

ANNUAL REPORT FOR THE KLAMATH NETWORK INVENTORY PROGRAM: FY 2003 NON-NATIVE PLANT INVENTORY

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INTRODUCTION

Non-native plant species are a major management concern across the Klamath Region. Many non-native plants are ecologically harmful, altering natural and/or historic scenes and impairing the natural function of native plant communities. In low elevation parks, such as Redwood and Whiskeytown, non-native species comprise over 25% of the flora, and a number of these species are highly invasive. The relative level of concern for each non-native plant species varies among parks and habitats, with a range of implications for native biodiversity. Most parks in the network, however, are concerned about the present distribution and potential spread of these species and the potential threats to native ecosystems.

Disturbance can enhance the probability of non-native plant establishment in native plant communities (Rejmanek 1989, Hobbs 1991), especially when non-native plant propagules are present (Crawley 1987). Therefore, non-native plants will most likely establish in areas that have both a ready seed source and which undergo repeated disturbance. Human disturbed areas in parks, such as campgrounds, corrals, hiking and pack trails, pastures, and road corridors, are typically most susceptible to establishment of non-native plant species. Among natural systems, ecosystem types which combine abundant moisture and nutrients with frequent disturbance, such as river corridors and riparian areas, appear to be especially vulnerable to invasion by non-native species (Macdonald et al. 1988, DeFerrari and Naiman 1994, Stohlgren et al. 1998, and others).

In its inventory study plan (Acker et al. 2001), the Klamath Network outlined two overarching goals for its inventory program: (1) document 90% of the vascular plant and vertebrate species believed to occur in each park; and (2) determine the distribution and abundance of species of special management interest in each park. Non-native plant species consistently ranked among the highest priorities for biological inventory among the Klamath Network parks. In this inventory project, we sought to gather information on the presence, distribution, and abundance of non-native plant species in five of the six network parks.

METHODS

General Approach

The information needs varied among the parks based on management objectives and previous inventories. As a result, we employed three primary survey methods, singly or in combination, in each park: (1) site profile surveys of known disturbed areas, (2) targeted mapping of invasive species, and (3) establishment of quantitative belt plots for non-native vegetation. Additionally, a site information form (Appendix 1), which summarized environmental conditions and vegetation characteristics, was completed for each survey site.

Site profile surveys were used to identify the non-native species presence and abundance at sites known to have high levels of human disturbance. Abundance was a simple 5 point scale based on estimated cover at the site (Table 1). Surveys were completed in areas affected by ongoing visitor use and park management, and/or historic impacts such as historic home sites, mining, and logging. Sites were treated as bounded polygons with species information collected as attributes of the polygon. We did not document fine-scale distributions within the sites. The surveys were intended to provide an overview of non-native species presence at likely entry points into the park.

Table 1. Cover classes for non-native species sampled in site profile and quantitative belt plot inventories and for estimation of ground disturbance at belt sample points.

Abundance Code		Definition
O = <1%	Cover	Species present, Occasional
R = 1-5%	Cover	Species present, Rare
U = 5-25%	Cover	Species present, Uncommon
C = 25-50%	Cover	Species present, Common
A = 50-100%	Cover	Species present, Abundant

Targeted species mapping was used to locate new populations of non-native species or to map particular noxious species in sensitive habitats. These included hiking reconnaissance along park boundaries and riparian zones as well as some roadside surveys.

Quantitative belt plots were installed on randomly selected linear (≥ 400 meters) road and trail segments, and encompassed different elevation and vegetation strata in each park. Each 4 hectare plot contained four 400 meter x 25 meter (1 ha) belts arranged parallel to a straight section of road or trail (Figure 1). Plot establishment methods were standardized prior to the field season and each potential field site was evaluated for safety before plot installation. Plots were not installed on slopes greater than 100% (45 degrees). If both sides of the road fit the slope criteria, a coin was flipped to choose which side to sample. The 400 meter line was then paced out by the crew and compass bearings were taken perpendicular to the road or trail at 0 m, 200 m, and 400 m along the line. These values were averaged to receive the transect bearing. Plots were installed using slope distance—plot areas were not adjusted for slope. The plot corners were marked with GPS way points. In WHIS and LAVO, photo points were also taken to

illustrate the habitat sampled. The setup time per plot ranged from approximately 0.5 to 2 hours depending on habitat and terrain.

Within each 400 m x 25 m (1 ha) belt, a crewmember conducted a purposive search for 45 minutes, recording presence and abundance of all non-native species encountered. At one hundred, two hundred, and three hundred meters into the belt, point characterizations of canopy cover were collected using a convex spherical densiometer held at 1.2 m above the ground. At these same points slope was recorded with a clinometer in the downslope direction, and evidence of ground disturbance was recorded within a 12.5 meter radius. Ground disturbance (evidence of bare soil, trampling, etc.) was recorded using the cover class categories used for non-native species cover (Table 1). Ancillary data (vegetation type, UTM Coordinates, slope curvature, etc.) were collected at the mid-point (200 m) of each belt

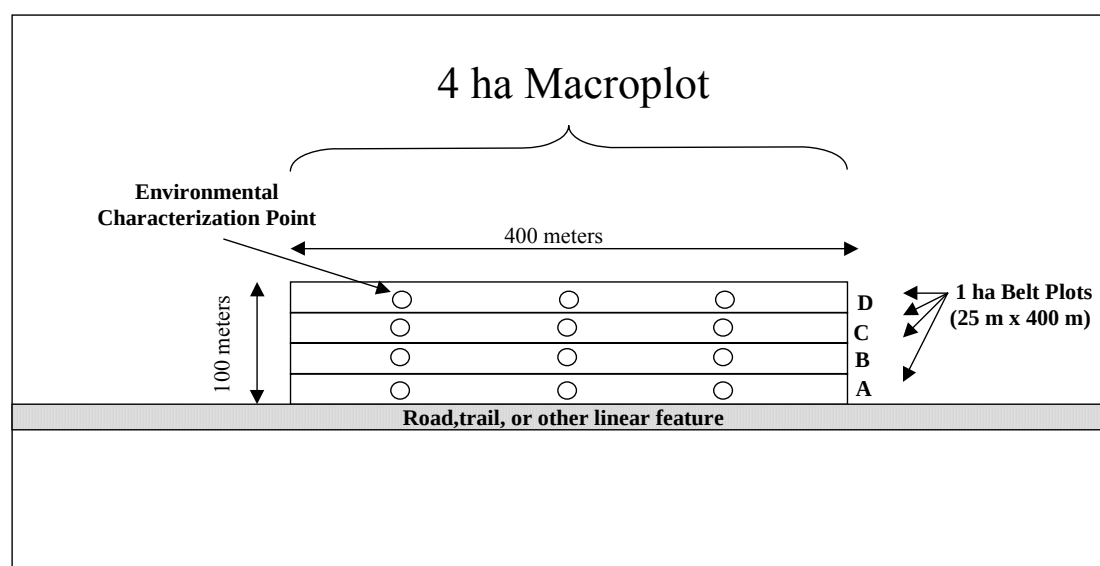


Figure 1. Aerial view of the four (1 ha) quantitative belt plots used in non-native plant sampling. Quantitative belt plots A-D are arrayed parallel to a road or trail at increasing distances into the native vegetation. Each quantitative belt is 400 m long and 25 m wide and comprises one hectare, for a total of 4 hectares per aggregate sample. Environmental sampling points are shown.

