

Non-Native Plant Survey at Great Sand Dunes National Park and Preserve



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Foreword

This report presents the results of a non-native plant survey performed in Great Sand Dunes National Park and Preserve (GRSA) in 2004. The purpose of the survey was to identify and map the distribution of non-native plant species that were of concern to park resource managers or were known to be potentially invasive in other areas. The survey at GRSA was part of a larger inventory and mapping project initiated by the Intermountain Region (IMR) of the National Park Service (NPS). Several cooperators mapped 19 national parks in the Intermountain Region of the western US. The goals of the IMR project were to develop a database that would assist resource managers with invasive plant management and control, provide baseline data for long term monitoring efforts, and facilitate data sharing within the NPS and with external agencies.

The specific goals of resource managers at Great Sand Dunes were:

- to develop maps of non-native plant species to assist with non-native plant management,
- to search newly acquired lands for non-native plant presence,
- to identify areas with relatively few non-native plants,
- to search for potential new invaders.

To achieve these goals we surveyed the area of interest using two different sampling methods. In general, we demarked the area of primary interest with transects. These transects were walked and the occurrence of target non-native plants and other variables were recorded with Global Positioning System (GPS) receivers. In areas of secondary interest, or areas that were too topographically difficult to sample intensively we still used transects but targeted them to follow the landscape or geographical features. Therefore, this approach was biased, providing information around a certain feature but not at a distance from that feature. However, in combination with our primary method we are confident our survey provides representative data of the species occurrence in the environment.

Maps of target plant species' distributions are provided in the report, as well as tables summarizing the acres infested by each species mapped. No sampling method is completely accurate and we therefore provide an estimation of the uncertainty associated with sampling each species. The invasive plant database and maps produced from the survey of Great Sand Dunes National Park are a singular look at the invasive plant distribution in the summer of 2004. The data should be considered baseline, or a starting point from which to monitor and assess changes in invasive plant populations in the area over time. A short discussion of the next phase, monitoring invasive plant populations, is included in a recommendations section.

Introduction

Site description

Great Sand Dunes National Park and Preserve is administered by the NPS, U.S. Department of the Interior. Great Sand Dunes National Monument was established in 1932 to preserve the unique geological and hydrological features of the Great Sand Dunes. Great Sand Dunes National Park and Preserve is located in south-central Colorado, on the east side of the San Luis

Valley. In 2000, the Great Sand Dunes National Park and Preserve Act designated the expansion of the Monument and initiated the process of acquiring surrounding lands that had retained unique natural resource values. In September 2004, Great Sand Dunes received National Park status after acquiring adjacent lands of the Baca Ranch. Portions of this new acreage will be managed in partnership with The Nature Conservancy, who currently owns the Medano and Zapata Ranches adjacent to the park. The new park and preserve is approximately 150,000 acres.

The original Monument boundary encompassed the 39 square mile (approximately 38,000 acres) dune field and portions of Medano and Sand Creek, two streams on the perimeter of the dunes that contribute to factors responsible for dune formation. The administrative offices and many visitor use facilities (visitor center, amphitheater campground, picnic ground) are located within the old monument boundary. In 2000, the Park Service acquired approximately 42,000 acres of the Sangre de Cristo Wilderness, previously managed by the US Forest Service. This landscape consists of montane meadows and forests and alpine peaks and lakes and is managed by the Park Service as Great Sand Dunes Preserve. The Medano Pass Primitive Road accesses the preserve and is a popular destination for many visitors. The 2004 invasive plant survey occurred in targeted areas of the park and preserve. Resource managers at Great Sand Dunes were interested in obtaining information about the distribution of non-native plants on some of the newly acquired lands as well as in high use and disturbed areas of the old monument.

Site disturbance history

Great Sand Dunes National Park is shaped by wind and water. Prevailing southwesterly winds move sand from the San Juan Mountains and the San Luis Valley and the physiography of the Sangre de Cristo Range slows the wind through low mountain passes, leaving the sand deposited in dunes against the mountain front. Wind most likely carries weed seeds from sources in the San Luis Valley and deposits them downwind in the park. Wind can exacerbate other disturbances such as overgrazing. Shifting sands play an active role in shaping vegetation communities in the sand sheet, burying some communities and scouring others.

Several natural disturbance factors have influenced vegetation at Great Sand Dunes. Perennial streams such as Medano Creek and its tributaries support rich riparian systems of willow and dogwood. Groundwater supports interdunal wetlands or ephemerally wet meadows that can host rushes and sedges and often willow. Ephemeral streamflow and storm runoff creates dry, eroded arroyos. Stand replacement fires have occurred at Great Sand Dunes, most recently burning grassland, aspen, and pinyon-juniper communities near the visitor center. Beavers have dammed portions of upper Medano Creek, felling aspen stands and flooding meadows. Ungulates graze the grasslands and montane meadows.

Human disturbance is generally limited to areas of administrative use, and high visitor use areas such as the Medano Creek corridor. Access to the west side of the park is limited, thus the highest concentration of use occurs on the east side of the park where the entrance station is located. There is a developed campground and picnic ground and several maintained trails in the park. The Medano Pass Primitive Road accesses several picnic sites/rest areas and many popular though largely undeveloped and dispersed campsites. The west side of the park has several two-track roads that the Park Service uses for administrative access.

Justification for action

According to the NPS, the invasion of non-native plant species (exotics, non-indigenous species, invasive species, or weeds) is one of the most serious threats that Park Service administered lands face today, and exotic plants infest 2.6 million acres of NPS lands (National Park Service 2005). Non-indigenous species are considered the second greatest threat to biodiversity after habitat destruction (Randall 1996). When such species have characteristics that permit them to rapidly invade new areas and out-compete native plants for light, water, and nutrients they are often termed “invasive weeds” (Westerbrooks 1998).

A “noxious weed” is any plant species that has been designated by a federal, state or county government as injurious to public health, agriculture, recreation, wildlife or property (Sheley et al. 1999). Colorado has defined noxious weeds as “plant species that are not indigenous (non-native) to the state of Colorado and meet at least one of several criteria regarding their negative impacts upon crops, native plant communities, livestock, and the management of natural or agricultural systems” (Colorado Department of Agriculture 2003). The management of “noxious weeds” is justified by the Colorado Noxious Weed Act, which empowers counties and municipalities to develop and review integrated noxious weed management plans, recommend management criteria, and ensure that landowners have an integrated noxious weed management plan in place when necessary. Weed management plans are required by the Colorado Noxious Weed Act to integrate all appropriate methods, including education, prevention, mechanical methods, biological controls, cultural methods, and general land management practices. Therefore, to meet NPS objectives and to comply with state and county law it is necessary to obtain information about where target species are in the environment to be able to manage them.

The three phases of non-native species management

Management of non-native species (non-indigenous species or NIS) should be regarded as a three-phase process: inventory/survey, monitoring, and management (Figure 1). Although all three phases can be performed simultaneously, considering them as different phases is important for conceptual, theoretical, methodological, logistic and practical reasons. The first phase, inventory/survey, determines which species are present and their distribution within the environment. This is the aim of the current study. The second phase, monitoring, provides information about how patches are changing with time, their impact on the ecosystem and the impact of management on the patch. The final phase, management, is important for control of non-native patches and populations, by reducing their distribution and impact.

Under most land management scenarios, it is not possible to observe all of the plants or even plant communities in a managed area. In most cases we do not know which non-indigenous species are present within a managed area, their frequency or their distribution pattern, how much their distribution is changing and, finally, the impact they are having on the endemic ecosystem. It is only armed with all of this information that land managers can begin to make knowledgeable decisions about control or management of invasive species.

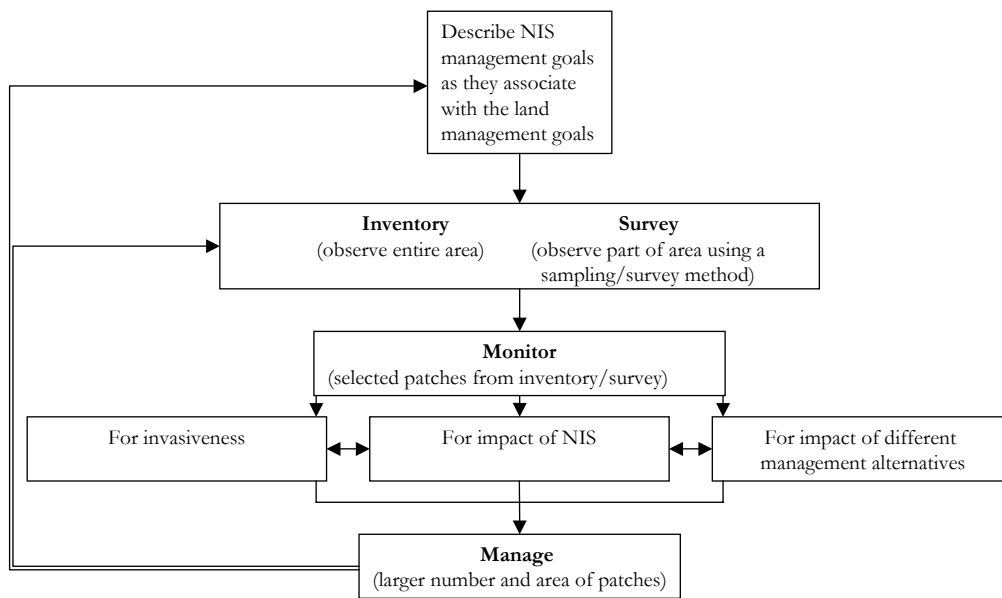


Figure 1. Three phases of non-native species management.

While researchers and managers often use the terms inventory and survey interchangeably, there are distinctions between the terms. An inventory samples the entire population within given boundaries, similar to a census. For example, an inventory of GRSA might involve the systematic search for noxious weeds along 10 m transects within the entire park boundary. For large management areas, inventories become cost-prohibitive, time-consuming, and therefore impractical. A survey samples a subset of the population within a larger boundary. Areas for survey might be selected randomly or using prior knowledge about invasive plant biology and ecological processes. Mapping records the geographic location of invasive plant infestations. Resource managers and scientists have used numerous different survey methods and Rew et al. (in press) evaluated the accuracy of 7 of these methods for sampling the frequency of a species in the environment.

Methods

Sampling protocol

Montana State University (MSU) performed sampling in Great Sand Dunes from May 22 - August 24, 2004. The IMR weed mapping project targeted 6,000 acres of the 150,000 Great Sand Dunes National Park and Preserve for mapping. Approximately 6,032 acres were surveyed using 82 and 164 ft (25 m and 50 m) wide transects or searching intuitively following landscape features. We developed a list of target species (Appendix 1) by consulting with NPS resource managers. We worked with Fred Bunch, Chief of Natural Resources to prioritize areas for mapping based on knowledge of existing weed populations, weed ecology (dispersal and habitat), sources of disturbance, and GRSA management objectives.

We used two sampling approaches to survey for non-native plant species at Great Sand Dunes. The primary method involved searching along parallel transects following a UTM northing or easting within the boundary of the search area. We used this systematic transect method primarily along the high use Medano Creek corridor and in the open rangelands of the Medano Ranch. An alternative method was utilized if the search area followed a landscape or manmade feature such as a creek drainage or ditch, or if we were targeting potential habitat (interdunal wetlands) in the western portion of the park. Instead of following a UTM northing or easting, mappers followed a landmark (i.e. wetland boundary or stream bank), visually maintaining a given transect width. We used this “intuitive” transect method to search the tributaries of Medano Creek on the west side of the Sangre de Cristo divide and to search for the interdunal wetlands on the west side of the dunes.

Transect widths for primary and secondary sampling methods were based on visibility and were generally constrained by topography and vegetation density. At GRSA we used 82 ft (25 m) and 164 ft (50 m) transect widths (distances were measured in meters for transects because UTM coordinate system units are in meters). We found 164 ft (50 m) transect widths to provide best coverage while maximizing mapping speed and efficiency in the open grasslands and subirrigated pastures of the Medano Ranch. Along the more densely vegetated riparian area of Medano Creek, we narrowed our transect widths to 82 ft (25 m) to enable better detection of non-native plants.

When sampling along transects, the 3-member mapping crew spread out 82 ft (25 m) from each other and followed an east-west UTM northing. Crew members used the coordinate display window on the GPS receiver to navigate along the transect. Mappers generally stayed abreast of one another as they moved along the midpoint of the transect, visually searching a 42 ft (12.5 m) swath on either side. When the mapper encountered an infestation, s/he would visually assess the perimeter of the patch. If the patch was small enough that the boundary could be seen, the mapper would pace or visually estimate the length and width of the patch, then collect the remaining field attributes. If the patch continued out of vision, the mapper would use an adaptive strategy and spiral out from where the patch was first encountered to determine the extent of the infestation. If the patch continued out of the mapper’s transect (25 m), s/he would communicate with other crew members via two-way radio to determine if other crew members had also encountered the same patch and how to proceed with mapping (who would map the patch). In this manner, each patch was considered unique and mapped only once. In general, if 150 ft (46 m) or more separated patches, they were considered unique metapopulations. We found that 82 ft (25 m) was the minimum width appropriate for surveying areas where visibility was adequate, weeds were common, and patches were generally larger than 82 ft (25 m) wide. If smaller widths were used weed patches often crossed several transects, which made coordinating the mapping among surveyors more complicated.

Mapping non-native plant infestations as points or polygons

At GRSA, non-native plant infestations were recorded as point or polygon features. In most cases, it is far easier in terms of time and efficiency to map a patch as a point, recording length and width attributes for calculating acreage later. For most non-native plant management objectives or baseline surveys, point data provides satisfactory resolution needed to address management planning and this is the method we used. Defining a patch’s shape and size with a

polygon might be important if monitoring is the objective. However, capturing the perimeter of a non-native plant patch with mapping grade GPS receivers (even 1 m accuracy) might not be accurate enough to detect small changes in the patch shape and size, and measuring the patch with a tape measure could still be more accurate. Further, the exact perimeter drawn around a non-native plant patch is often a subjective decision of the mapper attempting to delineate diffuse or convoluted boundaries of vegetation.

When mapping a point, the surveyor stood in the approximate center of the patch and logged positions (X, Y coordinates) with the GPS receiver. Generally, 20 or more positions were logged. The GPS software averaged these positions to create a single point feature. Generally, we mapped patches less than or equal to 1.5 acres (approximately 350 ft x 350 ft) as points.

When mapping a polygon, the surveyor walked the perimeter of the patch recording a position at each vertex of the polygon, or each location where the polygon changed shape. An alternative method for capturing polygon infestations involved using point features to define the perimeter of a non-native plant patch. The points were later converted into a polygon feature in ArcView by essentially “connecting the dots”. This method was useful if the infestation was large (>3 ac) and/or convoluted, or the terrain and/or vegetation cover made it difficult to delineate the patch visually. For example, Canada thistle (*Cirsium arvense*) was scattered throughout the riparian vegetation along Medano Creek near the Visitor Center. Instead of attempting to find the perimeter without prior knowledge of the distribution, we recorded the boundary of Canada thistle with point features as we encountered it along transects. If a polygon was recorded from GPS points, we recorded this in the “Notes” field of the database. In such areas where there were large, pervasive, convoluted weed infestations (for example, perennial pepperweed (*Lepidium latifolium*) on the west side of the Medano Ranch), the distance between clumps of weeds in the same population was increased to 250 ft (76 m). We considered large weedy areas to be essentially the same population.

