Revised Inventory of Non-Indigenous Plants at Little Bighorn Battlefield National Monument

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Prepared by:
Erik Lehnhoff and Patrick Lawrence
Department of Land Resources and Environmental Sciences
Montana State University
Bozeman, MT 59717

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Foreword

This report presents the results of a non-indigenous plant inventory performed at Little Bighorn Battlefield National Monument (LIBI) in June 2010. The purposes of the inventory were to:

- map the distribution of non-indigenous plant species (NIS) that were of concern to park resource managers or were known to be potentially invasive in other areas
- assess change in NIS population sizes since the 2004 inventory
- develop maps of NIS distribution to assist with NIS management
- identify areas with relatively few NIS

To achieve these goals we conducted an NIS inventory of LIBI, including the Custer battlefield, the Reno-Benteen battlefield and the Tour Road. The inventory was conducted by walking transects spaced 30 m apart and searching for NIS within a 15 m swath on either side of the transect line. The occurrence of target NIS and other variables were recorded with Global Positioning System (GPS) receivers.

Maps of target NIS distributions are provided in the report, as well as tables summarizing the acres infested by each species mapped. The GIS files and maps produced from the inventory of LIBI are a singular look at the invasive plant distribution in the summer of 2010. The data for most species can be compared to the 2004 inventory to assess changes in invasive plant populations in the area over time; however, some NIS were mapped for the first time during this inventory.

Introduction

Site description

Little Bighorn Battlefield National Monument (LIBI) is administered by the National Park Service (NPS), U.S. Department of the Interior. It was established as a National Cemetery in 1879. In 1946 it was designated a National Monument by the U.S. Congress to preserve the historical character and cultural integrity of the site of a significant battle between the US Calvary and several Great Plains Indian allies. Little Bighorn Battlefield is located in Crow Agency, MT, within the Crow Indian Reservation, on a ridge above bluffs that drop steeply to the Little Bighorn River. The Monument is located in the northwestern Great Plains physiographic province and the vegetation types there consist primarily of northern mixed-grass prairie with areas of sagebrush (*Artemisia tridentata*) steppe. A small portion of the Monument consists of riparian woodland along the floodplain of the Little Bighorn River. LIBI is 765 acres comprised of the Custer Battlefield and the Reno-Benteen Battlefield, which are separated by the Tour Road right-of-way easement.

Justification for action

According to the NPS, the invasion of non-indigenous plant species (exotic plants, non-native plants, invasive species, or weeds, hereafter collectively termed NIS) 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). Montana has defined noxious weeds to include "...any exotic plant species established or that may be introduced in the state which may render land unfit for agriculture, forestry, livestock, wildlife, or other beneficial uses or that may harm native plant communities" (County Noxious Weed Control Act (CNWCA)). The control of “noxious weeds” is justified by the CNWCA (7-22-2101 MCA), which requires the control of designated noxious weeds within county districts. Weed management plans are required by the CNWCA to incorporate all appropriate methods, including education, prevention, mechanical methods, biological controls, cultural methods, and general land management practices. Exotic species will not be allowed to displace native species if displacement can be prevented (NPS 2006). 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 2010 inventory helps to meet these objectives by providing current NIS distribution data which can determine if and how the distribution of NIS has changed since the last survey in 2004 and serve as a baseline inventory for NIS mapped for the first time during this inventory.

Non-indigenous plant survey history

Several vegetation surveys have been completed for Little Bighorn including (Bock et. al. 1987), (Simonson 2000), and (Bock and Bock 2006). The surveys provided inventories of vascular plants in the park and analyzed species composition and richness. The surveys did not provide site-specific data on the spatial distribution of non-indigenous plants. However, the 2006 survey noted of Bulbous bluegrass (*Poa bulbosa*) in A Survey Of The Vascular Plants And Birds Of Little Bighorn National Battlefield (Bock and Bock 2006), "It was not observed on the Battlefield or in the vicinity of Hardin, Montana, in the 1980s. We first observed it along some town streets in Hardin in 2003, and noted it then on one isolated field plot (B6) and in several areas along the road near Last Stand Hill. By May 2006, it lined the entrance road to the Battlefield and was conspicuous along the Battlefield roads themselves. It also had moved out from the roadsides into the grassland itself, although it has not yet established at the Reno-Benteen site in any major way."

There has been considerable monitoring and treatment of NIS at Little Bighorn by several NPS parks and programs including Yellowstone National Park, Bighorn Canyon National Recreation Area, Little Bighorn Battlefield National Monument, Exotic Plant Management Team, and Inventory and Monitoring Program. Locations of invasive plants were recorded and listed in various reports.

An NIS inventory was performed in LIBI from July 14 - 17, 2004 by Montana State University (MSU) (Wood and Rew 2005). Approximately 740 acres were inventoried using 30 m, 40 m, and 50 m wide transects or searching along roads.

A second NIS inventory (reported herein) was performed by a different MSU crew from June 7 – 9 and June 28 – July 1, 2010. Approximately 802 acres, including the entire Custer battlefield, the Reno-Benteen battlefield and the tour road, were inventoried using 30 m wide transects and searching along road. Four populations of St. Johnswort (*Hypericum perforatum*) were inventoried on August 9, 2010.

Methods

Sampling protocol

The inventory targeted NIS that were found in the 2004 inventory and were of management concern to LIBI managers (Table 1). The MSU inventory crew varied from four to two members (including Dan Campbell, Patrick Lawrence, Erik Lehnhoff and Landon Zimmerman), depending on the day and personnel available. Several LIBI employees (including Tyrel Miller, Michael Stops, Melana Stichman, BillWatson and Joe Woody) also assisted in the inventory. The MSU crew typically operated the Global Positioning System (GPS) receivers and looked for NIS populations while LIBI employees assisted by locating additional NIS populations. On some transects, LIBI employees operated GPS receivers as well. The inventory began on June 7, 2010, but after two days of work, it became apparent that some forb populations were not being noticed because the species were not flowering and therefore difficult to observe among the dense stands of grass. At this point, the inventory was halted and reconvened on June 28, 2010.

During this second phase of the inventory, the area from the first phase was randomly walked to attempt to locate NIS populations missed previously.

Table 1. Target species for 2010 inventory.

Species	Common Name	State Noxious Weed List
Acroptilon repens	Russian knapweed	MT, WY
Bromus inermis	Smooth brome	
Berteroa incana	Hoary alyssum	MT
Bromus tectorum	Cheatgrass	
Cardaria draba	Whitetop, hoary cress	MT, WY
Centaurea biebersteinii	Spotted knapweed	MT, WY
Centaurea diffusa	Diffuse knapweed	MT, WY
Cirsium arvense	Canada thistle	MT, WY
Cirsium vulgare	Bull thistle	
Convolvulus arvensis	Field bindweed	MT, WY
Cynoglossum officinale	Houndstongue	MT, WY
Elaeagnus angustifolia	Russian olive	
Euphorbia esula	Leafy spurge	MT, WY
Halogeton glomeratus	Halogeton	
Hypericum perforatum	St. Johnswort	MT, WY
Linaria dalmatica	Dalmatian toadflax	MT, WY
Poa bulbosa	Bulbous bluegrass	
Salsola tragus	Russian thistle	

We used two sampling approaches to inventory NIS. The primary method involved searching along parallel transects within the fenced boundary of LIBI (Figure 1). Along the road between the Custer Battlefield and the Reno-Benteen Battlefield we sampled by driving slowly down one side of the road and then the other, visually searching the area away from the road.

Transect widths of 30 m were used, based on the recommendation from the 2004 inventory. The 2004 inventory used 30 m, 40 m and 50 m wide transects, and found 30 m widths to provide best coverage while maximizing mapping speed and efficiency in the mixed-grass prairie ecotype.

When inventorying along transects, the mapping crew spread out 30 m from each other and followed previously delineated transect lines that were parallel to the LIBI boundary (in the Custer Battlefield transects were northwest-southeast and in the Reno-Benteen Battlefield they were north-south). Crew members used the coordinate display window on the GPS receiver to navigate along the transect. Mappers moved along the midpoint of the transect, visually searching a 15 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 record a "start" point for the patch in the GPS, and then continue walking along the transect. A patch "end" point was created when the population clearly ended. In the case of species with patchy but widespread distribution (primarily the grasses bulbous bluegrass (P*oa bulbosa*), downy brome or cheatgrass (*Bromus tectorum*) and smooth brome (*Bromus inermis*), it was often difficult to distinguish where one population ended and another began. For all species except *B. tectorum*, we considered plants to be within a single population if they were not separated by more than 10 m. In the case of *B. tectorum*, which was even more widespread than the other species, the rule was set as 30 m.

B. tectorum was only mapped in approximately one sixth (the northeast section) of the Custer Battlefield. Because of the widespread distribution of this species, and the significant delays it was causing in the inventory, MSU and LIBI agreed to stop collecting data for it. However, we did collect enough data to model the distribution of *B. tectorum* across LIBI as discussed in the GIS Data Analysis section below.

When mapping a point, the mapper stood in the approximate center of the patch and logged positions (X, Y coordinates) with the GPS receiver. Generally, 30 or more positions were logged. The GPS software averaged these positions to create a single point feature.

GPS mapping protocol

Weed infestation location and attributes were recorded with mapping grade GPS receivers equipped with Trimble TerraSync™ software. We used Trimble's GeoExplorer XT and GeoExplorer XH receivers, which have a manufacturer specified accuracy of 50 cm (XT unit) and10 cm – 30 cm (XH unit). All data were differentially corrected with GPS Pathfinder Office (v. 4.20) and exported to ArcGIS for analysis.

Trimble TerraSync™ allows the user to set the unit for maximum productivity or maximum precision (or a range in between). Setting for high precision requires more satellites that are higher above the horizon to minimize the signal to noise ratio. High productivity allows mapping with fewer satellites and a higher signal to noise ratio. During the inventory, all units were set to maximum productivity. This meant a signal to noise ratio of 33, satellites as low as 5 degrees above the horizon and a maximum position dilution of precision (PDOP) of 20. Some field precision may have been lost with this setting, but post processing of the data assured that all points were within an accuracy of less than 1 m.

