35.774
<b>Totals</b>	<b>387.931</b>	<b>0.970</b>	<b>145.711</b>	<b>534.612</b>

Because not all crew members may have chosen to map *Salsola iberica* and *Melilotus officinalis*, the acreage values and corresponding distribution maps for these species should be considered to represent sample surveys rather than complete inventories.

Rare endemic plants were found on 7.11 acres (Table 6) of the searched Park lands. The most abundant targeted rare plant species found by the field crew was *Astragalus concordius*. This species was found inhabiting 6.615 acres, representing 0.17 percent of the total land inventoried in 2006. Populations ranged in size from 0.001-acre to 0.50-acre, but the vast majority of the patches were 0.01-acre. *Astragalus concordius* was most commonly found in open grassy meadows on Horse Ranch Mountain. The crew also found small amounts of *Carex haysii*, *Aquilegia formosa* v. *fosteri*, and *Asplenium adiantum-nigrum* along Camp Creek. The crew did not find *Eriogonum racemosum* v. *zionis* along the targeted areas of Camp Creek and Horse Ranch Mountain, but did find it within the perimeter of the ClearTrap Burn. The crew did not find any *Calochortus ambiguus*, *Draba asprella*, *Erigeron canaani*, *Erigeron jonesii*, *Erigeron religiosus*, *Erigeron jamesii*, *Eriogonum panguinense*, *Heterotheca jonesii*, *Penstemon higginsii*, *Penstemon humilus* v. *obtusifolia*, or *Viola charlestonensis* on Horse Ranch Mountain. Additionally the crew did not find *Aster welshii*, *Chimaphila menziesii*, *Epilobium nevadense*, *Erigeron sionis*, *Jamesia americana* v. *zionis*, *Lomatium graveolense*, *Selaginella utahensis*, *Sphaeromeria ruthiae*, or *Viola clauseniana* along the inventoried sections of Camp Creek. However, the time of the year may have been a factor in the crew's ability to identify rare plants during this inventory. Much of the inventory took place in mid-September when many of the plants had already passed a recognizable stage of growth. At the time of the inventory many of the plants had either senesced or had been heavily grazed by animals. Several plants found contained some characteristics of the targeted rare plants but often did not exhibit enough distinguishing characteristics to be verified. Thus it is possible that the crew missed some of the targeted species.

**Table 6: Acres inhabited by rare endemic plant populations within inventoried areas of Zion National Park in 2006.**

<b>Species</b>	<b>Acres Inhabited</b>
<i>Asplenium adiantum-nigrum</i>	0.010
<i>Aquilegia formosa</i> v. <i>fosteri</i>	0.023
<i>Astragalus concordius</i>	6.615
<i>Carex haysii</i>	0.350
<i>Eriogonum racemosum</i> v. <i>zionis</i>	0.112
<b>Totals</b>	<b>7.110</b>

Appendix C contains maps showing the overall distribution and relative abundance of all mapped weeds (no species distinction) within the boundaries of inventoried areas. Appendix D contains maps of individual weed species occurrences and weed-free areas within all inventoried portions of Zion National Park. Appendix E contains maps showing the overall distribution of the targeted rare plant populations found within the same inventoried areas. Following is a summary of the weed and rare plant situation within individual 2006 inventory units of Zion National Park.

ClearTrap Burn (Area Number 10; Inset Map A, B, C, D)

The ClearTrap burn represents an approximately 5,000-acre area on the east side of the Park that was burned in 2004 as part of a prescribed fire treatment. Roughly 4,500 acres within the treatment perimeter were actually burned at the time. The area includes Cable Mountain and Deertrap Mountain as well as plateaus along the East Entrance Trail and Echo Canyon Trail. Crews inventoried the area by walking 50-m or 75-m transects across the fields, concentrating on areas that demonstrated heavy burning. Some areas showing little evidence of burning, such as the tips of smaller plateaus covered in unburned manzanita and junipers, were left for future inventory efforts. The vegetation present at individual sites in 2006 was heavily influenced by the intensity of the fire in 2004. For example, intensely burned areas were generally very open with good visibility, and the existing canopy cover consisted mostly of weedy and native forbs. Areas covered with mature stands of oak prior to the fire were often very lush and thick with waist-high oak regrowth in 2006, making them much more difficult to inventory. Areas of ponderosa pine were more open and contained little understory, resulting in good visibility. Portions of the unit previously dominated by juniper / pinyon pine stands had moderately good visibility in 2006, often with only a light understory of grasses or forbs, native or weedy.

The primary objective of mapping the ClearTrap Burn was to determine the relative abundance of invasive grass species, focusing especially on *Bromus tectorum*. As expected, *Bromus tectorum* was found throughout the entire inventory unit, in both heavily and moderately burned areas, as well as in non-burned sites. However, it was much more common in burned areas, and especially in the most open portions. It didn't seem to matter whether those open areas had existed prior to the burn, or whether they were the result of complete oak / juniper / pinyon removal by the fire. Concentrations of *Bromus tectorum* were especially heavy on Deertrap Mountain and in the meadows at the junction of the Deertrap Mountain Trail and the Cable Mountain Trail. Patches ranged in size from 0.001-acre to 5-acres, although most were 0.10-acre or smaller. In areas where fire-related disturbance was most severe, *Bromus tectorum* often occurred in large

somewhat continuous patterns. Areas that were minimally disturbed or undisturbed by fire usually contained relatively few *Bromus tectorum* infestations. Most patches found on such sites were small (0.01 or 0.001-acre in size), and typically were located around the bases of unburned trees. This pattern may suggest some kind of establishment or survival advantage associated with the micro-habitat created beneath a tree's canopy -- at least for *Bromus tectorum* growing under the conditions found in the southern Utah region.

*Bromus inermis* was also found within the burned area. This species occurred primarily in small drainages and in the lower wet meadows of the unit. Within these areas, *B. inermis* formed almost solid monocultures along the drainage bottoms. Due to high density and continuous nature of these relatively solid stands, several of these infestations were mapped as linear or polygon features.

*Verbascum thapsus* was the second most frequently recorded species within the inventory unit, although it was not a targeted species in 2006. Patches were often small and of a low density. The highest concentration of *V. thapsus* was found in the eastern third of the inventory unit. Interestingly, this species' distribution also appeared to follow drainage bottoms, and the majority of patches were found in intermittent-riparian habitats. No *V. thapsus* was found on Deertrap Mountain and only a small handful of plants were discovered on Cable Mountain.

Additional non-target species found within the inventory unit include *Cirsium vulgare*, *Salsola iberica*, *Melilotus officinalis*, and *Tamarix ramosissima*. *Cirsium vulgare* was found lightly scattered within the inventoried area, although mostly concentrated on the eastern portion near the park's boundary fence. Infestations were small, often consisting of only a few plants in each recorded patch. Small patches of *Salsola iberica* were also found scattered within the unit. The majority of these patches were located near the center of the unit and were often less than 0.01-acre in size. Small patches of *Melilotus officinalis* were found and documented along the Park's east boundary. Field notes indicate that *M. officinalis* was found in other areas of the inventory unit but not mapped, thus the inventory of this particular species should not be considered complete.

Crews were surprised to find infestations of *Tamarix ramosissima* within the inventory unit. Infestations were found in a variety of places within the unit, none of which would normally be considered riparian. Infestations consisted of several various-sized saplings, many of which were flowering at the time of the inventory. While the majority of recorded patches were found near the center of the inventory unit, two small patches were recorded on Cable Mountain. It is quite possible that additional patches of *Tamarix ramosissima* exist in the unit, but were not found due to their small patch size (often only one to few plants), young growth stage (commonly 12- to 24-inch saplings), and their resemblance to some other abundant weedy forbs.

Other species seen but not mapped include *Malva neglecta*, *Lactuca serriola*, *Chenopodium album*, *Sisymbrium altissimum*, *Descurainia pinnata*, *Epilobium* sp., and *Taraxacum officinale*. *Lactuca serriola*, *Chenopodium album*, and *Epilobium* sp. were especially prevalent in the heavily burned areas and were often the dominant species in those areas.

Although not a priority within the ClearTrap Burn, crew members did note the presence of the rare plant *Eriogonum raceomosum* v. *zionis*. A small number of plants were found along the

Deertrap Trail, growing along the sandstone ledges on one of the rock outcrops that the trail bisects. These recorded patches should not be considered a complete inventory of this particular species within the ClearTrap Burn. It is very likely other plants of this species as well as other rare plant species were within the inventory unit but were not actively searched for by the crew.

Overall the ClearTrap Burn was heavily infested with *Bromus tectorum* and other non-target weedy species. Native shrubs, forbs, and grasses were seen within the unit, but will have to compete rigorously for resources with the vast number of non-native plants present in many areas. Visibility varied according to the amount of vegetation present, but the crew was confident of having found 90 percent or more of all 0.01-acre or larger patches of the targeted weed species. No other obvious disturbances were noted aside from the prescribed fire. The inventory unit was assigned an ecological status level four due to vast amount of weedy grasses and weedy forbs present in the area.

#### Horse Ranch Mountain (Area Number 11; Inset Map )

Horse Ranch Mountain is a large oakbrush-covered mountain found in the Kolob region of Zion National Park. Four crew members concentrated their efforts on searching for thirteen of the targeted rare and endemic plants potentially found on Horse Ranch Mountain. The search area was an approximately 200-ft strip along the Park boundary, as well as any immediately adjacent areas that might contain potential rare plant habitat. In addition to inventorying rare plants, the crew was asked to record any invasive grasses encountered.

The inventory of Horse Ranch Mountain was difficult due to heavy stands of oakbrush and manzanita. Visibility was very limited throughout much of the area, so crews concentrated on those areas most likely to contain the targeted species. Much of the area did not appear to have ideal habitat for the targeted rare plants due to the heavy vegetation. Crew members did record points of what they believed to be *Astragalus concordius*. These plants were found in pockets containing few grasses in the meadows scattered along the Park boundary east of Horse Ranch Mountain. They were also found on rocky outcrops scattered throughout the heavy stands of oak. The majority of patches recorded were found on the cliffs above Camp Creek. Patches of *A. concordius* varied in range from 0.001-acre to 0.50-acre and individual patches contained anywhere from 1 plant to 1000 plants in each patch. Most of the patches recorded were 0.01-acre in size. It must be noted that the identification of *Astragalus concordius* was not certain because at the time of this inventory the plant specimens were well past bloom and therefore lacked one or more critical morphological features needed for species verification. Therefore, all specimens inventoried as *A. concordius* are listed as “unsure ID” within the notes section of the dataset.

No other rare plant species were found along the Park boundary in this unit. However, the crew was to target two rare *Penstemon* species within the inventoried area. Unfortunately, these areas had been heavily grazed before the inventory; and although some specimens of *Penstemon* were found, they could not be positively identified as the rare species.

Horse Ranch Mountain contained three of the targeted invasive grass species. The most commonly recorded species was *Bromus inermis*, which occurred throughout the inventoried area. Infestations along the Park boundary were widespread on both sides of the fence and it appears to have spread into the Park from the adjacent private lands. Infestations were found both in open fields as well as throughout the dense oakbrush. *Dactylis glomerata* was also

widespread throughout the area, although more patchy in its distribution. The majority of the plants were found under the oakbrush and small meadows along the Park boundary. Much of the *D. glomerata* was found interspersed with infestations of *B. inermis*, and also was likely spread from patches on the adjacent private lands. Patches of *D. glomerata* ranged in size from 0.001-acre to 1-acre and averaged a moderate canopy cover.

*Bromus tectorum* was found in only three small patches in this inventory unit. Each of these infestations was found in open areas containing little other vegetation. A senesced 0.001-acre patch was found on the cliff edge above the North Fork of Taylor Creek. A second 0.001-acre senesced patch was discovered on the south edge of a foothill near the Park boundary scattered in a rocky opening among the oakbrush. A 0.01-acre patch of *B. tectorum* was also found in a small meadow above the private road cutting through the Park south of Horse Ranch Mountain.

Additional non-targeted invasive species found and mapped include *Verbascum thapsus*, *Cirsium vulgare*, and *Onopordum acanthium*. *Verbascum thapsus* occurred throughout much of the inventoried area. Many of the patches were found near on the edges of stock ponds scattered throughout the searched area. Open meadows and oakbrush stands also appeared to be favored habitats. Little *V. thapsus* was found on open rocky or manzanita-covered slopes. Overall, this species was not present in high amounts, and several of the observed patches had been pulled earlier in the summer by the NPS weed crew. The majority of *Verbascum thapsus* patches found were less than 0.01-acre, although size ranged from 0.001-acre to 2.5-acres. *Onopordum acanthium* was also fairly frequent on Horse Ranch Mountain. Patches of *Onopordum acanthium* were generally larger than those of *V. thapsus*, ranging in size from 0.001 to 0.10 acre. Patches were found in many of the small open meadows within the inventoried unit, and many of them had been pulled earlier in the season by the NPS weed crew. *Cirsium vulgare* was found primarily along springs, wet meadows, and stock ponds. Patches of *C. vulgare* were small, often consisted of only a few plants. Additional non-native species seen but not mapped include *Lactuca serriola*, *Erodium cicutarium*, *Chenopodium album*, *Phleum pretense*, and *Agropyron cristatum*.

Visibility was fairly limited throughout much of the area due to the dense native oakbrush and manzanita stands. As a result, the crew struggled to achieve the desired level of search coverage, detection confidence. Based solely on the visibility and percentage of land searched in this unit, it is possible that the crew found as few as 70-75 percent of 0.01-acre and larger patches. However, based on the results of their searches into dense stands of brush, it appears that the majority of invasive plants actually occurred in the open meadows, around stock ponds, and along the Park boundary (all of which were searched thoroughly). The same site relationship appeared true for the rare plants -- most were found in open meadows or small clearings among the trees, and none were found under dense stands of oak or manzanita. Based on this observed plant distribution, it is likely that the crew still found at least 90 percent of all 0.01-acre patches of the invasive species and rare plants within the inventoried area, even though there was as much as 30 percent of the total land area that could not be searched thoroughly.

Most areas inventoried on Horse Ranch Mountain did not seem consistent with the preferred habitat described for the thirteen targeted rare species. Most of those species are known to prefer sandy or rocky soils in pockets of various sandstones. However, the majority of area searched consisted of heavy brush. Those sites resembling the "ideal" habitat for the targeted rare plants



were mostly along the tops and bases of cliffs, which were not searched as intensively since the Park boundary was the inventory priority. These areas should be searched more thoroughly and at an earlier time in the growing season.

The area was assigned an ecological status level four due to the high presence of invasive grasses. As a side note, the fences were down in several locations along the Park boundary on Horse Ranch Mountain, and cattle trespass was noted in a few locations. This trespassing is likely contributing to the spread of the invasive species already present and could lead to introductions of new invasive species not already in the Park.

#### Plateau north of Horse Ranch Mountain (Area Number 12; Inset Map G)

This inventory unit is on a plateau north of Camp Creek in the northeast corner of the Park. The inventory focus for this area was the same thirteen rare plants and the four invasive grass species targeted for Horse Ranch Mountain. Two crew members inventoried this area, accessing it from the private land adjacent to the Park. Since much of the area was densely covered with brush species, the crew focused on the open areas along the cliff edges considered most likely to contain the targeted rare plants. The only rare plant species located was the *Astragalus concordius*. As on Horse Ranch Mountain, the plants mapped were assumed to be *Astragalus concordius* since they had many of the characteristics of this species. As stated earlier, they could not positively be identified due to the lack of key features such as flowers and/or fruits. These plant species were always found in open areas rather than associated with the heavy canopy cover of oak or manzanita. Most of the patches were found along the cliffs above Camp Creek. Populations were small and varied in size from 0.001 to 0.25-acres, although the majority of infestations were 0.01-acre. No other rare plant species were positively identified at this time. However, several plants were found that closely resembled (and might have been) the targeted species. However, they could not be positively identified because they had either been grazed or had already senesced.

The crew also found four of the targeted invasive species in this unit. *Bromus inermis* was scattered across the plateau in several patches ranging in size from 0.001 to 1 acre. Patches occurred primarily along the north and south edges of the plateau. Five small patches of *Dactylis glomerata* were also found, primarily along the north rim of the inventory unit. An acre of *Elymus repens* was discovered along the Park boundary, and a second smaller 0.001-acre patch was found along the north edge of the plateau. A single 0.01-acre patch of *Bromus tectorum* was found near the large patch of *Elymus repens* along the Park boundary.

Although not targeted species, the crew also found *Verbascum thapsus* and *Onopordum acanthium* in this unit. A single 0.001-acre patch comprised of *Verbascum thapsus* rosettes was found on the north rim of the plateau. A single 0.001-acre patch of *Onopordum acanthium* was found in the southeast corner of the inventory unit along the Park boundary. This small infestation was dispersing seeds at the time of the inventory. Additional non-native species seen but not mapped include *Phleum pretense* and *Agropyron cristatum*.

As in the inventory of Horse Ranch Mountain, visibility varied according to the density of shrubs in any particular area. However, the overall composition of plants was similar to Horse Ranch Mountain and the crew felt confident that it saw at least 90 percent of all 0.01-acre patches of the targeted invasive species and rare plant species. When the area is re-inventoried, it is our

recommendation that it occur earlier in the season to make patch detection and species verification easier.

The crew noted that the Park fence was down in several locations, and that livestock had entered the Park and actively grazed on Park property. This type of disturbance could not only impact local rare plant populations, but also may lead to the introduction of new invasive species into remote sections of the Park. This was the only obvious disturbance noted within this inventory unit. The area was assigned an ecological status level two.

#### Buck Pasture Mountain, Beatty Point, Death Point (Area Number 13; Inset Map E)

The inventory of this unit was conducted in conjunction with Horse Ranch Mountain by two crew members who were sent to search for the targeted rare plants and invasive grasses. The inventoried area was covered by heavy stands of oak, serviceberry, and manzanita, making complete coverage very difficult in many areas. Visibility was often limited and crew members found it difficult to see more than a few feet at a time in many instances. Although the Park boundary was walked from one canyon rim to another, the brush in the remainder of the unit was too thick for complete transects to be walked. Thus the area should be considered a sample survey rather than an inventory, as individual crew members could not guarantee that at least 90 percent of all 0.01-acre patches of rare plants or grass species could be seen. However, the area was heavily covered in shrubs and the majority of the unit lacked an understory of forbs and grasses. Thus it is unlikely that a large number of the targeted species of either rare plants or invasive grasses were present.