Mapping the survey area

Mappers recorded a transect start and end feature on each transect searched. These point features were used to generate a transect line in ArcGIS 9.0 (ArcView). The transect lines were used to calculate the project survey area.

The GPS receivers were programmed to record a position every 100 ft (30 m) along the mappers search path. These “non-feature” positions or “between-feature” positions were exported to ArcView and used to calculate the survey area in addition to areas where transects were used by on-screen digitizing around the search paths.

GPS mapping protocol

Weed infestation location and attributes were recorded with mapping grade GPS receivers. We used Trimble’s GeoExplorer XT and GeoExplorer 3 receivers, which have a manufacturer specified accuracy of 3 – 16 ft (1 – 5 m) after post-processed differential correction (+/- 1 cm per 100 km from the base station used for differential correction). The GeoExplorer XT was capable of receiving real-time differential GPS signals. All data were differentially corrected and exported to ArcView.

As a rule, in terrain with an unobstructed view of the sky mappers set the PDOP mask to 6. Trimble considers positions collected with a PDOP of 6 or less to be of excellent accuracy. A value of 7 – 8 is considered acceptable accuracy. In most areas with steep terrain features (canyons or mountain fronts) or with significant overstory vegetation such as in upper Medano Creek, a PDOP of 6 or less could not be achieved. In addition, at certain times the satellite configuration simply prevented logging by receivers with a PDOP of 6 or less. In these instances, surveyors bumped the PDOP mask up to level where logging could continue. Of 616 non-native plant point features recorded 112 had a PDOP greater than 6, and 62 of those points had a PDOP of greater than 8. The highest PDOP recorded was 26.3.

Database design and metrics collected

MSU utilized minimum mapping standards established by the North American Weed Management Association (NAWMA 2002), which were accepted for the project by the NPS Intermountain Region Weed Mapping Committee. We followed the database development guidelines created by the IMR Weed Mapping Committee (National Park Service 2001) as a starting point to design the field data dictionary used to collect environmental attribute data with GPS receivers. Because MSU was mapping several Rocky Mountain Network (RMN) Parks, we utilized attributes and attribute values developed by non-native plant managers at Glacier National Park. Glacier has been documenting non-native species since the early 1980s and using this historical data, developed an extensive Microsoft Access database. Managers at Glacier requested that we utilize their “Exotics” database fields and attributes for RMN parks where possible to simplify merging datasets.

The data dictionary served as an interface for collecting non-native plant attributes efficiently and accurately. Spatial data were exported to ArcView in shapefile format. Additional administrative or spatially derived attributes were added to the database after field mapping was completed. The tabular dBASE files (.dbf files) were exported to Microsoft Excel format.

Field data elements

The following list reviews the field data elements captured for each non-native plant patch that was mapped and how values were assigned.

Species – A list of target species was developed by consulting with NPS resource managers (Appendix 1). Currently accepted scientific names were recorded. The Integrated Taxonomic Information System (ITIS) was used to reference currently accepted nomenclature (<http://www.itis.usda.gov>).

Canopy Cover – Mappers visually estimated the percent canopy cover of the non-native plant patch assigning a whole number from 1 – 100. A surveyor envisioned a perimeter around the non-native plant patch and estimated the percent of ground covered by the vertical projection of the non-native plant foliage, including small gaps in the canopy. If a small patch or single species was mapped the area covered by foliage relative to the perimeter around the plant(s) was high.

Patch Length, Patch Width – Mappers either paced or visually estimated the length and width of the infestation and recorded the distance in feet.

Phenology – The growth stage of the majority of plants in the infestation. The range of values included rosette, bolt, prebud, bud, early bloom, full bloom, fruit, and fall regrowth.

Distribution – The spatial distribution or spatial pattern of the infestation. Descriptions of the values follow in Table 1.

Table 1. The range of values followed by a brief description for the distribution attribute.

Distribution value	Description
Scattered	Individual or small clusters of weeds thinly scattered with no apparent spatial pattern
Clumped	Weeds growing in distinct clusters separated by weed free areas within the larger area considered to be the patch
Continuous cover	Weeds essentially growing in a monoculture with a very distinct edge
Gradient	Weed cover dense in the center of the patch, thinning out toward edges of patch
Isolated individual	Single weed plant
Isolated patch	Isolated group of weeds with contiguous individuals mapped as a unique feature (used generally when no other NPP occurred within 300 ft)

Community – The dominant form of the plant community in which the infestation occurred. The range of values included forest, shrub, grass, mixed, barren, alpine, riparian, and wetland.

Dominant Species – A list of dominant species was developed from the NPS inventory of vascular plants at GRSA and in consultation with resource managers (Appendix 2). Mappers visually estimated the dominant species growing in association with the non-native plant species. Dominance was determined by the species with the highest percent canopy cover. If single or few non-native plants were mapped, dominant species were determined for 0.1-acre area surrounding the plants.

Disturbance – Mappers identified the disturbance factor with the greatest apparent impact on the area infested by the non-native plants (Table 2).

Table 2. Disturbance factors adapted from the IMR weed mapping guidelines (NPS 2001).

Disturbance Factor	Comment
Ag/livestock grazing	
Animal disturbance	Not from livestock
Construction/development	
Fire suppression	Impacts resulting from active fire suppression, i.e. fireline
Geothermal	
Habitat improvement	
Hydrology	Effects from hydrologic resources; could be ground water or surface water (intermittent, ephemeral, perennial streams)
Irrigation/ditching	
Mining/quarries	
Oil/gas development	
Recreation	Impacts from developed or undeveloped recreational sites such as barren areas around picnic tables
Right-of-way	Road and roadside impacts such as ditches; roads might be surfaced or not
Trail/ORV/outfitter	
Utility	i.e., power lines or areas around transformers
Wildfire	
Wind/erosion	
Other	
None apparent	

Ecological Status – A numeric value from 1 – 4 based on a qualitative description of the level of infestation that identifies ability of site to recover to natural state once the non-native plants have been removed (Table 3).

Table 3. Ecological status classifications developed by the IMR weed mapping guidelines (NPS 2001).

Description	Class
No weeds. The management emphasis is preventing weed encroachment.	1
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.	2
Large-scale infestation with 30% or greater understory of residual grasses and good potential productivity. Management of these sites in a way that selects for the recovery of the residual native grasses and shrubs has good potential for control but not eradication of the weeds. There may be more	3

that one noxious weed species but the underlying biologic integrity of the unit is good.	
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.	4

Slope – Mappers recorded the average steepness of the terrain in which the weed infestation grew in degrees. Slope categories included low (0-20°), moderate (21-45°), high (46-80°), and vertical (81-90°).

Aspect – Mappers stood in the approximate center of the weed infestation, facing down the fall line, and recorded the compass direction of the aspect in categories of north, northeast, east, southeast, south, southwest, west, northwest, and level.

Distance to Water – Mappers estimated the distance to the closest source of water from 1 to 1,000 ft. Sources of water included perennial, intermittent, and ephemeral streams and wetlands or areas saturated by groundwater. Other sources of water included irrigation ditches and stock tanks. If the source of water was greater than 300 ft, the accuracy of the estimated distance was less reliable. If the distance to the closest water source was unknown, the mapper recorded 1000 ft.

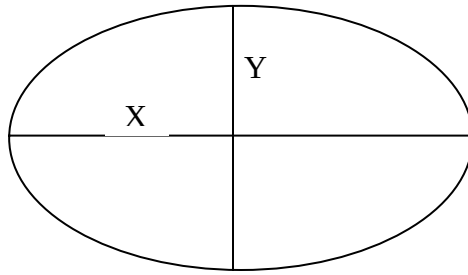
Notes – Mappers recorded any relevant notes concerning the weed infestation in the notes field. Often it was easier and quicker to record extensive notes by hand. Each mapper maintained a field notebook for recording this extra information noted while mapping and transcribed the data at days end.

Other required data elements, GIS/GPS derived

The IMR database development guidelines (National Park Service 2001) required other administrative data elements that were populated in a GIS. Some data elements were derived from the GPS settings. The following is a list of additional data elements for GRSA.

Coordinates – Embedded in GPS data and exported to GIS. Universal Transverse Mercator (UTM) northing and easting coordinates were added to the dBase table.

Area – Calculated in the GIS using the formula for the area of an ellipse in square feet (Figure 2). Field gathered length and width of patch were used as the semi-major and semi-minor axes.



$$\text{Area} = X/2 * Y/3 * \text{Pi}$$

X = semi-major axis (length)

Y = semi-minor axis (width)

Figure 2. Patch length and width was estimated and used to calculate the patch size as the area of an ellipse.

Acres – Calculated in the GIS by dividing area (ft²) by 43,560 ft² (square feet per acre).

Lifeform – Derived in the GIS and identifies the physiognomic class of the non-native plant species as a tree, shrub, grass or forb.

Elevation – Embedded in GPS data and exported to GIS. Hand mapped locations do not have an elevation value.

Maximum PDOP – Position dilution of precision (PDOP) reflects the accuracy of GPS measurements. Embedded in GPS data and exported to GIS. A value of 6 or less can indicate excellent accuracy (likely within 1-5 meters) while >6 – 8 can indicate acceptable accuracy.

Date – Embedded in GPS data and exported to GIS. Indicates date of mapping.

Surveyor – Recorded with GPS data and exported to GIS. The name of the mapper who recorded the non-native plant infestation.

Integrated Taxonomic Information System (ITIS) code – Species name of the invasive plant was based on current ITIS accepted nomenclature. The Natural Resource Conservation Service Plants database was used to derive the code for the ITIS name of the invasive plant (USDA 2004).

Datum – The datum in which the spatial data are stored. All data for the IMR mapping project are in the UTM coordinate system and the North American Datum (NAD) of 1983.

UTM zone – Zone of the spatial data. GRSA data are in UTM zone 13N.

Country – United States (USA)

State – Colorado (CO)

County – Alamosa or Saguache

NPS region – NPS code for Intermountain Region (IMR)

NPS Inventory and monitoring network – NPS code for Rocky Mountain Network (RMN)

NPS unit – NPS code for park (GRSA)

Source of data – Person who manages data at GRSA (Fred Bunch).

Results

Acres infested with non-native plant species

We surveyed approximately 6,032 acres of Great Sand Dunes. A summary of the survey, including area surveyed, cumulative infested area and total infested area with error bars, and uninfested area with error bars, is presented in Figure 3. We calculated the total land area occupied by weeds, including overlaps in physical space (a number of species might occupy portions of the same physical space but each area is considered a unique infestation and added separately), for a cumulative infested area of 1,227 acres (Table 4). Further, we calculated the total infested area of all species, (a number of species might infest the same physical space but the area infested is counted only once). Total infested area was estimated to be 1,059 acres.

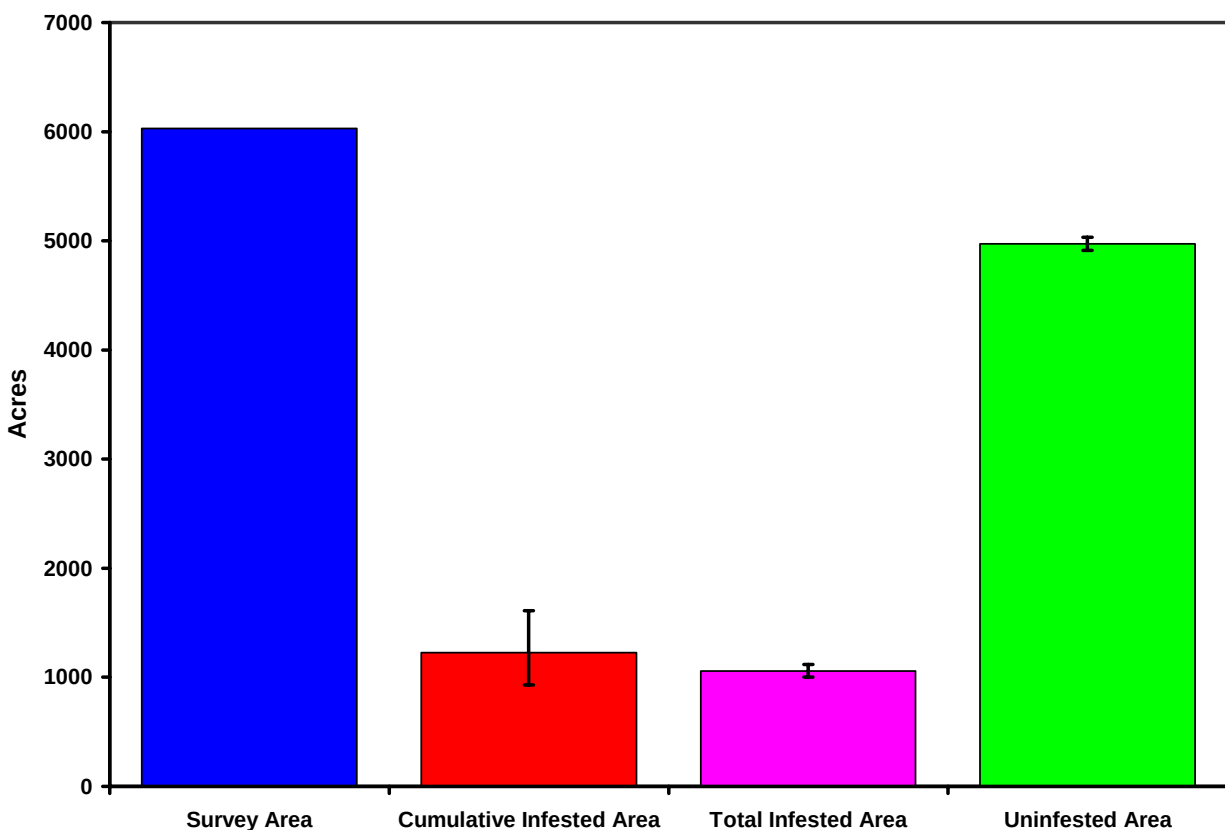


Figure 3. Area surveyed, infested, and uninfested. Cumulative infested area sums all overlapping patches. Total infested area is limited to the area occupied by any number of non-native plant species, regardless of how many might occupy the same physical site (i.e. overlapping patches are not summed separately).

Table 4. Area surveyed, infested, and uninfested.

	Estimated Acres	Estimated Acres Low	Estimated Acres High
Survey Area	6031.5		
Cumulative Infested Area	1226.7	928.4	1611.5
Total Infested Area	1058.7	1000.1	1118.7
Uninfested Area	4972.8	5031.4	4912.8

Estimating error associated with mapping

When calculating the area of a weed infestation mapped as a point feature we used the estimated length and width to calculate the patch size as the area of an ellipse. When infestations were mapped as polygons, the GIS software was used to calculate the area. In each instance, a single acreage estimate for the patch was the result. All sampling methods and mapping crews make errors. To reflect these inaccuracies we provide a potential range of acreage values that represent the potential uncertainty associated with mapping. We think this is a more accurate reflection of reality than a single acreage value. Managers should be able to more effectively plan and allocate

limited resources by understanding the uncertainty associated with estimating acreage from mapping.