Park-specific Activities

Whiskeytown National Recreation Area

At Whiskeytown National Recreation Area (WHIS) inventory effort was divided between three activities (Table 2): (1) site profile surveys were completed for eight locations considered to be the most highly impacted areas of the park, (2) targeted populations of Himalayan blackberry (*Rubus discolor*) were inventoried along seven stream corridors, and (3) ten quantitative plots were installed at sites that spanned the elevation range of the park (Appendix A, Fig. 1).

Table 2. Non-native plant inventory locations at Whiskeytown National Recreation Area, 2003.

Site Profile Surveys	Targeted Mapping	Quantitative Belt Plots
Brandy Creek Beach	Brandy Creek	Coggins Park
Carr Powerhouse	Crystal Creek	Muletown Rd
Headquarters	Grizzly Gulch	Paige Bar Rd
NEED camp	Lower Clear Creek	Peltier Valley Rd
Oak Bottom	Upper Clear Creek	Queen Mary
Oakie Flats	Whiskey Creek	Shasta Bally Rd
Tower House	Willow Creek	Shasta Divide
Whiskey Creek Boat Launch		Sheep Camp
		Trinity Mtn Rd
		Whiskey Creek Rd

Lava Beds National Monument

At Lava Beds National Monument (LBE), the sampling was aimed at augmenting efforts underway within the park to map non-native invasive species. Seven quantitative belt plots were installed in the park, along both road and trail sides (Appendix B, Fig. 1). Three of the four roadside plots were located along the main park road: the Main Park Road plot was located 1 mile west of Captain Jack's stronghold, the Canby's Cross plot was located 0.5 mile west of Canby's Cross, and the NE boundary plot was located 0.4 mile west of the northeast boundary. The fourth roadside plot was located along Medicine Lake Road. Trailside plots were installed along Three Sisters Trail, Hardin Butte Trail, and Fleener Chimney

Oregon Caves National Monument

Due to the small size of Oregon Caves National Monument (ORCA), and the extensive knowledge by the staff about the existing vegetation, only two quantitative belt plots were installed. Both of the plots were installed along the Big Tree Trail (Appendix C, Fig. 1).

Lassen Volcanic National Park

In Lassen Volcanic National Park (LAVO), five quantitative belt plots were installed along roads and trails, and targeted species mapping was completed along portions of the park boundary. Three quantitative belt plots were installed along Juniper Lake Road: at the south boundary sign, approximately 1 mile north of the south boundary, and near the ranger station. Plots were also installed on Twin Meadows Trail and Mt. Harkness Trail (Appendix D, Fig. 1).

Boundary surveys were completed along the southern boundary with Lassen National Forest (Appendix E, Fig. 2). The boundary surveys consisted of targeted searches with four crew members walking twenty meters apart parallel to the park boundary. Two creeks crossed the boundary in the survey area and were followed into the park. Panther Creek was surveyed from the boundary to its source and an unnamed creek was followed from the boundary to Twin Meadows. In a separate survey, LAVO staff hiked the southern park boundary from Highway 89 to the southwest corner of the park, then north to the western flank of Brokeoff Mountain. The two person LAVO crew walked parallel approximately 50 m apart, and surveyed a strip of boundary about 100 m wide.

Crater Lake National Park

Natural Resource staff at Crater Lake National Park (CRLA) decided that targeted species mapping and site profiles surveys of the park roads and main facility areas were a higher priority than installing quantitative belt plots. Highways 138 and 62 (the entrance station road from Hwy 62 to Lodgepole Picnic Area) were surveyed using the CRLA non-native plant road inventory protocol. A driving inventory was also completed along Grayback Drive. Site profile surveys were completed at Rim Village and Mazama Campground, and targeted species mapping occurred at Annie Creek, Lost Creek, Thousand Springs, Cleetwood Trail, Godfrey Glen Trail, and trails from Lightning Springs, Rim Village, and Annie Springs to the Pacific Crest Trail.

Data Summary and Analysis

Data were summarized in graphical or tabular form for the site profile and quantitative belt plot inventories. Tabular summaries of data included presence, abundance, and number of non-native species at each site. Abundance was calculated using a five-point scale corresponding to Table 1, where a score of 1 was given to occasionally (<1% cover) seen species and a score of 5 to abundant (50-100% cover) species. For the quantitative belt plots, abundance scores were averaged across the four belts. In addition, species frequencies across sites were summarized for both site profile and quantitative belt plots in each park where they were completed.

We analyzed data from the quantitative belt plot in terms of five environmental variables collected in the field or summarized from topographic maps (Table 3). We used stepwise multiple linear regression to evaluate the explanatory power of the variables and to select a model of controls on non-native plant species richness. We report only variables in the model that were significant at the $p < 0.05$ level.

Table 3. Environmental variables used in multiple regression analysis for (1 ha) quantitative belt plots.

Variable Code	Variable Definition
ELEV	PLOT ELEVATION IN METERS
OCOV	PLOT OVERSTORY COVER (AVERAGE OF THREE SAMPLE POINTS)
BELT	BELT NUMBER (1-4) INCREASING DISTANCE FROM ROAD OR TRAIL
DIST	DISTURBANCE AT SAMPLING POINT (1-5 SCALE)
SLOPE	SLOPE OF BELT (AVERAGE OF THREE SAMPLING POINTS)

RESULTS

General Findings

Patterns of Non-native Species Richness

The mean richness of non-native species in the 1 ha belt subplots declined sharply from low elevations of WHIS to the higher elevations at LAVO (Figure 2). At low elevations, richness declined with belt distance from the road or trail, but this pattern was not evident at mid and high elevation sites. Most of the mid elevation sites were in LABE, where overstory vegetation cover was low. Most high elevation sites were in LAVO, where richness was low overall. We also noted that the number of non-native species was much lower in forest and chaparral vegetation than in more open steppe or woodland environments. General patterns of richness and environmental conditions for each belt of the quantitative belts plots in each park are provided in Table 4.