Crew members did find and record four small populations of the suspected *Astragalus concordius* within the inventory unit. Specimens lacked flowers and fruits but were virtually identical to those found on Horse Ranch Mountain. No other targeted rare plant species were found.

The crew did find and record infestations of the targeted species *Bromus inermis*, *Bromus tectorum*, and *Dactylis glomerata*. Four populations of *Bromus inermis* were found near an old homestead site along the Park boundary. Two 0.10-acre patches and a 0.01-acre patch were recorded in the open field next to a cabin found at the site. An additional 0.001-acre patch was found along the fenceline north of the homestead site. A single 0.01-acre senesced patch of *Bromus tectorum* was also found at the homestead site along the Park boundary. Additional infestations of *Bromus tectorum* were found on Death Point south of Buck Pasture Mountain. Several small senesced patches were found at the bases of juniper trees along the east rim of the plateau. These patches were 0.001-acre in size and difficult to reach due to the steepness of the terrain along the rim. A 0.001-acre patch of *B. tectorum* was also found in a small dry gully on the southeast tip of Buck Pasture Mountain. A 0.001-acre patch of *Dactylis glomerata* was also found in this gully. A second 0.001-acre patch of *D. glomerata* was found at the homestead site along the Park boundary.

Although not targeted, the crew mapped three additional non-native species. *Verbascum thapsus* was found along the Park boundary in several places, as well as in the small meadow at the homestead site and on top of Buck Pasture Mountain. An additional *V. thapsus* patch was found at the north tip of Death Point. *Verbascum* patches were between 0.001 and 0.10 acre and often comprised of solely of rosettes. A single 0.01-acre patch of *Cirsium vulgare* was found at the homestead site in a seed-dispersing stage. An additional 0.01-acre patch of *Melilotus officinalis*

was found in the small meadow at the homestead site. Other species seen but not mapped include *Lactuca serriola*, *Malva neglecta*, and *Chenopodium album*.

As stated earlier, the visibility was extremely limited within this inventory unit, and few rare plants or invasive species were found. No obvious disturbances were observed in the area although it was noted that the Park fenceline was down along the boundary and livestock were present on the adjacent private lands. The unit was comprised of mostly native species with few invasive species, and so was assigned an ecological status level two.

#### Camp Creek (Area Number 14; Inset Maps G, H)

Camp Creek is a small creek within the Kolob region, which is the northern-most portion of the Park. The primary objective of the Camp Creek inventory was to target twelve rare plants potentially found in that area, as well to document any invasive plant species. Crew members walked the creek bed and searched the surrounding banks and fields for all targeted species. While the focus was along the main creek, the crew also searched two large side drainages.

The crew found three of the targeted rare plant species in the upper portions of Camp Creek. Five small patches of what are believed to be *Aquilegia formosa* v. *fosteri* were found along the creek's banks growing amid stands of rushes. Four populations were found below the "narrows" section of the creek, while a fifth population was found in the upper reaches of the unit above the "narrows." Population sizes ranged from 0.001-acre to 0.01-acre, with 1 to 100 plants per population. Specimens lacked flowers at the time of the inventory and could not positively be identified, so crews indicated "unsure ID" in the notes section of each recorded population.

The crew also found two populations of *Carex haysii* in the upper portion of Camp Creek. One 0.10-acre patch consisted of approximately 101-1000 plants and the second population was recorded as 0.25-acre and had between 11-50 plants. A single 0.01-acre patch (51-100 plants) of an *Asplenium* species was found in a hanging garden along the cliff walls in the "narrows" section of the unit. These ferns were not positively identified as the rare *Asplenium adiantum-nigrum*, but the crew felt that the ferns were significant (and likely to be the target species), and so mapped the population. No other rare plants were found along the creek, although time was spent primarily along the creek bed which did not generally represent the type of habitat considered most suited to some or most of the targeted rare species. Many of the rare plant species targeted for Camp Creek favored sandy pockets in sandstone slickrock, which was not found directly along the creek bed. It is possible that more of the targeted species inhabit the slopes surrounding Camp Creek, which were not searched at this time.

In addition to rare plants, the crew found several non-targeted invasive species along the creek bed. However, none of the targeted invasive species were observed in Camp Creek. *Tamarix ramosissima* was the primary invasive species found. In all instances, patches of *T. ramosissima* consisted of no more than one or two saplings. In a number of instances, the sites had been previously treated, and the individual trees found were most likely resprouts from those treated trees. Saplings of *T. ramosissima* were also found in the two side drainages inventoried.

Numerous patches of *Verbascum thapsus* were also found along the banks of Camp Creek. Infestations were rarely larger than 0.001-acre and mostly comprised of rosettes. Patches were usually scattered under willows and on sandy flood banks. *Cirsium vulgare* was also found under

the willows and along the sandy banks. Infestations almost always consisted of single plants that were dispersing seeds at the time of the inventory. Additional *Cirsium vulgare* patches were found in one of the side drainages. Small patches of *Salsola iberica* were found scattered in the same side drainage. *Melilotus officinalis* was found scattered in small patches at the mouth of Camp Creek.

Four small patches of *Elaeagnus angustifolia* were also observed in Camp Creek. A single 0.001-acre patch consisting of a single sapling occurred near the mouth of Camp Creek. Three additional 0.001-acre patches were found near the middle section of the creek where the two side drainages were inventoried. Each of these patches consisted of small saplings which were most likely the regrowth of previously treated mature trees. Additional species seen but not mapped include *Lactuca serriola*, *Chenopodium album*, and *Taraxacum officinale*.

Visibility was generally good along the creek. The canopy cover of native plants varied along the creek. There were several large healthy stands of willows as well as sandy banks covered in cottonwood seedlings. There were also numerous stands of rushes and *Aster* species lining the banks throughout much of the inventory unit. The native plant community appeared to be relatively diverse and healthy at this time. No obvious disturbances aside from seasonal flooding were present. Overall the area was only moderately infested with invasive species and was assigned an ecological status level two.

## CONCLUSIONS / RECOMMENDATIONS

The primary objectives of this project were to document the distribution and relative abundance of targeted non-native invasive plant species and designated rare and endemic plants species across the range of habitats and areas of management concern within Zion National Park. As with the information contained in the 2003-2004 report, it is anticipated that this 2006 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 plant management.

During 2006 the USU crew noted that Zion National Park continues to implement weed control strategies and practices. It was obvious that mechanical techniques to control *Onopordum acanthium* and *Cirsium vulgare* had been used in several inventoried sites around meadows and stock ponds in the Horse Ranch Mountain inventory unit. Additional control measures were seen in Camp Creek to control *Tamarix ramosissima* and *Elaeagnus angustifolia*. Crews also found piles of *Verbascum thapsus* that had been pulled along portions of the Cable Mountain trail. The NPS employees assigned to the 2006 mapping project were also able to elaborate on other ongoing control projects being implemented in the Park because they had been part of the seasonal weed crew.

USU urges the Park to review and improve its management plan for invasive plant species. Regularly scheduled weed inventories of all managed lands should be a part of all future versions of the plan. Permanent monitoring sites should be established to evaluate the impact and spread of weeds, and to evaluate the effectiveness of its weed management approaches. Zion National

Park is encouraged to become an active member of a local Cooperative Weed Management Area, if it has not already done so.

A similar recommendation is made for the Park's management of its rare and endemic plant populations. USU urges the Park to develop a written management plan for rare plant species in ZION if one has not already been developed. If one already exists, the Park is encouraged to review it on a regular basis as well as continue to search Park lands on a routine schedule. The time of year for the 2006 rare plant inventory was not ideal for many of the targeted species, as many of the plants were past the critical growth stage(s) for species verification. Future inventories might take into consideration the flowering time of the targeted plants to ensure positive identification as well as make plants more visible to field crews.

All NCPN Parks that were inventoried between 2003 and 2006 are in the enviable situation of still having the majority of their lands free of targeted invasive weeds. In Zion National Park 86.6 percent of the acres inventoried in 2006 were free of all targeted species. Furthermore, 94.9 percent of the acres inventoried in the three years combined (2003, 2004, 2006) were free of all targeted species. And, because areas selected for this inventory were generally considered to be the sites most likely to be infested, it can be assumed that those ZION lands not inventoried have an even higher proportion of weed-free acres. Furthermore, 100 percent of all inventoried lands in 2006 were completely free of at least 31 species of great concern to the region (Appendix F).

#### **ACKNOWLEDGEMENTS:**

We express appreciation to the Northern Colorado Plateau Network in Moab, UT, for their vision and efforts in continuing this inventory project. We are grateful to Cheryl Decker for her ongoing interest in maintaining this project as well as her help in logistical planning and coordination. Above all, we thank the dedicated USU and NPS crew members who encountered potentially dangerous situations and considerable physical hardship in the intense summer heat and rugged backcountry of southern Utah to collect this information.

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## **Appendix Tables and Figures**

**Appendix A. Crew Qualifications and Project Quality Assurance for the 2006 Inventory of Invasive Non-native Plants and Rare Endemic Plants in Zion National Park.**

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

- 1997 Mt. Naomi Wilderness Area, Cache County, UT
- 1998 Wellsville Mountains Wilderness Area, Cache and Box Elder Counties, UT
- 1999 Franklin Basin Recreation Area, USFS Logan Ranger District, Cache County UT
- 2000 Rich County Public Lands (BLM, USFS), UT
- 2001 Hardware Ranch WMA, UDWR, Cache County, UT
- 2001 Bud Phelps WMA, UDWR, Cache County, UT
- 2002 Hawkins Fire, USFS, Bannock County, ID
- 2002 Canyon Fire, USFS, Franklin County, ID
- 2002 Cherry Creek Fire, USFS, Bannock County, ID
- 2002 West Fork Fire, BLM, Bannock County, ID
- 2002 Dinosaur National Monument, Green River District, UT
- 2003 Invasive Non-native Plant Inventories conducted in portions of ARCH, BLCA, CANY, CARE, COLM, HOVE, NABR, MEVE, ZION; Northern Colorado Plateau Network, National Park Service
- 2004 Invasive Non-native Plant Inventories conducted in portions of ARCH, BLCA, BRCA, CANY, CARE, CEBR, and DINO; Northern Colorado Plateau Network, National Park Service
- 2005 Invasive Non-native Plant Inventories conducted in portions of BRCA, CANY, CARE, and DINO; Northern Colorado Plateau Network, National Park Service
- 2005 Yampa River corridor, Moffat and Routt Counties, CO

Kim Andersen (crew leader) has considerable experience working on the USU crew in past years. Kim has a Bachelor of Science degree in Fisheries and Wildlife from the College of Natural Resources and is currently working towards a Master's Degree in Weed Science. Kim began work on the USU crew in 1999, and has been crew leader since 2000. She has additional experience with invasive weed GPS mapping projects in Grand Teton National Park. Ruth Richards has a Bachelor of Science degree in Crop Science and a Master's Degree in Weed Science. She has worked on the USU mapping crew for three years and currently is employed as the Weed and Pest Supervisor for Bighorn County in Greybull, Wyoming. Anna Schmidt has a Bachelor of Science degree in Nutrition. She has considerable outdoor skills and participated in numerous outdoor survival courses. She also participated in the annual training course taught at Utah State



University.

Alexia Savold, Fleur Nicklen, and Kathy Davidson have worked at least one season in Zion National Park as biological research technicians. Each was part of Zion's seasonal weed crew in 2006 and had prior experience in weed identification.

All USU weed survey crew members were required to pass a written exam in weed identification and mapping skills before being hired. Each also had passed an upper-division university course in weed identification, biology, and management, and/or has extensive practical experience in wildland plant identification. Once hired, USU and NPS crew members also attended a 3-week classroom and outdoor training course in early May in wildland weed mapping techniques taught by Dr. Dewey at Logan during 2006. Crew members were provided with weed identification field guide book, taxonomic keys, and pressed reference specimens of all targeted weeds. During the course of the summers USU crew members were quizzed periodically with fresh plant specimens provided by the crew leader and/or Dr. Dewey. Dr. Dewey also spent several days working with individual crew members under field conditions. To further authenticate findings, Dr. Dewey and/or the crew leader re-visited representative areas in each park that had been previously mapped by the USU crew, using the most recent crew-generated weed infestation maps to compare them against their own field observations.

## Weeds Detected



**Figure 1.** *Bromus tectorum* found underneath a juniper in the ClearTrap Burn, ZION PR-52.



**Figure 2.** *Bromus tectorum* found in the ClearTrap Burn inventory unit, ZION PR-52.



**Figure 3.** Typical infestation of *Bromus tectorum* in the ClearTrap Burn, ZION PR-57.



**Figure 4.** Bighorn sheep standing in a patch of senesced *Bromus tectorum* along the Mount Carmel road on the east side of the Park.

# Invasive Non-native Plants Detected



**Figure 5.** *Bromus inermis* found along the Park boundary on Horse Ranch Mountain.



**Figure 6.** *Dactylis glomerata* found underneath oak brush on Horse Ranch Mountain, ZION PR-66.



**Figure 7.** *Dactylis glomerata* found in oak brush on Horse Ranch Mountain.



**Figure 8.** *Elymus repens*.\*

\*Photo not taken in Park.

# Invasive Non-native Plants Detected



**Figure 9.** *Tamarix ramosissima* found in the ClearTrap Burn, ZION PR-77.



**Figure 10.** Landscape view of *Tamarix ramosissima* found in the ClearTrap Burn, ZION PR-77.



**Figure 11.** *Tamarix ramosissima* saplings found in the ClearTrap Burn, ZION PR-65.



**Figure 12.** Landscape view of *Tamarix ramosissima* saplings found in the ClearTrap Burn, ZION PR-65.

# Invasive Non-native Plants Detected



**Figure 13.** *Onopordum acanthium* flowering on Horse Ranch Mountain, ZION PR-67.



**Figure 14.** *Onopordum acanthium* infestation on Horse Ranch Mountain, ZION PR-49.



**Figure 15.** *Verbascum thapsus* flowers on Horse Ranch Mountain, ZION PR-69.



**Figure 16.** *Verbascum thapsus* infestation on Buck Pasture Mountain, ZION PR-73.

# Invasive Non-native Plants Detected



**Figure 17.** *Cirsium vulgare* found in the ClearTrap Burn, ZION PR-64.



**Figure 18.** Landscape view of an infestation of *Cirsium vulgare* found in the ClearTrap Burn, ZION PR-64.



**Figure 19.** *Melilotus officinalis*.\*



**Figure 20.** *Salsola iberica* found along Camp Creek.

\*Photo not taken in Park.

# Rare Endemic Plants Detected



**Figure 21.** *Astragalus concordius*.\*



**Figure 22.** *Eriogonum racemosum* v. *zionis*.\*



**Figure 23.** *Aquilegia formosa* v. *fosteri*.\*



**Figure 24.** *Asplenium adiantum-nigrum*.\*

# Zion National Park Inventoried Landscapes



**Figure 25.** Anna Schmidt in the ClearTrap Burn.



**Figure 26.** View of the ClearTrap Burn, ZION PR-63.



**Figure 27.** Typical inventory site in the ClearTrap Burn, ZION-4674.



**Figure 28.** Northern portion of the DeerTrap Plateau within the perimeter of the ClearTrap Burn, ZION PR-60.



# Zion National Park Inventoried Landscapes



**Figure 29.** Inventoried area north of the DeerTrap Trail in the ClearTrap Burn, ZION PR-56.



**Figure 30.** Inventoried area infested with *Bromus tectorum* in the ClearTrap Burn, ZION PR-57.



**Figure 31.** Looking south over the Inventoried area on Horse Ranch Mountain, ZION PR-70.



**Figure 32.** Looking south over the Inventoried area on Horse Ranch Mountain, near ZION PR-70.

# Zion National Park Inventoried Landscapes



**Figure 33.** Looking north to the plateau inventoried by crew near Horse Ranch Mountain, ZION PR-71.



**Figure 34.** Hillside inventoried for rare plants on Horse Ranch Mountain, ZION PR-72.



**Figure 35.** Hillside inventoried for rare plants on Horse Ranch Mountain.



**Figure 36.** Inventoried area along the Park boundary below Horse Ranch Mountain containing thick brush.

# Zion National Park Inventoried Landscapes



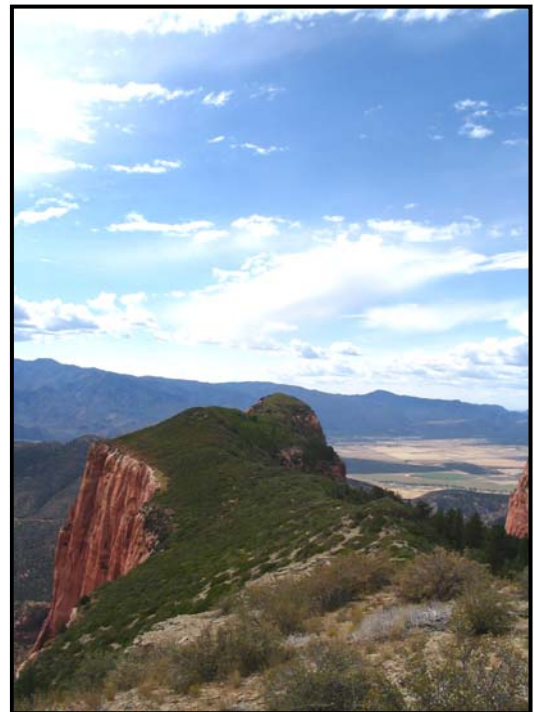
**Figure 37.** Looking south to the inventoried area of Death Point.