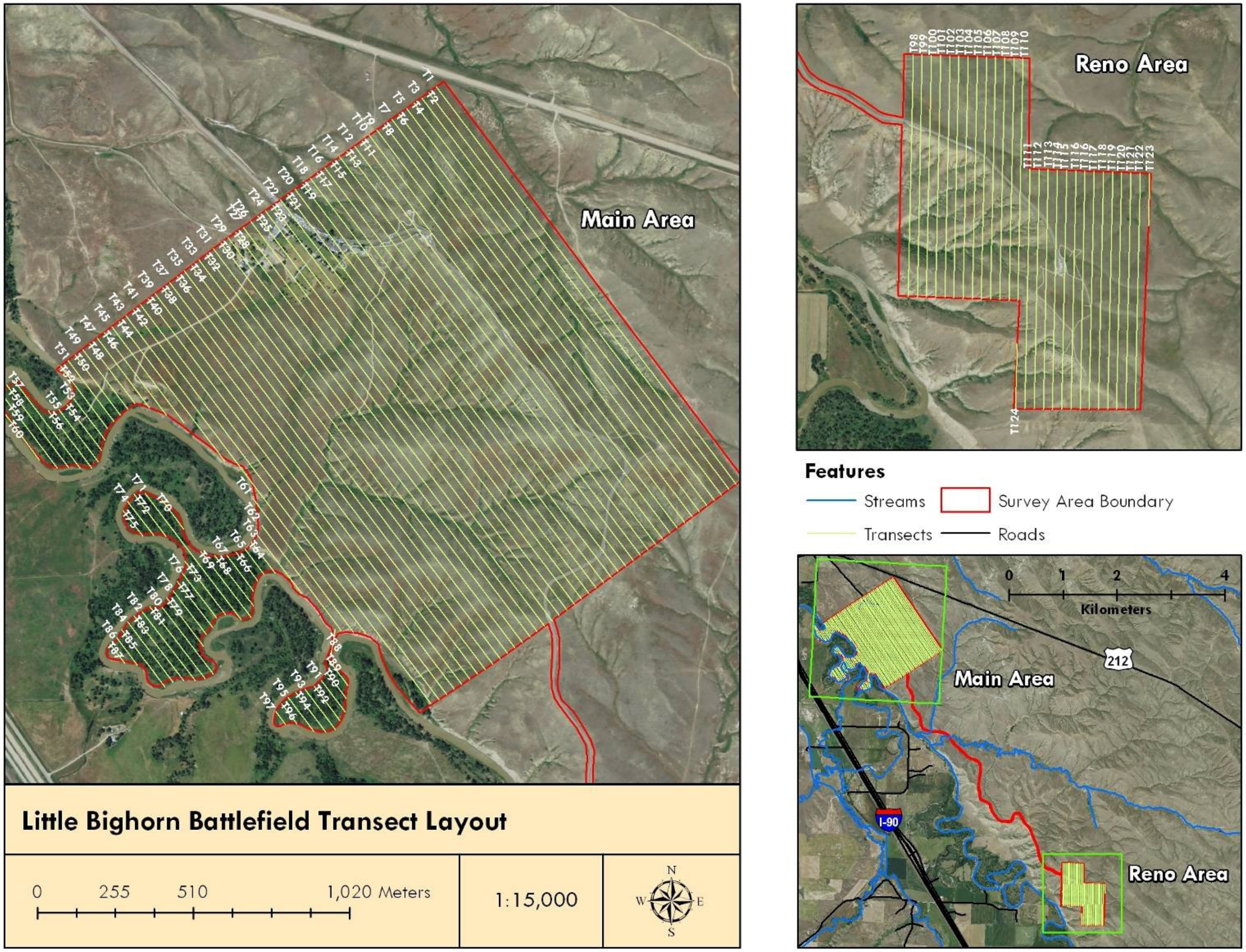

Figure 1. Transects for 2010 inventory.

Metrics collected

MSU utilized minimum mapping standards established by the North American Weed Management Association (NAWMA 2002, http://www.nawma.org/Mapping/MappingMain.pdf). We used a data dictionary similar to what was used in 2004. The data dictionary served as an interface for collecting non-indigenous plant attributes efficiently and accurately. Spatial data were exported to ArcGIS in shapefile format.

Field data elements

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

Species – A list of target species was provided by LIBI. Currently accepted scientific names were recorded.

Canopy Cover – Mappers visually estimated the percent canopy cover of the non-indigenous plant patch assigning a whole number from 1 – 100. A mapper envisioned a perimeter around the non-indigenous plant patch and estimated the percent of ground covered by the vertical projection of the non-indigenous 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.

Density – The density (number of plant stems per square meter) of individual plants in the entire population was estimated and recorded as the following classes: 0, 1-11, 12-32, 33-100, 101-316, 317-1,000 and > 1,000.

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

Distribution – The spatial distribution or spatial pattern of the infestation. Descriptions of the values follow in Table 2.

Community – Mappers recorded the plant community as shrub, grassland, riparian or other.

Table 2. Distribution categories.

Distribution value	Description
Scattered	Individual or small clusters of weeds thinly scattered with no apparent spatial pattern
Discrete patches	Weeds growing in distinct clusters separated by weed free areas within the larger area considered to be the patch
Interconnected patch	Weeds essentially growing in a monoculture with a very distinct edge

Disturbance – Mappers identified the disturbance factor with the greatest apparent impact on the area infested by the non-indigenous plants (Table 3).

Table 3. Disturbance factors.

Disturbance Factor	Comment
Animal disturbance	Impacts from animal life including insects
River	Impacts from flooding of Little Bighorn River.
Road	Road and roadside impacts such as ditches
Trail	Hiking trails
Wind/erosion	Erosion other than that from river
Other	Any other type of disturbance
None apparent	

Notes – Mappers recorded any relevant notes concerning the weed infestation in the notes field.

GIS Data Analysis

Field data required considerable post processing in ArcGIS (v. 9.3), a geographic information system (GIS). The GIS was used to calculate areas for all populations marked with single points based on the estimated values of population length and width. For populations marked by start and end points, GIS was also used to join these start and end points along transects to create rectangles based on the estimated population widths. For all target species (except *B. tectorum*) the total area infested by the species was calculated by summing all of the individual rectangle areas for the species. For *B. tectorum*, which was not mapped throughout the entire area, a predictive model of its distribution was created in a GIS. The model used logistic regression of confirmed presence and absence points in the inventoried area to determine the relationship of these points with landscape factors including elevation, slope and aspect to predict where *B. tectorum* would occur throughout the rest of the area. Distance to roads, trails or water were not significant in the model. A predictive map was generated depicting the probability of occurrence for *B. tectorum* at LIBI.

The following is a list of additional GIS data elements for LIBI.

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 as a rectangle using the estimated length and width values.

Acres – Calculated in the GIS by dividing area (m^2) by 4,047 m^2 (square meters per acre).

Elevation – Embedded in GPS data and included with DEM file.

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

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. LIBI data are in UTM zone 13N.

Potential Sources of Error

The largest potential source of error in any survey or inventory project is failing to identify existing populations. This error can be reduced by limiting the search distance on either side of the transect midpoint. The MSU crew performing the inventory has found that searching 5 m each side of the transect midpoint is effective in most grassland and forested areas. The crew that performed the 2004 inventory, however, found that in the open grasslands of LIBI, a 15 m swath on each side of the transect midpoint was effective. While wider transects allow areas to be covered more rapidly, populations will inevitably be missed when searching such a wide swath. The error of missed populations cannot be accounted for when processing the data, other than to assume a percentage of populations missed and the sizes of these populations. We did not do this for this report.

Another way to avoid missing existing NIS populations is to perform the inventory during the peak flowering period for the target species, as this facilitates sighting of populations. The 2004 inventory was conducted in mid-July, while the 2010 inventory was conducted in early and late June. Early June 2010 was prior to the flowering of most target species which did not begin flowering until later in the month and some populations were likely missed because of this.

Two other sources of error that can easily be estimated are instrument error and user error. Trimble states the GeoExplorer XT and GeoExplorer XH receivers have accuracies of 50 cm and 10 cm – 30 cm, respectively under optimal conditions with post-processed differential correction. These potential errors are very low and insignificant when compared with user error. The biggest source of user error was most likely incurred when estimating size (length and width) of the non-indigenous plant patch. To reflect these potential inaccuracies we provide a 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. Therefore, we accounted for potential error by calculating a low and high acreage for each NIS. Low and high area estimates were calculated as simply -/+ 10 % of the original calculated values.

Results

Acres infested with non-indigenous plant species

We inventoried approximately 802 acres at LIBI, including the Custer Battlefield, the Reno-Benteen Battlefield and the right-of-way along the Tour Road connecting the two battlefields. We calculated the cumulative 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). We also 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). Without *B. tectorum*, the cumulative and total infested areas are 86.0 and 68.46 acres, respectively. Including the predictive model results of *B. tectorum*, the cumulative and total infested areas are 462.3 and 444.7 acres, respectively. Table 4 shows these results (including *B. tectorum*), the uninfested area, as well as low and high area estimates. While this table shows some area of the park as uninfested, this is for target species only and does not include NIS such as *Bromus japonicus*, *Melilotus officinalis* and *Tragopogon dubius* which were widespread. We did not find any significant areas within the park that were completely free of NIS.

Table 4. Area inventoried, infested, and uninfested (includes *B. tectorum*).

	Estimated Acres	Estimated Acres Low	Estimated Acres High
Inventory Area	802.4		
Cumulative Infested Area	462.3	416.1	508.6
Total Infested Area	447.7	402.9	492.5
Uninfested Area	354.7	399.5	309.9

Non-indigenous plant species composition at LIBI

Of the 18 target NIS on the search list (Table 1), we found 14 during the inventory (Figures 2 and 3; Table 5). Other NIS encountered which were not on the list included *M. officinalis*, *B. japonicus*, *T. dubius* and sulfur cinquefoil (*Potentilla recta*). *M. officinalis* and *B. japonicus* were widespread throughout LIBI as reported in the 2004 inventory results. *P. recta* was found at two locations along the Tour Road. Details for each target NIS encountered follow.

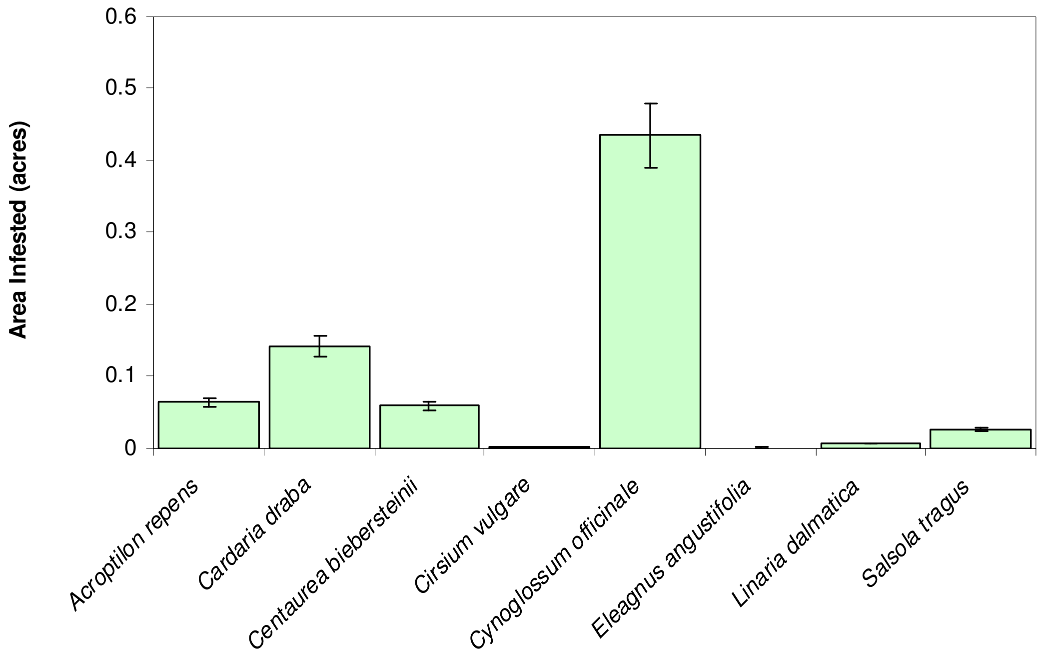

Figure 2. NIS composition of inventory area with accuracy of estimates shown as error bars.