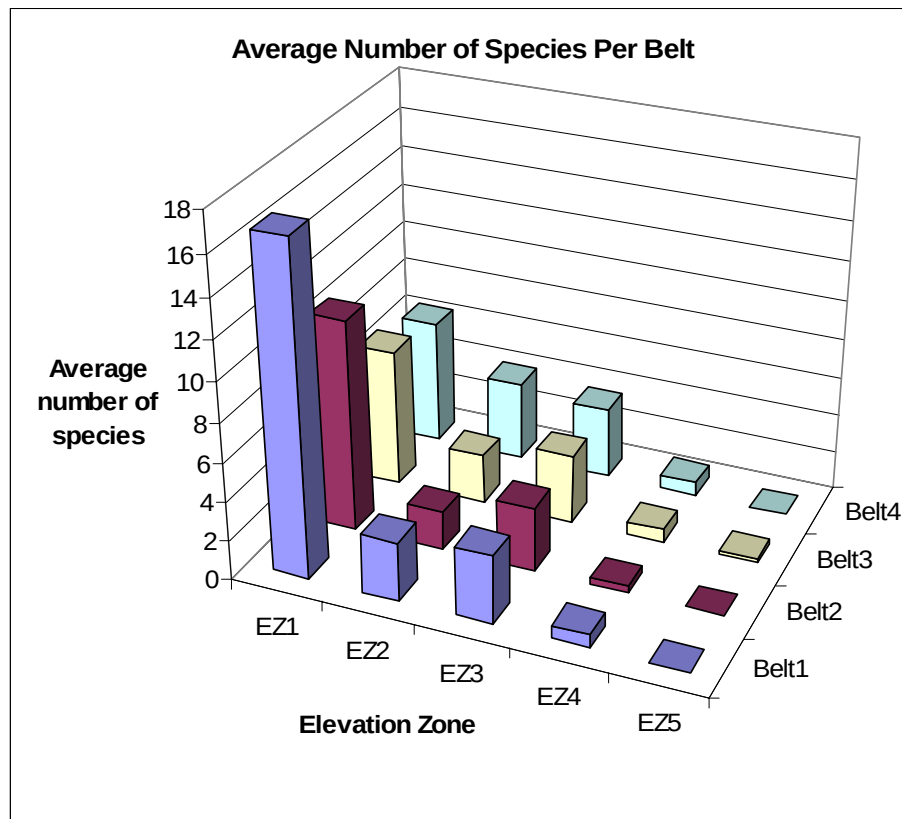


Figure 2. Average species richness in (1 ha) quantitative belt blots grouped by elevation zone (EZ1 = 0-500 m, EZ2 = 500-1000 m, EZ3 = 1000-1500 m, EZ4 = 1500-2000 m, EZ 5 = 2000-2500 m) and belt distance from a road or trail. (Belt 1 = 0-25 m, Belt 2 = 25-50 m, Belt 3 = 50-75 m, Belt 4 = 75-100 m).

Stepwise multiple regression selected only two variables as significantly associated with the richness of non-native plant species in a quantitative belt plot. Plot elevation (ELEV) explained a significant share of the variation in non-native richness (partial $R^2 = 0.33$, $p < 0.001$), followed by overstory cover (OCOV) (partial $R^2 = 0.13$, $p < 0.001$). Belt number was nearly significant ($p = 0.099$) after accounting for the ELEV and OCOV.

Although we cannot eliminate the contribution of unmeasured factors, these findings suggest the importance of the biophysical environment in controlling the distributions of many non-native species in the Klamath Network parks. Since all samples were collected near roads or trails which may provide vectors for invasion of non-native plant species, we speculate that climatic or other large scale factors, not dispersal, limit the pool of species that can effectively invade the vegetation at a given location. Vegetation cover also appeared to be a more effective control on non-native species richness than distance from a road or trail (i.e., belt number), suggesting that many of the non-native species in the Klamath Region are more limited by light availability than by proximity to a source of plant propagules.

Table 3. Regression model selected from stepwise multiple regression on individual 1 ha belt samples with partial coefficients of determination (R^2) and Analysis of Variance table.

Multiple Regression Model				Model R2	
Non-native Species Richness = 14.65 – 0.007*ELEVATION – 0.063*OVERSTORY COVER					
Partial R2		0.33	0.13		0.46
Analysis of Variance Table					
Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	1492.645	2	746.322	38.779	<0.001
Residual	1789.845	93	19.246		

Park-specific Findings

Whiskeytown National Recreation Area

Site Profile Surveys: We found 68 different non-native plant species during the site profile surveys at WHIS (Table 5). Seventeen of these species were identified by CalEPPC (1999) as species of ecological concern. The number of non-native species per site ranged from 25-44 species. Twelve species were found at every site surveyed (frequency = 100%), while 19 species were found at only one site (frequency = 12.5%). Twenty-three species had a recorded abundance of 3 (uncommon, 5-25% cover) in at least one site, and no species comprised greater than 25% cover at any site.

Targeted Species Mapping: Targeted mapping of Himalayan blackberry (*Rubus discolor*) revealed linear infestations extending the length of all stream corridors mapped (Table 2), except

Brandy Creek. The populations tended to be most extensive and contiguous near Whiskeytown Lake, and diminished with distance upstream from the lake.

Quantitative Belt Plots: In the ten quantitative belt plots installed at WHIS, we encountered 41 non-native plant species including eight CalEPPC (1999) species of ecological concern (Table 6). All of these species were also encountered in the site profile surveys. Two plots had no non-native species, four plots had less than 10 species, and the other four plots ranged in species richness from 15-38 species. As we noted in the multipark survey, there was a negative correlation between plot elevation and non-native species richness. The lower elevation plots contained five to thirty-eight non-native plant species, mid elevation plots contained four to eight species, and high elevation plots contained zero to one species. Klamath weed (*Hypericum perforatum*) and hairy cat's ear (*Hypochaeris radicata*) were the most frequently encountered species (frequency = 70% and 60%, respectively), while red brome (*Bromus madritensis ssp. rubens*) had the highest mean abundance value recorded in a plot (abundance = 3, uncommon, 5-25% cover). Species abundance maps were prepared for *Ailanthus altissima*, *Avena fatua*, *Bromus diandrus*, *Bromus madritensis ssp. rubens*, *Centaurea solstitialis*, *Hypericum perforatum*, *Rubus discolor*, and *Verbascum thapsus* (Appendix A, Fig. 2-9 respectively).

Table 4. Mean (S.D.) elevation, species richness, overstory cover, slope, and surface disturbance for quantitative belts 1-4 in each park. Number of sample sites (N) is noted immediately below the park code. Means are in bold with standard deviations immediately to the right.

PARK	ELEVATION		BELT	SPECIES RICHNESS		OVERSTORY COVER		SLOPE		DISTURBANCE	
	MEAN	S.D.		MEAN	S.D.	MEAN	S.D.	MEAN	S.D.	MEAN	S.D.
LABE N=7	1342.6	126.7	1	4.9	3.6	0.6	1.2	2.0	1.3	1.7	0.7
			2	4.9	3.6	0.6	1.6	2.0	0.9	1.5	0.7
			3	5.3	3.6	0.2	0.5	1.4	0.7	1.5	0.6
			4	5.3	3.6	0.2	0.5	1.8	0.5	1.4	0.6
LAVO N=5	2098.6	99.7	1	0.2	0.4	49.6	16.1	6.6	3.0	1.4	0.5
			2	0.0	0.0	54.7	11.0	9.1	4.5	1.1	0.2
			3	0.2	0.4	42.3	21.3	7.7	3.7	1.5	0.4
			4	0.0	0.0	55.5	30.6	8.4	6.8	1.2	0.3
ORCA N=2	1500	0	1	1.0	0.0	71.3	23.8	23.0	3.3	1.3	0.5
			2	0.0	0.0	67.6	36.1	24.0	2.8	1.5	0.7
			3	0.0	0.0	51.0	41.3	21.5	0.7	1.3	0.5
			4	0.0	0.0	69.8	31.9	23.2	3.5	1.2	0.2
WHIS N=10	733.2	490.3	1	9.1	11.1	56.1	31.2	17.6	5.9	2.1	0.6
			2	5.9	7.5	65.8	25.7	19.8	9.0	1.6	0.6
			3	4.0	5.9	63.0	32.1	20.7	7.6	1.5	0.7
			4	4.1	5.7	61.4	33.3	20.7	6.0	1.4	0.5

Lava Beds National Monument

Seven quantitative belt plots were installed in LABE, and a total of 13 different non-native species were found including three CalEPPC (1999) species of ecological concern (Table 7).