The two sources of error were instrument error and user error. Trimble states the GeoExplorer XT and GeoExplorer 3 receivers have an accuracy of 3 – 16 ft (1 – 5 m) under optimal conditions with post-processed differential correction. The biggest source of user error was most likely incurred when estimating size (length and width) of the non-native plant patch. We had high confidence that we correctly identified the weed species and that we located some portion of the weed patch (we might not have been standing in the exact center of the patch but we located at least some portion of the patch). However, we had less confidence in our estimates of polygon area. Therefore, we accounted for potential error by calculating a low and high acreage for each infestation.

Further, we had more confidence in locating the approximate center of the patch for point data than we had confidence in locating a point on the perimeter of a polygon. Therefore, for patches mapped as point features we simply estimated an error of +/- 10%. In practical terms, for every 10 ft (3 m) in length or width we paced or visually estimated, there was likely one foot (plus or minus) of error associated. For polygon features there was error associated with the entire perimeter of the polygon. Patches mapped as polygons were less accurate than patches mapped as points because they were generally larger and more complex and we did not stand in the center and average GPS positions. Therefore, we used a larger error estimate of +/- 100 ft (30 m) from the radius of each polygon and calculated a low and high area estimate. For each non-native plant patch mapped as either a point or polygon, we calculated the +/- error and thus, a low and high acreage.

Non-native plant species composition at GRSA

Eleven target non-native plant species were recorded in GRSA (Figures 4 and 5) and their infestation levels are provided in Table 5. The composition of non-native plants within the survey area is important for planning management strategies uniquely targeted to each particular species. For example, Canada thistle might be managed differently than leafy spurge (*Euphorbia esula*), even though infestations might overlap.

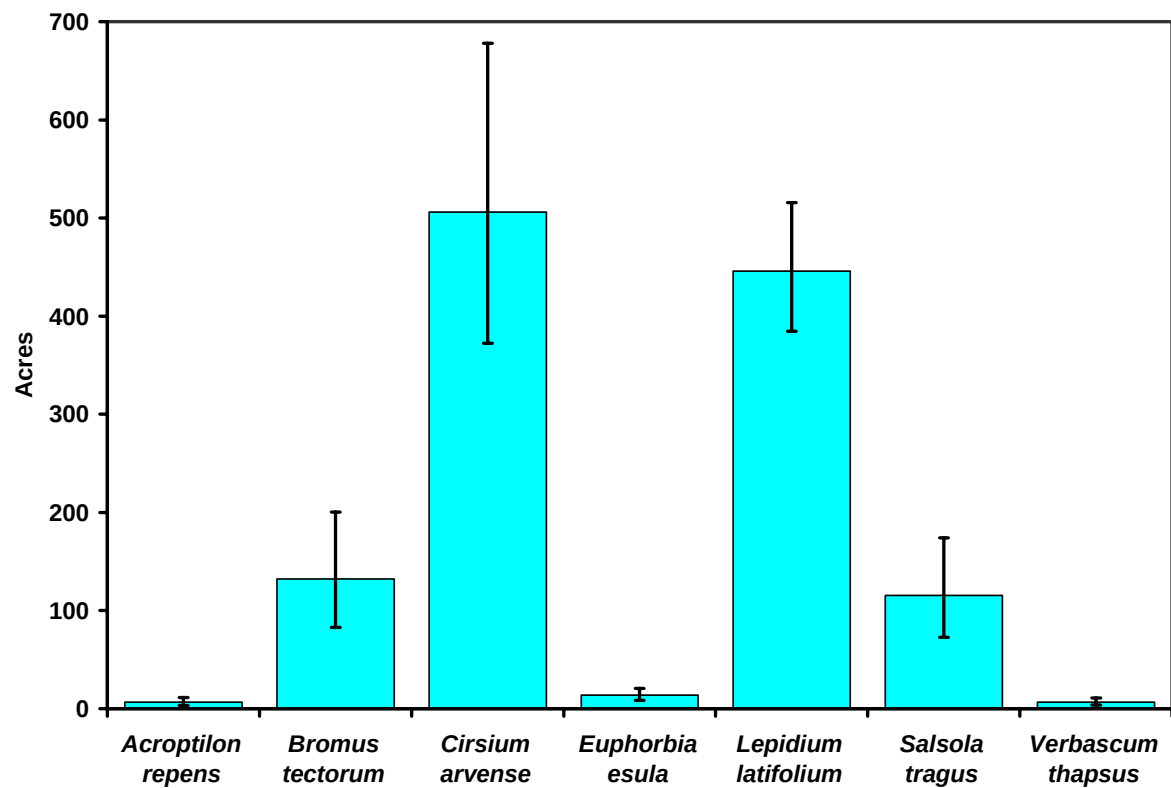


Figure 4. Non-native plant composition of survey area with accuracy of estimates shown as error bars.

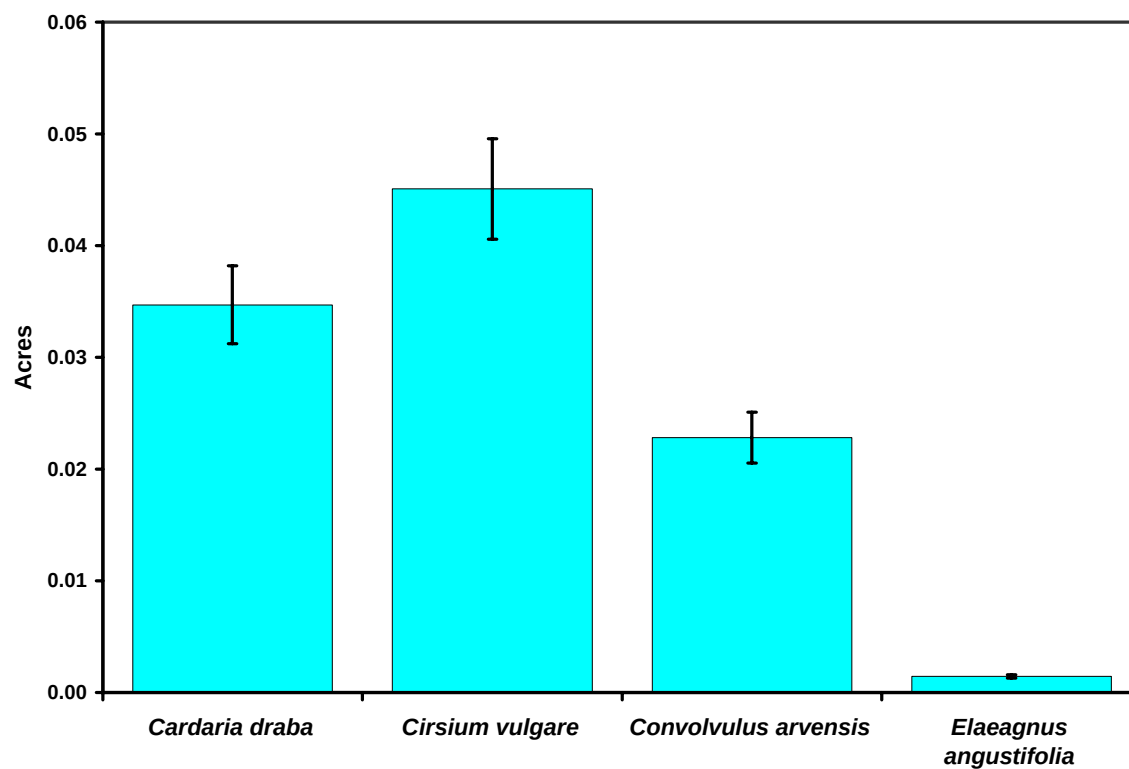


Figure 5. Non-native plant composition of survey area continued. Note change in Y-axis range.

Table 5. Non-native plant composition of survey area.

Species	Estimated Acres	Estimated Acres Low	Estimated Acres High
<i>Acroptilon repens</i>	6.68	3.44	11.37
<i>Bromus tectorum</i>	132.17	82.81	200.29
<i>Cardaria draba</i>	0.03	0.03	0.04
<i>Cirsium arvense</i>	505.78	372.37	678.14
<i>Cirsium vulgare</i>	0.05	0.04	0.05
<i>Convolvulus arvensis</i>	0.02	0.02	0.03
<i>Elaeagnus angustifolia</i>	0.001	0.001	0.002
<i>Euphorbia esula</i>	13.93	8.46	20.85
<i>Lepidium latifolium</i>	445.93	384.87	515.64
<i>Salsola tragus</i>	115.49	72.55	174.29
<i>Verbascum thapsus</i>	6.60	3.84	10.81
SUM	1226.70	928.43	1611.51

RUSSIAN KNAPWEED (*Acroptilon repens*)

We mapped eleven patches of Russian knapweed at GRSA. Four small patches occurred on the east side of the park within the old National Monument boundary; the remaining seven patches were located on the Medano Ranch (Figures 6 and 7). Park managers were aware of the one patch at the Mosca Pass Trailhead and had been hand pulling the population for several years. Managers were not aware of the remaining patches in Pinyon Flats Campground, at the mouth of Buck Creek, and near the old cabins at Shocky's Crossing. The patches at the campground, Mosca Pass Trailhead, and Shocky's Crossing were small (less than 0.1 acres) and could potentially be controlled by hand pulling. The patch at the mouth of Buck Creek appeared to be well established and consisted of a 0.4-acre area of nearly continuous cover. This patch should be controlled and monitored for spread.

Managers of the Medano Ranch were not aware of the Russian knapweed infestation on their western boundary. We mapped a five-acre patch and several other smaller patches in the drier grasslands and mixed grass/shrublands. We did not find Russian knapweed in the subirrigated pastures; however, tall grasses and greater biomass reduced visibility. We recommend that suitable habitat (grasslands and mixed grass/shrublands) along the western boundary be regularly surveyed and monitored.

CHEATGRASS (*Bromus tectorum*)

Cheatgrass was predominantly mapped along roads and trails, in disturbed meadows along Medano Creek and on dry, south-facing exposures in canyons of the Sangre de Cristo Range (Figure 8). We mapped cheatgrass where we encountered it, however, it often extended beyond the extent of our search areas; therefore, the data for cheatgrass should be considered incomplete. Because of its tendency to form large monocultures, cheatgrass is difficult to delineate. If the goal of the NPS is to comprehensively manage cheatgrass at GRSA, obtaining more site-specific data on distribution and abundance of cheatgrass might be achieved more accurately and efficiently with remote sensing or environmental modeling.

WHITETOP (*Cardaria draba*)

We mapped three small patches of whitetop at GRSA (Figures 9 and 10). One patch was located behind the horse stables (approximately 25 x 5 ft or 0.003 acres). The other two patches were located close to the western boundary of the Medano Ranch (0.01 and 0.03 acres). The patches were small and have good potential for successful eradication.

CANADA THISTLE (*Cirsium arvense*)

Canada thistle occurred in the mesic drainages on the east side of the park and in extensive infestations in the subirrigated meadows and pastures on the Medano Ranch (Figures 11 and 12). Canada thistle also occurred in the ephemeral wetlands west of the dunes. From our observations, Canada thistle occurred in greatest densities in areas of the 2000 wildfire around the Visitor Center. We mapped two large patches (2 and 6 acres) along Medano Creek east of the Visitor Center and a large patch (5 acres) in regenerating aspen (*Populus tremuloides*) north of the horse stables. The Canada thistle in this aspen stand was very dense in spring fed areas. Long term monitoring might help managers understand the successional trend of Canada thistle in similar habitats after wildfire. The aspen in this stand was vigorously regenerating.

Canada thistle was ubiquitous in moist meadows and along streambanks in upper Medano Creek. Most patches were small (less than 0.5 acres) and occurred in areas with healthy native vegetation. However, several patches did show evidence of mortality to the surrounding vegetation due to herbicide effects. Monitoring might help managers determine how invasive Canada thistle is over time in the upper Medano Creek drainage and what impact management is having on the populations and the native vegetation.

In tributaries of Medano Creek (excluding Mosca Creek) with fewer disturbances from recreation, we found small, isolated patches of Canada thistle. All but one patch (23 of 24) in the burned area at the mouth of Buck Creek were less than 0.1 acre. During the month of June, we had difficulty distinguishing Canada thistle from *Cirsium canescens*, a native thistle similar in appearance during rosette and prebud stage. It is likely that we misidentified Canada thistle in the upper sections of Garden Creek and Sawmill Creek. We are especially doubtful of the solitary small rosette we found in the entire survey area of Garden Creek because we saw no other sign of Canada thistle.

BULL THISTLE (*Cirsium vulgare*)

We found one 125 x 25 ft patch of bull thistle along an irrigation ditch on the Medano Ranch (Figure 13).

FIELD BINDWEED (*Convolvulus arvensis*)

We found two small isolated patches of field bindweed along CO Highway 150, the main road to the entrance station (Figure 14). The patches were small and have good potential for successful eradication.

RUSSIAN OLIVE (*Elaeagnus angustifolia*)

We found two infestations of Russian olive in a mesic meadow close to the western boundary of the Medano Ranch (Figure 15). One patch consisted of a single small sapling and the other of two small saplings. These invasive trees should be eradicated before they reproduce. Regular surveys should be implemented to monitor for spread from downwind sources in the San Luis Valley.

LEAFY SPURGE (*Euphorbia esula*)

Leafy spurge was of considerable concern to park managers and they were interested in obtaining detailed acreage and location information from the 2004 survey. When the park acquired US Forest Service lands as part of the Great Sand Dunes National Preserve, they also acquired management of a leafy spurge population in upper Medano Creek. We estimated the total acreage of leafy spurge in the areas we surveyed to be approximately 14 acres. The greatest concentration of leafy spurge occurred in the meadow around the old homestead cabin and along the creek (Figure 16). We found three patches spread downstream from this core infestation area. We mapped a 12-acre area of leafy spurge that we considered one patch or polygon. The canopy cover was not continuous but the distance between clumps or plants was less than 150 feet, thus we considered it one metapopulation.

We also mapped four scattered patches of leafy spurge west of the Medano Pass Road, below Pinyon Flats Campground. We found the leafy spurge spreading down the dry braided arroyos at the mouth of Garden Creek. Periodic surveys around and downstream from these patches should be implemented.

We searched the upper Medano Creek corridor along UTM eastings, following a north-south transect at 82 ft (25m) intervals. On the southeast side of Medano Creek we generally ended the transects when we entered the aspen stands on the slopes above the creek because the thick canopy interfered with the GPS signal. On the northwest side of Medano Creek, if we encountered a leafy spurge patch and could still receive a GPS signal, we continued on the transect for approximately 350 ft after the last patch. Because of time and equipment limitations, we did not sample at a great distance from the core infestation of leafy spurge.

PERENNIAL PEPPERWEED (*Lepidium latifolium*)

In 2004 we only mapped perennial pepperweed west of the dunes. There were extensive infestations of perennial pepperweed along the western boundary of the Medano Ranch (Figure 17). In one large mesic meadow along the western boundary, pepperweed was so pervasive it became impractical to map it as unique patches, therefore we lumped patches into one 350-acre polygon. There were other large patches north of the meadow and around Dollar Lake. Infestations thinned to the northeast toward the sand sheet. However, there were several patches in some of the distant ephemeral wetlands. All of these patches were small and might be successfully eradicated. These upwind areas should be periodically surveyed for further establishment.