**Figure 38.** Inventoried area on Death Point heavily covered by serviceberry and oak brush.

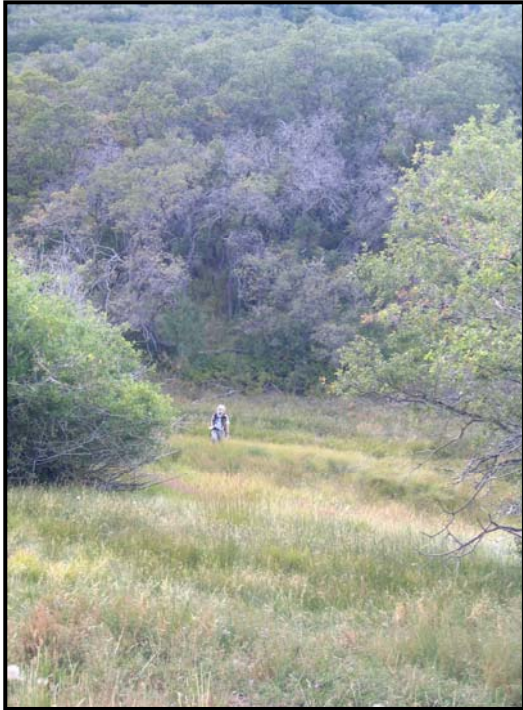


**Figure 39.** Inventoried hillsides on Buck Pasture Mountain, ZION PR-51.

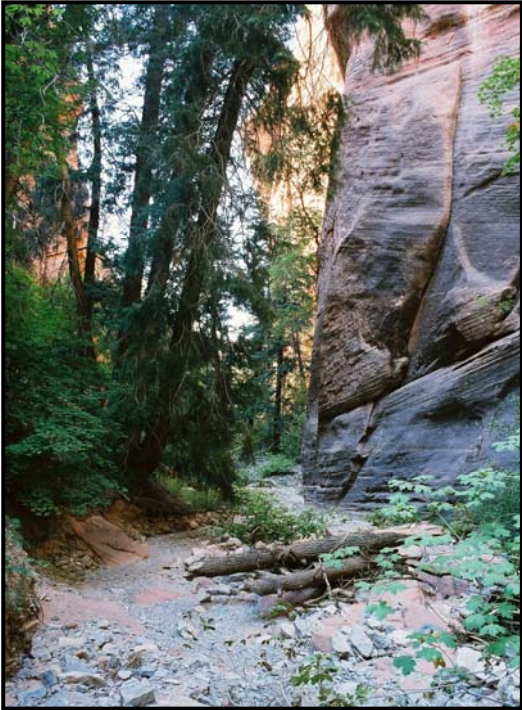


**Figure 40.** Inventoried area along Beatty Point, west of Buck Pasture Mountain, ZION PR-75.

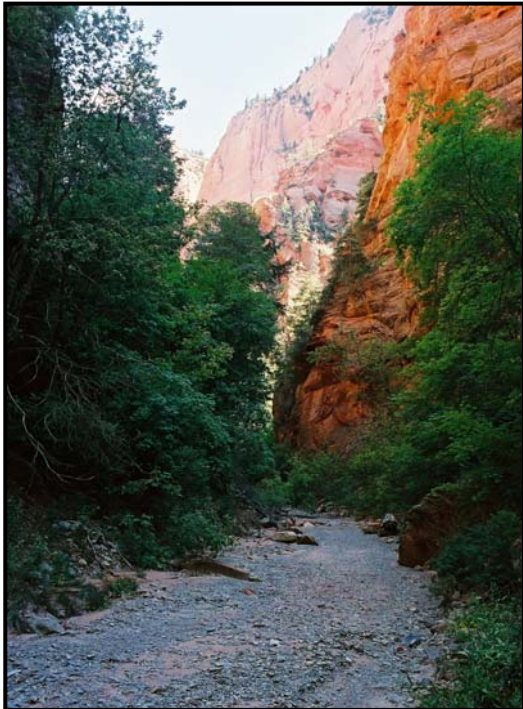
# Zion National Park Inventoried Landscapes



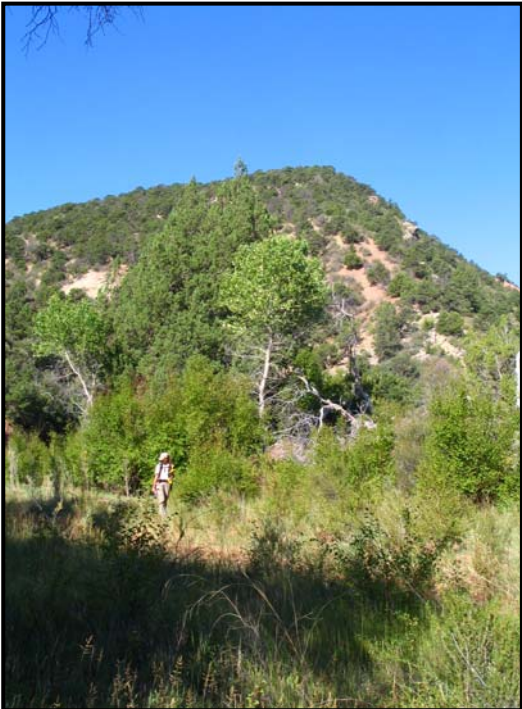
**Figure 41.** Inventoried meadow below Horse Ranch Mountain.



**Figure 42.** Looking down-canyon along an inventoried portion of Camp Creek.



**Figure 43.** Looking up-canyon along an inventoried portion of Camp Creek.



**Figure 44.** Kim Andersen searching a portion of Camp Creek.

# Crew



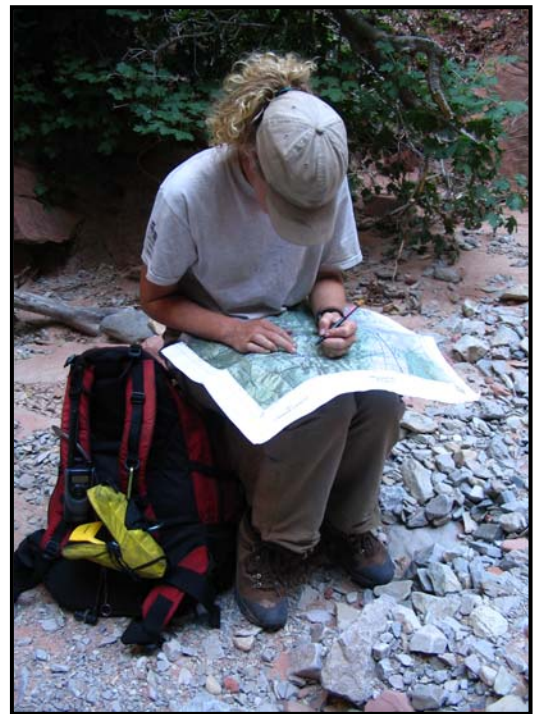
**Figure 45.** Alexia Savold (NPS) and Kim Andersen (USU) planning for a day of mapping in the ClearTrap Burn.



**Figure 46.** Alexia Savold (NPS), Fleur Nicklen (NPS), and Kim Andersen (USU) studying the day's targeted rare plants on Horse Ranch Mountain.



**Figure 47.** Kim Andersen instructing Alexia Savold and Fleur Nicklen in GPS use before mapping on Horse Ranch Mountain.



**Figure 48.** Kim Andersen studying a map in Camp Creek.

# Crew



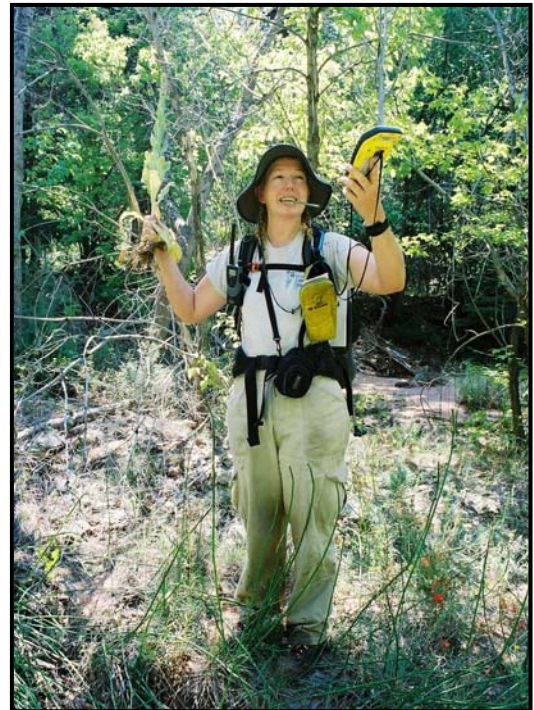
**Figure 49.** Crew participated in a morning planning session on Horse Ranch Mountain.



**Figure 50.** Anna Schmidt collecting a weed point for *Bromus tectorum* in the ClearTrap Burn.



**Figure 51.** Kim Andersen using a taxonomic key to identify an unknown *Aster* sp. in Camp Creek.

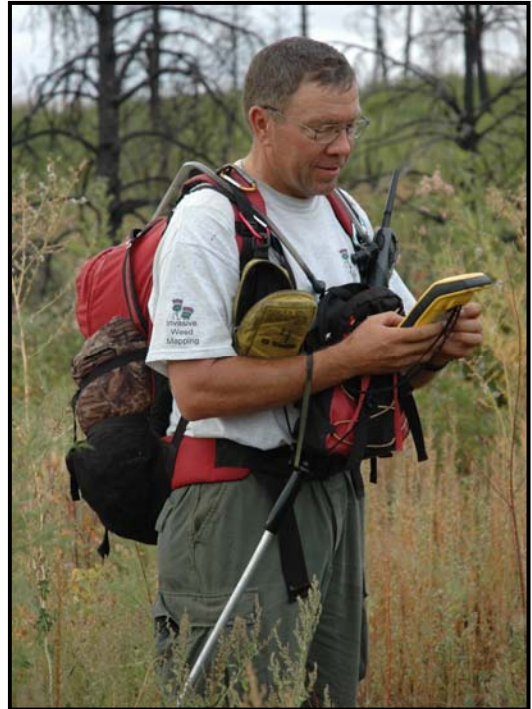


**Figure 52.** Ruth Richards collecting a data point for *Verbascum thapsus* found in Camp Creek.

# Crew



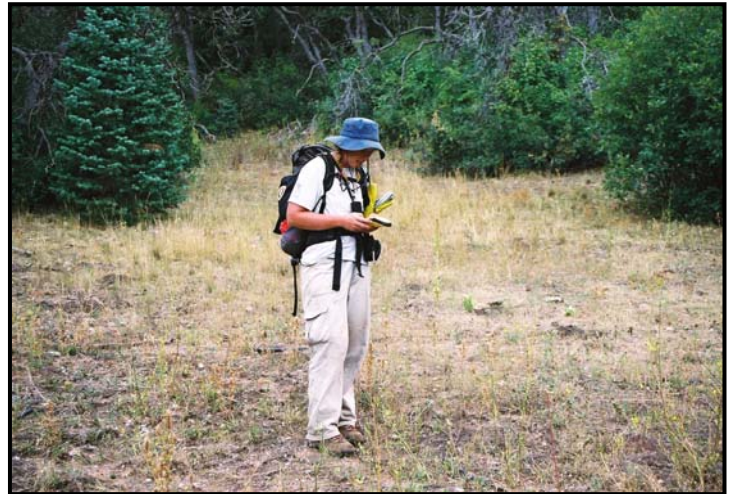
**Figure 53.** Alexia Savold and Fleur Nicklen collecting data points for *Astragalus concordius* on Horse Ranch Mountain.



**Figure 54.** Steve Dewey (project PI) collecting a data point in the ClearTrap Burn.



**Figure 55.** Kim Andersen searching along Camp Creek for targeted rare plants.



**Figure 56.** Ruth Richards collecting a data point on Buck Pasture Mountain.

# Crew



**Figure 57.** Steve Dewey mapping an infestation of *Tamarix ramosissima* in the ClearTrap Burn.



**Figure 58.** Ruth Richards collecting a photo point of the inventoried area in Camp Creek .



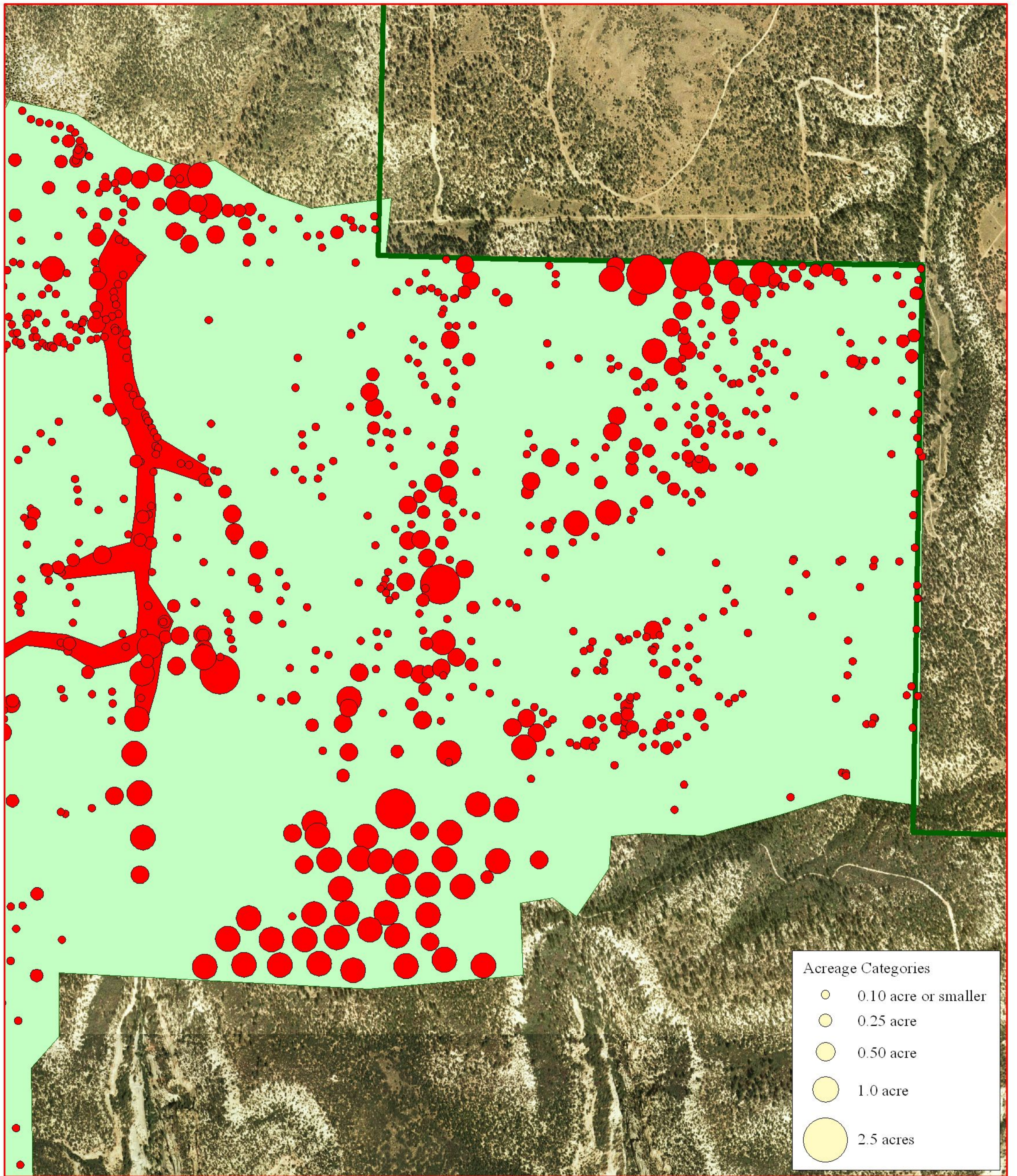
**Figure 59.** Fleur Nicklen and Kim Andersen reviewing data collected on Horse Ranch Mountain.