Species richness ranged from 1-11 species per plot. The most frequent and most abundant species encountered was cheat grass (*Bromus tectorum*). Cheat grass was found in all four belts of every quantitative plot installed in the park and had a mean abundance ranging from 3 (uncommon, 5-25% cover) to 4 (common, 25-50% cover) in each plot. Overall, we found little difference in the total non-native species richness from disturbed roadsides into the native vegetation. (i.e. between the four belts) within a plot. This may be due to the high amount of sunlight exposure throughout the park (see Table 4). Species abundance maps were prepared for *Bromus tectorum*, *Cirsium vulgare*, and *Verbascum thapsus* (Appendix B, Fig. 2-4 respectively)

Oregon Caves National Monument

The forest in Oregon Caves National Monument is primarily old growth, and the trail system in the park receives moderately low impact from visitors. The only non-native species found in the two quantitative belt plots was common dandelion (*Taraxacum officinale*). Dandelion was found only in the first belt (0-25 m from the trail) and had a mean abundance of 0.25 (occasional, <1% cover) in both plots surveyed. The populations were already known, and were expected to fall within the plots.

Lassen Volcanic National Park

Within the five quantitative belt plots installed in LAVO only one non-native plant species was found, common dandelion (*Taraxacum officinale*). The dandelions were found in two plots on Juniper Lake Road and had a mean abundance of 0.25 (occasional, <1% cover) in each plot. In these plots, dandelions were only located in wet sunny areas or within three meters of a road. The quantitative plots in LAVO had low species richness overall—both highly shaded and exposed, sunny areas.

Dandelion was also the only non-native species encountered during the boundary surveys (Appendix E Fig 2). It was found only in areas near small springs and streams, located miles from any trail or road. There was evidence of livestock entering the park from the U.S. Forest Service land, and the dandelions were consistently found near cattle manure. Therefore, we suspect that these specific dandelions were brought into the park by grazing cattle from neighboring lands. The LAVO survey crew did not find any non-native plants during their boundary survey. Most of the survey fell within red fir forest or rocky outcrops covered with manzanita, neither of which are good habitat for non-natives. However, they found several wet meadows along the western park boundary that would constitute sufficient habitat for bull thistle.

Crater Lake National Park

A total of eight non-native plant species were found in CRLA including three CalEPPC (1999) species of ecological concern (Table 8). The most frequent and most abundant species encountered was common dandelion (*Taraxacum officinale*). Seven non-native species were found on the section of the park entrance road from Highway 62 to lodgepole picnic area (the Hwy 62 plot). For the other sites, species richness ranged from 0-4 species per site. During the highway surveys, non-native plants were only encountered within three meters of the roadside.

In the three visitor use areas, the non-native plants only occurred in the most disturbed areas—against buildings, along walkways, or in the cracks of concrete parking areas. The trail surveys and the driving survey of Grayback Drive yielded no exotic species. The three riparian areas surveyed contained a total of two non-native plant species, common dandelion (*Taraxacum officinale*) and bull thistle (*Cirsium vulgare*). The dandelion was found in the Lost Creek Campground along the stream and at Thousand Springs. The bull thistle was found along Annie Creek within 100 meters of the park boundary in an area of light human disturbance and also at Thousand Springs.

Table 5. Non-native plant species frequency, richness, and abundance in site profile surveys at Whiskeytown National Recreation Area, 2003. Species are sorted by descending frequency of occurrence. Abundance was calculated using a five-point scale from 1 (occasional) to 5 (abundant). (*) indicates that the species is found on the CalEPPC (1999) list.

Species Code	Brandy Creek Beach	Carr Power- house	Head- quarters	NEED Camp	Oak Bottom	Oakie Flats	Tower House	Whiskey Creek Boat Launch	SPECIES FREQUENCY
<i>Aira caryophylla</i>	3	2	2	2	2	2	2	2	100
<i>Bromus diandrus</i> *	3	2	2	2	3	2	3	1	100
<i>Centaurea solstitialis</i> *	2	3	2	1	2	3	2	2	100
<i>Cynodon dactylon</i>	2	3	3	3	1	1	2	2	100
<i>Erodium brachycarpum</i>	2	2	1	2	2	3	3	2	100
<i>Erodium cicutarium</i>	2	1	3	1	2	1	3	2	100
<i>Plantago lanceolata</i>	3	3	2	1	2	1	2	2	100
<i>Poa bulbosa</i>	3	3	2	2	3	3	3	3	100
<i>Rubus discolor</i> *	2	3	2	3	3	3	3	3	100
<i>Stellaria media</i>	2	3	1	1	2	1	3	2	100
<i>Taraxacum officinale</i>	2	2	2	1	2	2	2	2	100
<i>Torilis arvensis</i>	2	2	2	2	2	2	3	2	100
<i>Crucianella angustifolia</i>	3	1	1	2	2	1	2		87.5
<i>Digitaria ischaemum</i>	2	2	1	3	1	1	2		87.5
<i>Hypericum perforatum</i> *	2	1	1	2	2		1	2	87.5
<i>Hypochaeris glabra</i>	3		2	2	2	2	2	2	87.5
<i>Hypochaeris radicata</i>	3	2	2	2	2		2	2	87.5
<i>Verbascum thapsus</i> *	1	1	1	1		1	2	2	87.5
<i>Barbarea verna</i>	1	2	2	2		2		1	75
<i>Convolvulus arvensis</i>	1	1	1	1			1	2	75
<i>Rumex acetosella</i>	1	1		2	1		2	3	75
<i>Rumex crispus</i>		2	1	1	1		2	2	75
<i>Vicia sativa</i>	1	2	1	1			1	2	75
<i>Ailanthus altissima</i> *		3	1	1		2	2		62.5
<i>Filago gallica</i>	1	2			2	1		1	62.5
<i>Matricaria discoidea</i>	1	2	1			1	2		62.5
<i>Medicago polymorpha</i>		3	3		2		2	3	62.5
<i>Raphanus sativus</i>		2		1		2	1	2	62.5
<i>Senecio vulgaris</i>	1	1	1		1		1		62.5
<i>Bromus hordeaceus</i>		1	2		2		1		50
<i>Cytisus scoparius</i> *		2		1		1	1		50
<i>Lathyrus latifolius</i>		3	1				1	2	50
<i>Liquidambar styraciflua</i>	2	1		1	1				50
<i>Lamium amplexicaule</i>		1				1	2		37.5
<i>Marrubium vulgare</i>		1				1	1		37.5

Table 5. (Cont.)