RUSSIAN THISTLE (*Salsola tragus*)

Russian thistle/tumbleweed was difficult to map accurately. In May and June, the seedlings were small and hard to detect. Thus, we generally only mapped areas where there were old tumbleweeds still visible or where there were larger, more visible infestations. There were large infestations along roads, in Pinyon Flats Campground, in dry arroyos, and on the lee side of dunes along Medano Creek where the wind deposited senesced plants (Figures 18 and 19). This survey should not be considered complete.

On the Medano Ranch, there were such extensive infestations of Russian thistle that it became impractical to spend the time mapping when there were other higher priority weeds. If the weed becomes a priority for management, other methods of mapping than ground-based mapping should be pursued.

COMMON MULLEIN (*Verbascum thapsus*)

Common mullein occurred in meadows along Medano Creek that were burned in the 2000 wildfire, in the picnic area, and along the rocky floodplain of Mosca Creek west of the Visitor Center (Figure 20). We found two other isolated patches on the steep side slopes below the Mosca Pass Trail and along Medano Creek south of the mouth of Castle Creek.

Russian knapweed (*Acroptilon repens*)

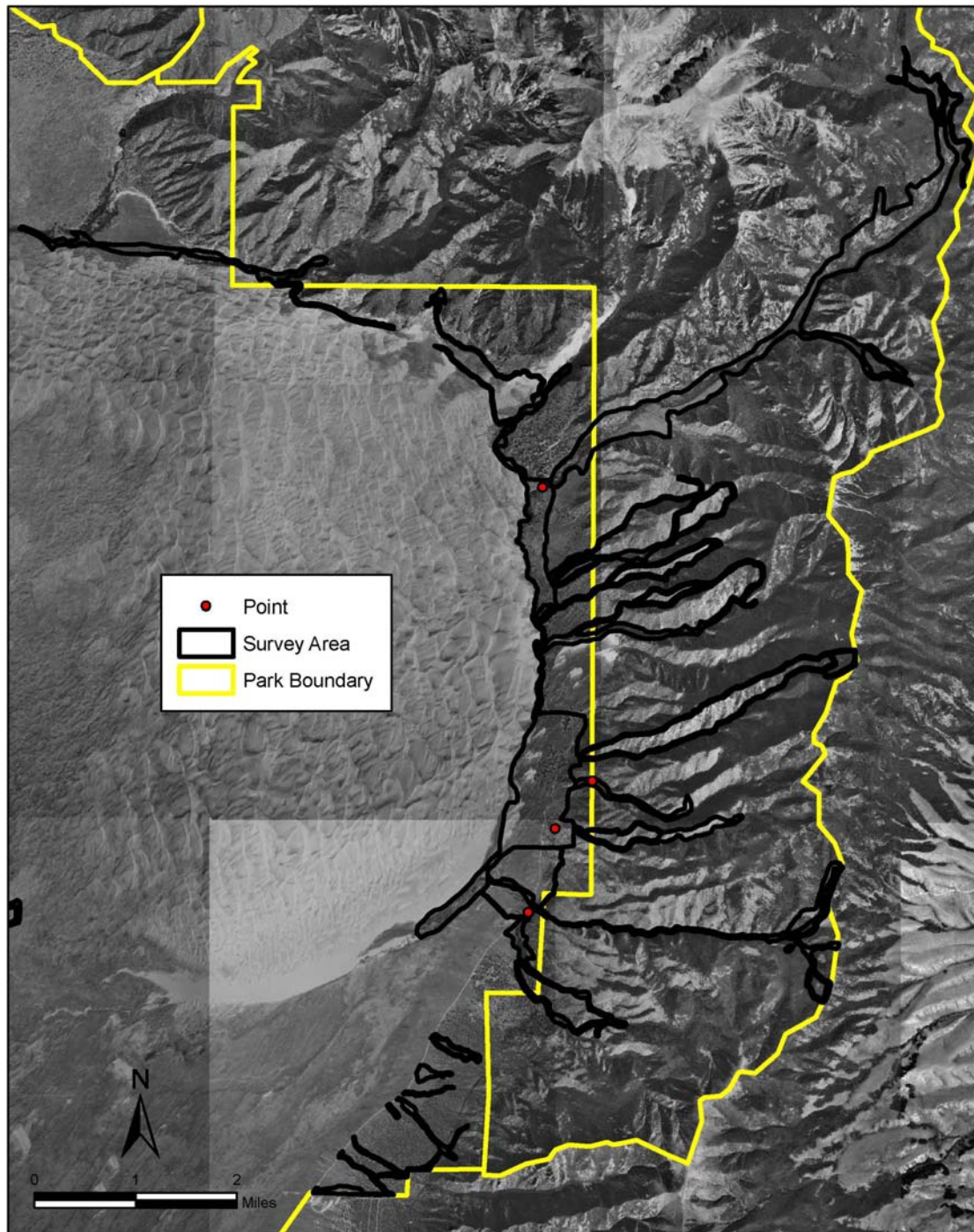


Figure 6. Map of Russian knapweed distribution on the east side of GRSA.

Russian knapweed (*Acroptilon repens*)

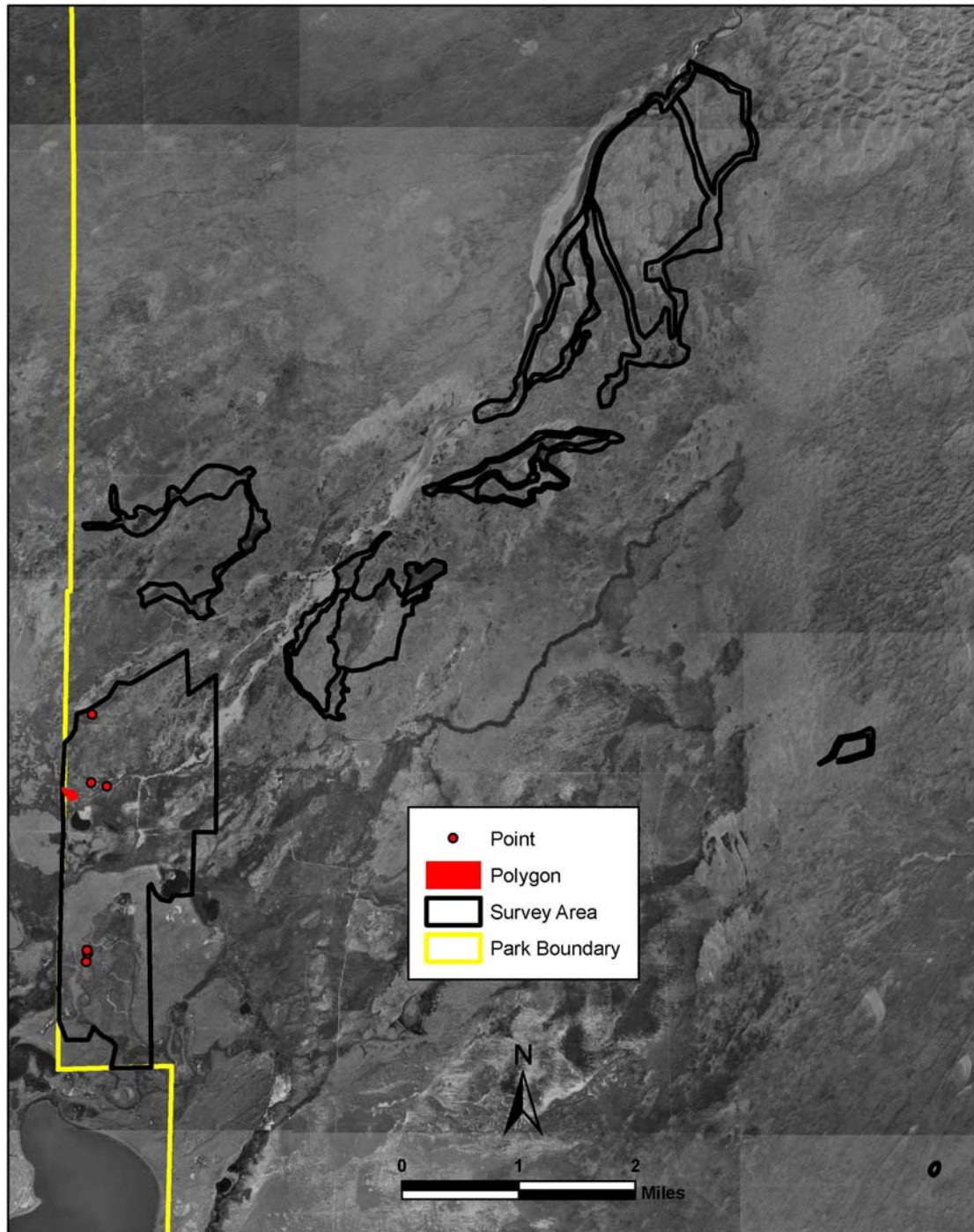


Figure 7. Map of Russian knapweed distribution on the west side of GRSA.

Cheatgrass (*Bromus tectorum*)

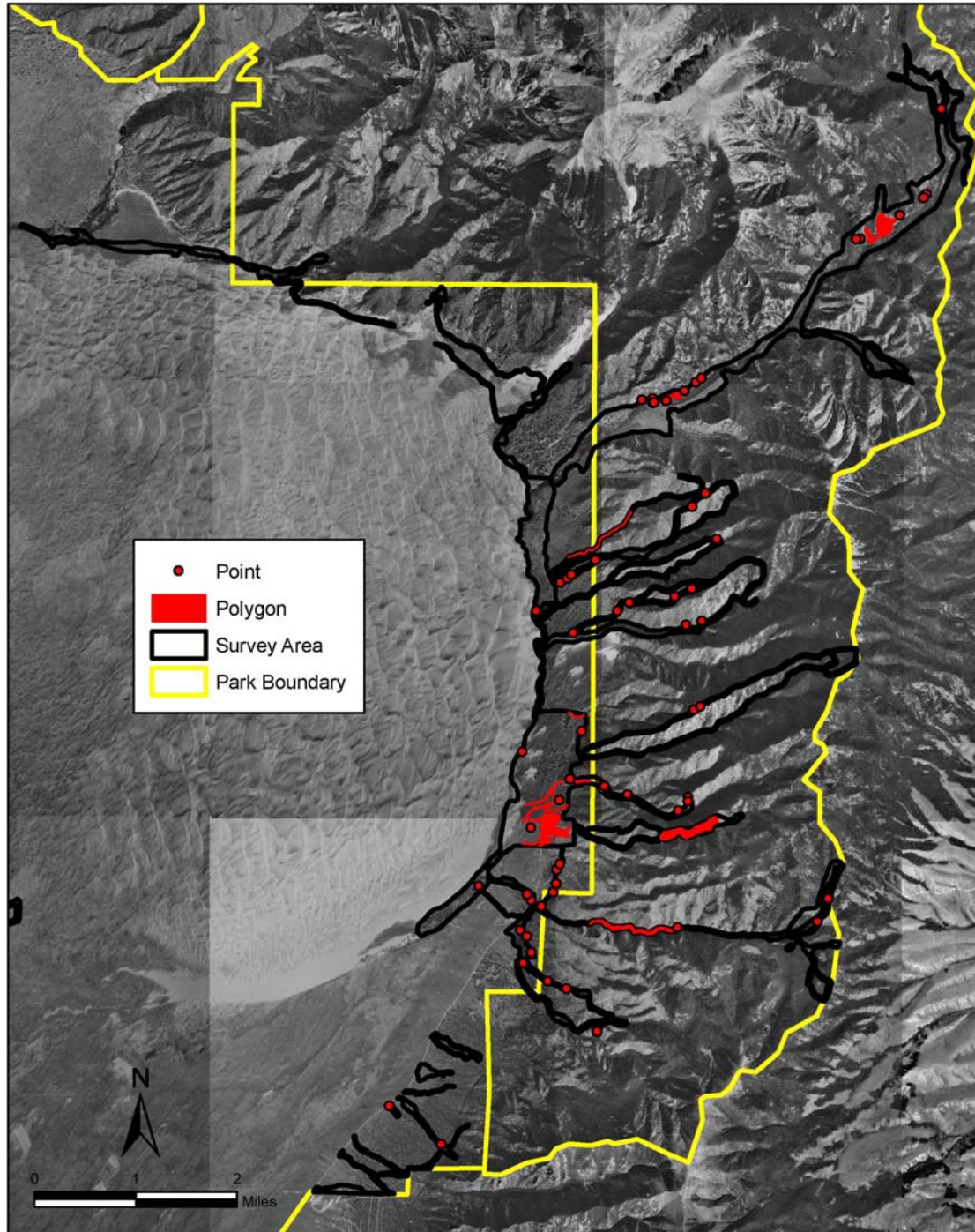


Figure 8. Map of cheatgrass distribution on the east side of GRSA.

Whitetop (*Cardaria draba*)

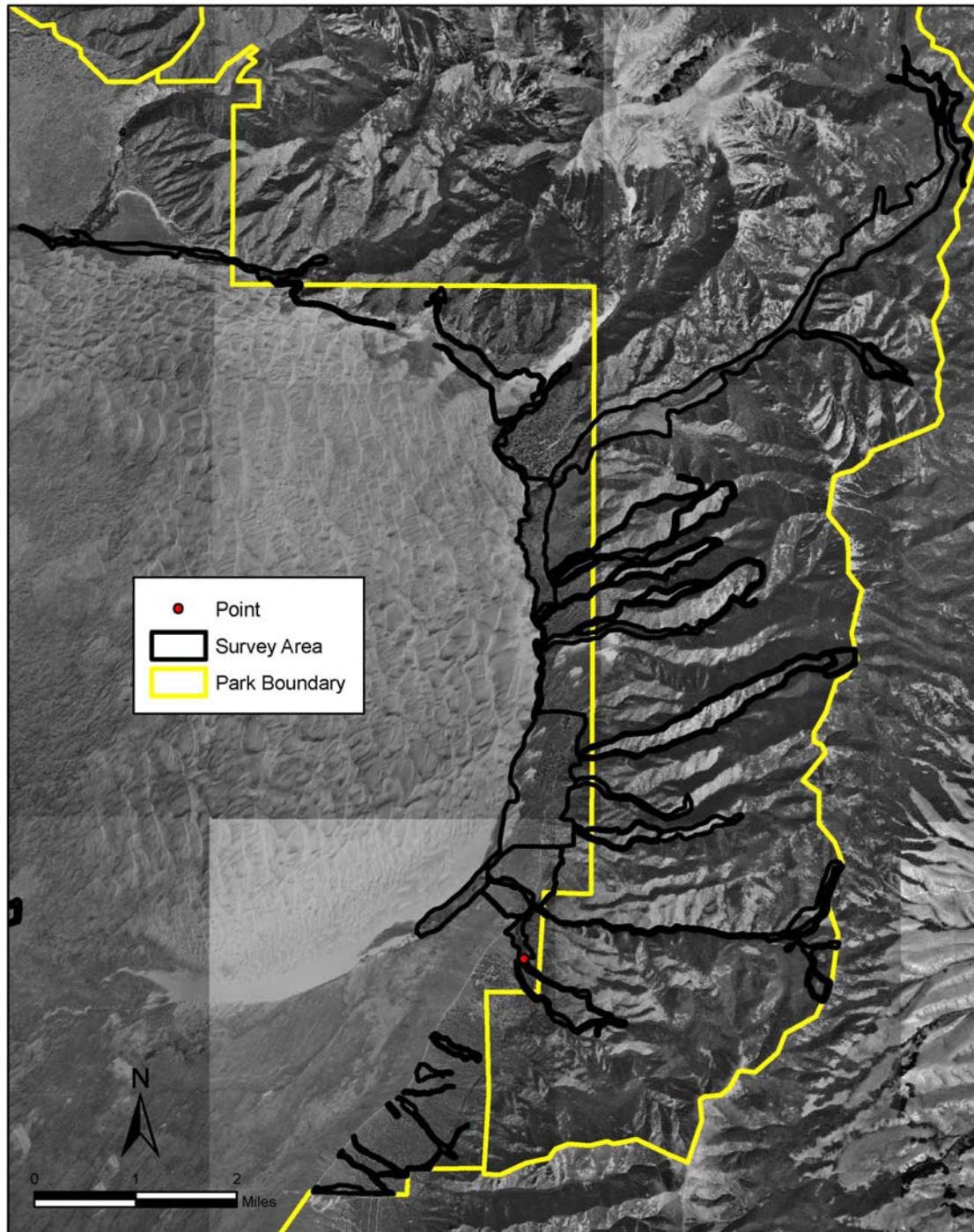


Figure 9. Map of whitetop distribution on the east side of GRSA.