**Figure 60.** Kim Andersen downloading and reviewing the day's data collected in the ClearTrap Burn.



Appendix C. Overall Weed Distribution in the ClearTrap Burn - ClearTrap I (Inset A)

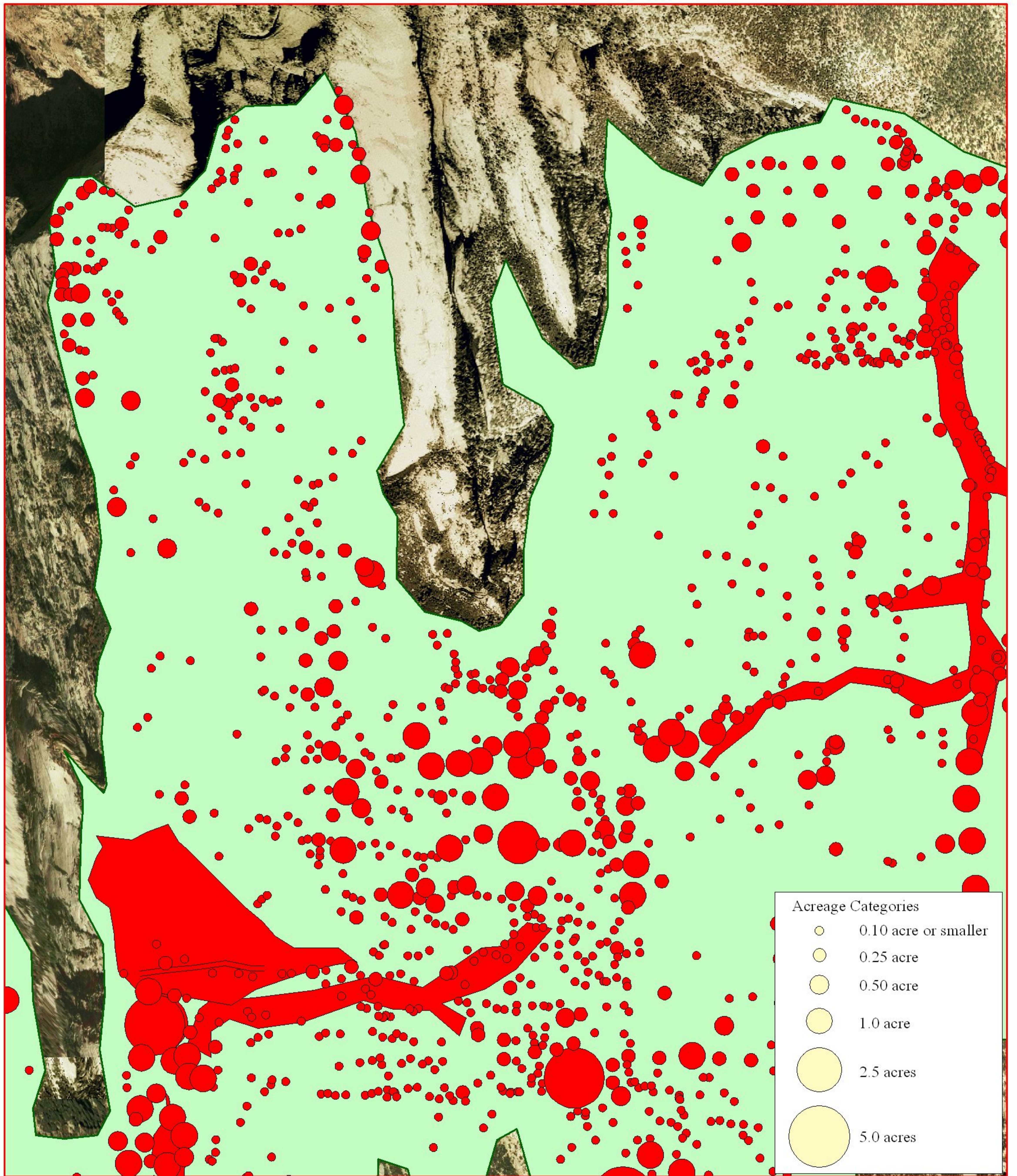


- Weed Points
- Weed Areas
- Area Inventoried
- Park boundary

0 300 600 900 Meters



1:14,000 Scale



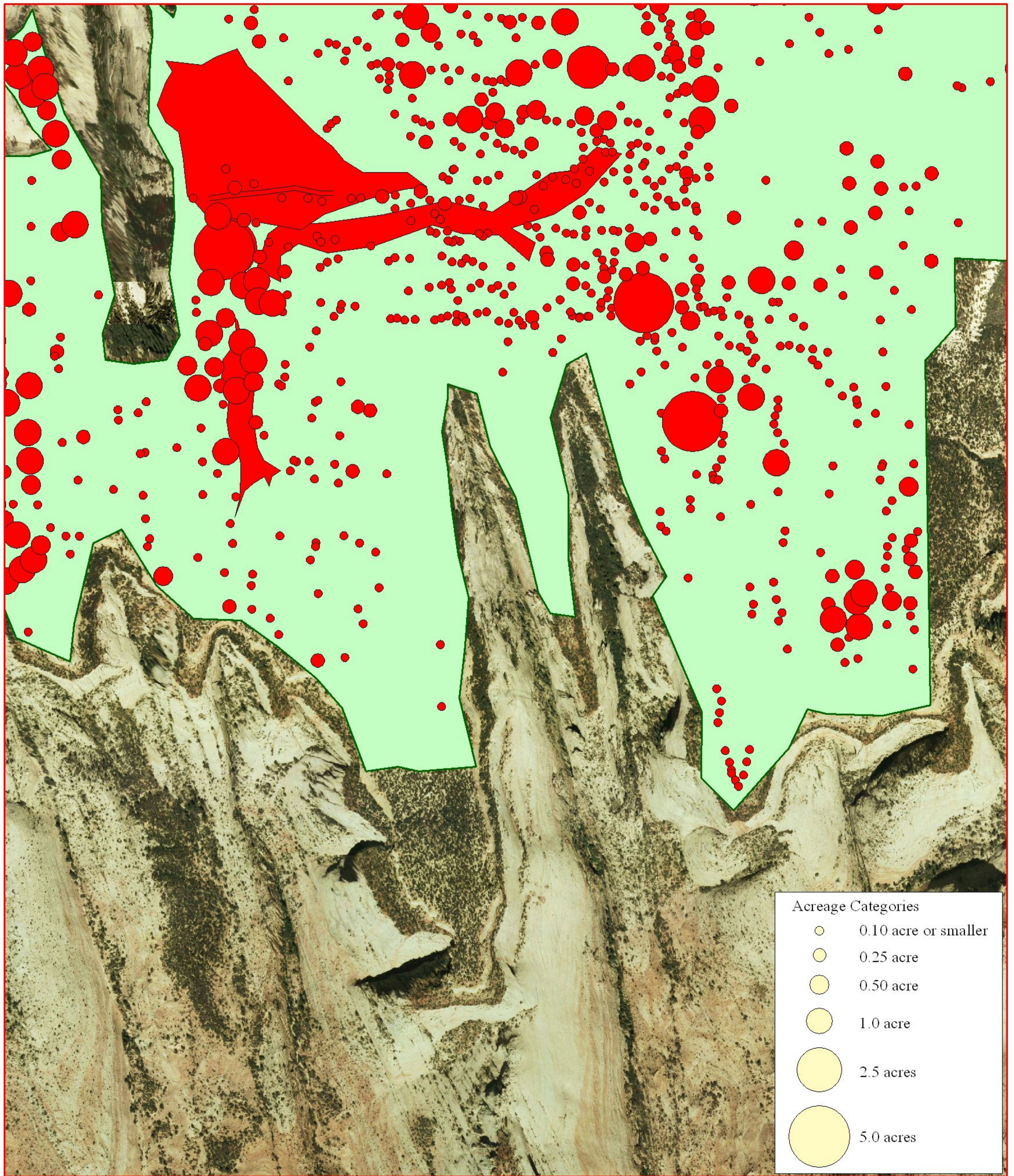
- Weed Points
- Weed Lines
- Weed Areas
- Area Inventoried

0 300 600 900 Meters



1:14,000 Scale

Appendix C. Overall Weed Distribution in the ClearTrap Burn - ClearTrap III (Inset C)

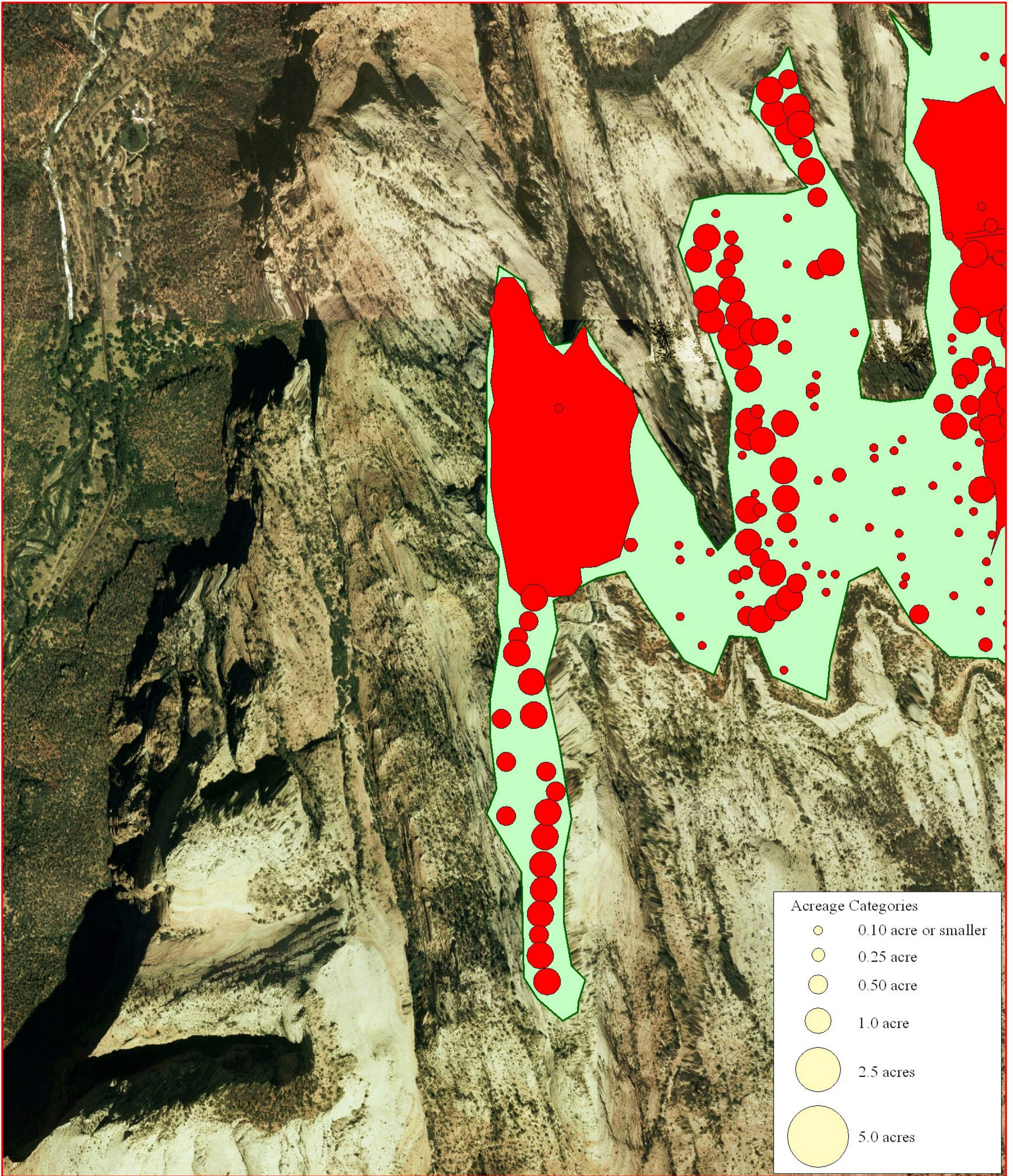


- Weed Points
- Weed Lines
- Weed Areas
- Area Inventoried

0 300 600 900 Meters



1:14,000 Scale



Acreage Categories	
	0.10 acre or smaller
	0.25 acre
	0.50 acre
	1.0 acre
	2.5 acres
	5.0 acres

- Weed Points
- Weed Lines
- Weed Areas
- Area Inventoried

0 300 600 900 Meters



1:14,000 Scale



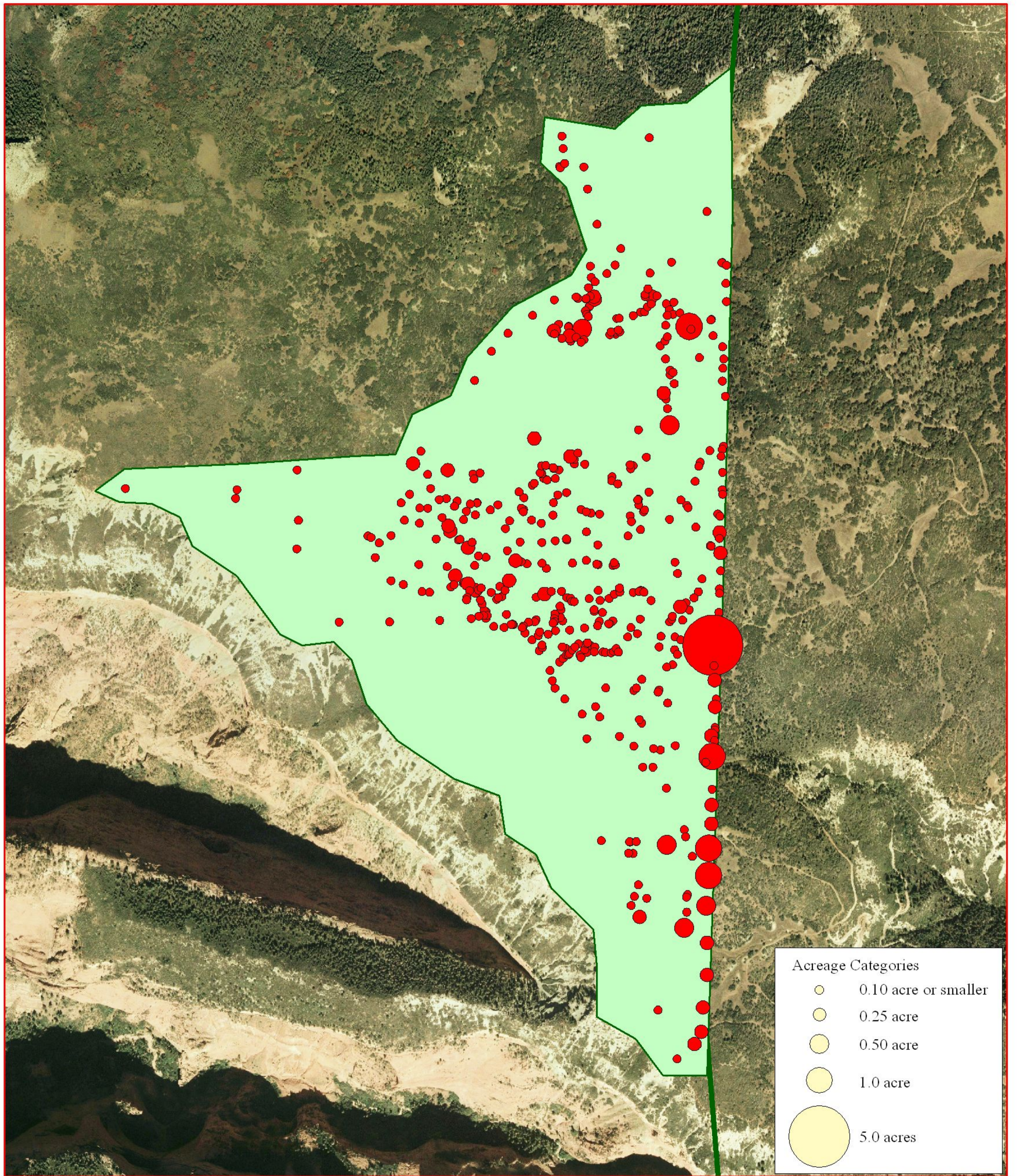
Acreage Categories  
○ 0.10 acre or smaller

- Weed Points
- Area Inventoried
- Park boundary






0 300 600 900 Meters


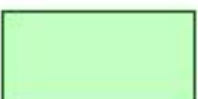



1:14,000 Scale

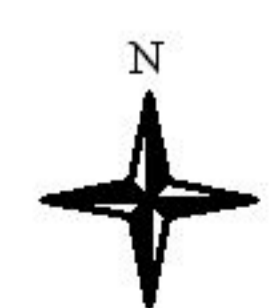


**Acreage Categories**

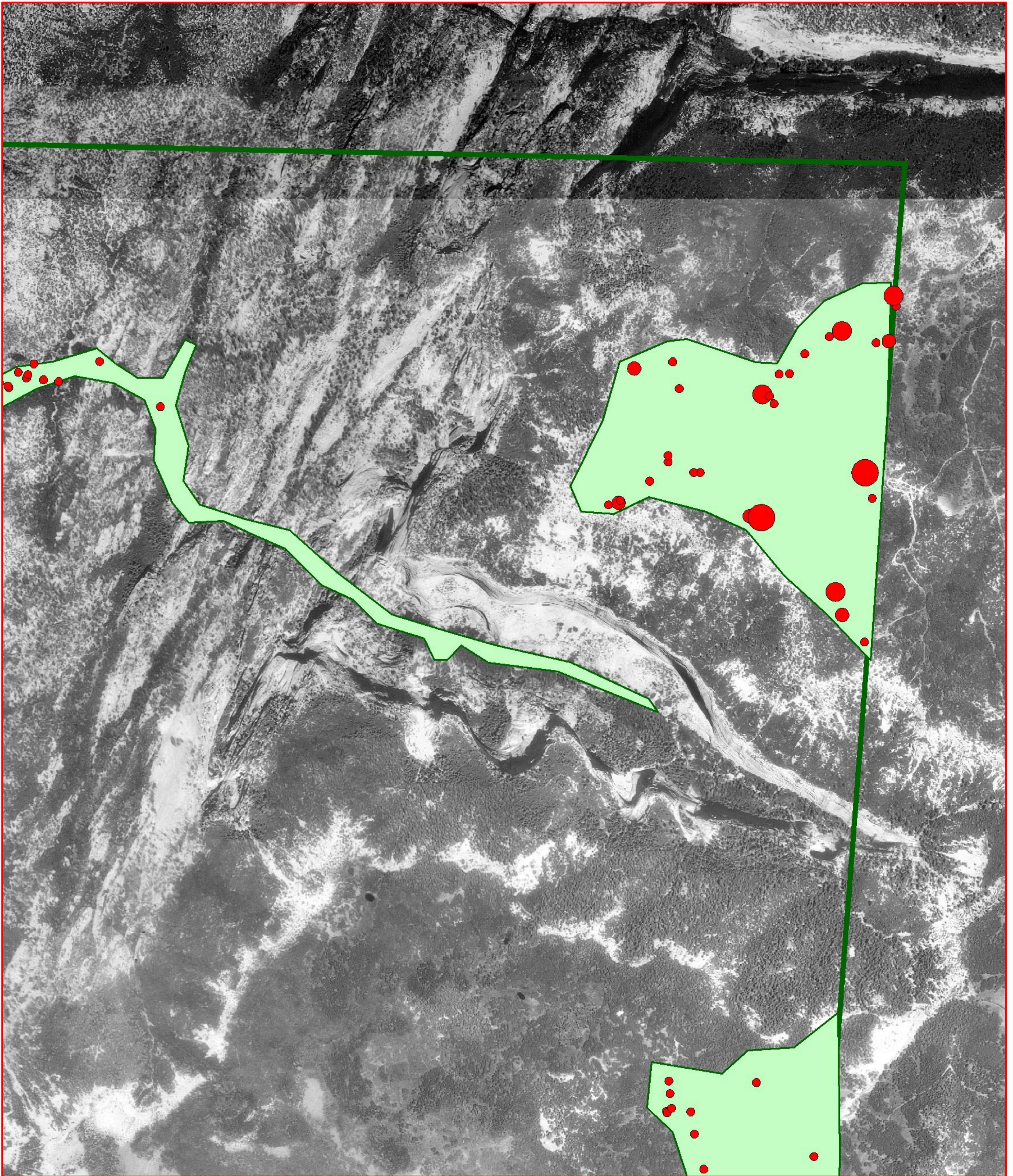
-  0.10 acre or smaller
-  0.25 acre
-  0.50 acre
-  1.0 acre
-  5.0 acres