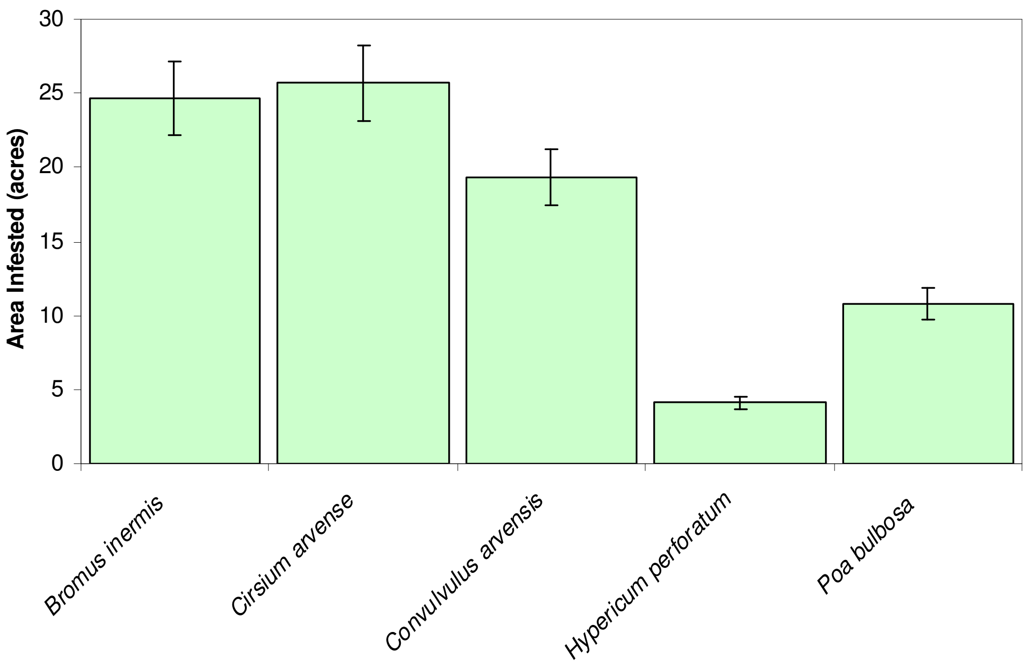

Figure 3. NIS composition of inventory area continued. Note change in Y-axis range. *B. tectorum* infested area not shown because this species was not mapped throughout the entire inventory area. It is predicted to occupy an area of 376.3 acres.

Table 5. Non-indigenous plant composition of inventory area.

Species	Estimated Acres	Estimated Acres Low	Estimated Acres High
Acroptilon repens	0.064	0.0576	0.0704
Berteroa incana	0.0	0.0	0.0
Bromus inermis	24.69	22.221	27.159
Bromus tectorum	376.3	338.67	413.93
Cardaria draba	0.143	0.1287	0.1573
Centaurea biebersteinii	0.060	0.054	0.066
Cirsium arvense	25.7	23.13	28.27
Cirsium vulgare	0.003	0.0027	0.0033
Convulvulus arvensis	19.31	17.379	21.241
Cynoglossum officinale	0.435	0.3915	0.4785
Eleagnus angustifolia	0.0012	0.00108	0.00132
Hypericum perforatum	4.10	3.69	4.51
Linaria dalmatica	0.0069	0.00621	0.00759
Poa bulbosa	10.745	9.6705	11.8195
Salsola tragus	0.027	0.0243	0.0297
SUM	**85.285**	**76.757**	**93.814**

RUSSIAN KNAPWEED (*Acroptilon repens*)

A. repens was mapped in one area in the western corner of the Custer Battlefield (Figure 4). It occupied 0.06 acres and had a cover of 1 % and density of <1 stem m^{-2}. This is similar to the amount mapped in 2004, but the locations within the park are different.

HOARY ALYSSUM (*Berteroa incana*)

B. incana was not identified during this inventory, although it has been noted to be present at LIBI. We likely did not find it during this inventory because of its very limited distribution within LIBI.

SMOOTH BROME (*Bromus inermis*)

B. inermis, which was not mapped in 2004, was prevalent throughout both park units with 329 populations mapped (Figure 5). The total acerage infested was between 22.2 and 27.2. The mean population size was 0.08 acres, the mean cover was 31 %, and the mean density was 33-100 stem m^{-2}.

CHEATGRASS (*Bromus tectorum*)

B. tectorum was distributed widely throughout LIBI. After half of one day of mapping it was necessary to cease mapping the species because of the extensive time required. We used the data obtained to develop a predictive map of *B. tectorum* distribution (Figure 6). This figure shows areas (totaling 376.3 acres) where *B. tectorum* has a 0.4 probability (i.e., 40% chance) of occurring. This figure is not intended to imply that *B. tectorum* will occupy all of the area shown. Rather, it may occur throughout the area in very patchy distribution. Most of the populations we observed were small (less than 5 m^2) but very dense (several hundred stems m^{-2}).

It is interesting to note that the 2004 inventory found only 15 populations of the species for a total coverage of less than one acre. The report also states, "In 1983, a fire killed a significant portion of the sagebrush throughout the park and resulted in increased establishment of non-indigenous grasses, particularly cheatgrass (*Bromus tectorum*)...There were extensive infestations of Japanese brome (*Bromus japonicus*) at Little Bighorn..." (Wood and Rew 2005). *B. japonicus* was not mapped in 2004 or 2010, however extensive populations were observed in 2010 as well.

WHITETOP (*Cardaria draba*)

We mapped one population of *C. draba* along the Tour Road (Figure 7). This 0.14 acre population, which was also recorded in 2004, had cover of 1 % and density of 1-11 stems m^{-2}. It should be noted that it had previously been treated with herbicide.

SPOTTED KNAPWEED (*Centaurea biebersteinii*)

We found only three populations of *C. biebersteinii* (Figure 8) with a mean patch size of 0.02 acres, and a total acreage infested of <0.1 acres. The mean percent cover was 21 % and the mean density was 1-11 stems m^{-2}. In 2004, populations were found along the Tour Road, but these populations were not identified in this inventory and had likely been treated with herbicide.

CANADA THISTLE (*Cirsium arvense*)

We found *C. arvense* in the same general locations as the 2004 inventory. In addition we mapped extensive populations in the riparian area which was not inventoried in 2004. In total we found 105 populations of *C. arvense* located mostly around developed areas, in ravines and throughout the riparian area (Figure 9). The rectangular patches shown in Figure 9 are an artifact of sampling along transects. Additionally, the extremely dense vegetation in the riparian area made sampling difficult, and accurately mapping all *C. arvense* populations along 30 meter wide transects was not possible. It could be assumed that the entire riparian area is patchily occupied by *C. arvense*, and the entire area could be shown as occupied. Representing the data as such would cause the number of discrete patches to decline (as multiple patches are combined) and the area reported to be occupied by *C. arvense* to increase. This, however, over-represents the abundance of *C. arvense*. Therefore, while showing *C. arvense* populations as long rectangles presents an inaccurate view of its distribution, so too would showing the entire area as being invaded. For the southernmost oxbow, however, we did combine all polygons into a single population. We feel that this most accurately represents the *C. arvense* distribution in this area.

Populations were larger than those of other NIS with a mean size of 0.21 acres. The total area infested was between 23.1 and 28.3 acres. The mean cover and density were 7.4 % and 1-11 stems m^{-2}, respectively.

BULL THISTLE (*Cirsium vulgare*)

We found two small, dense infestations of bull thistle (Figure 10). These were in different locations than those mapped in 2004. The mean size was <0.01 acres, while the cover was 14.5 % and the density was 1-32 stems m^{-2}.

FIELD BINDWEED (*Convolvulus arvensis*)

As in 2004, *C. arvensis* was widespread in the western portion of the Custer Battlefield and was also present along the Tour Road and to a lesser extent in the Reno-Benteen Battlefield (Figure 11). A total of 166 populations were mapped and the mean size was 0.12 acres for a total of between 17.4 and 21.2 acres. The mean cover and density were 10 % and 1-11 stems m^{-2}, respectively.

HOUNDSTONGUE (*Cynoglossum officinale*)

Fifty-nine populations of *C. officinale* were mapped, primarily in the riparian area (Figure 12). The 2004 inventory also found numerous populations in the portion of the riparian area mapped at that time as well as four populations along the Tour Road. We did not identify the roadside populations, as these had likely been treated with herbicide. *C. officinale* tends to grow as individual, scattered plants, and the mean population size was <0.01 acres. Total acreage infested was between 0.4 and 0.5 acres. The mean cover and density were 8 % and 1-11 stems m^{-2}, respectively.

RUSSIAN OLIVE (*Elaeagnus angustfolia*)

E. angustifolia is not a designated noxious weed in Montana; however, it is a non-indigenous and potentially invasive tree that can impact native vegetation in riparian woodlands. Two populations were found along the Little Bighorn River (Figure 13). These populations were each <0.01 acres in size and had 100 % cover with a stem density of 1-11 stems m^{-2}.

HALOGETON (*Halogeton glomeratus*)

Although one population of *H. glomeratus* was detected in 2004, the species was not identified during this inventory. It is possible that we may have missed some populations due to differences in phenology. Our inventory was conducted earlier in the year, and this species matures later in the summer than most of the target NIS.

ST. JOHNSWORT (*Hypericum perforatum*)

We mapped 167 populations of *H. perforatum* at the Custer Battlefield (Figure 14). This is far more populations than what were mapped in 2004. No populations were identified along the Tour Road or in the Reno-Benteen Battlefield. The mean population size was 0.02 acres and the mean cover and density were 3 % and 1-11 stems m^{-2}, respectively. The total area infested was between 3.69 and 4.51 acres.

LIBI staff was particularly concerned with misidentification of St. Johnswort. To minimize error from misidentification of the species, park staff performed a ground truth survey in July of all St. Johnswort populations inventoried. All but 13 populations (8%) were relocated; however, it is unknown whether this 8% represents a false absence during the ground truth survey or a false positive during the June 2010 survey. Regardless, 8% falls within the mapping error of the survey.

DALMATIAN TOADFLAX (*Linaria dalmatica*)

We mapped seven *L. dalmatica* populations in the Custer Battlefield and eight in the Reno-Benteen Battlefield (Figure 15), compared to two populations mapped during the 2004 inventory. Populations were small with a mean size of <0.01 acre and a total area infested of <0.01 acres. The mean cover and density were 13 % and 1-11 stems m^{-2}, respectively.

YELLOW SWEETCLOVER (*Melilotus officinalis*)

Consistent with the findings of the 2004 inventory, *M. officinalis* was widespread throughout the entire park. However, this species was not on the target list for 2010 and was not mapped.

BULBOUS BLUEGRASS (*Poa bulbosa*)

P. bulbosa was very widespread in the northeastern portion of the Custer Battlefield and there were a few occurrences along the Tour Road and in the Reno-Benteen Battlefield (Figure 16). We mapped a total of 139 populations for a total acreage of between 9.7 and 11.8 acres. The mean population size density and cover were 0.08 acres, 4 % and 1-11 stems m^{-2}, respectively. We observed *P. bulbosa* to be widespread in the pasture across the northeast fence boundary, and it is apparently spreading into the Custer Battlefield from there. Although park staff reported seeing *P. bulbosa* on the bluffs and floodplain, the field crew did not detect it there. This is possibly because *P. bulbosa* had senesced and dispersed most of its seed, which made the species difficult to detect.

SULFUR CINQUEFOIL (*Potentilla recta*)

P. recta was not on the target NIS list, but it is a Priority 2B noxious weed in Montana. Two small populations were found along the Tour Road (Figure 17). The mean population size was <0.01 acres and the mean cover and density were 10 % and 1-32 stems m^{-2}, respectively.

RUSSIAN THISTLE (*Salsola tragus*)

Nine small populations of *S. tragus* were mapped in the western portion of the Custer Battlefield (Figure 18). Far more populations were detected in 2004. We may have missed some populations due to differences in phenology as our inventory was conducted earlier in the year, and this species matures later in the summer than most of the target NIS. The mean population size was <0.01 acres and the mean cover and density were 7% and 1-11 stems m^{-2}. The total area infested was < 0.03 acres.