Whitetop (*Cardaria draba*)

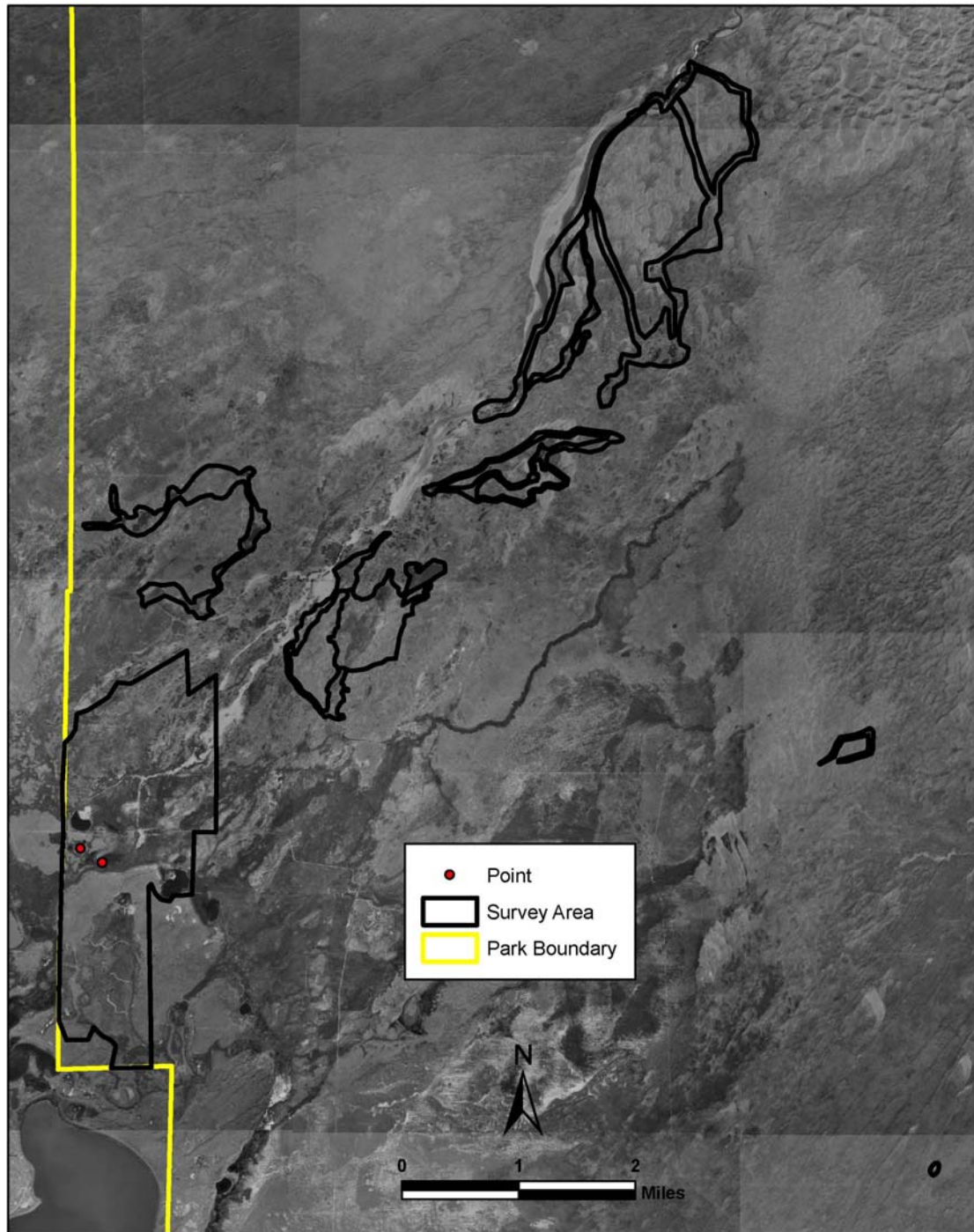


Figure 10. Map of whitetop distribution on the west side of GRSA.

Canada thistle (*Cirsium arvense*)

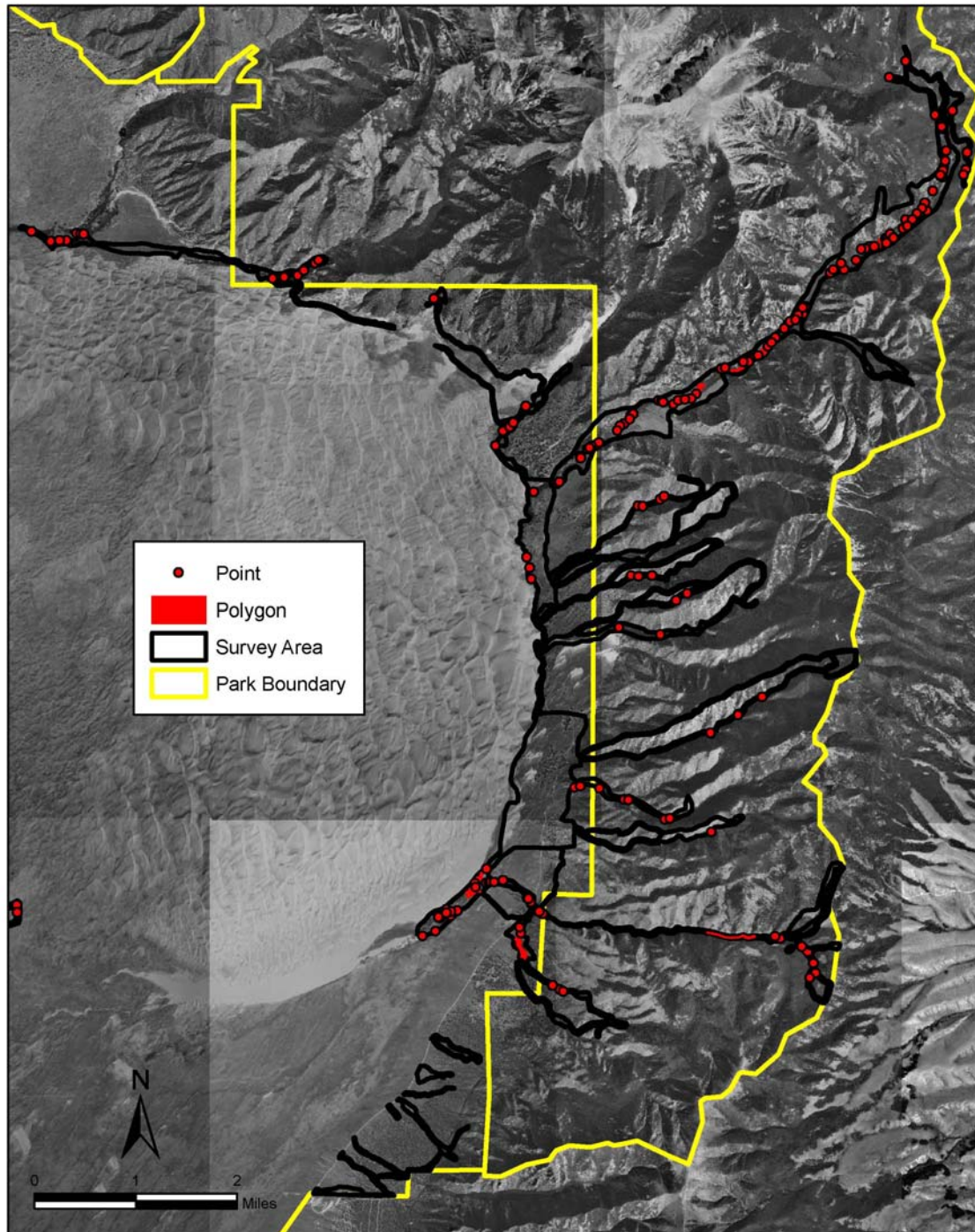


Figure 11. Map of Canada thistle distribution on the east side of GRSA.

Canada thistle (*Cirsium arvense*)

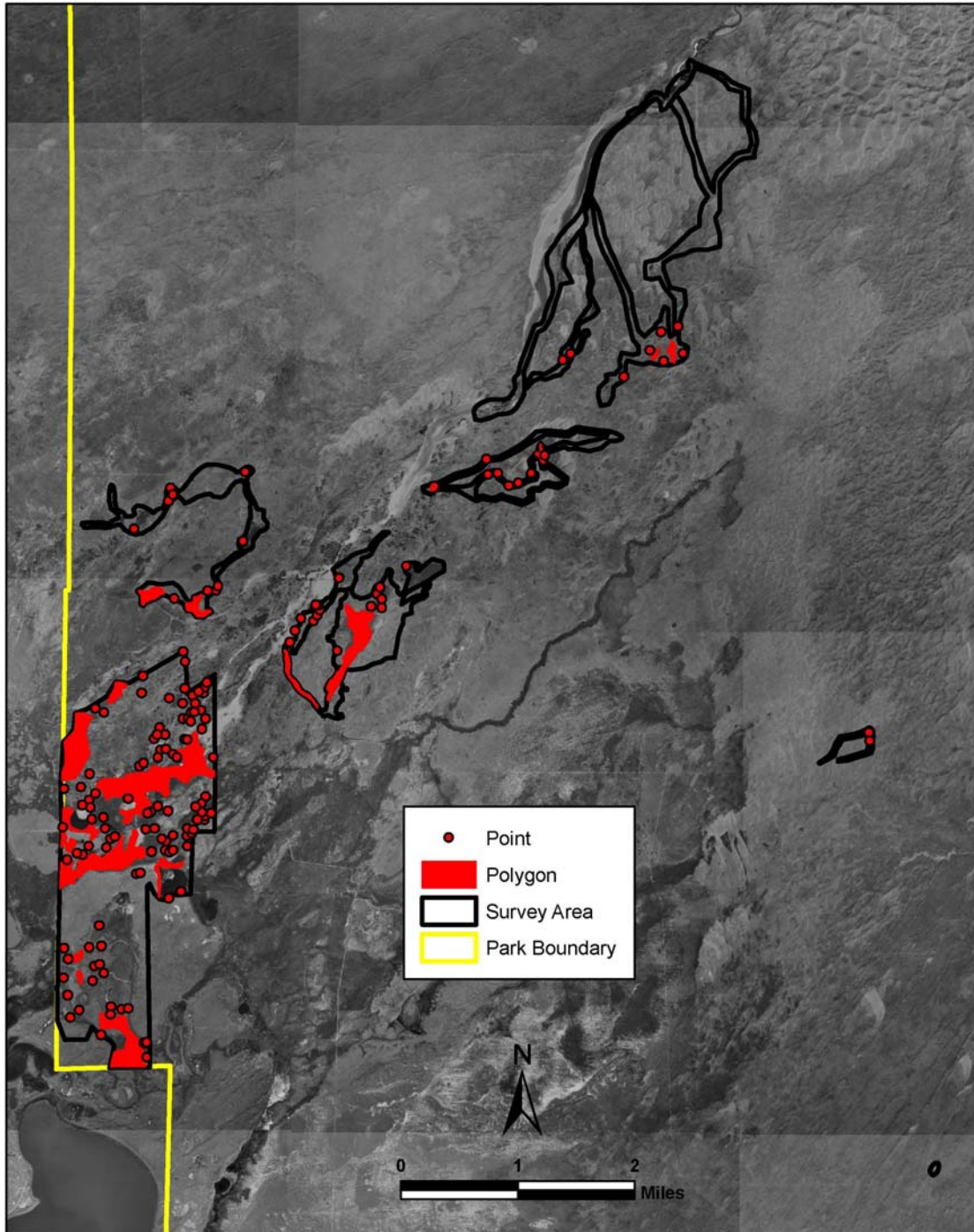


Figure 12. Map of Canada thistle distribution on the west side of GRSA.