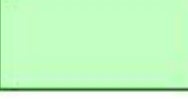

-  Weed Points
-  Area Inventoried
-  Park boundary

0 300 600 900 Meters



1:14,000 Scale



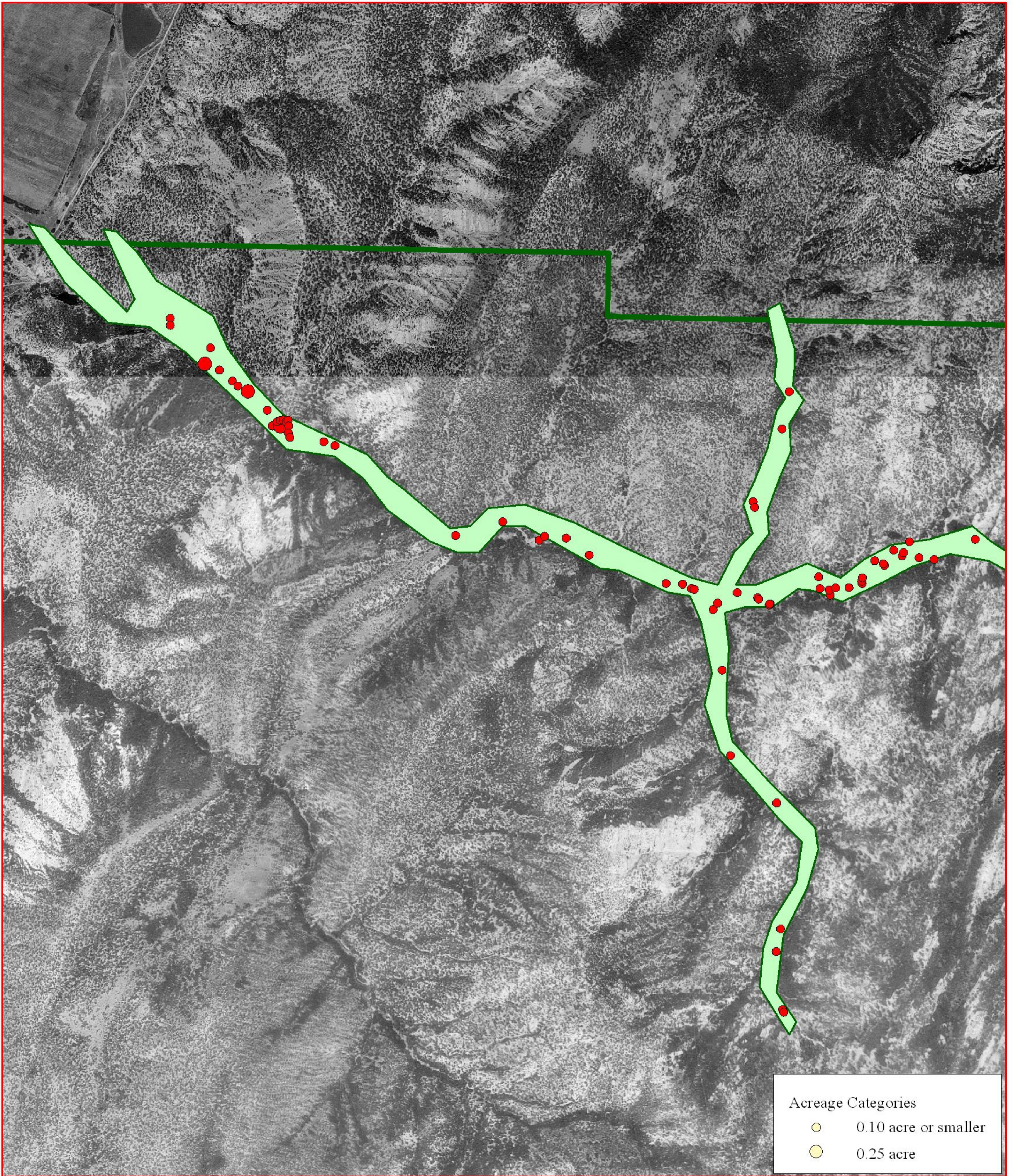
-  Weed Points
-  Area Inventoried
-  Park boundary

0 300 600 900 Meters



1:14,000 Scale

Inset G  
Utah State University  
Zion National Park  
2006 Inventory of Invasive Non-native Plants and Rare Endemic Plants  
Northern Colorado Plateau Network



- Weed Points
- Area Inventoried
- Park boundary

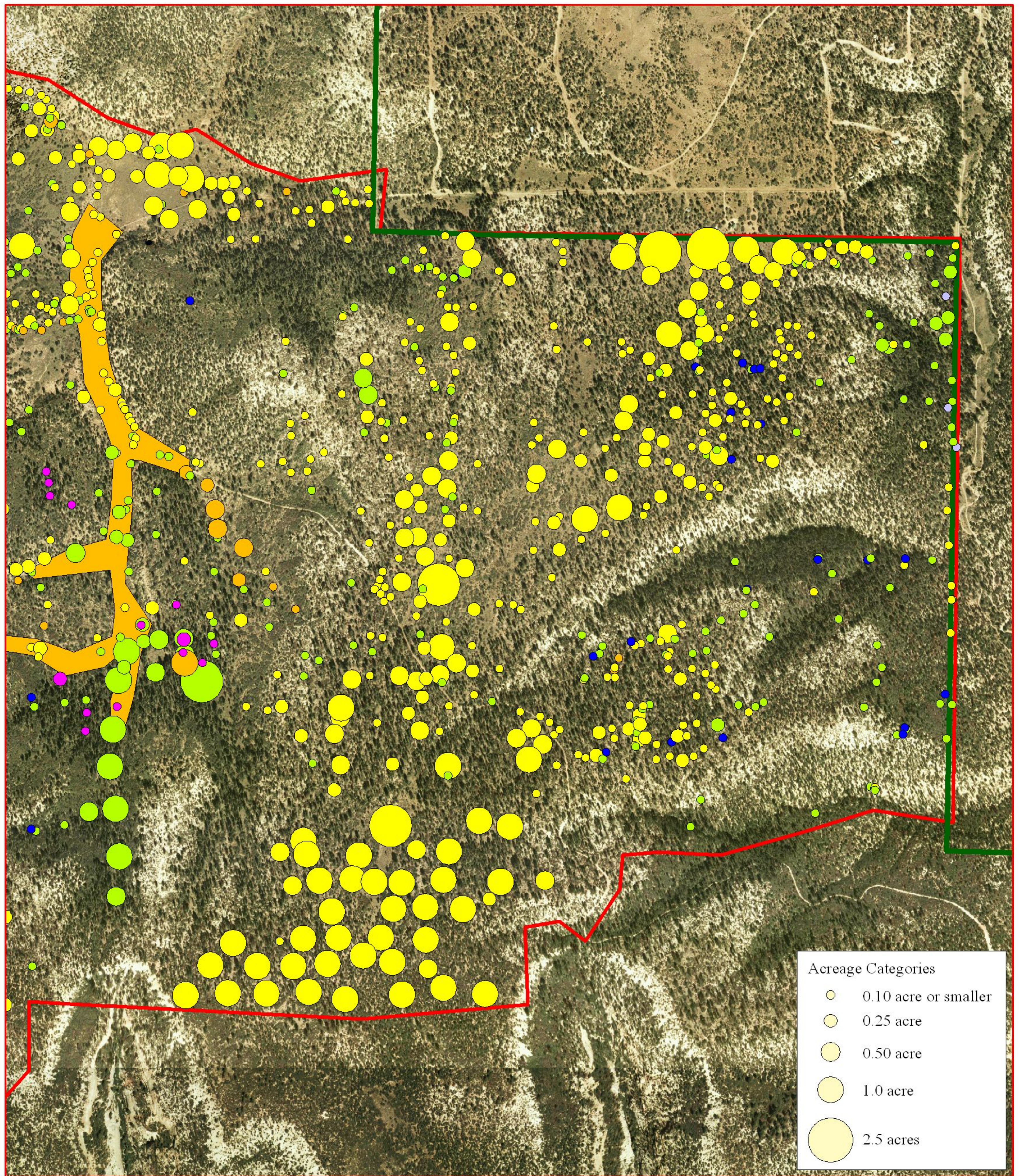
0 300 600 900 Meters

N  
1:14,000 Scale

Acage Categories  
● 0.10 acre or smaller  
● 0.25 acre



Appendix D. Location and relative size of invasive non-native plant infestations detected in the ClearTrap Burn  
 - ClearTrap I (Inset A)



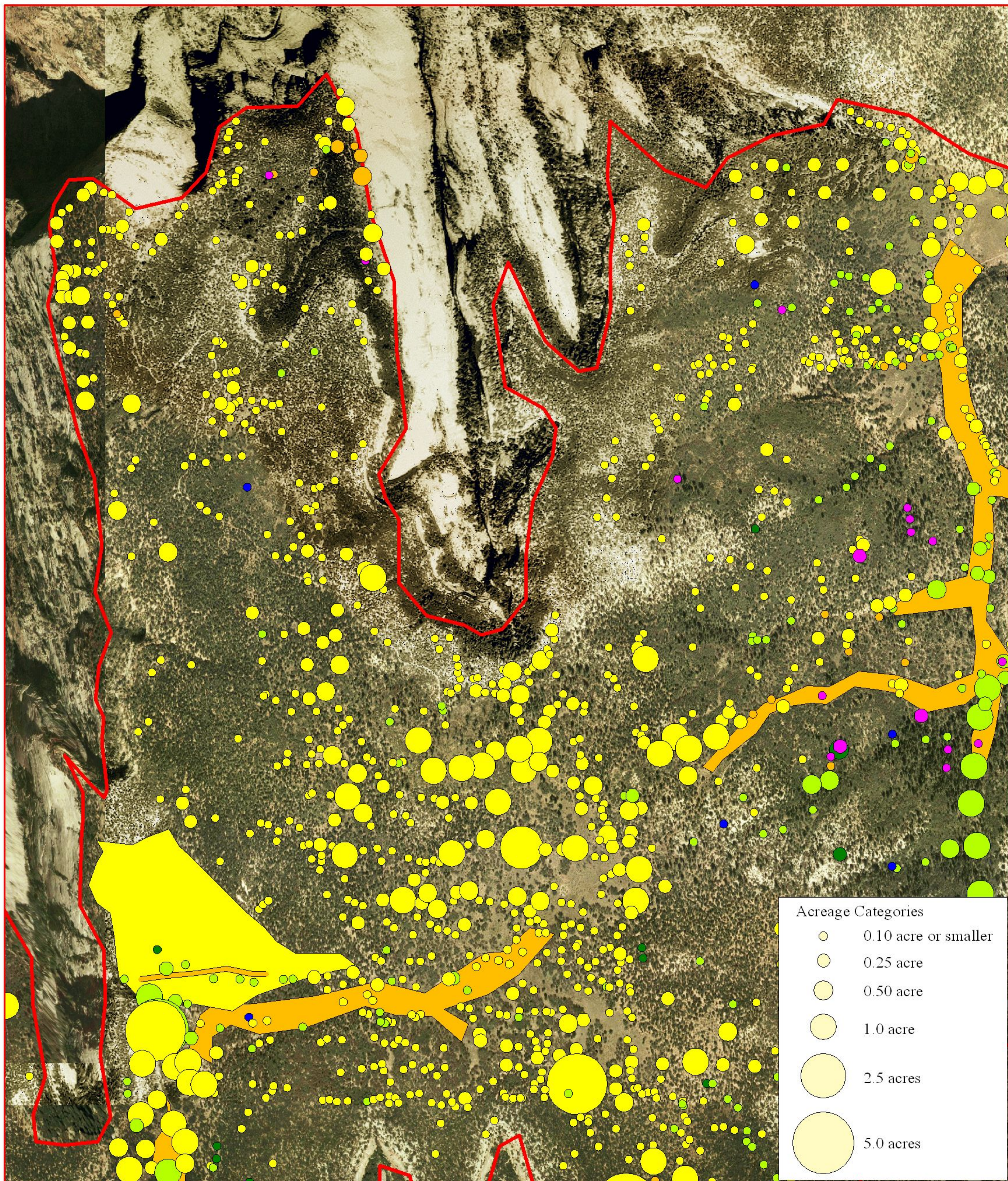
- |                              |                            |
|------------------------------|----------------------------|
| <i>Bromus inermis</i>        | <i>Tamarix ramosissima</i> |
| <i>Bromus inermis</i>        | <i>Verbascum thapsus</i>   |
| <i>Bromus tectorum</i>       | Area Inventoried           |
| <i>Cirsium vulgare</i>       | Park boundary              |
| <i>Melilotus officinalis</i> |                            |

0 300 600 900 Meters

1:14,000 Scale



Appendix D. Location and relative size of invasive non-native plant infestations detected in the ClearTrap Burn  
 - ClearTrap II (Inset B)



- |                        |                            |
|------------------------|----------------------------|
| <i>Bromus inermis</i>  | <i>Cirsium vulgare</i>     |
| <i>Bromus inermis</i>  | <i>Salsola iberica</i>     |
| <i>Bromus inermis</i>  | <i>Tamarix ramosissima</i> |
| <i>Bromus tectorum</i> | <i>Verbascum thapsus</i>   |
| <i>Bromus tectorum</i> | Area Inventoried           |

D-2

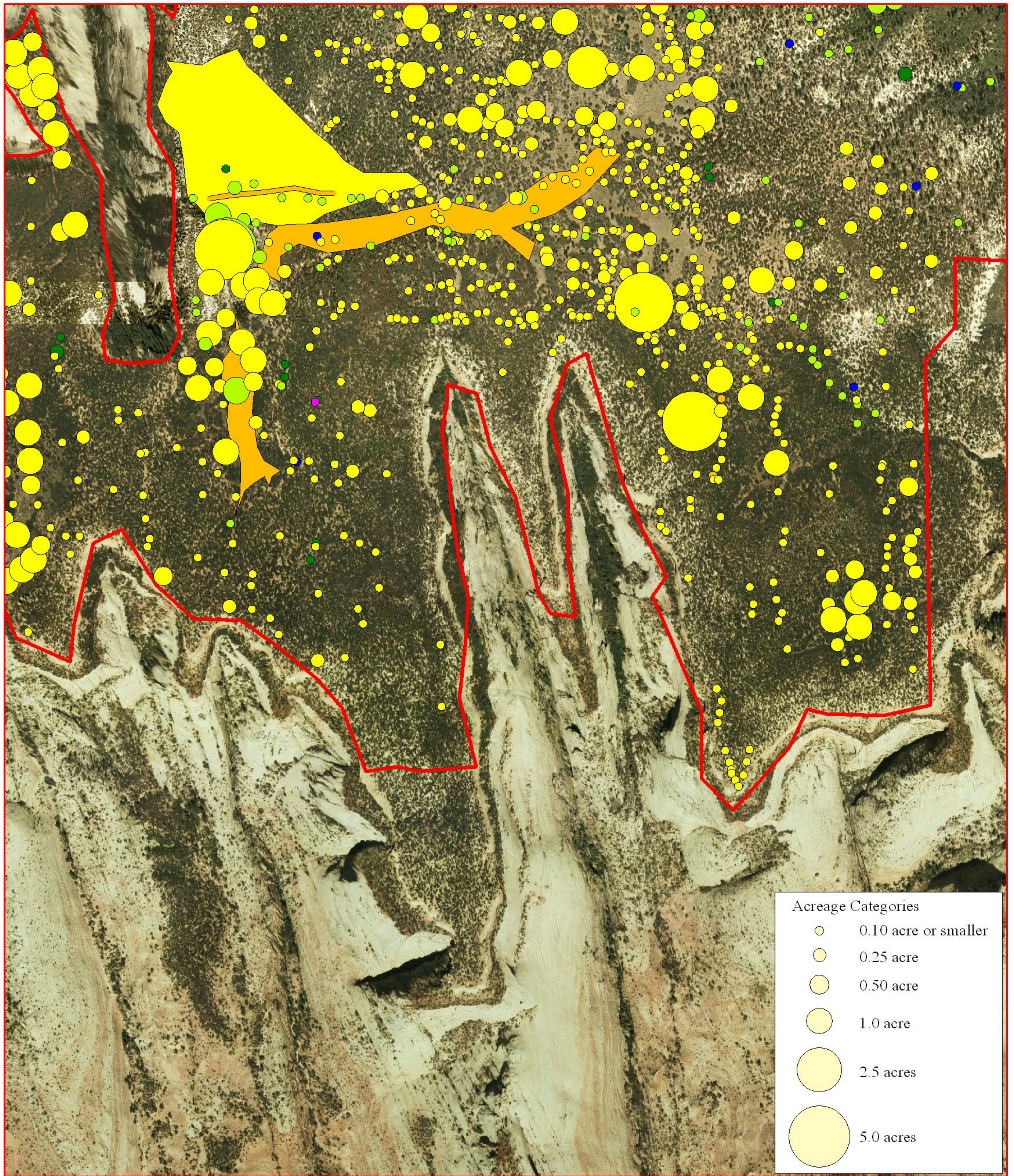
0 300 600 900 Meters



1:14,000 Scale

Inset B  
 Utah State University  
 Zion National Park  
 2006 Inventory of Invasive Non-native Plants and Rare Endemic Plants  
 Northern Colorado Plateau Network

Appendix D. Location and relative size of invasive non-native plant infestations detected in the ClearTrap Burn  
 - ClearTrap III (Inset C)



- |  |                        |  |                            |
|--|------------------------|--|----------------------------|
|  | <i>Bromus inermis</i>  |  | <i>Cirsium vulgare</i>     |
|  | <i>Bromus inermis</i>  |  | <i>Salsola iberica</i>     |
|  | <i>Bromus inermis</i>  |  | <i>Tamarix ramosissima</i> |
|  | <i>Bromus tectorum</i> |  | <i>Verbascum thapsus</i>   |
|  | <i>Bromus tectorum</i> |  | Area Inventoried           |