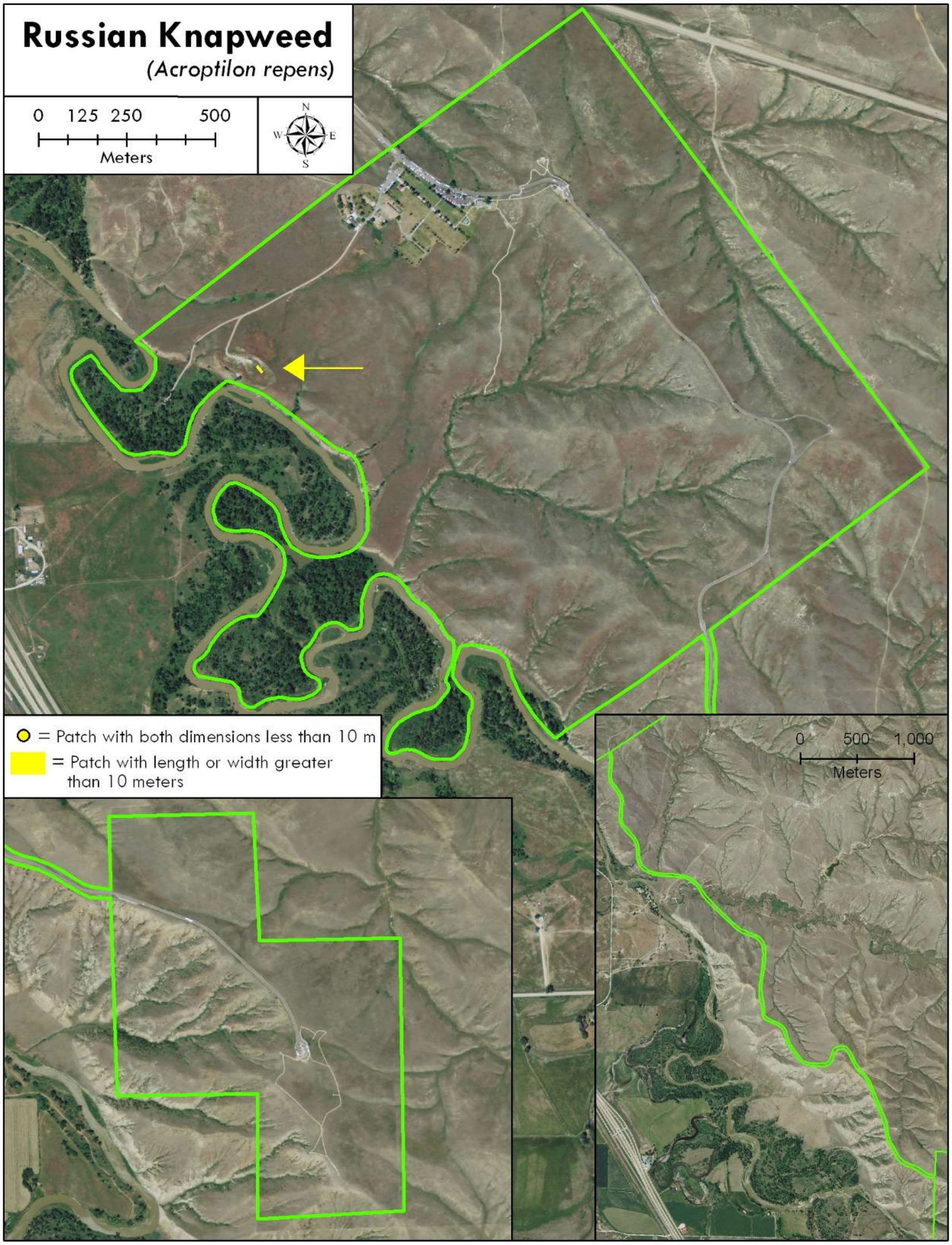

Figure 5. Map of Russian knapweed distribution in LIBI.

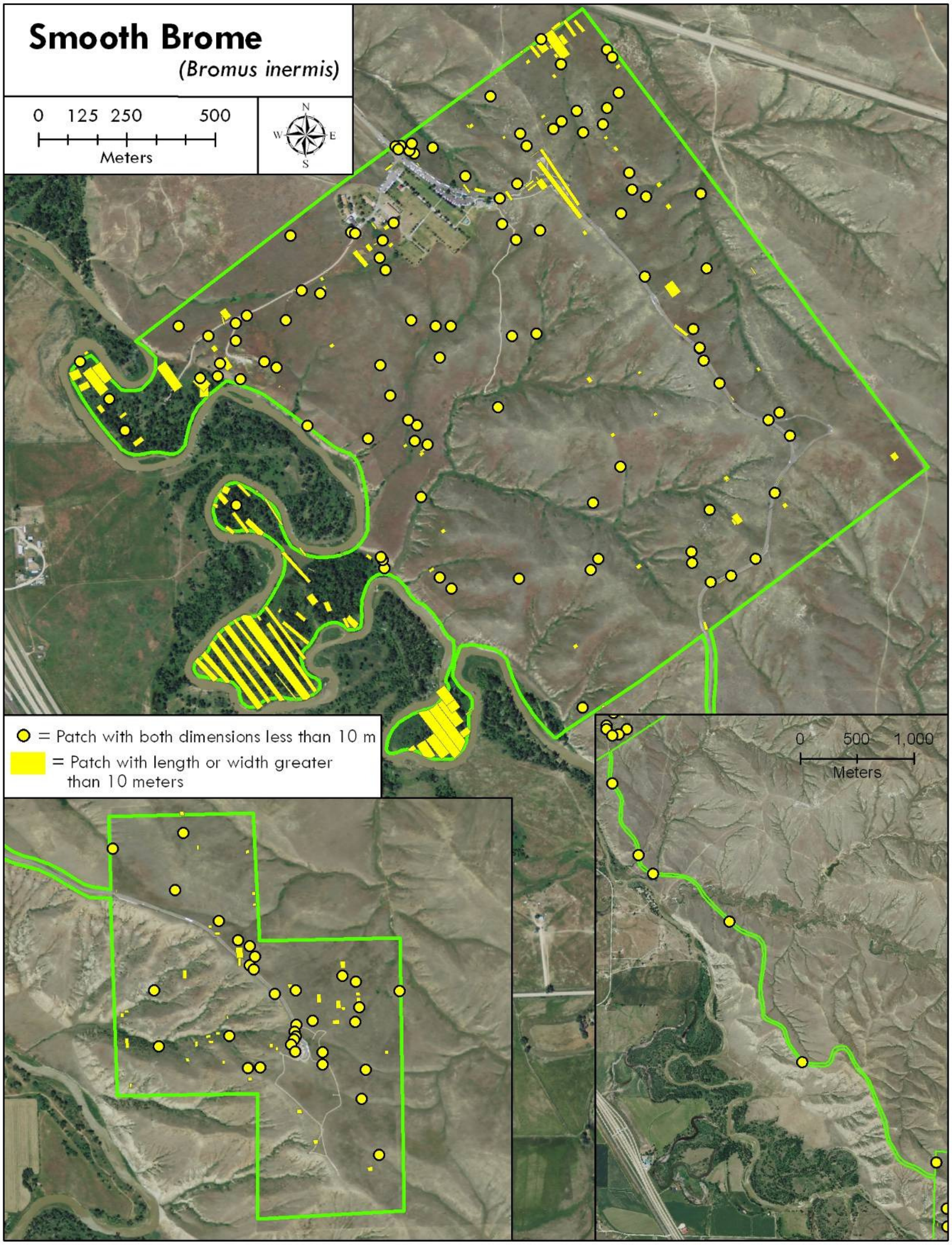

Figure 5. Map of smooth brome distribution in LIBI.

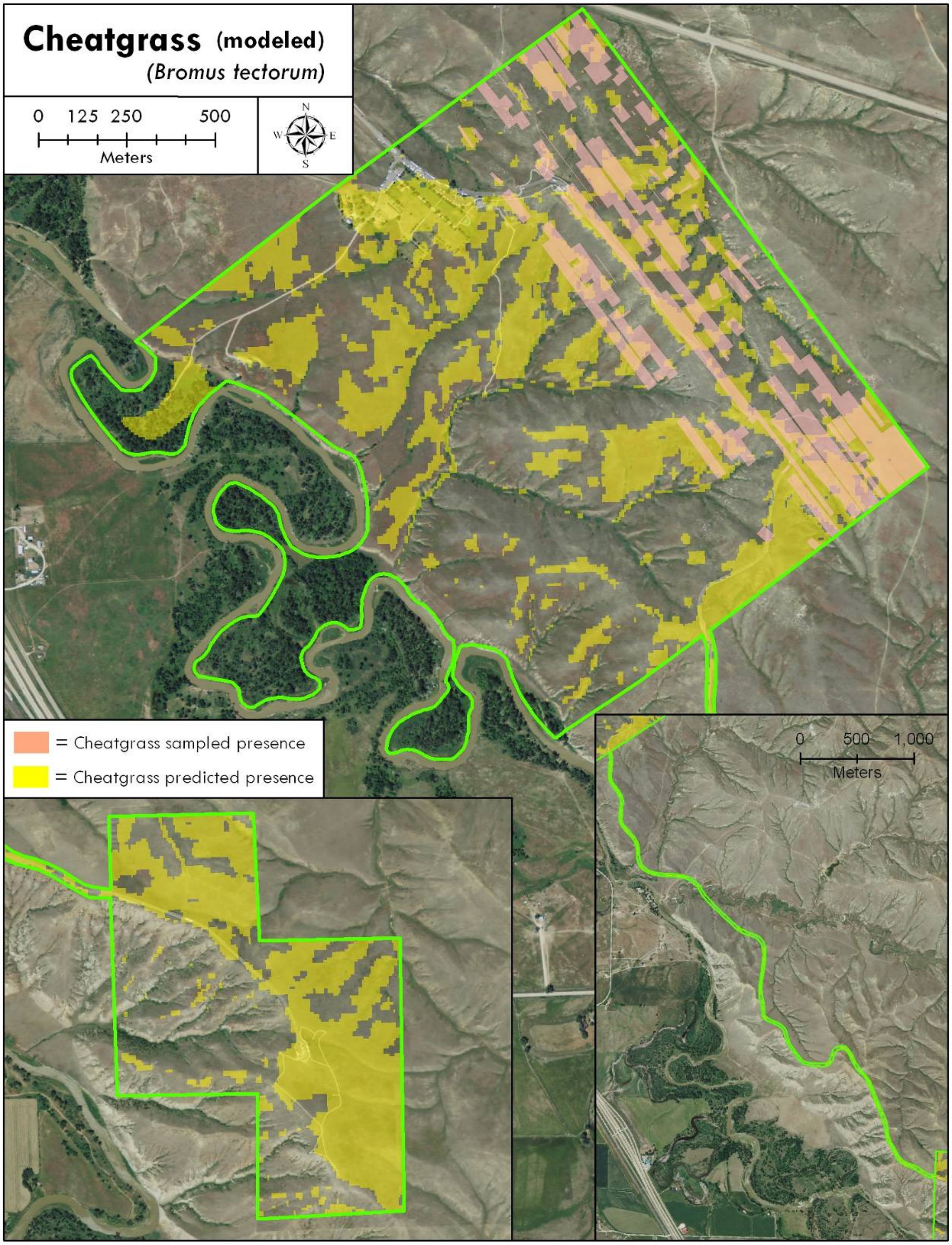

Figure 6. Mapped and predictive distribution of cheatgrass in LIBI.