Bull thistle (*Cirsium vulgare*)

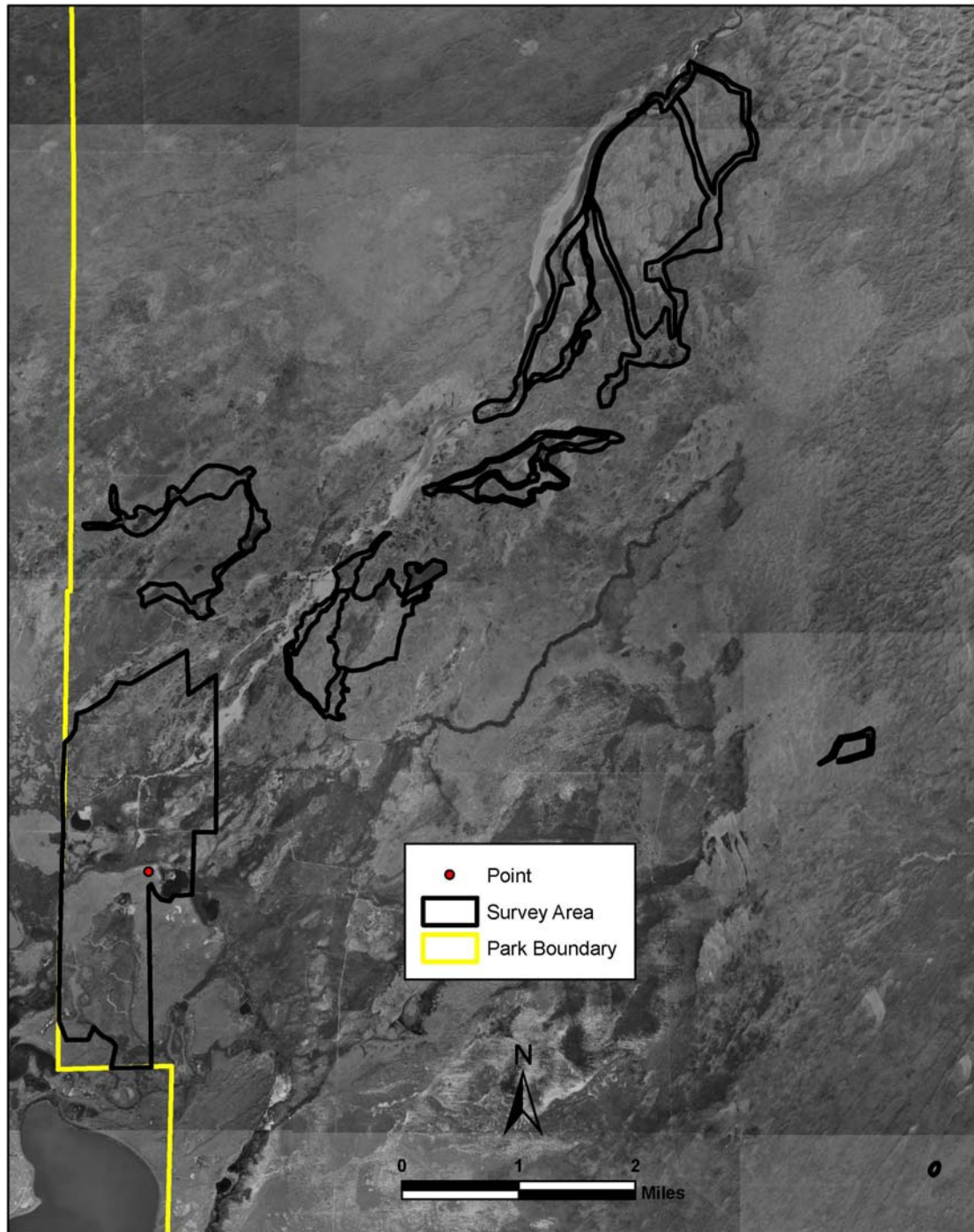


Figure 13. Map of bull thistle distribution on the west side of GRSA.

Field bindweed (*Convolvulus arvensis*)

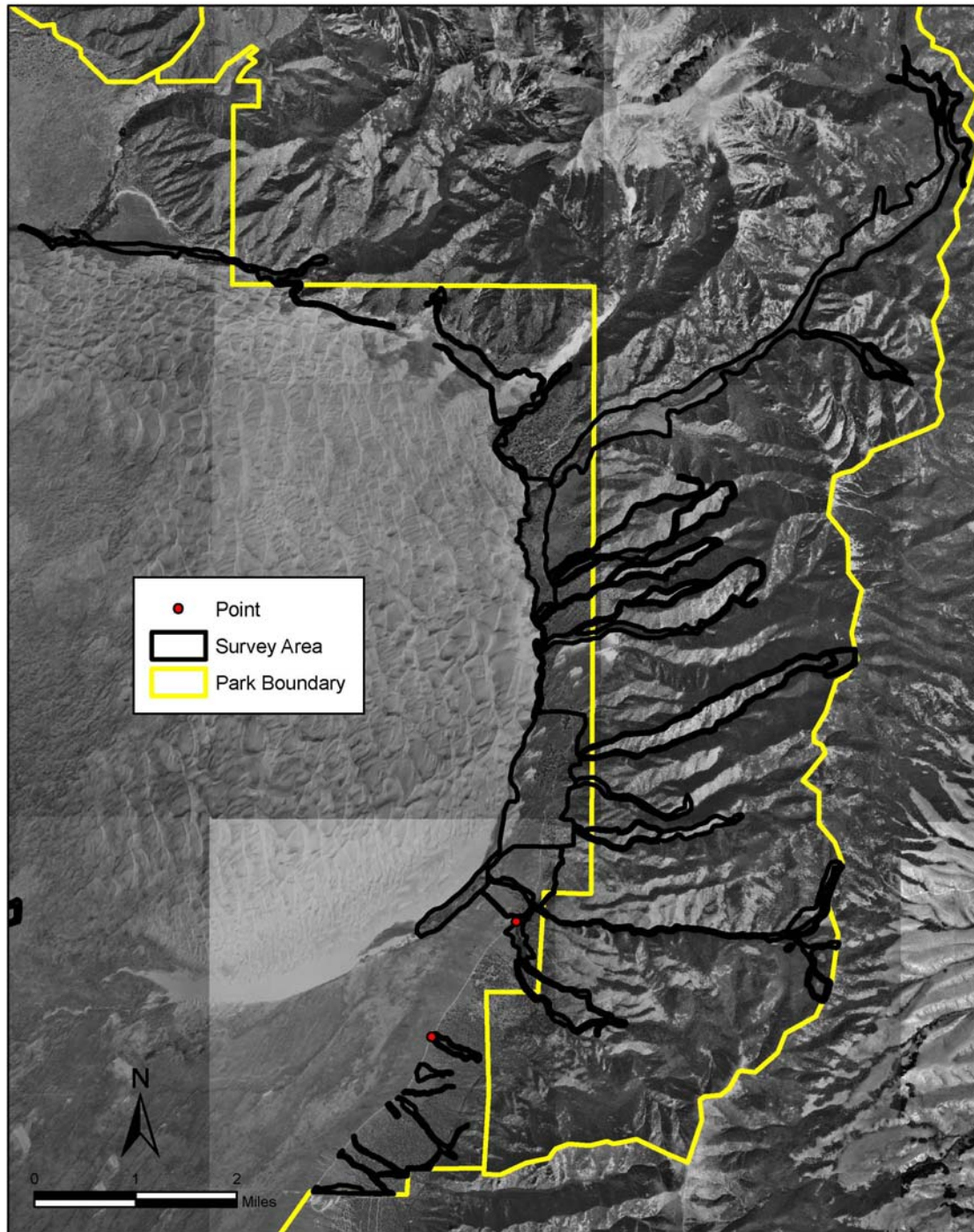


Figure 14. Map of field bindweed distribution on the east side of GRSA.

Russian olive (*Elaeagnus angustifolia*)

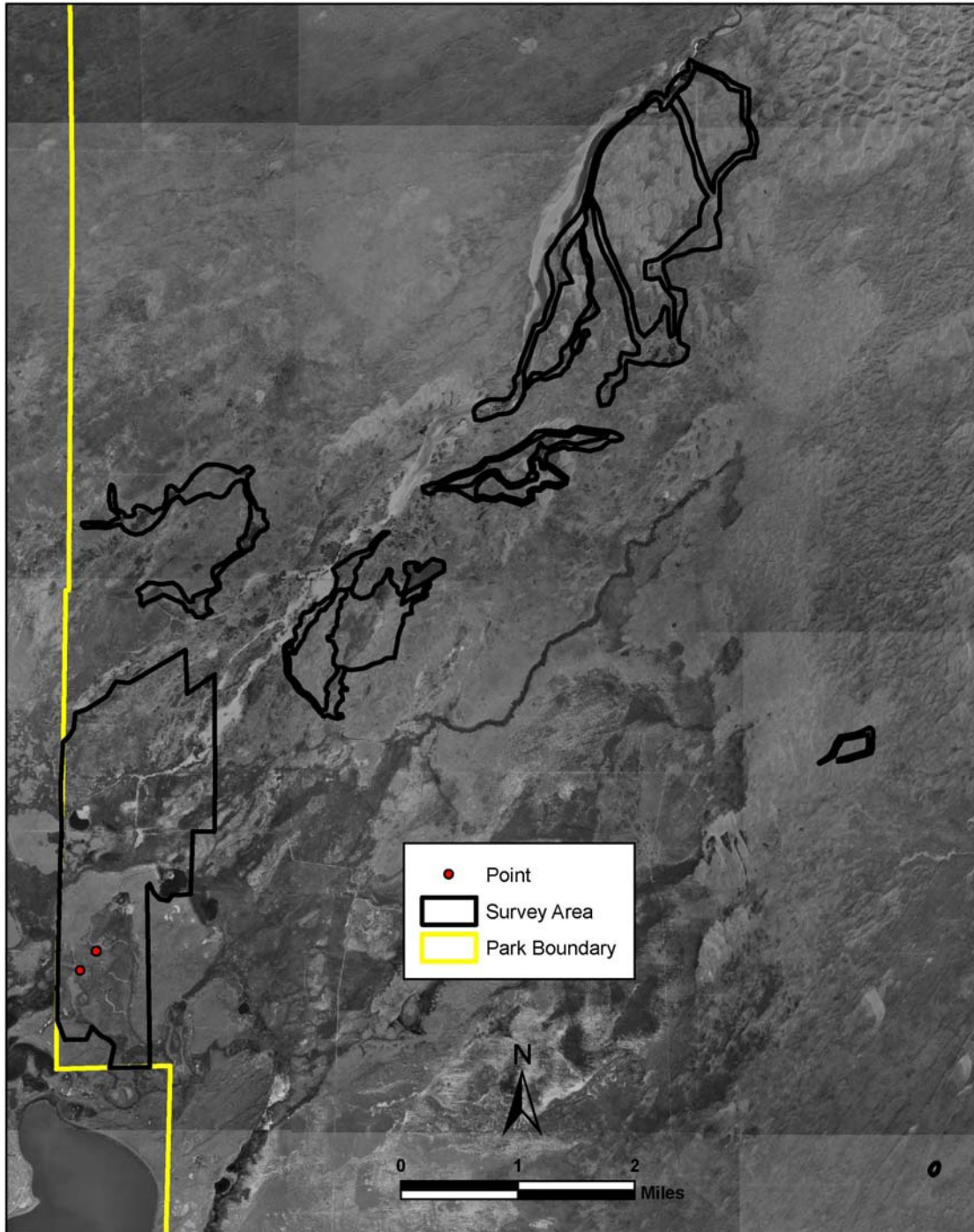


Figure 15. Map of Russian olive distribution on the west side of GRSA.

Leafy spurge (*Euphorbia esula*)

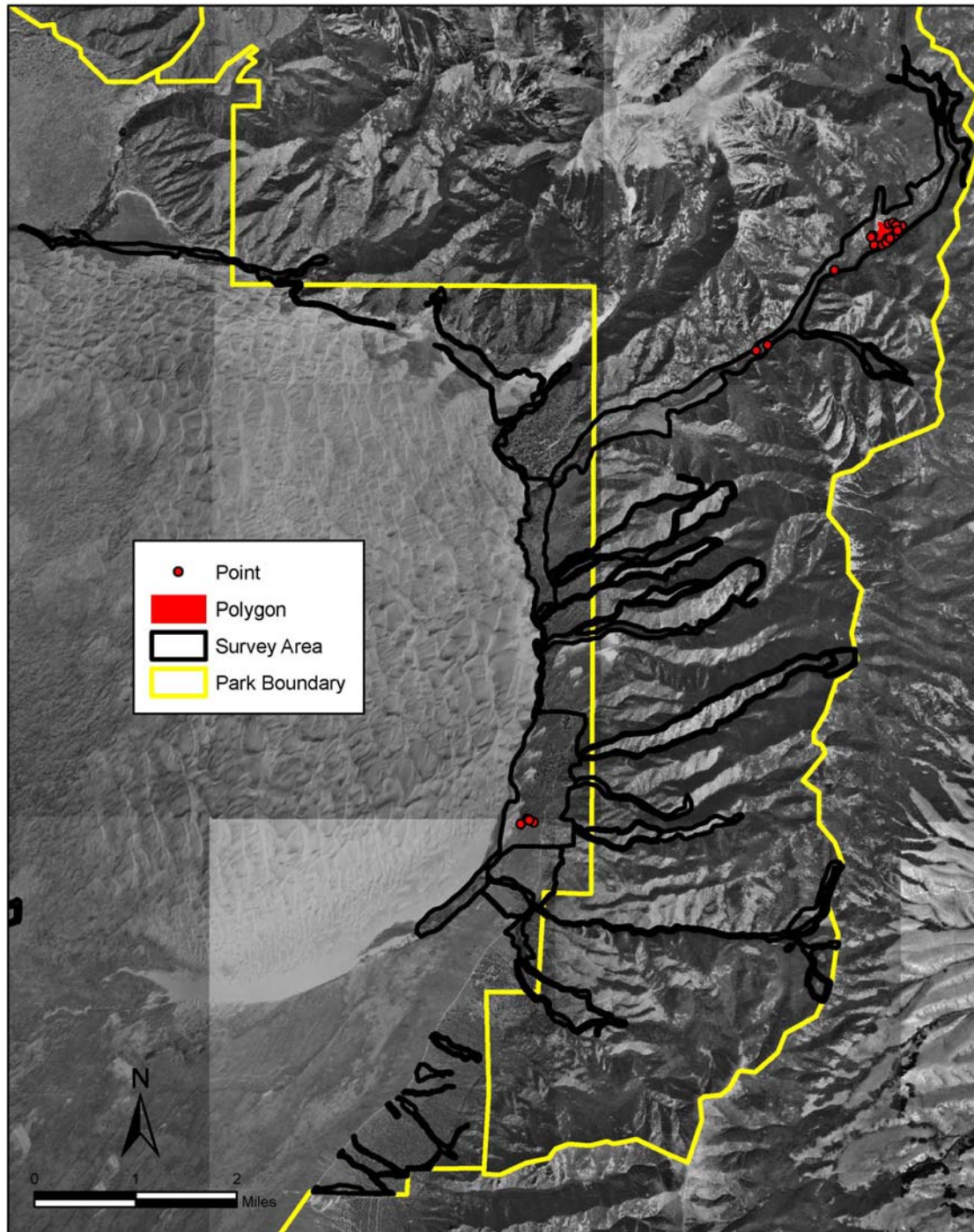


Figure 16. Map of leafy spurge distribution on the east side of GRSA.