Species Code	Brandy Creek Beach	Carr Power- house	Head- quarters	NEED Camp	Oak Bottom	Oakie Flats	Tower House	Whiskey Creek Boat Launch	SPECIES FREQUENCY
<i>Robinia pseudoacacia</i> *		2		1			2		37.5
<i>Bromus inermis</i>	2			1					25
<i>Cirsium vulgare</i> *	1			1					25
<i>Genista monspessulana</i> *		3		2					25
<i>Geranium molle</i>							3		25
<i>Hedera helix</i> *		2					1		25
<i>Malus sylvestris</i>				1			2		25
<i>Mentha spicata</i>					1		1		25
<i>Spartium junceum</i> *		2						3	25
<i>Spergularia bocconii</i>				2	1				25
<i>Trifolium hirtum</i>						2	2		25
<i>Trifolium repens</i>		2	2						25
<i>Verbascum blattaria</i>		1						1	25
<i>Vinca major</i> *		3					2		25
<i>Andropogon virginicus</i>	2								12.5
<i>Arabidopsis thaliana</i>							1		12.5
<i>Arundo donax</i> *			1						12.5
<i>Avena fatua</i> *					1				12.5
<i>Briza maxima</i>					2				12.5
<i>Bromus madritensis ssp. rubens</i> *					1				12.5
<i>Capsella bursa-pastoris</i>							2		12.5
<i>Chamaesyce nutans</i>			1						12.5
<i>Erodium botrys</i>					1				12.5
<i>Ficus carica</i> *		1							12.5
<i>Hordeum marinum</i>							1		12.5
<i>Hordeum murinum</i>					1				12.5
<i>Lactuca serriola</i>					1				12.5
<i>Plantago major</i>		1							12.5
<i>Poa annua</i>					1				12.5
<i>Potentilla glandulosa</i>	1								12.5
<i>Sorghum halepense</i>							1		12.5
<i>Veronica arvensis</i>							1		12.5
<i>Vulpia myuros</i>					2				12.5
SPECIES RICHNESS	30	43	31	33	34	25	44	28	

Table 6. Non-native plant species frequency, richness, and mean abundance in the aggregated 4 ha quantitative belt plots at Whiskeytown National Recreation Area, 2003. Species data are sorted by descending frequency of occurrence. Mean abundance was calculated using a five-point scale from 1 (occasional) to 5 (abundant). (*) indicates that the species is found on the CalEPPC (1999) list.

Species Code	Trinity Mtn Rd	Paige Bar Rd	Mule- town Rd	Whiskey Crk Rd	Sheep Camp	Peltier Valley	Shasta Divide	Coggins Park	Queen Mary	Shasta Bally Rd	SPECIES FREQUENCY
<i>Hypericum perforatum</i> *	0.50	1.00	1.50	0.75	1.50	1.25	0.75				70
<i>Hypochaeris radicata</i>	2.00	0.75	2.00	0.75		0.50	0.25				60
<i>Bromus madritensis ssp. rubens</i> *	3.00	0.25	3.00	1.75				0.25			50
<i>Convolvulus arvensis</i>	0.75	0.75	0.50		1.25		0.50				50
<i>Plantago lanceolata</i>	1.00	0.25		0.25	0.50	0.25					50
<i>Rumex acetosella</i>	0.25	0.25	0.50		0.25	0.25					50
<i>Aira caryophyllea</i>	2.00	1.50	2.25	0.25							40
<i>Avena fatua</i> *	2.75	0.25	1.75	0.50							40
<i>Briza maxima</i>	0.75	0.50	0.75	0.25							40
<i>Bromus diandrus</i> *	0.50	1.00	0.75	0.75							40
<i>Bromus hordeaceus</i>	2.25	0.50	1.25	0.50							40
<i>Spergularia bocconii</i>	0.50	0.50	1.50	0.25							40
<i>Taraxacum officinale</i>	0.25	0.25		0.25	0.25						40
<i>Torilis arvensis</i>	2.25		2.00	0.75		0.75					40
<i>Vulpia myuros</i>		0.50	1.25	0.50	0.75						40
<i>Centaurea solstitialis</i> *	2.00	0.25		0.25							30
<i>Crucianella angustifolia</i>	0.75		0.50	0.25							30
<i>Cynodon dactylon</i>	0.25	0.25			0.25						30
<i>Medicago polymorpha</i>	1.00	0.25	0.75								30
<i>Poa annua</i>	2.25		0.50				0.25				30
<i>Poa bulbosa</i>	1.25	0.50			0.25						30
<i>Filago gallica</i>	0.50		0.75								20
<i>Hypochaeris glabra</i>	1.00		0.25								20
<i>Rubus discolor</i> *	1.25	0.50									20

Table 6. (Cont.)

Species Code	Trinity Mtn Rd	Paige Bar Rd	Mule- town Rd	Whiskey Crk Rd	Sheep Camp	Peltier Valley	Shasta Divide	Coggins Park	Queen Mary	Shasta Bally Rd	SPECIES FREQUENCY
<i>Trifolium hirtum</i>	2.00		0.25								20
<i>Vicia sativa</i>	1.00	0.25									20
<i>Ailanthus altissima</i> *	1.25										10
<i>Barbarea verna</i>		0.25									10
<i>Capsella bursa-pastoris</i>	0.25										10
<i>Erodium botrys</i>	0.25										10
<i>Erodium brachycarpum</i>	0.75										10
<i>Erodium cicutarium</i>	0.50										10
<i>Hordeum murinum</i>	0.25										10
<i>Lactuca serriola</i>	0.25										10
<i>Lamium amplexicaule</i>	0.25										10
<i>Malus sylvestris</i>		0.25									10
<i>Matricaria discoidea</i>	1.00										10
<i>Raphanus sativus</i>	0.25										10
<i>Rumex crispus</i>	0.25										10
<i>Stellaria media</i>	0.75										10
<i>Verbascum thapsus</i> *	0.75										10
SPECIES RICHNESS	38	22	19	15	8	5	4	1	0	0	

Table 7. Non-native plant species frequency, richness, and mean abundance in the aggregated 4 ha quantitative belt plots at Lava Beds National Monument, 2003. Species data are sorted by descending frequency of occurrence. Mean abundance was calculated using a five-point scale from 1 (occasional) to 5 (abundant). (*) indicates that the species is found on the CalEPPC (1999) list.

Species Code	NE Boundary	Medicine Lake Rd	Main Park Rd	Hardin Butte Trail	Fleener Chimney	Three Sisters Trail	Canby's Cross	SPECIES FREQUENCY
<i>Bromus tectorum</i> *	4.00	3.25	3.00	4.00	4.00	4.00	3.00	100.0
<i>Descurainia sophioides</i>	2.50		2.00	0.25	2.00		3.00	71.4
<i>Holosteum umbellatum</i>	0.50		3.00	0.25	2.00		3.75	71.4
<i>Sisymbrium altissimum</i>	2.75		2.00	0.50	1.50		1.75	71.4
<i>Tragopogon dubius</i>	0.50	0.25	2.00		0.50		1.75	71.4
<i>Lactuca serriola</i>	1.00		1.50		0.25		2.00	57.1
<i>Erodium cicutarium</i>	1.00		2.00				1.50	42.9
<i>Verbascum thapsus</i> *			0.25	0.25			0.50	42.9
<i>Cirsium vulgare</i> *			0.50				0.75	28.6
<i>Lepidium perfoliatum</i>			0.75				0.25	28.6
<i>Marrubium vulgare</i>					1.00			14.3
<i>Salsola kali</i>		0.25						14.3
<i>Urtica dioica</i>							0.75	14.3
SPECIES RICHNESS	7	3	10	5	7	1	11	

Table 8. Non-native plant species frequency, richness, and abundance in site profile surveys and targeted species mapping at Crater Lake National Park, 2003. Species are sorted by descending frequency of occurrence. Abundance was calculated using a five-point scale from 1 (occasional) to 5 (abundant). (*) indicates that the species is found on the CalEPPC (1999) list.