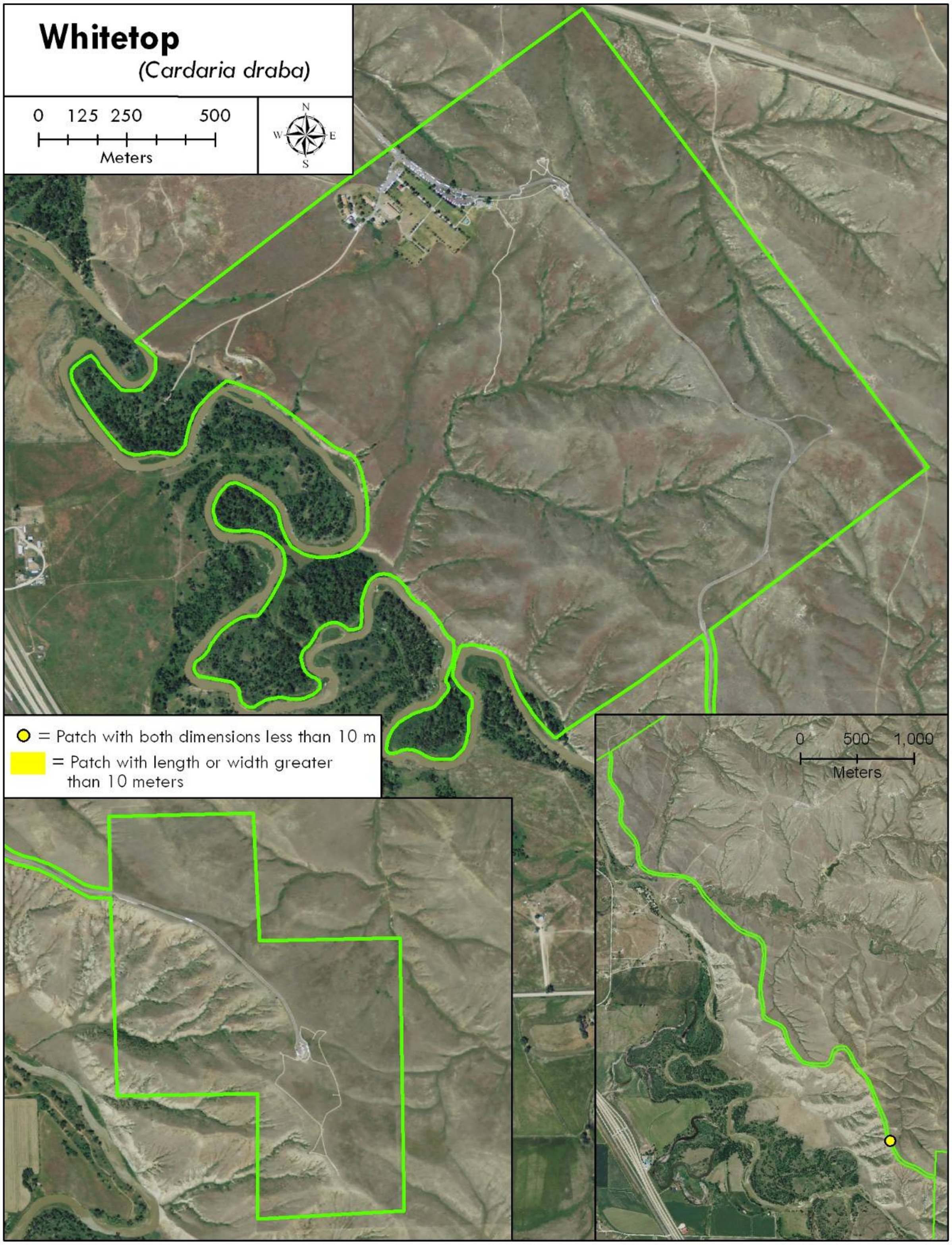

Figure 7. Map of whitetop distribution in LIBI.

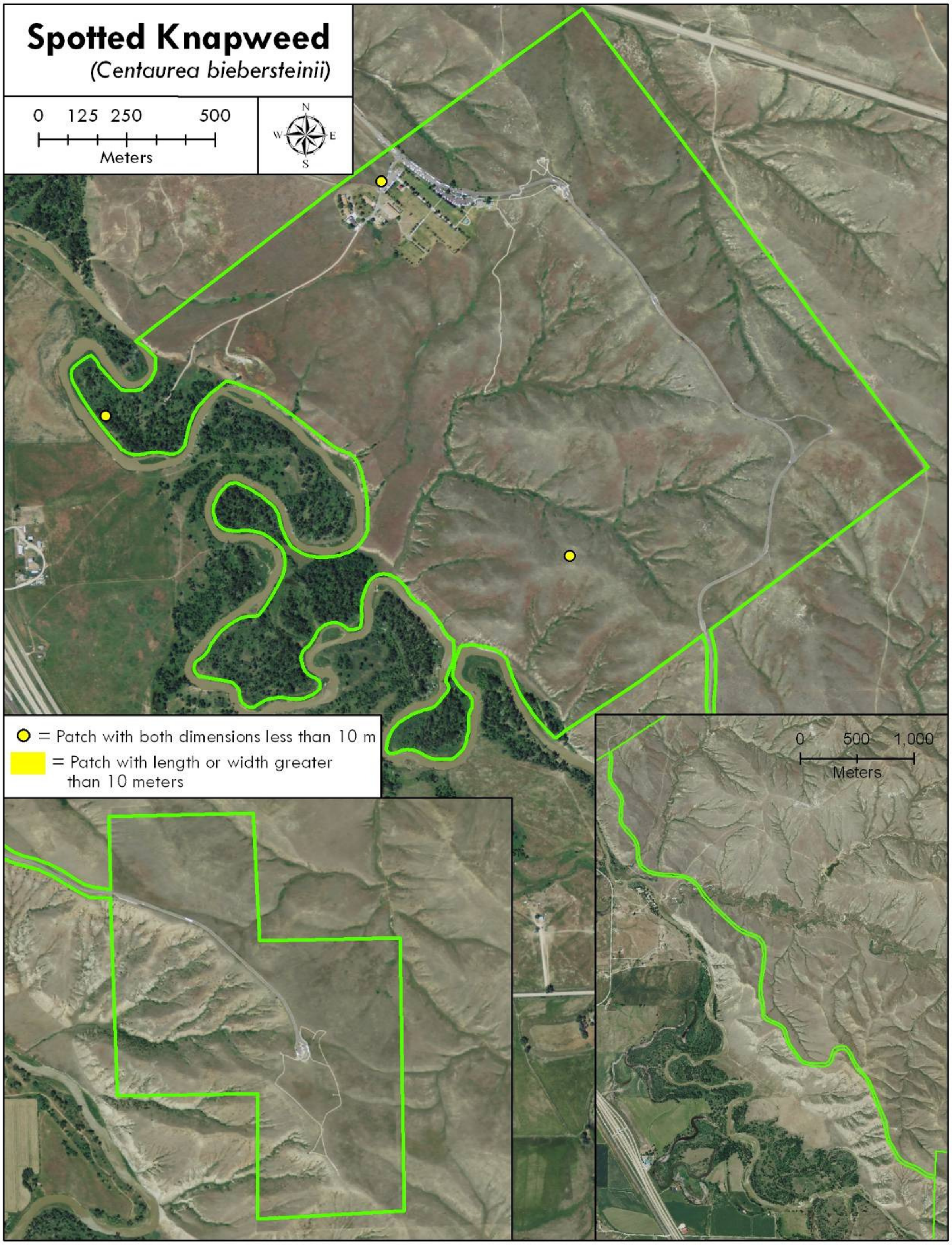

Figure 8. Map of spotted knapweed distribution in LIBI.

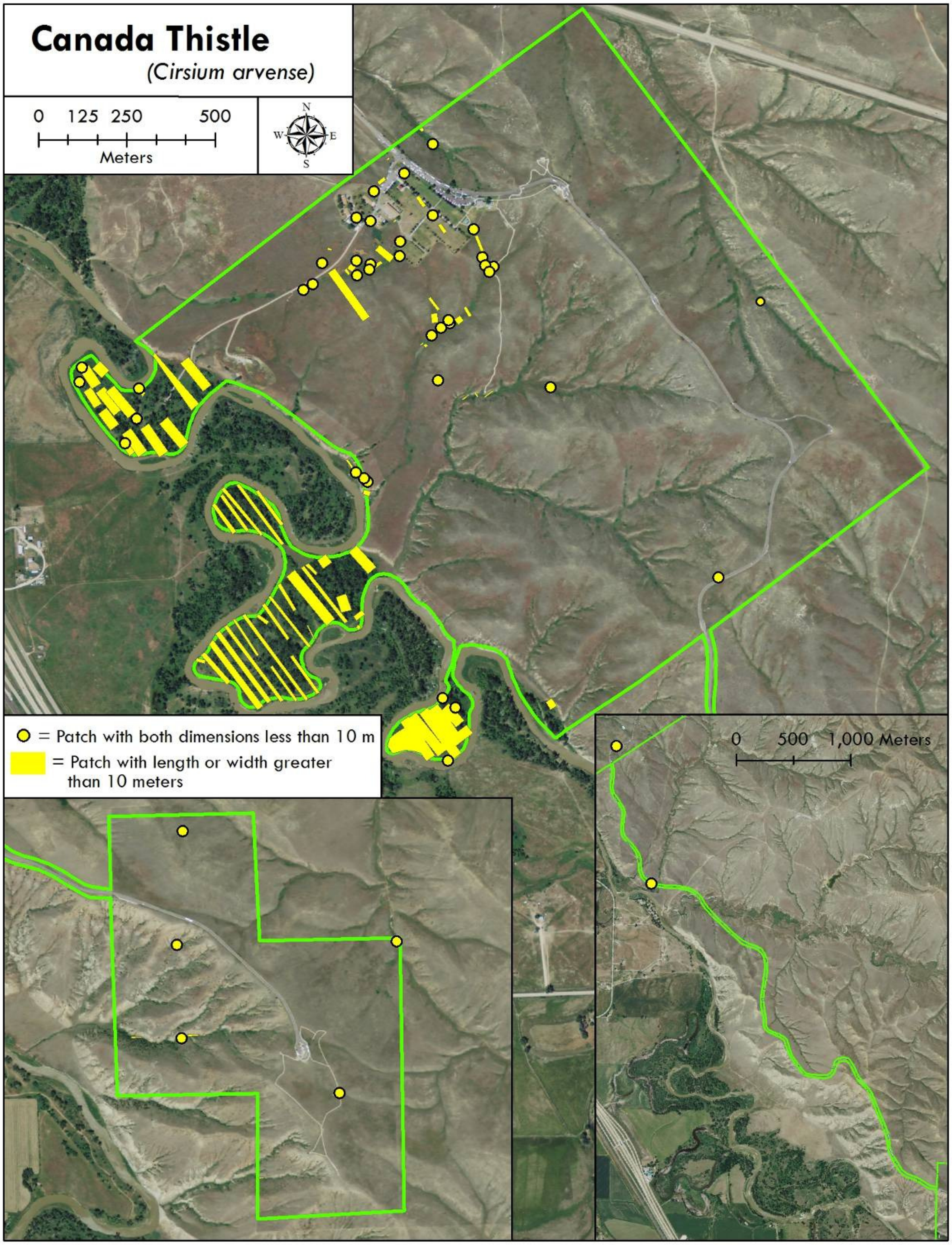

Figure 9. Map of Canada thistle distribution in LIBI.