Perennial pepperweed (*Lepidium latifolium*)

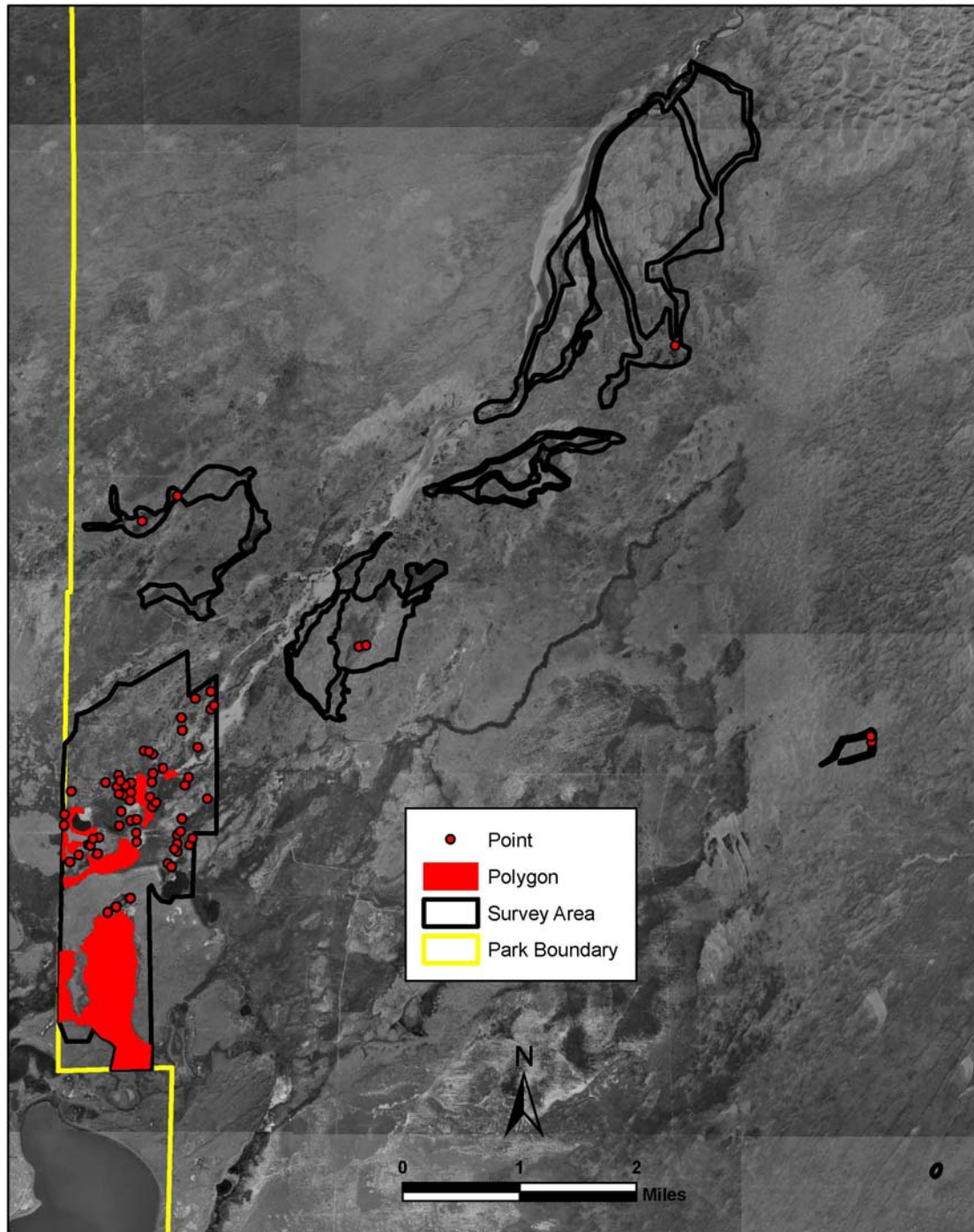


Figure 17. Map of perennial pepperweed distribution on the west side of GRSA.

Russian thistle (*Salsola tragus*)

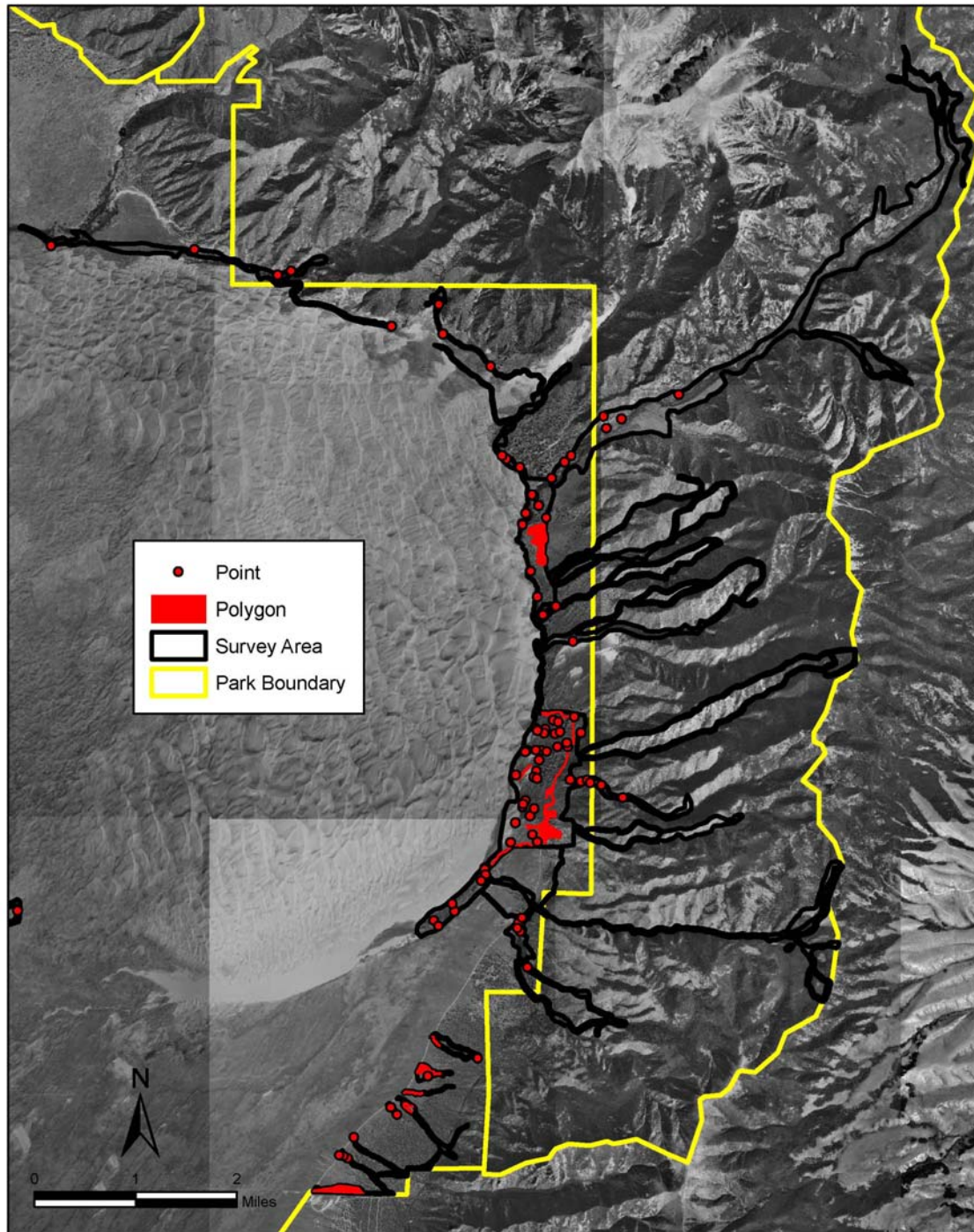


Figure 18. Map of Russian thistle distribution on the east side of GRSA.

Russian thistle (*Salsola tragus*)

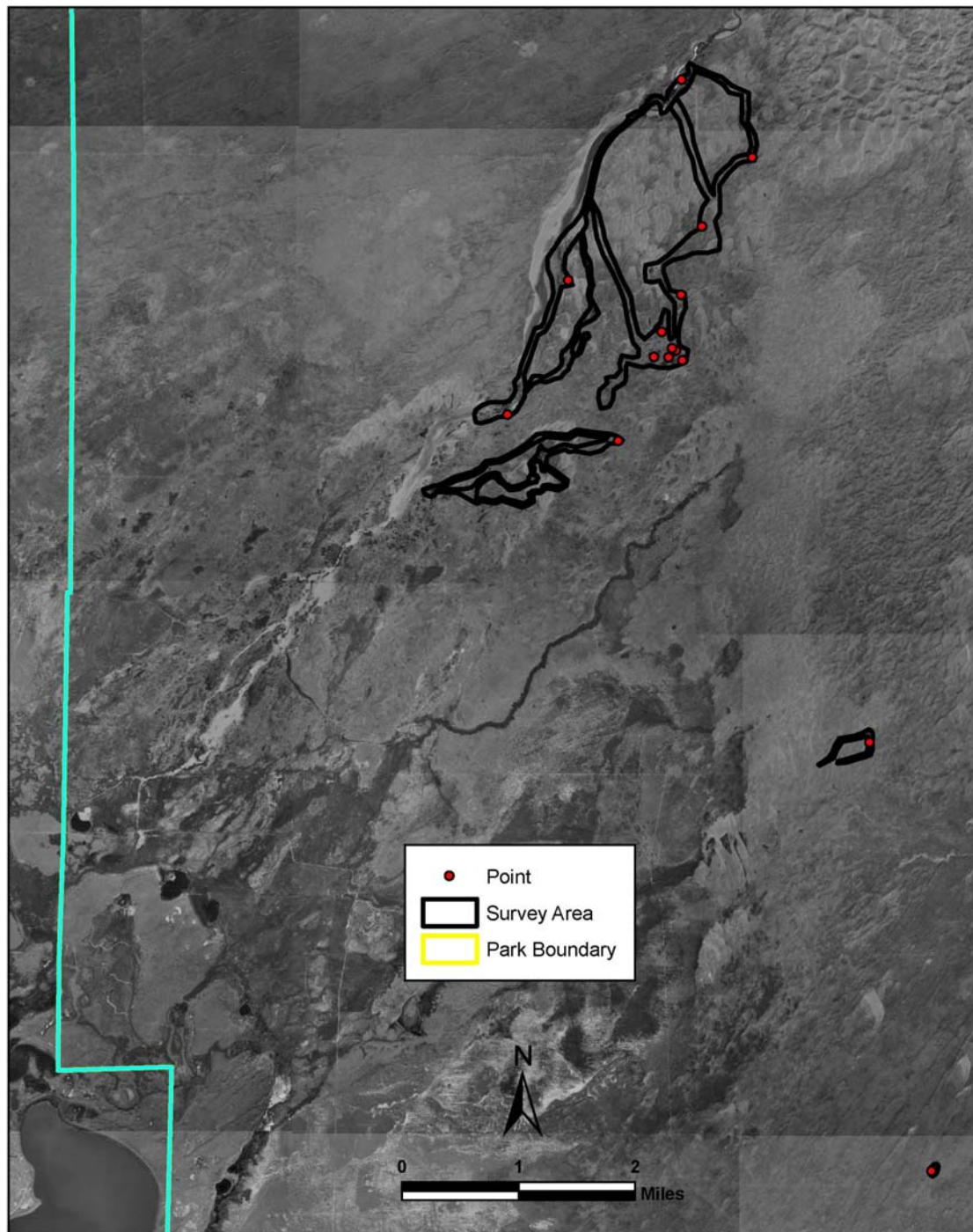


Figure 19. Map of Russian thistle distribution on the west side of GRSA. (Note difference in survey areas from other weeds mapped. We did not map Russian thistle in all survey areas.)

Common mullein (*Verbascum thapsus*)

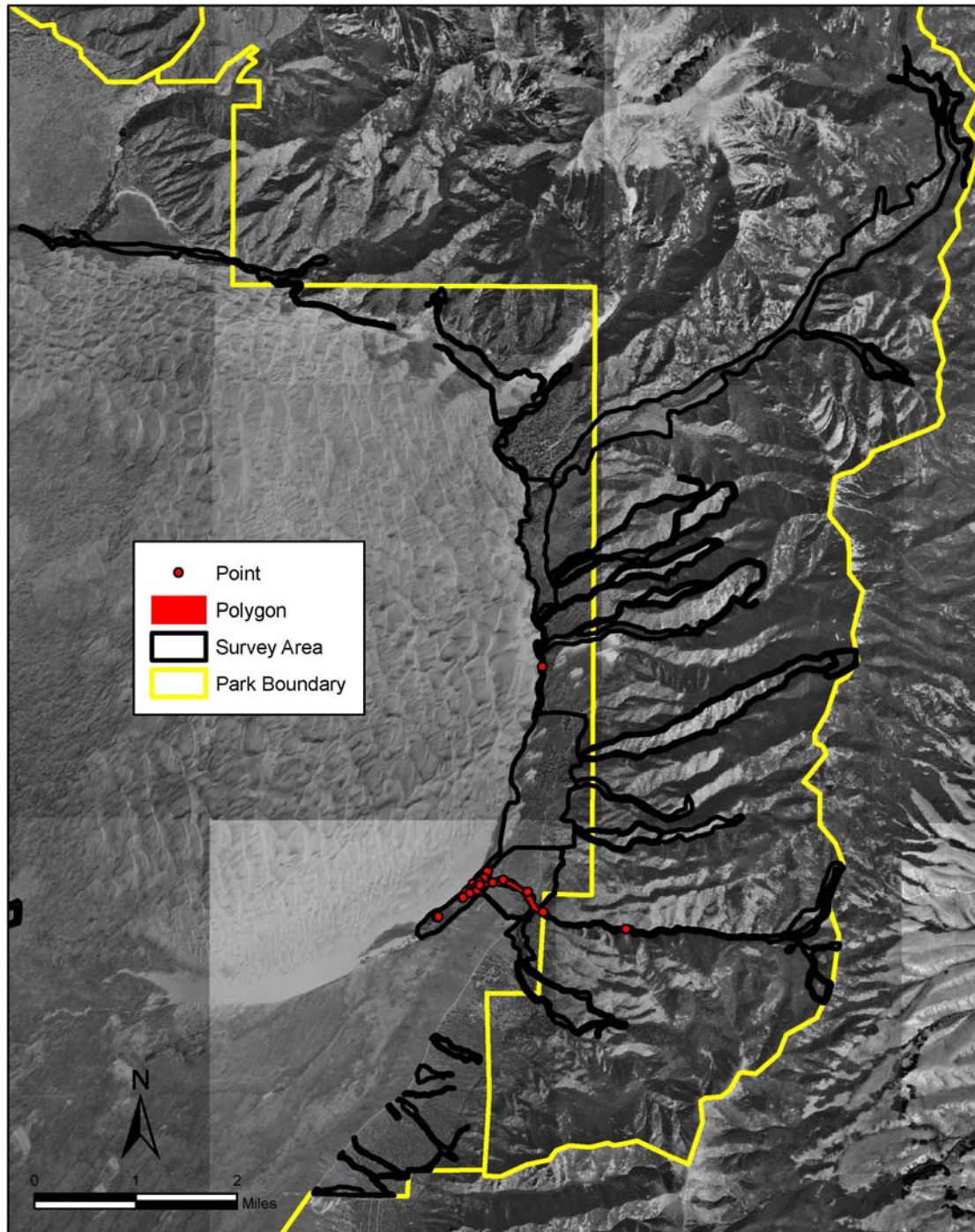


Figure 20. Map of common mullein distribution on the east side of GRSA.

Conclusion

The 2004 non-native plant survey provides managers at GRSA and the IMR with a snapshot of non-native plant distributions in portions of the National Park and Preserve and the Medano Ranch. This spatial data should assist resource managers in writing and implementing a weed management plan by providing estimates of location and abundance of non-native plants of concern. In addition, managers can use the resulting maps to assist with monitoring of non-native plants.

Total infested area is simply the estimated area within the survey area that is occupied by any non-native plant, whether it is one or many species. Total infested area is important because while it indicates the proportion of land within the survey area that is infested it also provides insight into the proportion of land that is potentially weed-free. This allows managers to prioritize management within the infested areas as well as to promote weed resistant plant communities in areas that are not invaded. From our survey, we estimated that 17% - 19% of the survey area was infested with one to several of the targeted non-native plants. A large proportion of the area we surveyed was not yet invaded with non-native plants.