Species Code	Hwy 62	Hwy 138	Thousand Springs	Rim Village	Lost Creek Camp	SPECIES FREQUENCY
<i>Taraxacum officinale</i>	2		3	1	1	80
<i>Hypericum perforatum</i> *	1	1		1		60
<i>Rumex acetosella</i>	1	1		1		60
<i>Cirsium vulgare</i> *	1		1			40
<i>Dactylis glomerata</i>	1					20
<i>Spergularia rubra</i>				1		20
<i>Trifolium repens</i>	1					20
<i>Verbascum thapsus</i> *	1					20
SPECIES RICHNESS	7	2	2	4	1	

INTERPRETATION AND MANAGEMENT RECOMMENDATIONS

From this survey, we can make several general assertions. There appears to be an inverse relationship between elevation and non-native species richness. This was demonstrated within parks with a large elevation gradient such as Whiskeytown, and across the parks sampled. Canopy cover also appears to be a major factor influencing the distribution and spread of non-native plants at a more local scale. In densely forested habitats, many species are most common near roads, but in open habitats such as Lava Beds National Monument this is not the case.

We noted only a weak effect of surface disturbance in our quantitative belt plot survey, but we did note high numbers of non-natives at disturbed sites within Whiskeytown and a number of species not seen elsewhere in the survey, suggesting that such sites are good places to start when looking at potential invaders. The focus of this inventory was to get an overview of the non-native species distribution and abundance in the Klamath Network in relation to the current environment. One potential addition to the findings here would be the disturbance history in each park. It is likely that the distributions of non-native plants in the parks are governed by historical as well as ecological factors.

A clear management implication from this work is that activities which lower canopy cover in low elevation environments are likely to increase the diversity of non-natives present. This may especially be the case in chaparral communities that harbor low non-native diversity when undisturbed, but much higher levels following disturbance (Keeley et al. 2003). Decreases in canopy cover seem pose a less severe problem in higher elevation environments of the Klamath Network, but moist, open meadow areas may prove susceptible to invasion by specific species (e.g. dandelion). We noted anecdotal evidence that trespass cattle may be favoring invasion of dandelion in Lassen Volcanic National Park, though it is unlikely that this species is a new arrival. Nonetheless, pack stock are likely to favor invasion in such areas.

For future inventory of non-native species, the field crew (A. Shufelberger, M. Commons) recommended that quantitative plots be decreased in size to allow an increase in sampling frequency. It was difficult to find straight stretches of road or trail at least 400 m long, and installation of the 400 m plots required a large amount of time. They further recommended that the use of 100 m tapes instead of 50 m tapes would save additional time. By decreasing the plot area, the risk of not finding all of non-native plants in the area increases, but the crew suggested that problem could be remedied with the larger number of sample plots.

Whiskeytown National Recreation Area

Whiskeytown National Recreation Area has the highest non-native plant abundance and richness of all the parks in the Klamath Park Network. We noted nearly ten times the number of non-natives in low elevation sites at Whiskeytown than at the other parks. Many of the plant species are short-lived annual plants that would be logistically inefficient to manage; however, several of the high priority annuals and biennials should be considered threats and managed as such. Identifying and mapping high priority non-native species throughout the park is recommended for future management of these populations.

The infestation of riparian corridors by Himalayan blackberry at Whiskeytown presents a special problem that may benefit from further study. Since it is unlikely that managers will be able to completely eradicate this species, an exploration of the ecological or historical controls that have prevented invasion of the Brandy Creek corridor seem warranted. Perhaps through study of Brandy Creek, park managers can better understand how and where the blackberry can be best contained.

Lava Beds National Monument

Lava Beds National Monument has a working non-native plant management program, which has proven effective on many of the park's priority species. Presently, the program's emphasis is on the front country areas of the park, and it has been assumed that many of the non-native plants present in the park can not survive without constant disturbance. However, given the results of this report, that assumption may need further investigation; therefore, future surveys in the backcountry areas of the park are recommended.

Oregon Caves National Monument

Oregon Caves National Monument has a working non-native plant management program. ORCA's "spot it, pull it" methodology seems to be effective due to the small size of the park. Upon an increase to the program, surveys of the backcountry areas of the park should be considered.

Lassen Volcanic National Park

Lassen Volcanic National Park has a working non-native plant management program. In addition to the work presently being performed, we recommend focused surveys in open, wet habitats of the park's backcountry. Within forested areas of the park, there are almost no herbaceous plants and no non-natives have been found in these areas. The Drakesbad Lodge seems to have the largest impact on the southern portion of the park. This is due in part to its

remote location within expansive meadows, and in part to the presence of a private horseback riding company. Presently there are no regulations requiring the private company to utilize any provisions for preventing weed dispersal. Other National Park sites have regulations in place to minimize equine weed dispersal, and these measures are recommended for the future.

Crater Lake National Park

Crater Lake National Park presently has a working non-native plant management program. The present priority of this program is mapping and controlling all non-native species along roads. Roadsides within the park will likely continue to receive impacts, and in turn may contain non-native plants. Therefore, we recommend that future surveys also include moist areas near park boundaries. These locations could harbor isolated populations that receive only occasional impact, so they could be effectively managed for the long term.

CONCLUSIONS

In general we noted two key findings in this field inventory, namely that species richness of non-native vegetation declines with elevation and overstory cover of native vegetation. Consequently, areas with the highest numbers of non-native species include low elevations of Whiskeytown National Recreation Area as well as the more open environments of Lava Beds National Monument. At higher elevations, far fewer species occurred, but dandelion and bull thistle were seen near disturbed sites and in wetter natural areas.

These broad scale patterns of non-native plant richness give an overview of the distributions of non-native species in the Klamath Network, but leave many questions unanswered: What are the controls on vigor and dominance of individual non-native species? How are native species and communities affected? Where and when can these species be eradicated? Which constitute the greatest threats? How do they respond to specific disturbances? How do they persist after disturbance? Although each park has some sense of what the priority species are, there is no common set of criteria for assessing invasion risk that incorporates the habitat variation in the Klamath Network Parks. There is clearly much more applied work to be done, but these findings illustrate the importance of landscape and vegetation context to the issue of non-native species distributions in the biophysically complex Klamath Region.