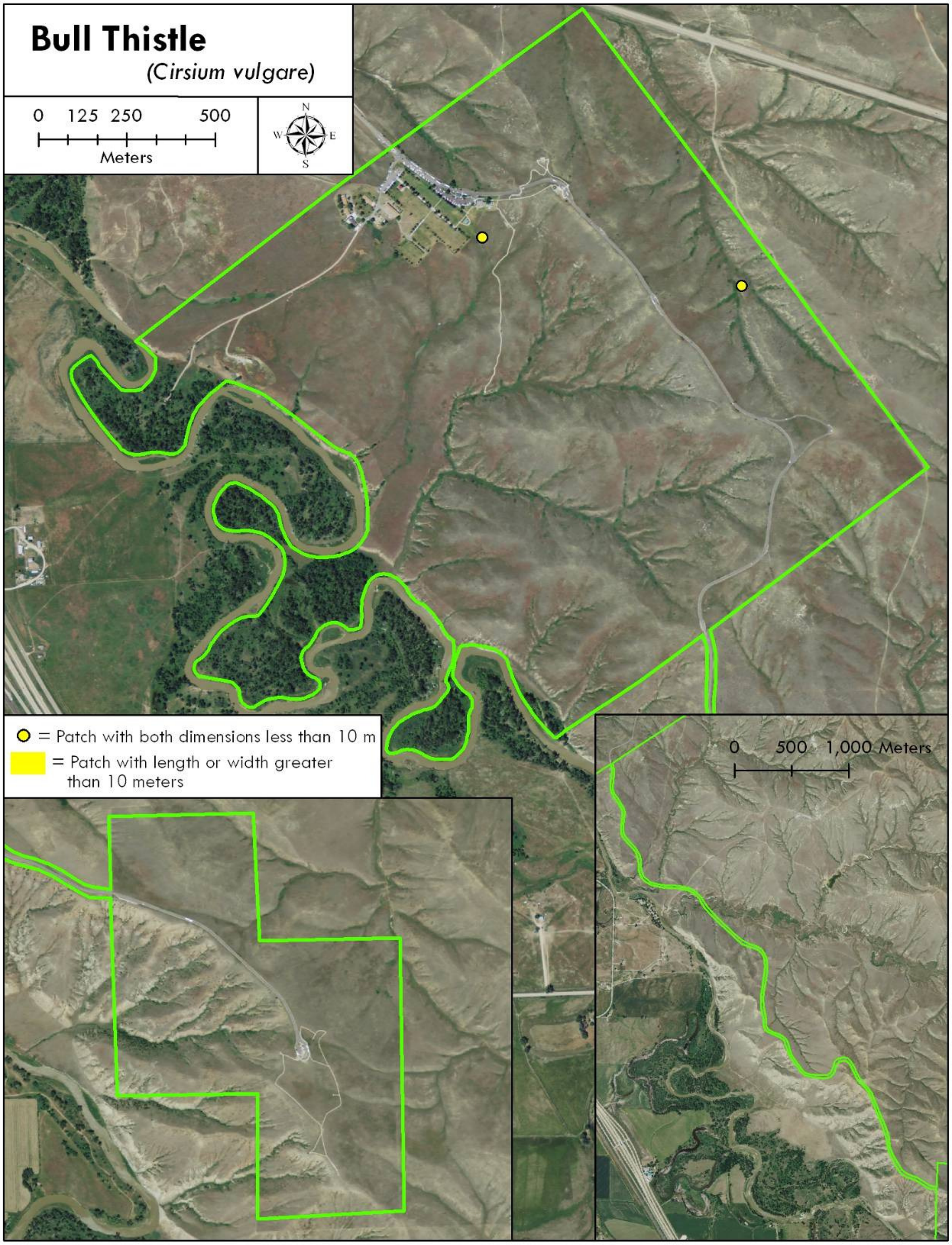

Figure 10. Map of bull thistle distribution in LIBI.

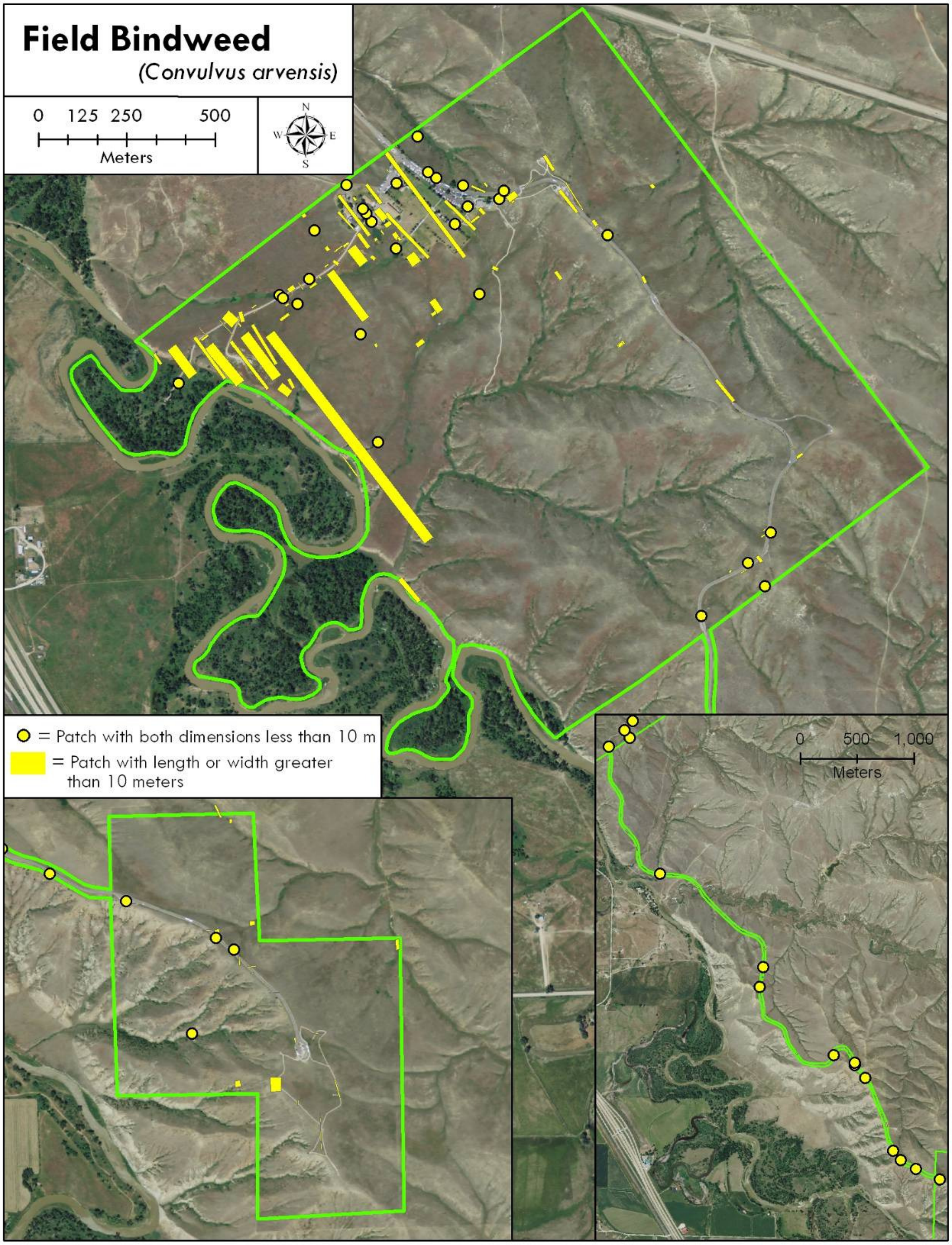

Figure 11. Map of field bindweed distribution in LIBI.

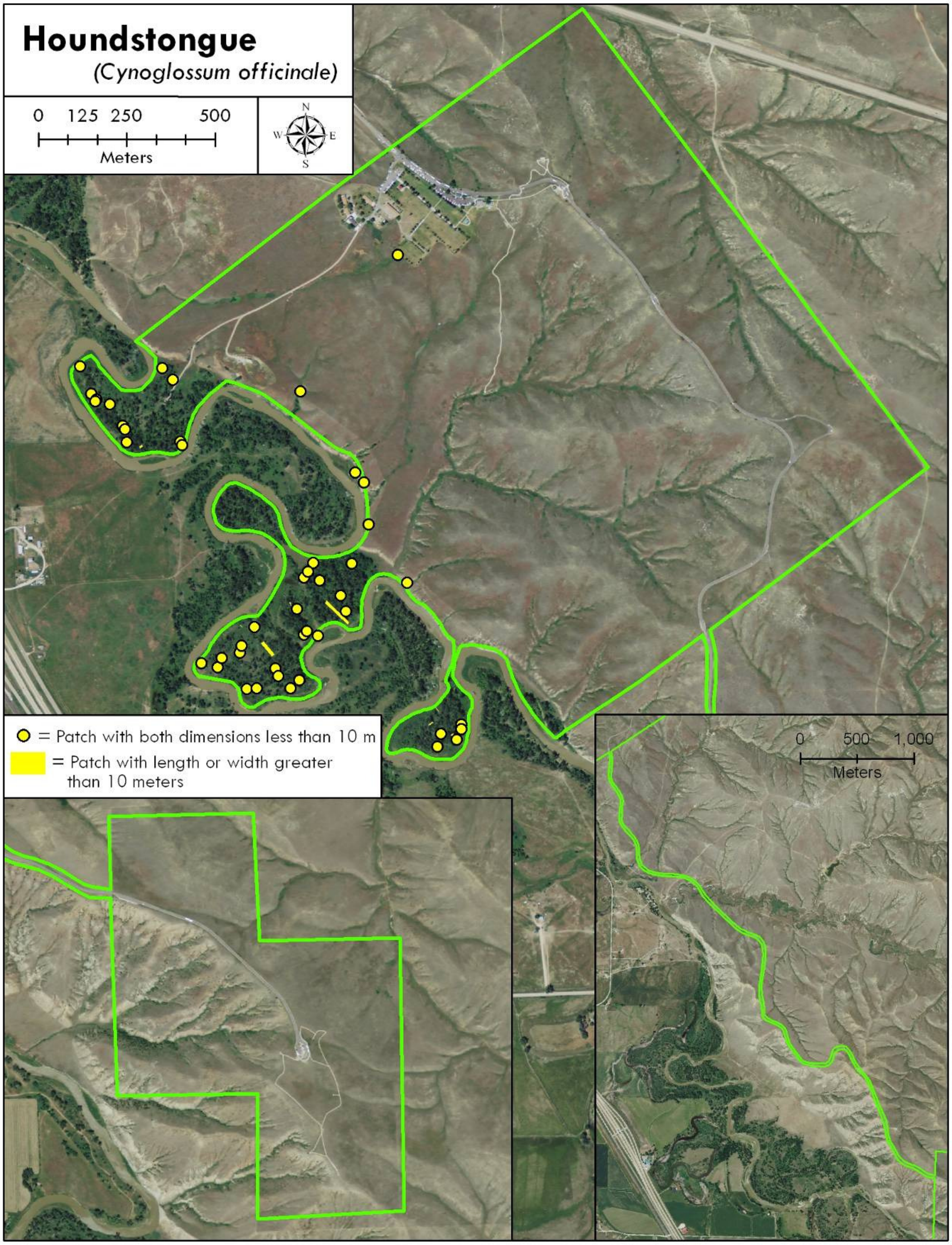

Figure 12. Map of houndstongue distribution in LIBI.