Great Sand Dunes National Park and Preserve is downwind from large infestations of invasive plants on agricultural lands in the San Luis Valley. Large infestations of Canada thistle and perennial pepperweed along the western boundary of the Medano Ranch should be contained before spread continues upwind into the park. Previously unknown infestations of Russian knapweed on the western boundary of the Medano Ranch should also be contained or eradicated if possible. Previously unknown infestations of leafy spurge were also detected downstream from a popular recreation corridor. We cannot stress enough the importance of repeated surveys to detect new or spreading infestations.

Several non-native plant species were present in small patches in the park or on the Medano Ranch. These species included Russian knapweed (0.5 ac in the park and 6.2 ac on the Medano Ranch), whitetop (0.03 ac total in the park and on the Medano Ranch), bull thistle (0.05 ac on the Medano Ranch), field bindweed (0.02 ac in the park), and Russian olive (0.001 ac on the Medano Ranch). These species should be targeted for eradication while populations are small and monitored for reinfestation or spread thereafter. Species of concern that we did not find in the park or on the Medano Ranch include spotted knapweed (*Centaurea biebersteinii*) and tamarisk (*Tamarix* spp). We recommend that periodic surveys continue to search for these and other invasive plants.

We recommend that managers use these data as a baseline for designing long-term monitoring of the invasiveness of non-native plants, of impacts of non-native plants on the ecosystem, and of the impacts of management on both non-native plants and the ecosystem. Following we provide guidelines on how this might be achieved.

Recommendations

Monitoring of non-native plant populations

As stated in the introduction, there are three phases of non-native plant species management, inventory/survey, monitoring and control. Once we have completed an inventory/survey, as we have for GRSA, the next phase is monitoring. There are different aspects of the monitoring phase:

- to monitor for new populations of non-native plants in close proximity to current populations,
- to evaluate if non-native plant populations are growing at a rate fast enough and consistent enough to be considered invasive (increasing in spatial extent),
- to determine if non-native plant populations are having a significant impact on an ecosystem, under the management objectives for that ecosystem,
- to determine if invasive species management is having a significant impact on the non-native plants, and on the ecosystem under the management (i.e. cost benefit analysis) objectives for that ecosystem,
- and to monitor for species not currently found in the area.

Here we will provide information on the first steps of monitoring, which is to determine which species, under which environmental conditions are changing most rapidly. By determining which species and populations in which environments are most invasive, they can be ranked. The problem list can then be systematically worked down as time and money allows. To achieve the ranking we need to select a number of patches and set up permanent markers to determine how much the patches are changing over time in situations where no management practices are being used and areas where they are. In this way, we could also evaluate which management practices are reducing the density or size of the patch as we intend, and if they are changing the occurrence and density of the native species. We may also want to evaluate different management practices and see how they compare.

Different monitoring objectives may require different methods to accomplish them. There is no set of well-tested conventional methods for monitoring. We have been experimenting with some methods in the field and with simulation models. Thus, the concepts for monitoring methods presented here are general, preliminary, and are suggested based on theory and experience, but are not well tested. Examining these different types of monitoring will be addressed in a forthcoming publication by Maxwell and Rew at MSU, however if any detailed information is desired before then please feel free to contact Lisa Rew by email at lrew@montana.edu, or visit the following website, which is regularly updated:

<http://weedeco.msu.montana.edu/class/LRES443/lres443.htm>.

Finding new colonies

Identifying new colonies of the non-native plant 7 ft to 328 ft (2 m to 100 m) around an existing population (patch) can be accomplished efficiently using adaptive sampling (Thompson and Seber 1996). This method first must determine the maximum distance that one can detect a new colony (a few plants). This will be called the identification distance. Once the distance is

- as a moving front where patches enlarge with expanding radius, and
- by establishing new colonies away from a source population, forming groups of patches (metapopulation) that can coalesce to form larger patches (Cousens and Mortimer 1995).

In order to rapidly determine if a population is increasing in spatial extent, we need to use a technique that will allow us to accurately quantify the area occupied so that the change in area can be detected from one generation (year) to the next. However, with the standard GPS used by most government agencies, consultants and county weed supervisors, the mean horizontal accuracy is rarely less than 3.3 ft (1.0 m) error. Therefore, at the rate that most populations (patches) spread, it would take a minimum of 4 to 5 years to be certain that the area of a patch was actually increasing, even at a consistent maximum spread per year. Our data indicates that one could not conclude invasiveness of any of the non-native plant populations measured with GPS over 2 years. If the GPS method is employed, there is certainly no reason to return to a patch to determine change in area for at least 4 years.

A more accurate and consistent approach would be to establish permanent points on the ground and measure the distance to patch borders with a tape measure. This is a “low tech” approach but will enable accurate detection of only small changes in patch borders, which is necessary to assess invasiveness in only a few years. It also does not take long to do. It is quite possible that populations might show increases in area occupied in one year, but not other years. If patches are mapped each year, the number of times the patch increases, decreases, or stays the same can be calculated and used to determine the degree of invasiveness. The degree of invasiveness that will trigger management or monitoring for ecosystem impacts is the decision of the manager.

A more complete description of the tape measure method is provided on the following website:
<http://weedeco.msu.montana.edu/class/LRES443/lres443.htm>

If monitoring shows that the species is invasive, (all replicate patches are expanding) then it should be monitored for impact and/or management could be initiated. If some patches are found to be consistently expanding and others not, then monitoring should continue and the patches that are expanding should be considered for management. Many may think that most non-native plant populations are expanding rapidly and that measuring that expansion is of academic interest and it would only delay proactive management to incorporate tedious measurements. In fact, where non-native plant patches/populations have been measured (data not published), there was high variability in area occupied from year-to-year and it was often difficult to make accurate measures and conclude that the population was consistently growing or declining.

Monitoring for non-native plant impacts

Monitoring populations found to be invasive for impacts on ecosystem function, species assemblage, and/or productivity can be complicated. There is a well-developed theory for quantifying the economic impacts of a weed on a crop in agroecosystems. A good review of the theory and methods for quantifying weed impacts in crops is available in Cousens and Mortimer (1995). There is a rich body of theory applicable to assessing impacts of invasive species on ecosystem function and species assemblage (Shea and Chesson 2002; Davis et al. 2000; Rejmánek et al. 2000; Mack et al. 2000; Levine 2000; Lonsdale 1999), but there are far less empirical studies that allow comparison of methods (Levine 2000). Quantifying impacts will

typically require small spatial scale observations over longer periods to draw conclusions with confidence. In order to offer some methodology that will comply with typical land management goals, that is, protecting ecosystems, one might establish permanent monitoring plots on the edge or on a tangent to the invasion, and observe the invasion and any coincidental change in the desirable plant community. If desirable species are consistently displaced, one might consider the invasive species to have a significant impact. Upon measuring a significant impact, it would be logical to commence management.

Methodology to quantify species displacement by invasive species requires careful consideration to ensure random selection of invasive populations and placement of sample plots. Random selection of populations or patches of an invasive plant should follow the same logic as selection for determining species invasiveness. That is, the selection of populations from across the environmental conditions where the species is found, within the specific management area. The best approach for selecting sample plots may be to create maps of the edge of several randomly chosen invasive plant patches, then randomly select edge points on the map that can be relocated in the field for repeated sampling (using GPS and field markers). Sample plots (quadrats) should be between 0.25 m² and 5 m² depending on the size of the plants. Larger plants require larger plots, and nesting of quadrat sizes would provide more information (Stohlgren et al. 2003).

Clearly, desirable species displacement does not necessarily result in disruption of ecosystem function, nor does the lack of species displacement mean that the ecosystem could not be significantly disrupted through influence on critical cycles or indirect effects. There is no conventional set of measures to detect these effects, so it will require a keen ability to observe changes, assess their significance and adapt the sampling methodology to quantify such changes. In turn, there must be careful weighing of significance of impacts of the invasive species against the potential disruption of the ecosystem from the management.

Monitoring for impact of non-native plant management

This phase of monitoring occurs after the invasiveness and negative impact of the non-native plant has been quantified, and involves monitoring for the impacts of weed management practices on ecosystem function, species assemblage, and/or productivity. Management would be initiated preferably only on part of a patch, or on one patch and not an adjacent patch of the same species. In this way, the impact of the management could be measured by continuing the same measurements, in the same plots, as established to quantify impacts of the invasive species. In addition, the same metrics of community response to the invasion should be good measures of community impact by management.

Appendix 1.

List of non-native plants that were targeted in the 2004 IMR weed survey.

Species	Common Name	Mapped in 2004	State Noxious Weed List
<i>Acroptilon repens</i>	Russian knapweed	X	CO, MT, WY
<i>Bromus tectorum</i>	Cheatgrass	X	CO
<i>Cardaria draba</i>	Whitetop, hoary cress	X	CO, MT, WY
<i>Carduus nutans</i>	Musk thistle		CO
<i>Centaurea biebersteinii</i>	Spotted knapweed		CO, MT, WY
<i>Centaurea diffusa</i>	Diffuse knapweed		CO, MT, WY
<i>Cirsium arvense</i>	Canada thistle	X	CO, MT, WY
<i>Cirsium vulgare</i>	Bull thistle	X	CO
<i>Convolvulus arvensis</i>	Field bindweed	X	CO, MT, WY
<i>Elaeagnus angustifolia</i>	Russian olive	X	CO
<i>Euphorbia esula</i>	Leafy spurge	X	CO, MT, WY
<i>Lepidium latifolium</i>	Perennial pepperweed	X	CO, MT, WY
<i>Salsola tragus</i>	Russian thistle	X	CO
<i>Tamarix spp</i>	Tamarisk		CO, MT, WY
<i>Verbascum thapsus</i>	Common mullein	X	CO

Appendix 2.

List of dominant species used in the 2004 IMR weed survey, adapted from GRSA vascular plant inventory.

SPECIES	COMMON NAME
<i>Acer glabrum</i>	Rocky Mountain maple
<i>Acroptilon repens</i>	Russian knapweed
<i>Agropyron cristatum</i>	Crested wheatgrass
<i>Alnus incana</i>	Thinleaf alder
<i>Alopecurus aequalis</i>	Shortawn foxtail
<i>Amelanchier alnifolia</i>	Serviceberry
<i>Artemisia drancunculus</i>	Wild tarragon
<i>Artemisia frigida</i>	Fringed sage
<i>Asclepias speciosa</i>	Showy milkweed
<i>Aster sp</i>	Aster
<i>Atriplex canescens</i>	4-wing saltbrush
<i>Betula fontinalis</i>	River birch
<i>Bouteloua gracilis</i>	Blue grama
<i>Bromus inermis</i>	Smooth brome
<i>Bromus japonicus</i>	Japanese chess
<i>Bromus tectorum</i>	Cheatgrass
<i>Calamagrostis canadensis</i>	Canada reedgrass
<i>Cardaria draba</i>	Whitetop
<i>Carduus nutans</i>	Musk thistle
<i>Carex sp</i>	Sedge
<i>Centaurea diffusa</i>	Diffuse knapweed
<i>Centaurea maculosa</i>	Spotted knapweed
<i>Ceratoides lanata</i>	Winterfat
<i>Cercocarpus montanus</i>	Mountain mahogany
<i>Chenopodium album</i>	White goosefoot
<i>Chrysothamnus greenei</i>	Greene's rabbitbrush
<i>Chrysothamnus linifolius</i>	Rabbitbrush
<i>Chrysothamnus nauseosus</i>	Rubber rabbitbrush
<i>Chrysothamnus parryi</i>	Parry's rabbitbrush
<i>Chrysothamnus viscidiflorus</i>	Douglas rabbitbrush
<i>Cirsium arvense</i>	Canada thistle
<i>Cirsium vulgare</i>	Bull thistle
<i>Comandra umbellata</i>	Toadflax
<i>Convolvulus arvensis</i>	Bindweed
<i>Danthonia intermedia</i>	Timber oatgrass
<i>Danthonia parryi</i>	Parry's oatgrass
<i>Distichlis spicata</i>	Salt grass
<i>Elaeagnus angustifolia</i>	Russian olive
<i>Elymus sp</i>	Wild rye
<i>Erigeron sp</i>	Fleabane
<i>Euphorbia esula</i>	Leafy spurge
<i>Glycyrrhiza lepidota</i>	Licorice root
<i>Grindelia squarrosa</i>	Gumweed
<i>Gutierrezia sarothrae</i>	Snakeweed
<i>Heterotheca villosa</i>	Hairy golden-aster
<i>Juncus sp</i>	Rush

<i>Juniperus scopulorum</i>	Rocky Mountain juniper
<i>Kochia scoparia</i>	Kochia
<i>Koeleria macrantha</i>	Junegrass
<i>Lepidium latifolium</i>	Perennial pepperweed
<i>Lupinus sp</i>	Silvery lupine
<i>Melilotus alba</i>	White sweet clover
<i>Melilotus officinalis</i>	Yellow sweet clover
<i>Muhlenbergia asperifolia</i>	Alkali muhly
<i>Muhlenbergia montana</i>	Mountain muhly
<i>Muhlenbergia pungens</i>	Sandhill muhly
<i>Munroa squarrosa</i>	False buffalo grass
<i>Oryzopsis hymenoides</i>	Indian rice-grass
<i>Pascopyrum smithii</i>	Western wheatgrass
<i>Phleum pratense</i>	Timothy grass
<i>Physocarpus monogynus</i>	Ninebark
<i>Picea engelmannii</i>	Englemann's spruce
<i>Pinus edulis</i>	Pinyon pine
<i>Pinus ponderosa</i>	Ponderosa pine
<i>Poa pratensis</i>	Kentucky bluegrass
<i>Poa sp</i>	Bluegrass
<i>Populus angustifolia</i>	Narrowleaf cottonwood
<i>Populus tremuloides</i>	Aspen
<i>Prunus virginiana</i>	Chokecherry
<i>Pseudotsuga menziesii</i>	Douglas fir
<i>Puccinellia airoides</i>	Alkali grass
<i>Redfieldia flexuosa</i>	Blowout grass
<i>Rhus trilobata</i>	Skunkbush
<i>Rosa sayi</i>	Prickly rose
<i>Rosa woodsii</i>	Wood's rose
<i>Salix exigua</i>	Coyote willow
<i>Salix sp</i>	Willow
<i>Salsola collina</i>	Slender Russian thistle
<i>Salsola tragus</i>	Prickly Russian thistle
<i>Sarcobatus vermiculatus</i>	Greasewood, Chico
<i>Shepherdia canadensis</i>	Russet buffaloberry
<i>Sitanion hystrix</i>	Squirreltail
<i>Solidago sp</i>	Goldenrod sp
<i>Sphaeralcea coccinea</i>	Orange globemallow
<i>Sporobolus airoides</i>	Alkali sacaton
<i>Sporobolus cryptandrus</i>	Sand dropseed
<i>Stipa comata (Hesperostipa comata)</i>	Needle-and-thread
<i>Stipa robusta</i>	Sleepy grass
<i>Stipa scribneri</i>	Scribner's needlegrass
<i>Tamarix parviflora</i>	Small flower tamarisk
<i>Tamarix ramosissima</i>	Tamarisk
<i>Trifolium pratense</i>	Red clover
<i>Trifolium repens</i>	White Dutch clover
<i>Typha latifolia</i>	Broadleaf cattail
<i>Verbascum thapsus</i>	Mullein
<i>Yucca glauca</i>	Yucca

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