D-3

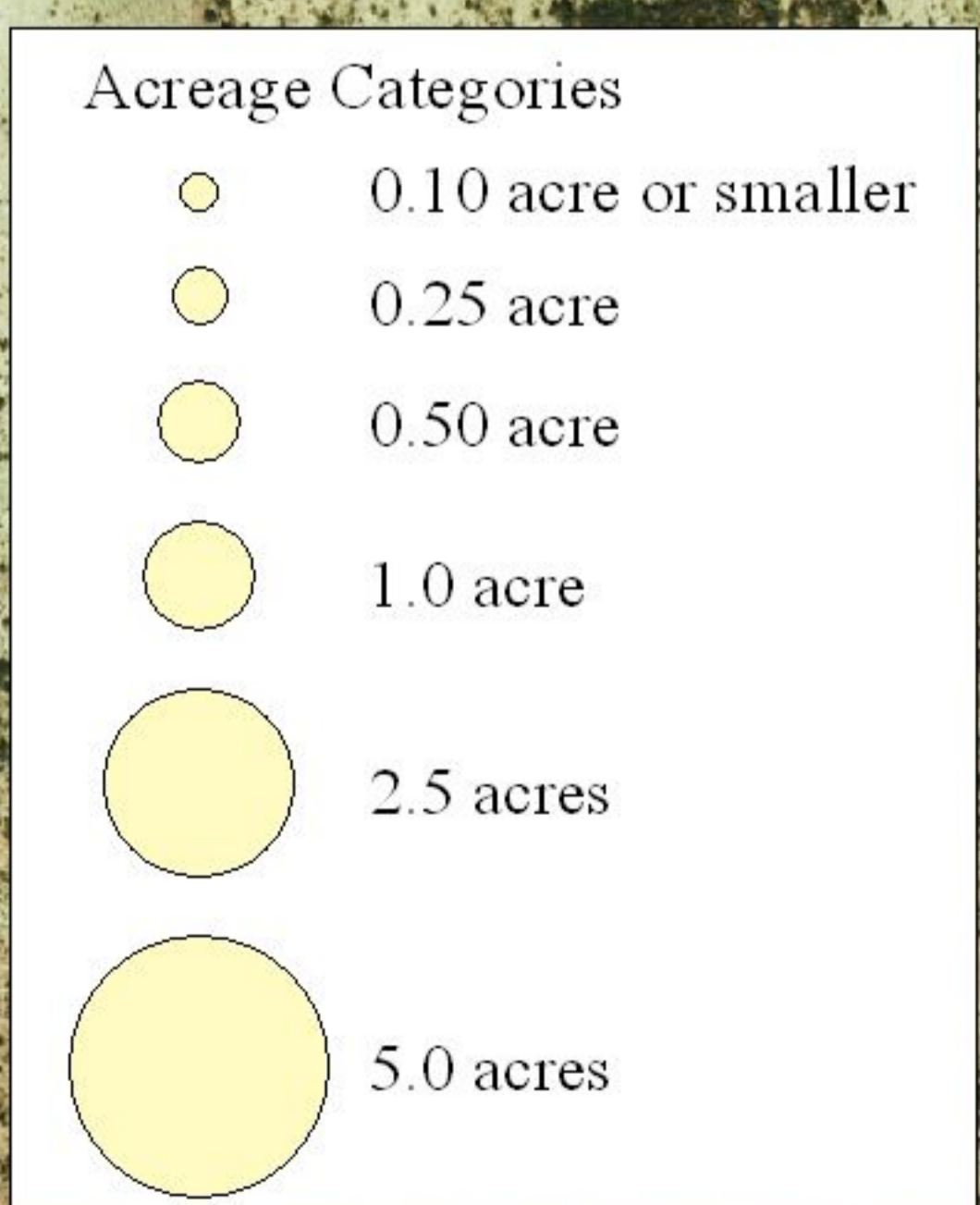
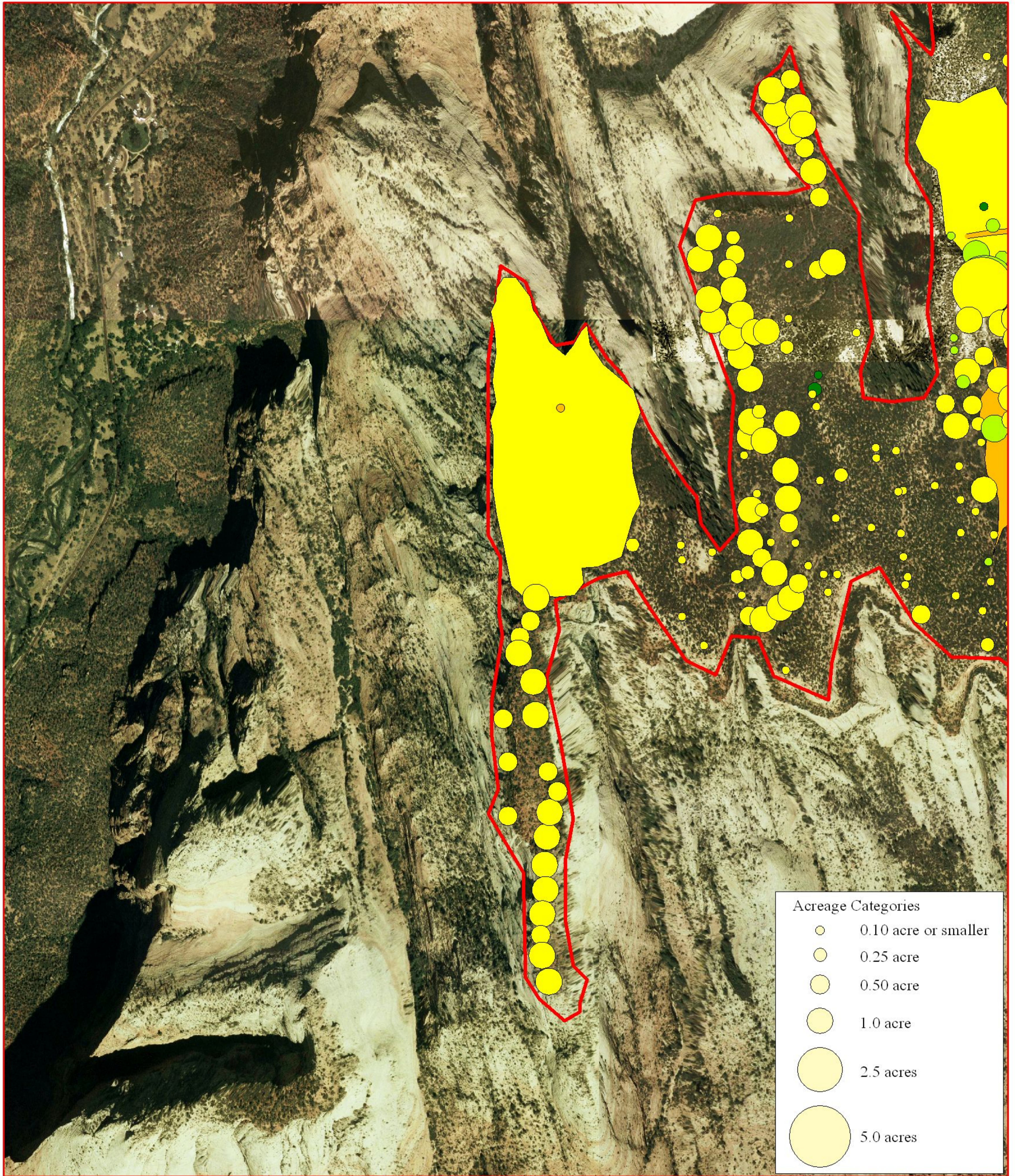
0 300 600 900 Meters



1:14,000 Scale

Inset C  
 Utah State University  
 Zion National Park  
 2006 Inventory of Invasive Non-native Plants and Rare Endemic Plants  
 Northern Colorado Plateau Network

Appendix D. Location and relative size of invasive non-native plant infestations detected in the ClearTrap Burn  
 - ClearTrap IV (Inset D)



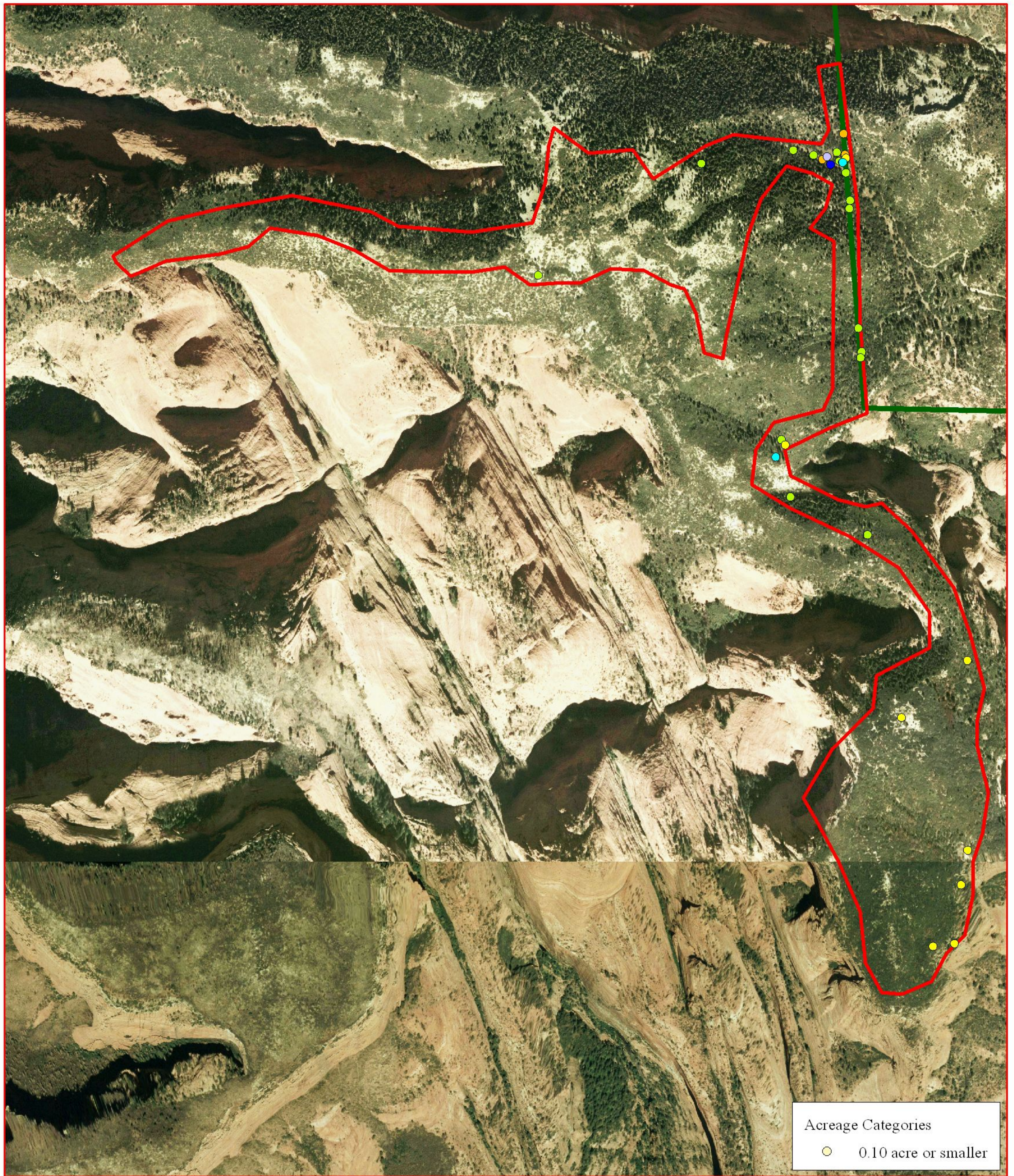
- Bromus inermis*
- Bromus inermis*
- Bromus inermis*
- Bromus tectorum*
- Bromus tectorum*
- Salsola iberica*
- Verbascum thapsus*
- Area Inventoried

0 300 600 900 Meters



1:14,000 Scale

Appendix D. Location and relative size of invasive non-native plant populations detected on Buck Pasture Mountain - Inset E



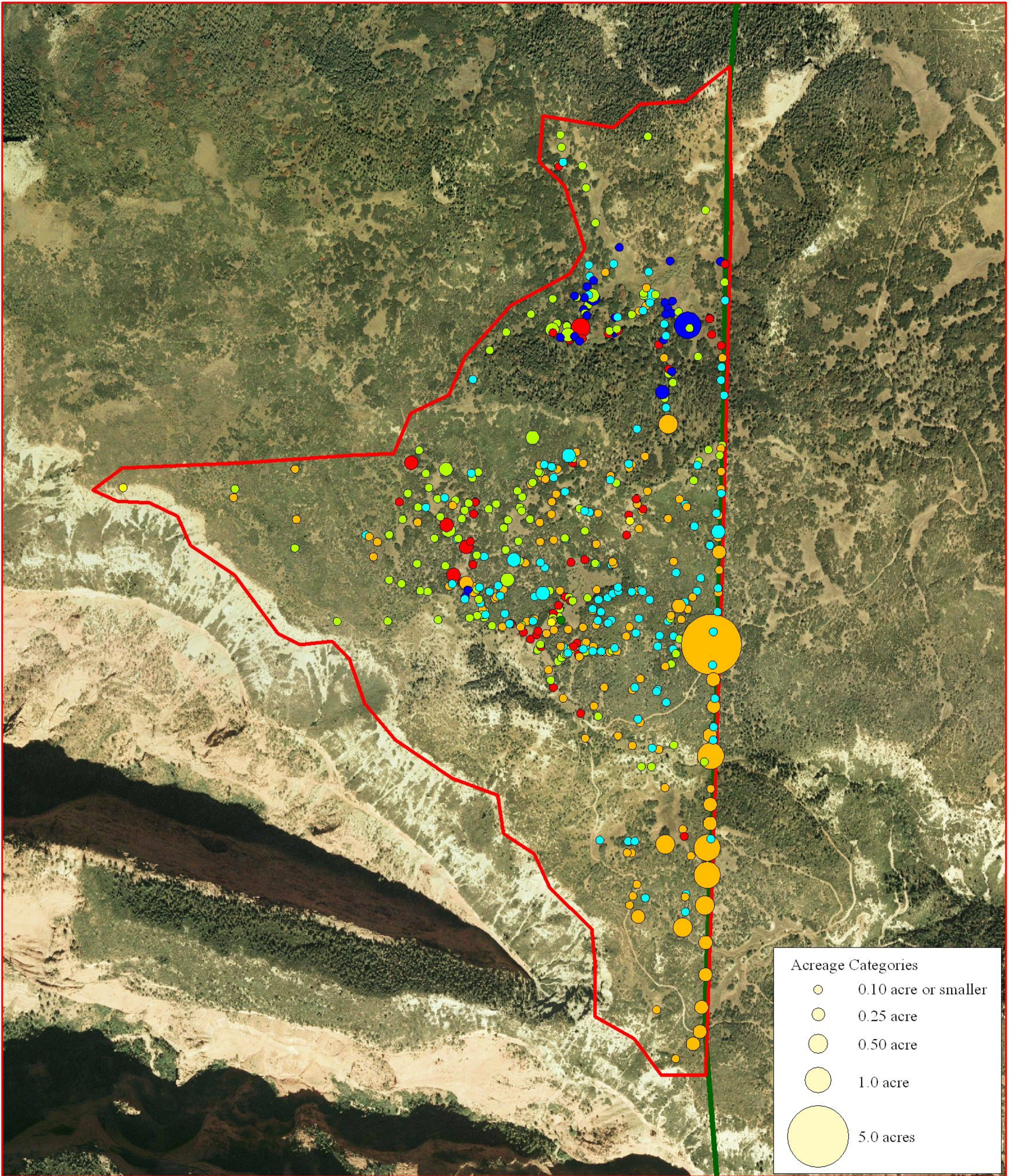
- *Bromus inermis*
- *Bromus tectorum*
- *Cirsium vulgare*
- *Dactylis glomerata*
- *Melilotus officinalis*