APPENDIX A. WHIS MAPS

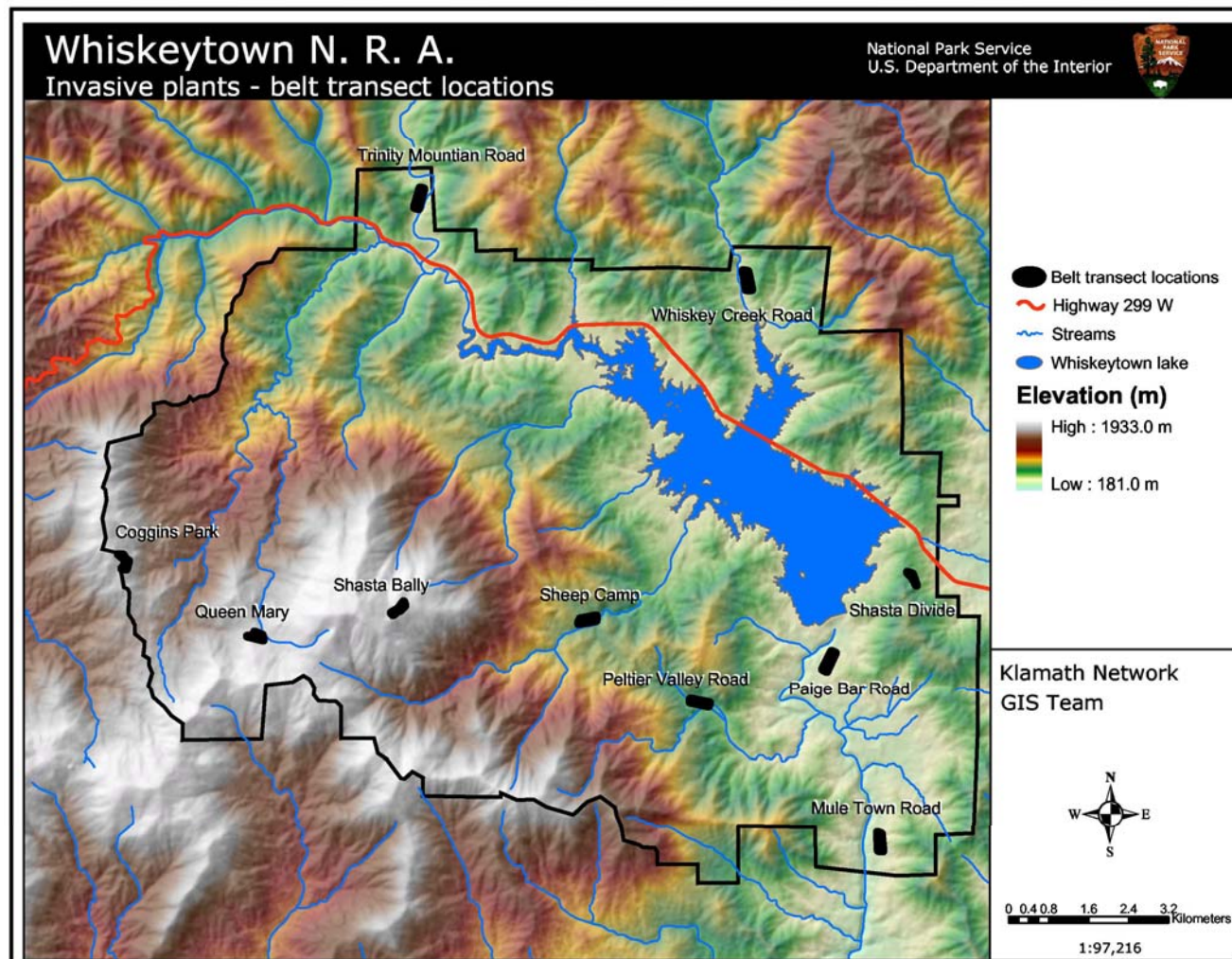


Figure 1. Location and name of quantitative belt plots in Whiskeytown National Recreation Area.

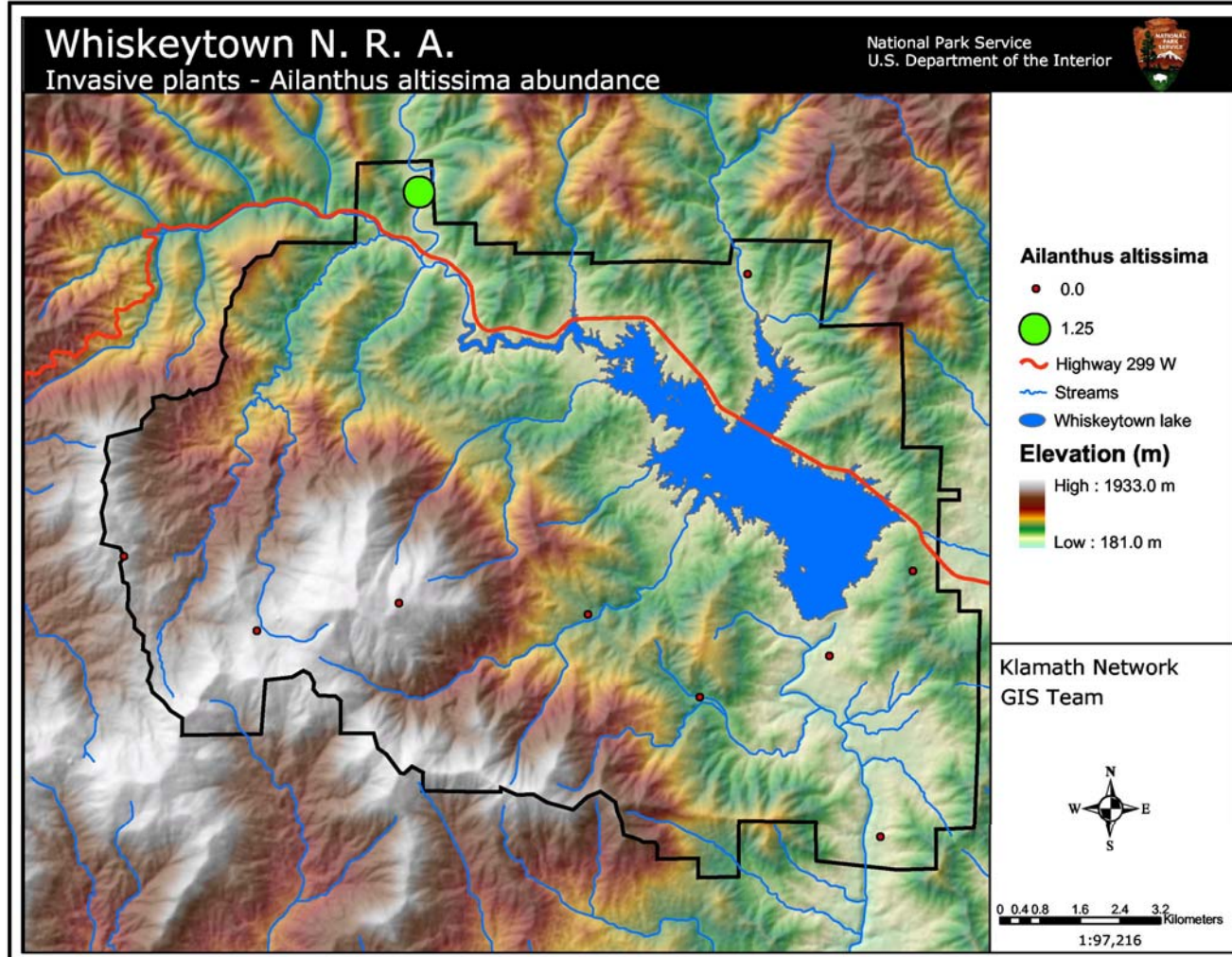


Figure 2. Abundance of *Ailanthus altissima* in quantitative belt plots at Whiskeytown National Recreation Area.