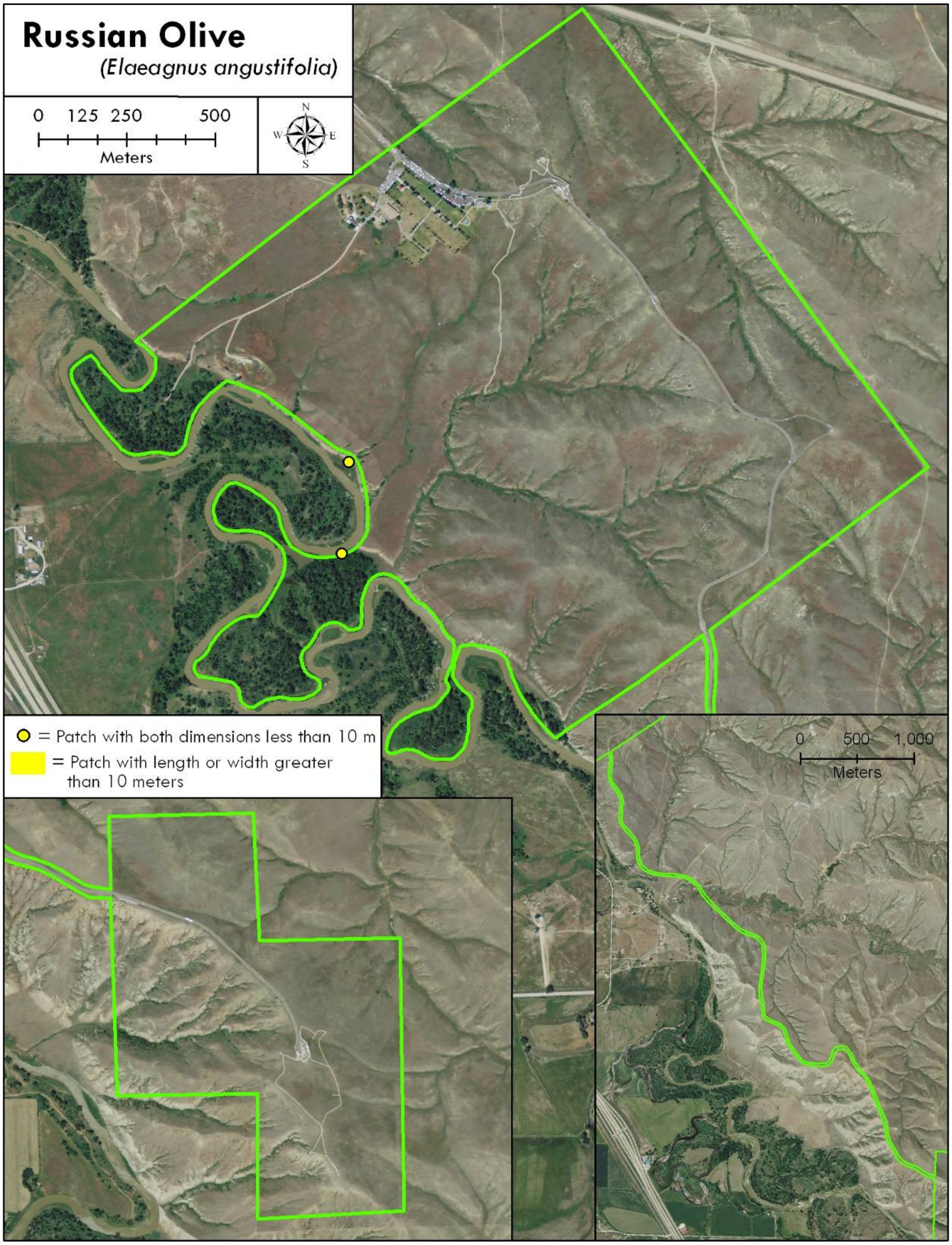

Figure 13. Map of Russian olive distribution in LIBI.

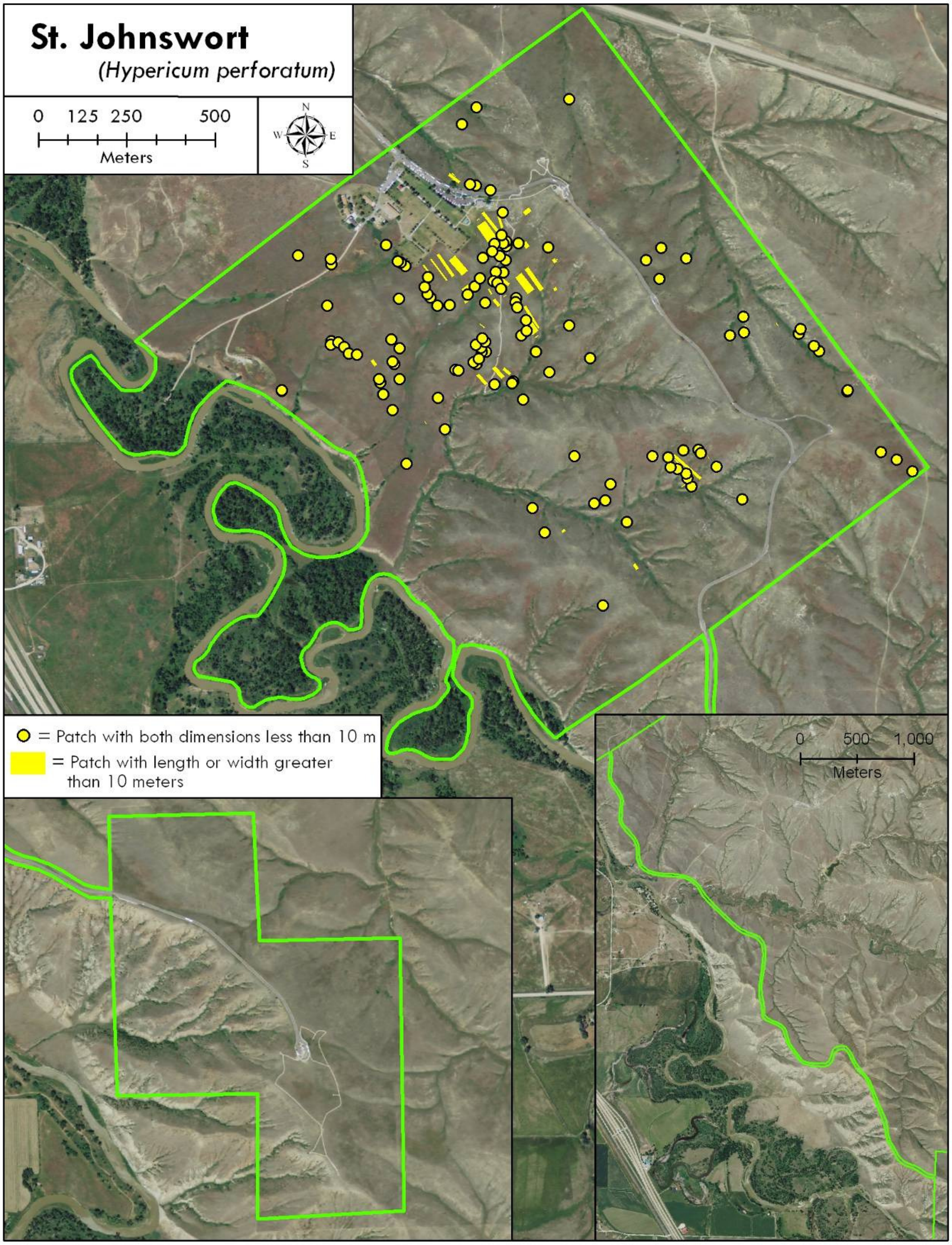

Figure 14. Map of St. Johnswort distribution in LIBI.

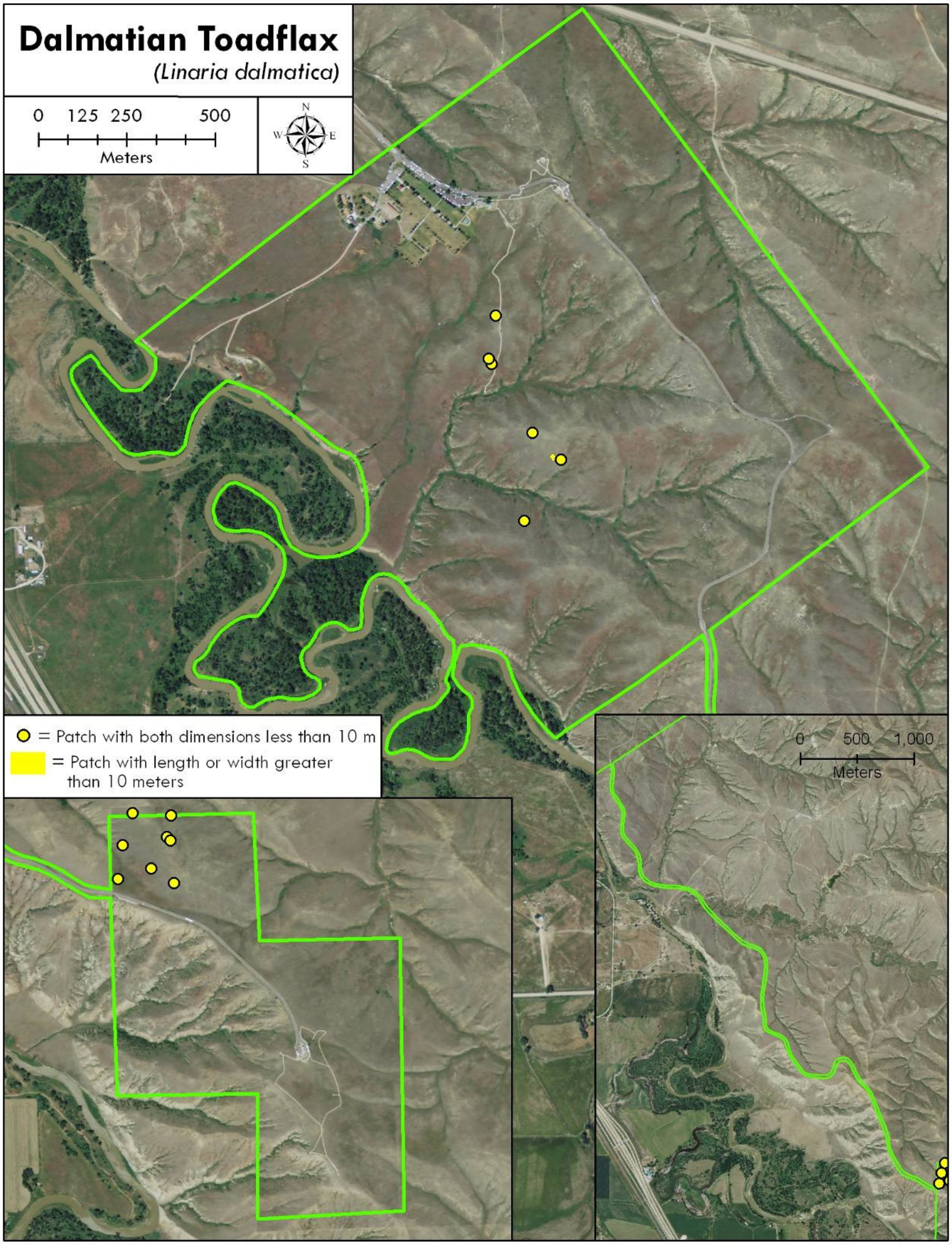

Figure 15. Map of Dalmatian toadflax distribution in LIBI.

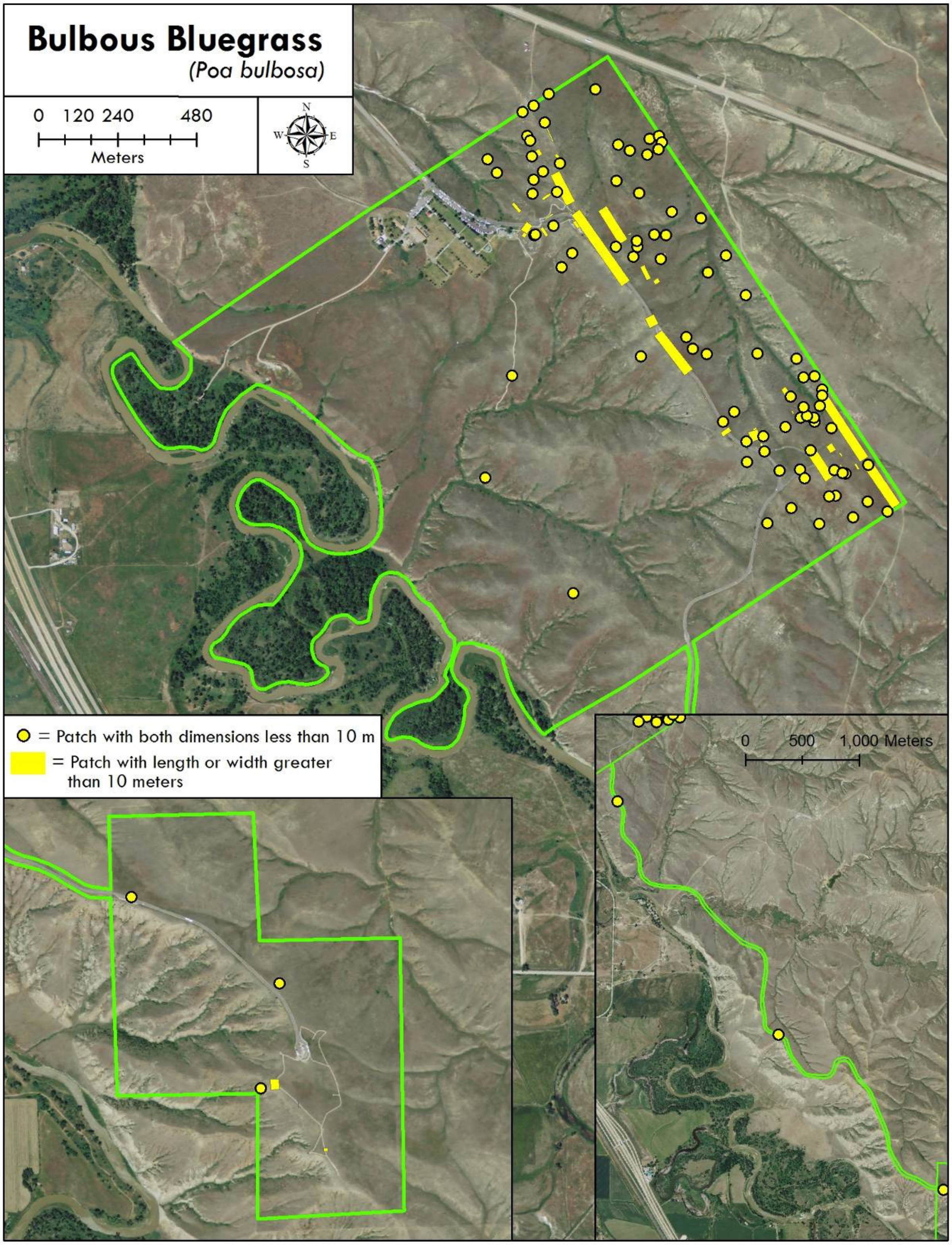

Figure16. Map of bulbous bluegrass distribution in LIBI.