- *Verbascum thapsus*
- Area Inventoried
- Park boundary

0 300 600 900 Meters



1:14,000 Scale

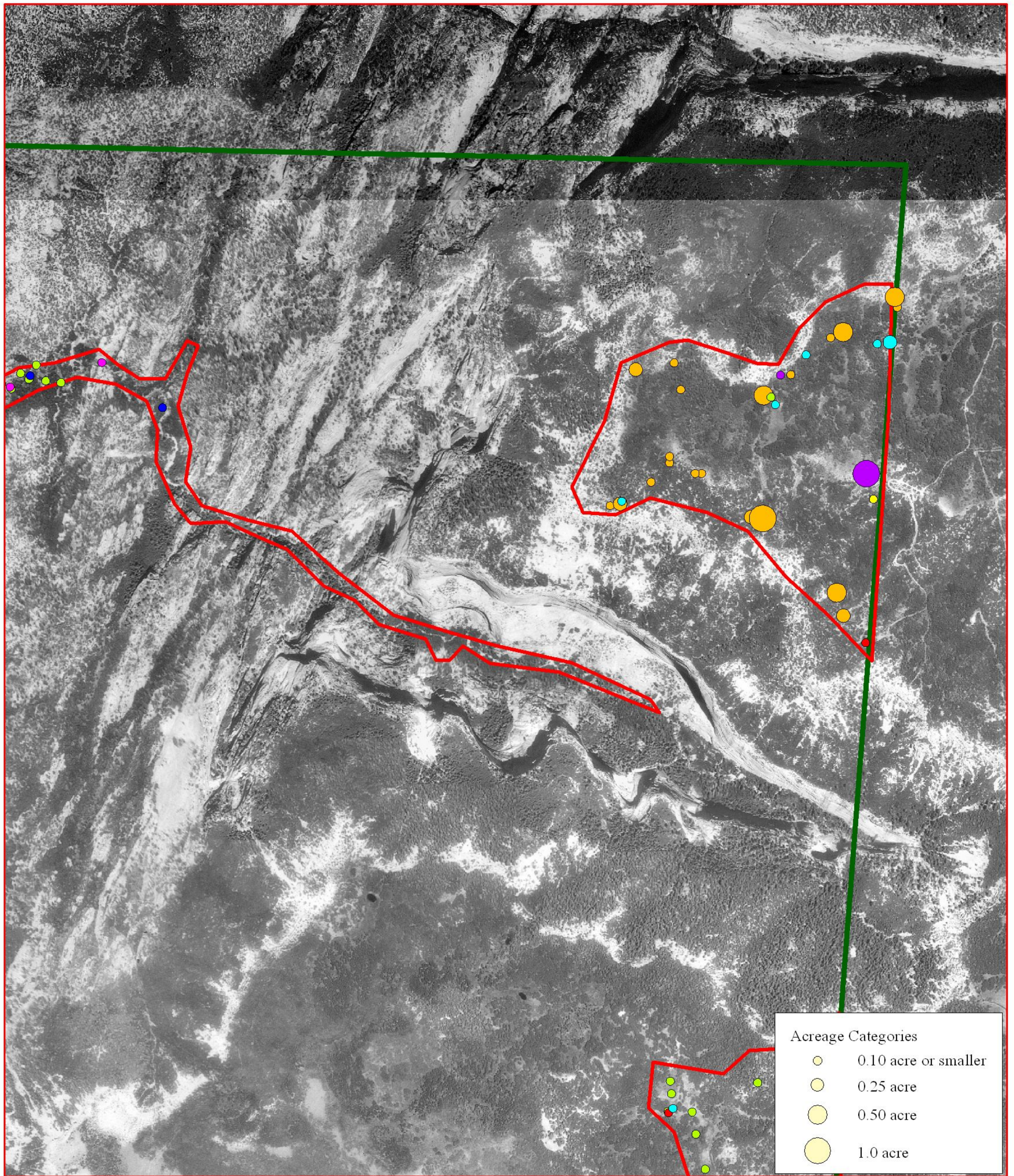


- |                              |                            |
|------------------------------|----------------------------|
| ● <i>Bromus inermis</i>      | ● <i>Salsola iberica</i>   |
| ● <i>Bromus tectorum</i>     | ● <i>Verbascum thapsus</i> |
| ● <i>Cirsium vulgare</i>     | □ Area Inventoried         |
| ● <i>Dactylis glomerata</i>  | □ Park boundary            |
| ● <i>Onopordum acanthium</i> |                            |

0 300 600 900 Meters

1:14,000 Scale

Appendix D. Location and relative size of invasive non-native plant infestations detected in upper Camp Creek - Inset G



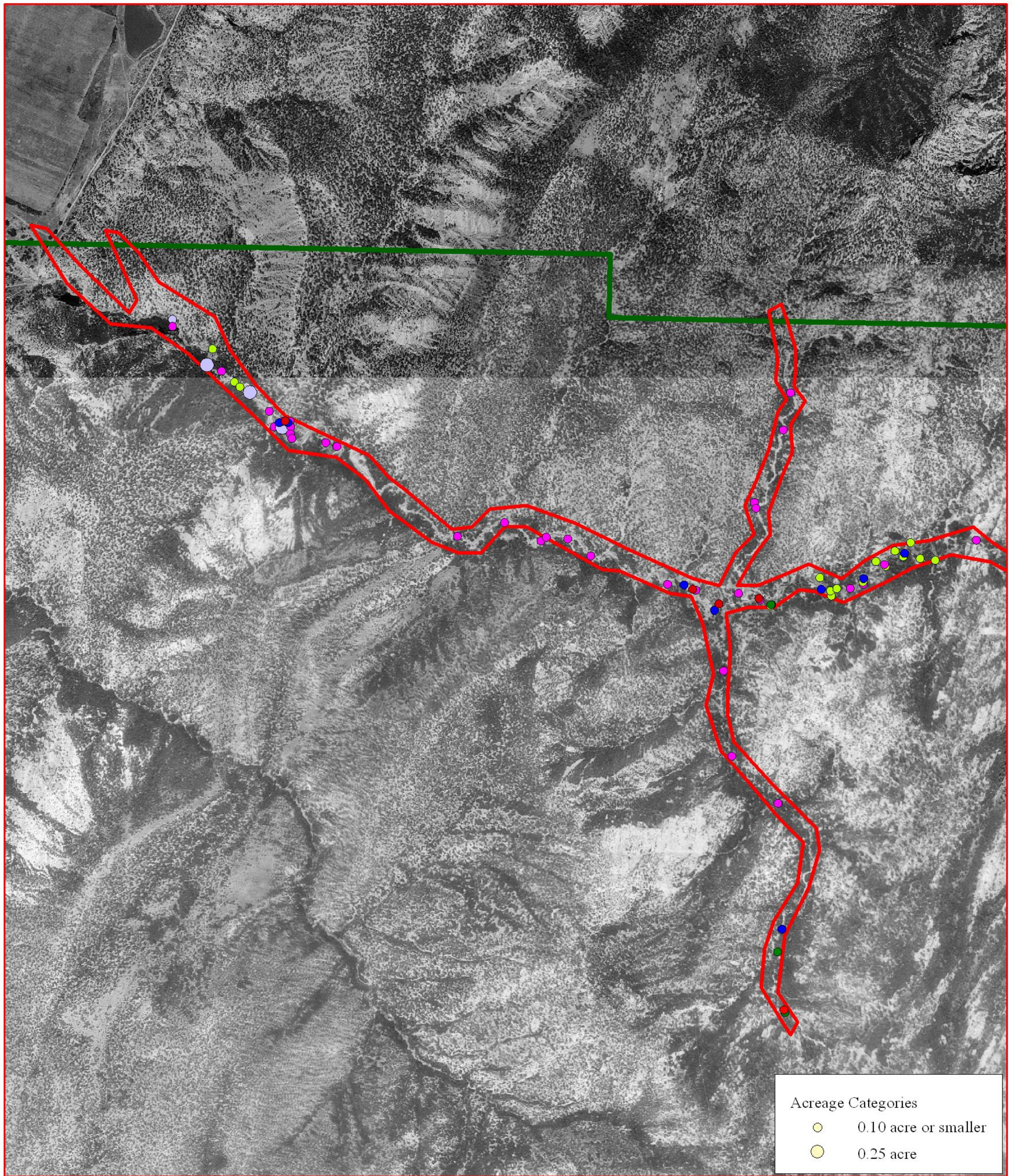
- |                             |                              |
|-----------------------------|------------------------------|
| ● <i>Bromus inermis</i>     | ● <i>Onopordum acanthium</i> |
| ● <i>Bromus tectorum</i>    | ● <i>Tamarix ramosissima</i> |
| ● <i>Cirsium vulgare</i>    | ● <i>Verbascum thapsus</i>   |
| ● <i>Dactylis glomerata</i> | □ Area Inventoried           |
| ● <i>Elymus repens</i>      | □ Park boundary              |

0 300 600 900 Meters

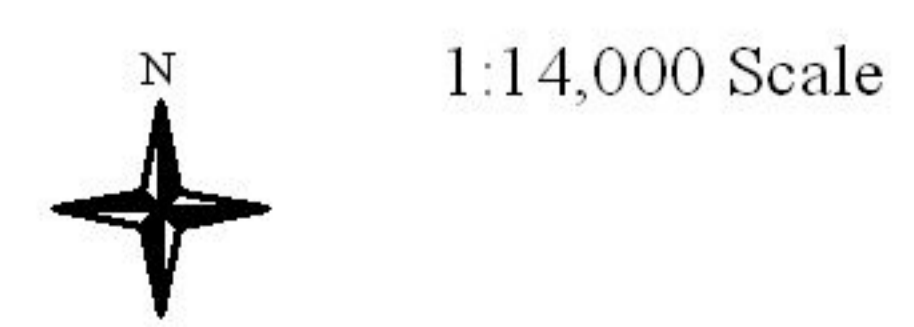


1:14,000 Scale

Appendix D. Location and relative size of invasive non-native plant infestations detected in lower Camp Creek - Inset H



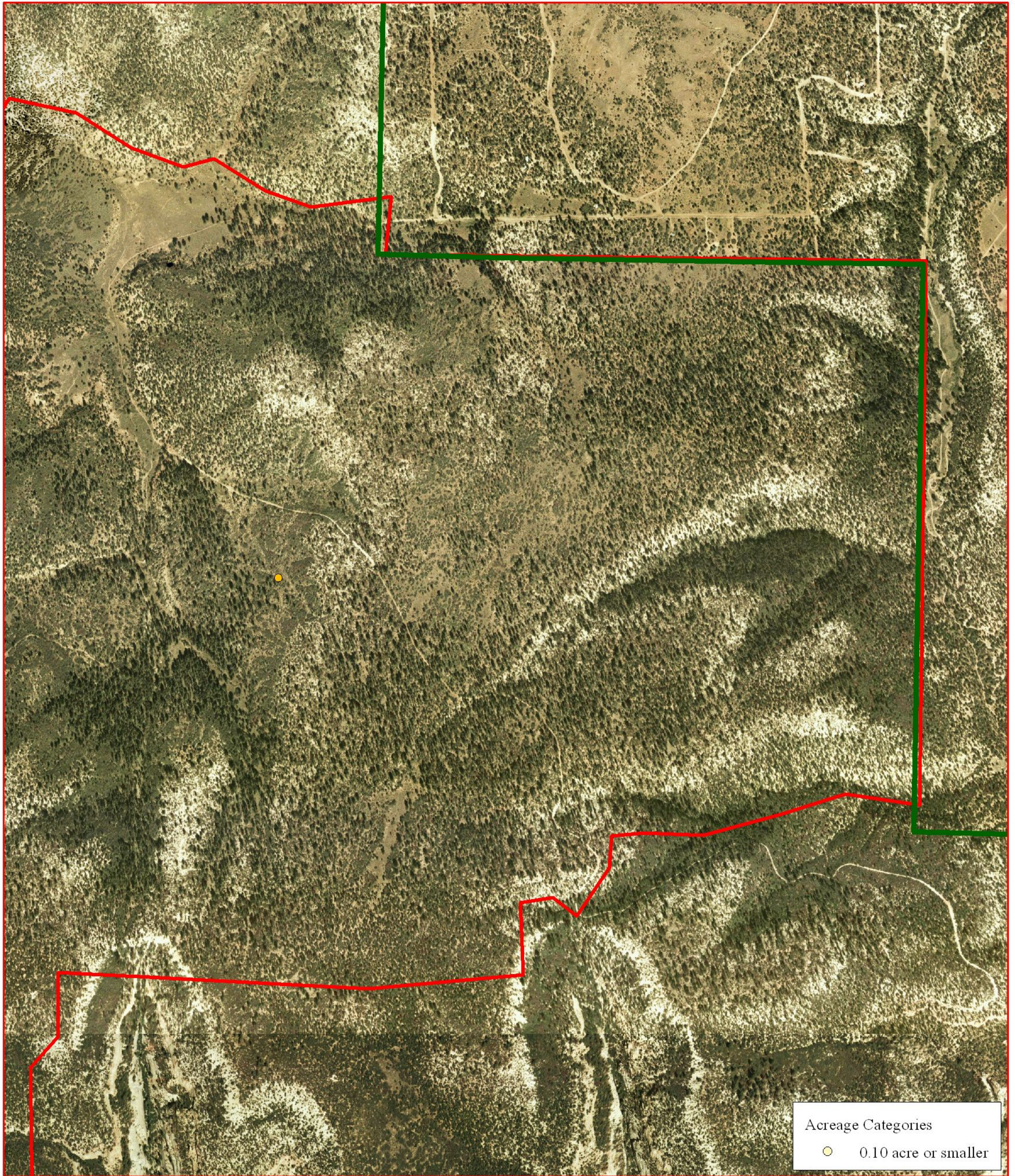
- |                                 |                              |
|---------------------------------|------------------------------|
| ● <i>Cirsium vulgare</i>        | ● <i>Tamarix ramosissima</i> |
| ● <i>Elaeagnus angustifolia</i> | ● <i>Verbascum thapsus</i>   |
| ● <i>Melilotus officinalis</i>  | □ Area Inventoried           |
| ● <i>Onopordum acanthium</i>    | □ Park boundary              |
| ● <i>Salsola iberica</i>        |                              |



- Acreage Categories
- 0.10 acre or smaller
  - 0.25 acre



Appendix E. Location and relative size of rare endemic plant populations detected in the ClearTrap Burn - ClearTrap I (Inset A)



Acreage Categories  
 ○ 0.10 acre or smaller

0 300 600 900 Meters



1:14,000 Scale

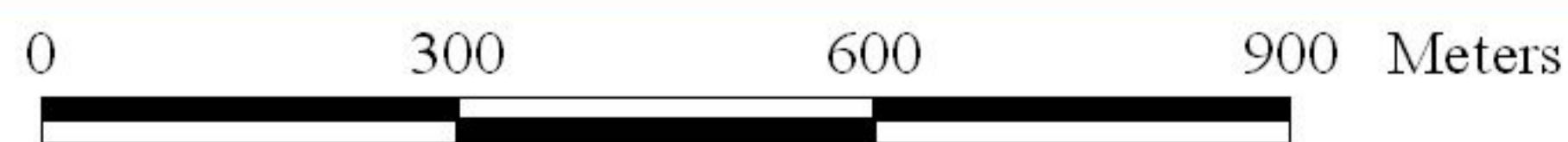
- *Eriogonum racemosum v. zionis*\*
- Area Inventoried
- Park boundary

\*Area not thoroughly searched for rare endemic plants



- \* No rare endemic plants recorded in this area\*
- Area Inventoried

\*Area not thoroughly searched for rare endemic plants



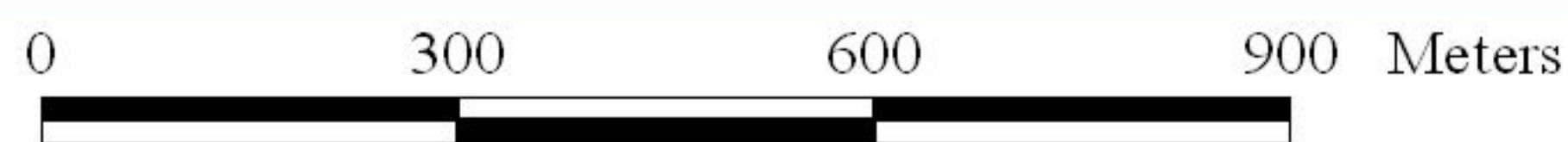
1:14,000 Scale

Inset B  
Utah State University  
Zion National Park  
2006 Inventory of Invasive Non-native Plants and Rare Endemic Plants  
Northern Colorado Plateau Network



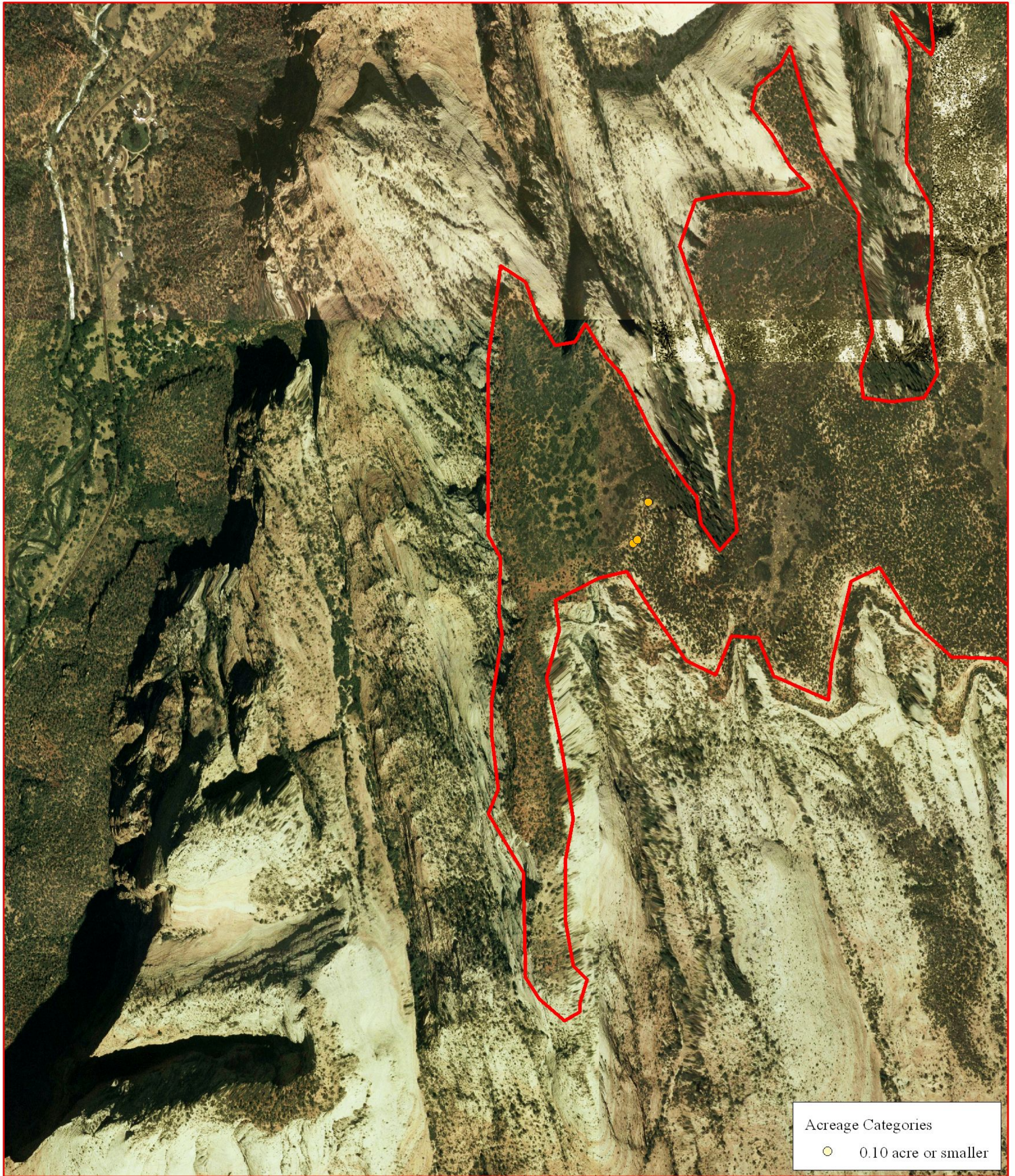
- \* No rare endemic plants recorded in this area\*
- Area Inventoried