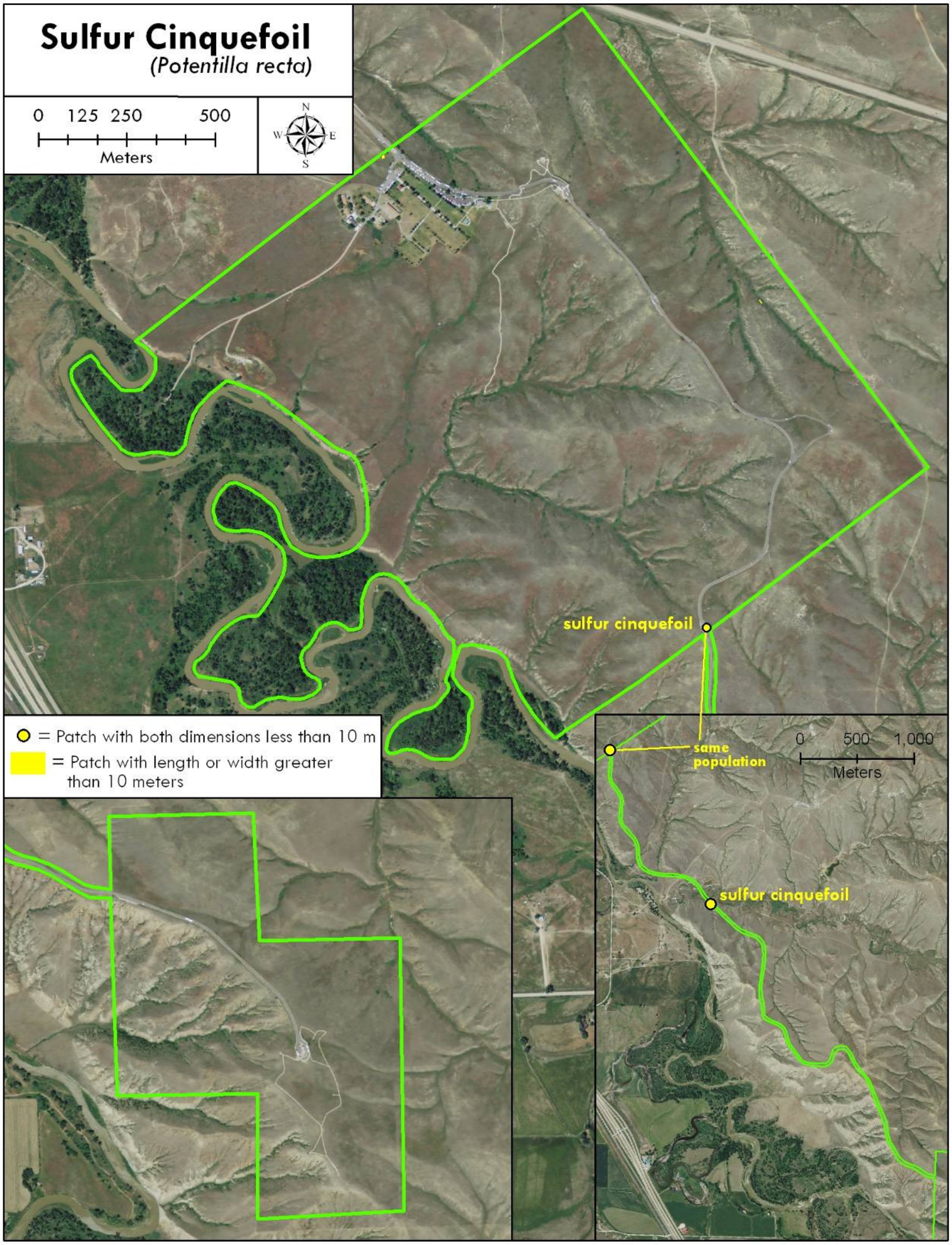

Figure 17. Map of sulfur cinquefoil distribution in LIBI.

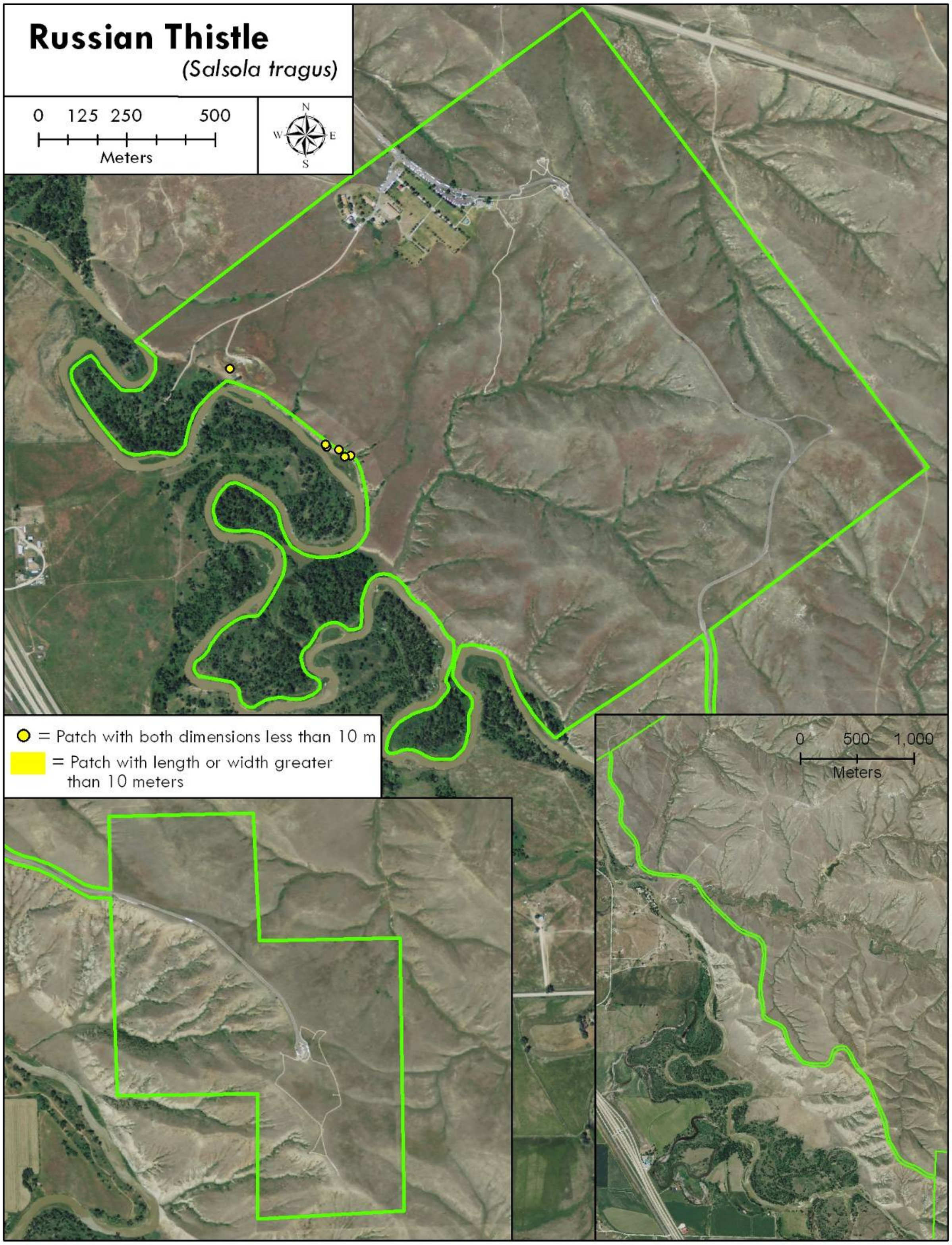

Figure 18. Map of Russian thistle distribution in LIBI.

Conclusion and Recommendations

Assuming that inventory methodology and detection accuracy did not differ between the 2004 and 2010 inventories, it appears that many species have increased their distribution at LIBI considerably. This is especially true for *B. tectorum* and *H. perforatum*, despite aggressive treatment in the case of the latter. *L. dalmatica* has also increased, but not to the extent of the aforementioned two species. *C. arvense* (Canada thistle) also appears to have increased its distribution in the Custer Battlefield, and densely occupies the riparian area; however, the 2004 inventory did not cover most of the riparian area so we do not know if it has increased here. The NIS grasses *P. bulbosa* and *B. inermis* have invaded much of the park, but these species also were not mapped in 2004 so change in their distribution is unknown. The only species that appears to have decreased in distribution is *S. tragus*; however, populations of this species may not have been identified during the inventory because of its phenology.

Most national parks or monuments have limited resources for managing NIS. Therefore, it is necessary to make informed decisions about which species, or individual populations of species, to manage. We believe that some species do not merit management, primarily because the lack of effective control measures and the extensive distribution make control infeasible. Specifically, the grass species *B. tectorum*, *B. japonicus* (which is widespread but was not mapped), *B. inermis* and *P. bulbosa* and the forbs *C. arvensis* (field bindweed) and *M. officinalis* (also not mapped in 2010) are extensive throughout the park and it is highly unlikely that effective control can be achieved. We believe that other species should be managed only in certain areas. *C. arvense* (Canada thistle) and *C. officinale* are widespread throughout the riparian area, and their control in this area would be extremely difficult and expensive. Control of these species outside of the riparian area, however, may be possible. Specifically, *C. officinale* was only mapped in a few places outside of the riparian area, and control in these areas is quite feasible and could slow the spread of the species outside of the riparian area. Likewise, the distribution of *A. repens*, *C. draba*, *C. biebersteinii*, *C. vulgare*, *E. angustifilia*, *L. dalmatica* and *S. tragus* is still relatively limited, and there is a greater likelihood for successful control. *H. perforatum* is widespread, and treatment success on the populations being treated since 1999 is unknown.

In addition to managing populations of NIS, population monitoring is important. Monitoring helps determine which specific populations are most invasive and having ecological impacts. For populations being treated, monitoring to determine treatment efficacy provides feedback to improve future management. The monitoring recommendations and resources presented in the 2004 report are still considered valid and are not repeated here. A few additional resources regarding prioritization and monitoring include Elzinga *et al*. (1999), Rew *et al*. (2007) and Lehnhoff *et al*. (2008).

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