\*Area not thoroughly searched for rare endemic plants



1:14,000 Scale

Inset C  
Utah State University  
Zion National Park  
2006 Inventory of Invasive Non-native Plants and Rare Endemic Plants  
Northern Colorado Plateau Network



Acreage Categories  
 ○ 0.10 acre or smaller

0 300 600 900 Meters

● *Eriogonum racemosum v. zionis*\*

□ Area Inventoried



1:14,000 Scale

Inset D  
 Utah State University  
 Zion National Park  
 2006 Inventory of Invasive Non-native Plants and Rare Endemic Plants  
 Northern Colorado Plateau Network

\*Area not thoroughly searched for rare endemic plants

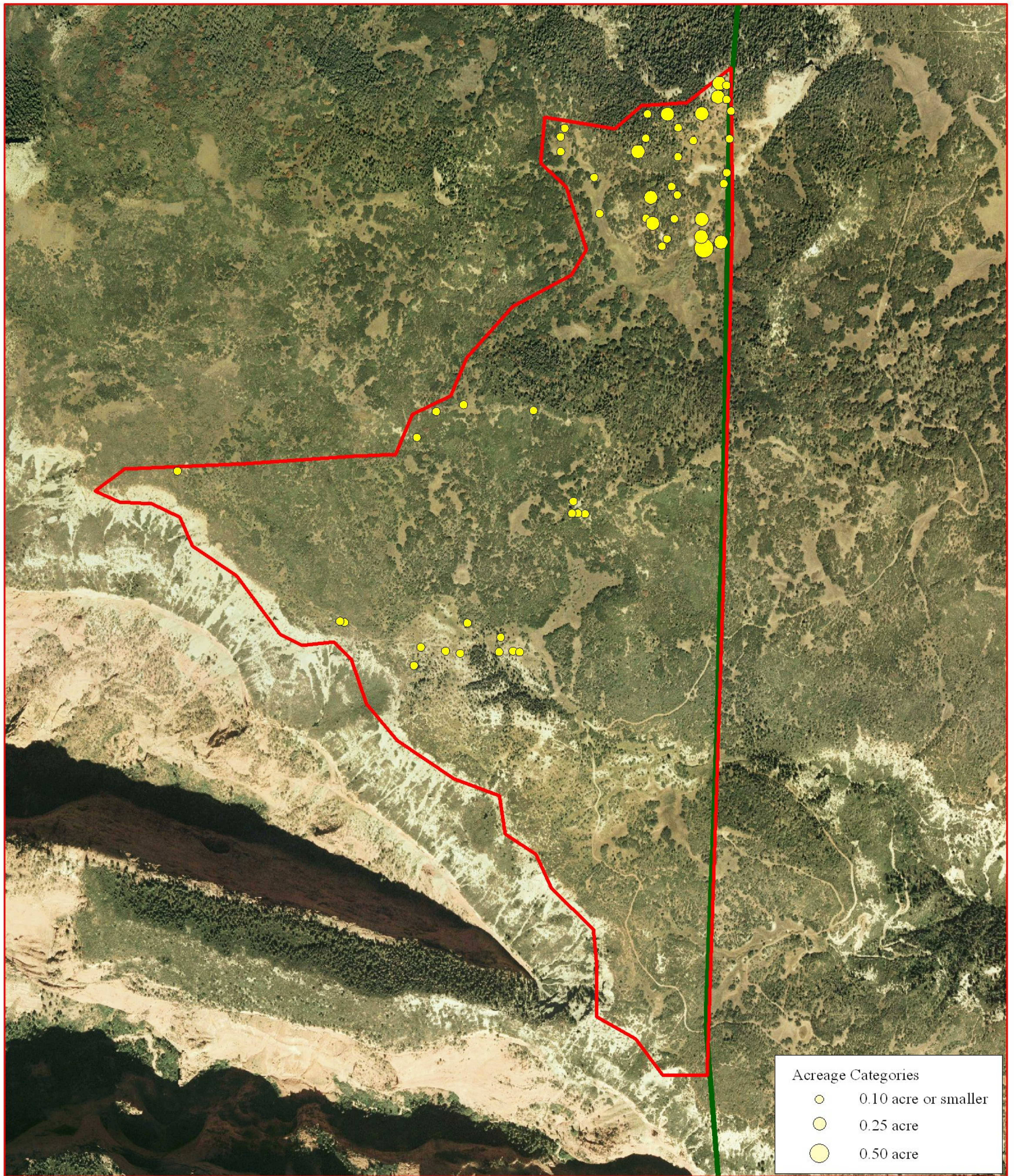


- *Astragalus concordius*
- Area Inventoried
- Park boundary

0 300 600 900 Meters



1:14,000 Scale



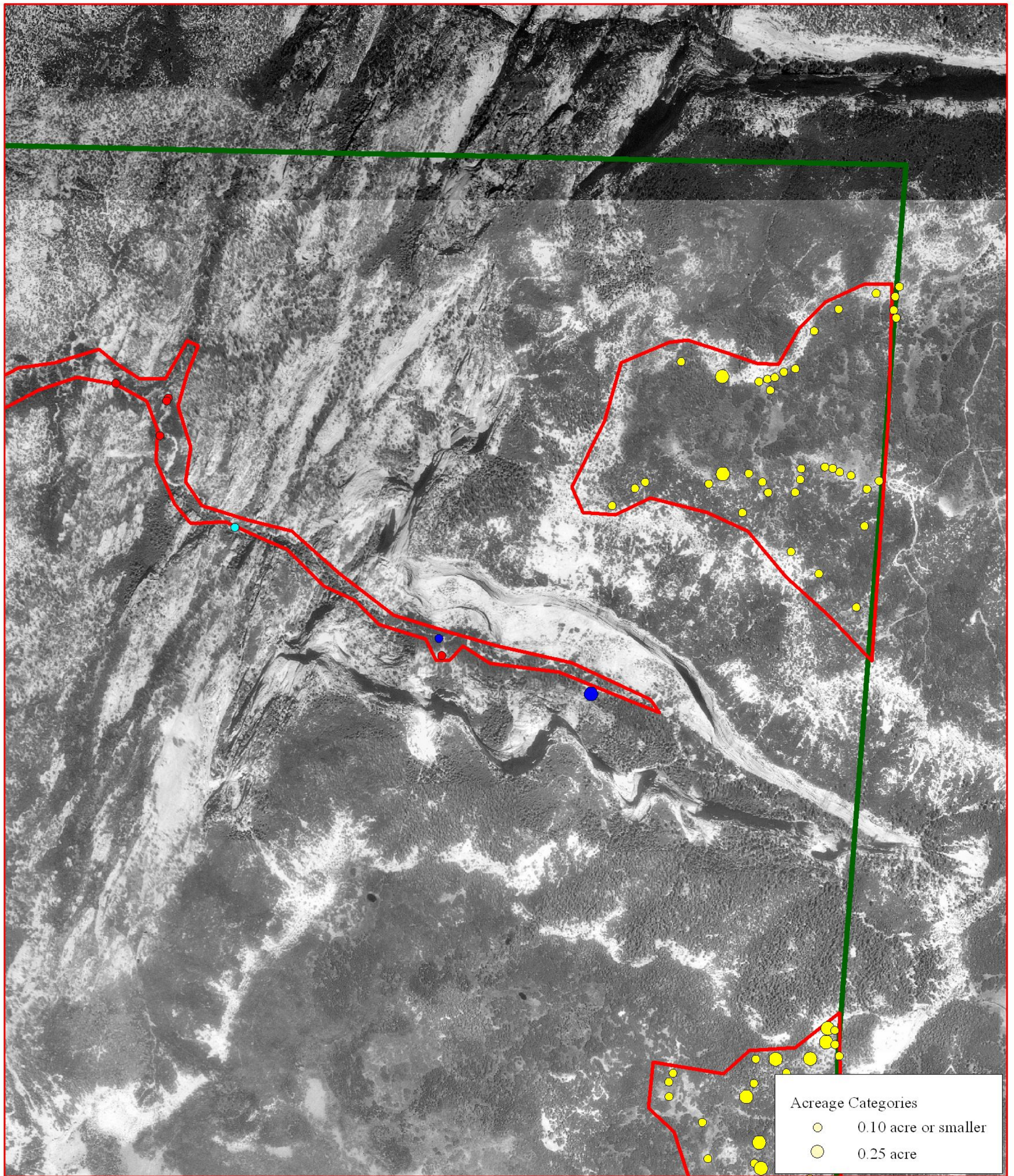
- *Astragalus concordius*
- Area Inventoried
- Park boundary

0 300 600 900 Meters



1:14,000 Scale

Appendix E. Location and relative size of rare endemic plant populations detected in upper Camp Creek - Inset G



● *Aquilegia formosa v. fosteri*

● *Asplenium adiantum-nigrum*

● *Astragalus concordius*

● *Carex haysii*

▭ Area Inventoried

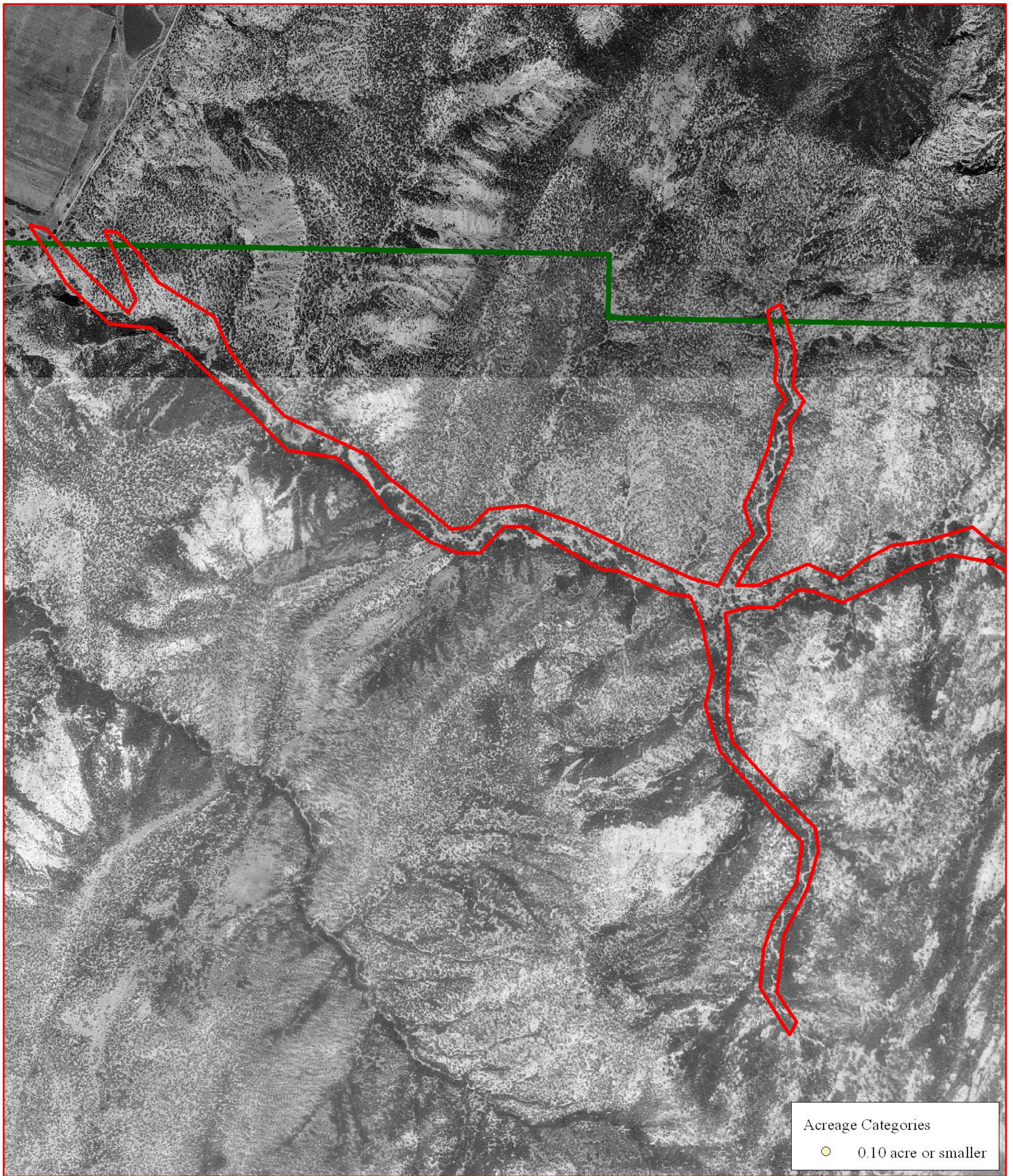
▭ Park boundary

0 300 600 900 Meters

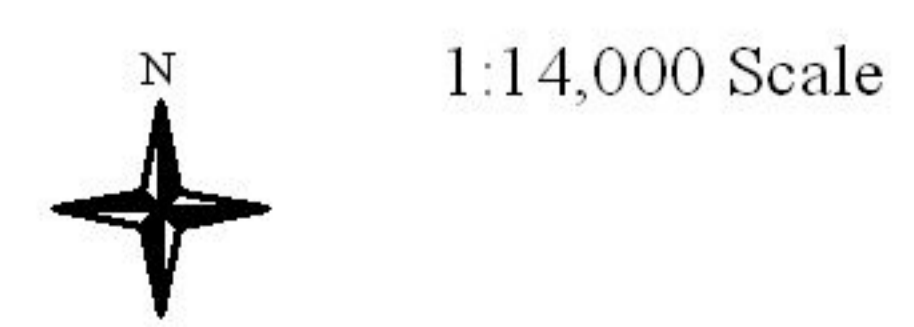
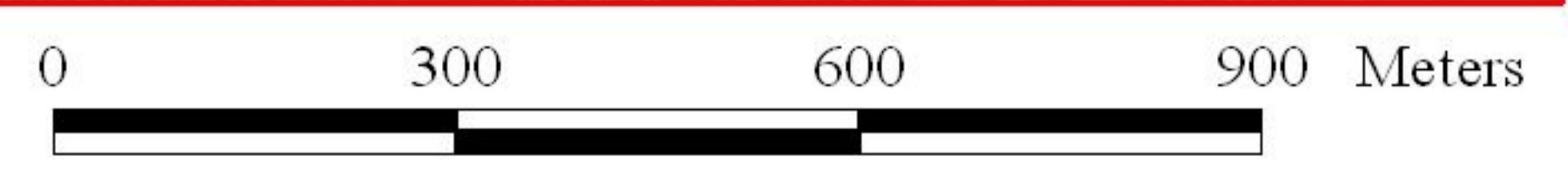


1:14,000 Scale

Inset G  
Utah State University  
Zion National Park  
2006 Inventory of Invasive Non-native Plants and Rare Endemic Plants  
Northern Colorado Plateau Network



- *Aquilegia formosa* v. *fosteri*
- Area Inventoried
- Park boundary



Acreage Categories  
○ 0.10 acre or smaller



Appendix F. Summary of occurrence and inventory status of the 47 non-native species listed in the GPS data dictionary, plus any additional species noted in the 2006 inventory of invasive plants in Zion National Park.

GPS Species	A	B	C	D	E	GPS Species	A	B	C	D	E
<i>Agropyron cristatum</i>			X			<i>Lepidium latifolium</i>				X	
<i>Ailanthus altissima</i>						<i>Linaria dalmatica</i>				X	
<i>Alhagi pseudalhagi</i>				X		<i>Linaria vulgare</i>				X	
<i>Anthemis L.</i>				X		<i>Lythrum salicaria</i>				X	
<i>Arctium minus</i>				X		<i>Marrubium vulgare</i>				X	
<i>Arundo donax</i>				X		<i>Moluccella laevis</i>				X	
<i>Asparagus sp.</i>			X			<i>Onopordum acanthium</i>	X				
<i>Brassica tournefortii</i>				X		<i>Phleum pratense</i>			X		
<i>Bromus inermis</i>	X					<i>Rubus discolor</i>				X	
<i>Bromus tectorum</i>	X					<i>Rumex crispus</i>				X	
<i>Cardaria draba</i>				X		<i>Salsola iberica</i>	X				
<i>Carduus nutans</i>				X		<i>Sorghum halepense</i>				X	
<i>Centaurea diffusa</i>				X		<i>Tamarix ramosissima</i>	X				
<i>Centaurea maculosa</i>				X		<i>Tragopogon dubius</i>			X		
<i>Centaurea repens</i>				X		<i>Tribulus terrestris</i>				X	
<i>Centaurea solstitialis</i>				X		<i>Verbascum thapsus</i>	X				
<i>Centaurea virgata</i>				X		<i>Ulmus pumila</i>				X	
<i>Chenopodium album</i>			X								
<i>Cirsium arvense</i>				X		<b>Other:</b>					
<i>Cirsium vulgare</i>	X					<i>Descurainia pinnata</i>			X		
<i>Conium maculatum</i>				X		<i>Epilobium sp.</i>			X		
<i>Convolvulus arvensis</i>				X		<i>Lactuca serriola</i>			X		
<i>Cynoglossum officinale</i>				X		<i>Malva neglecta</i>			X		
<i>Dactylis glomerata</i>	X					<i>Melilotus officinalis</i>		X			
<i>Elaeagnus angustifolia</i>	X					<i>Sisymbrium altissimum</i>			X		
<i>Euphorbia esula</i>				X		<i>Taraxacum officinale</i>			X		
<i>Halogeton glomeratus</i>			X								
<i>Hyoscyamus niger</i>				X							
<i>Isatis tinctoria</i>				X							
<i>Iva xanthifolia</i>				X							

A = Present - Full inventory  
 B = Present – Partial inventory  
 C = Present – Not Mapped  
 D = Searched For - Absent  
 E = No Information