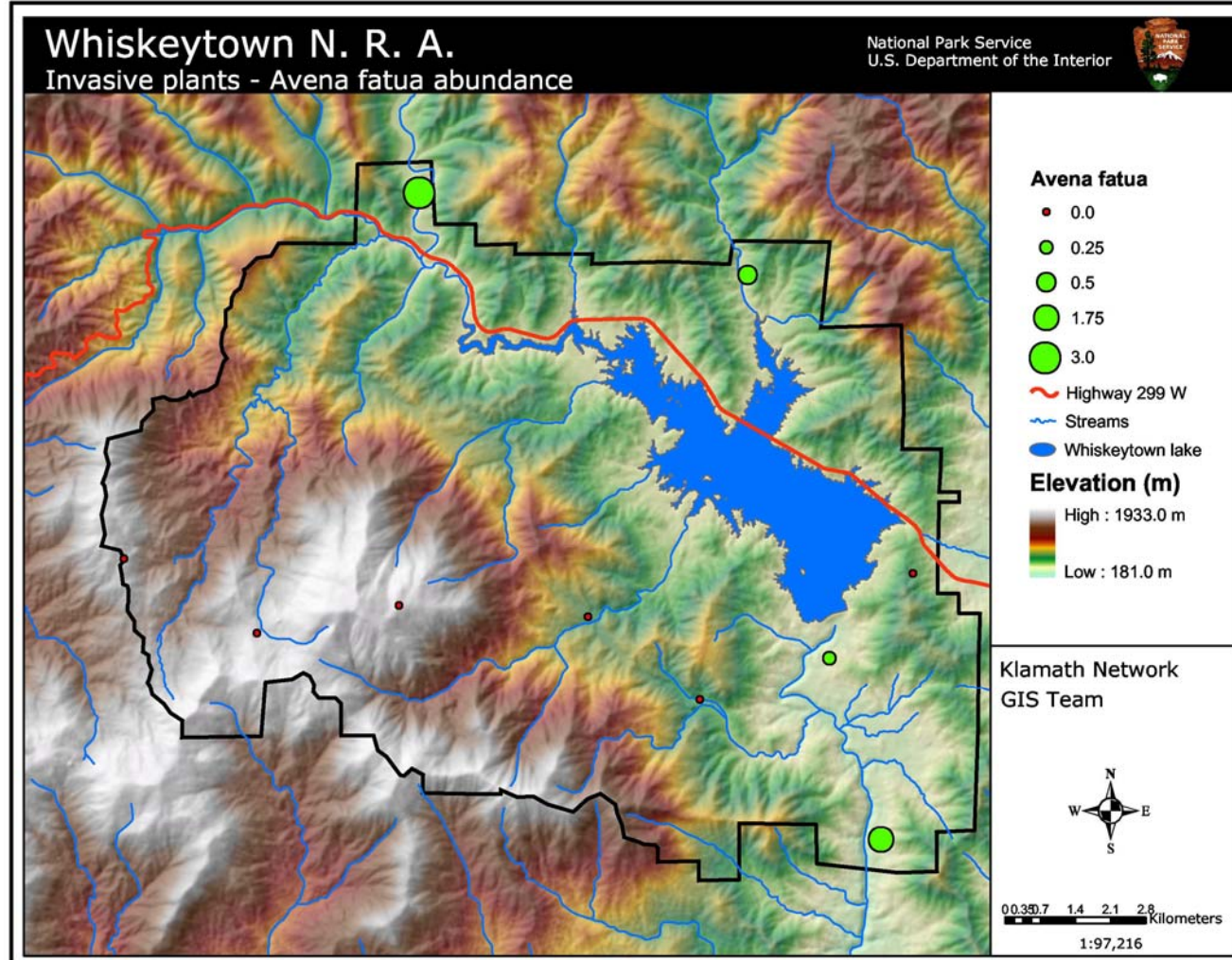


Figure 3. Abundance of *Avena fatua* in quantitative belt plots at Whiskeytown National Recreation Area.

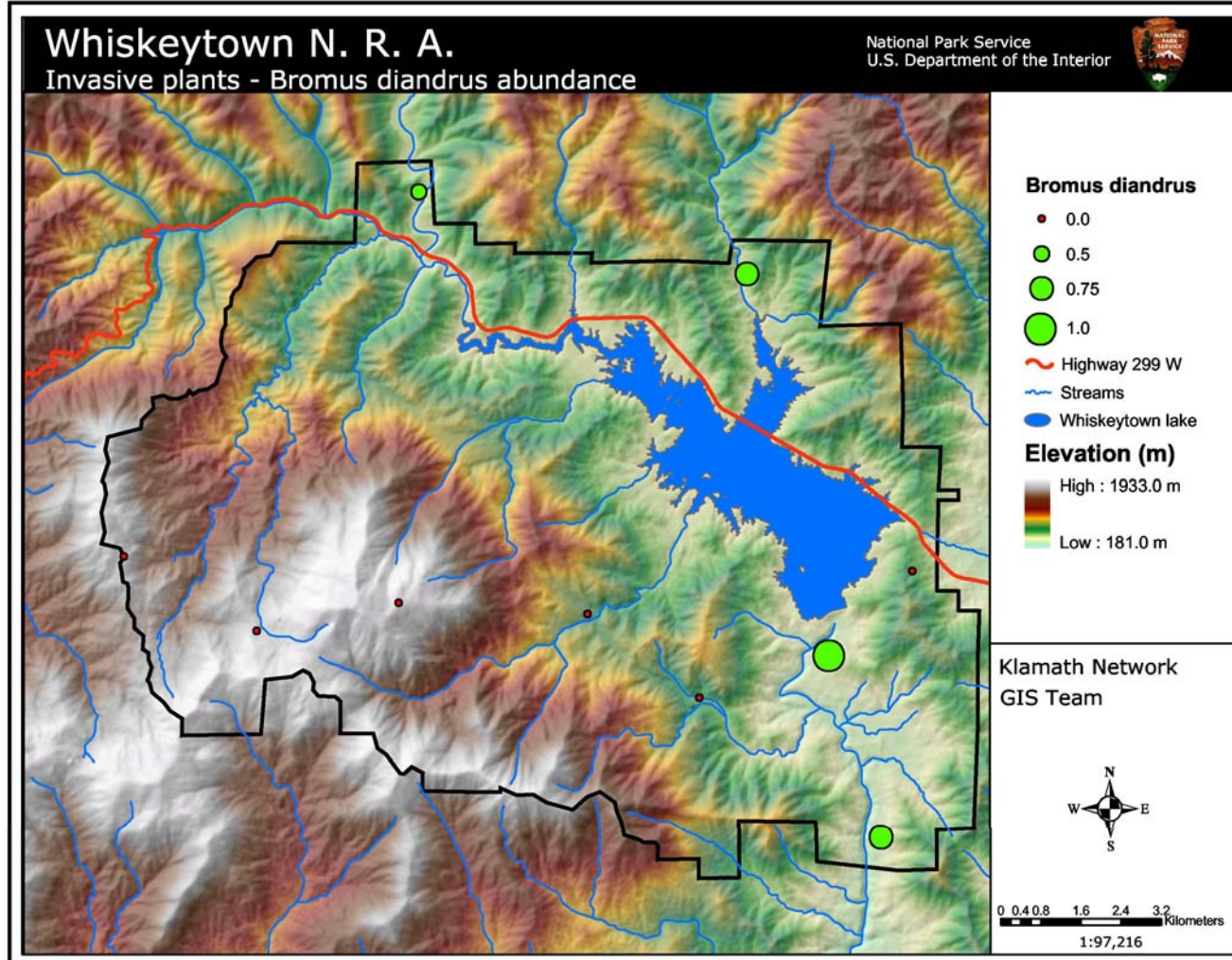


Figure 4. Abundance of *Bromus diandrus* in quantitative belt plots at Whiskeytown National Recreation Area.

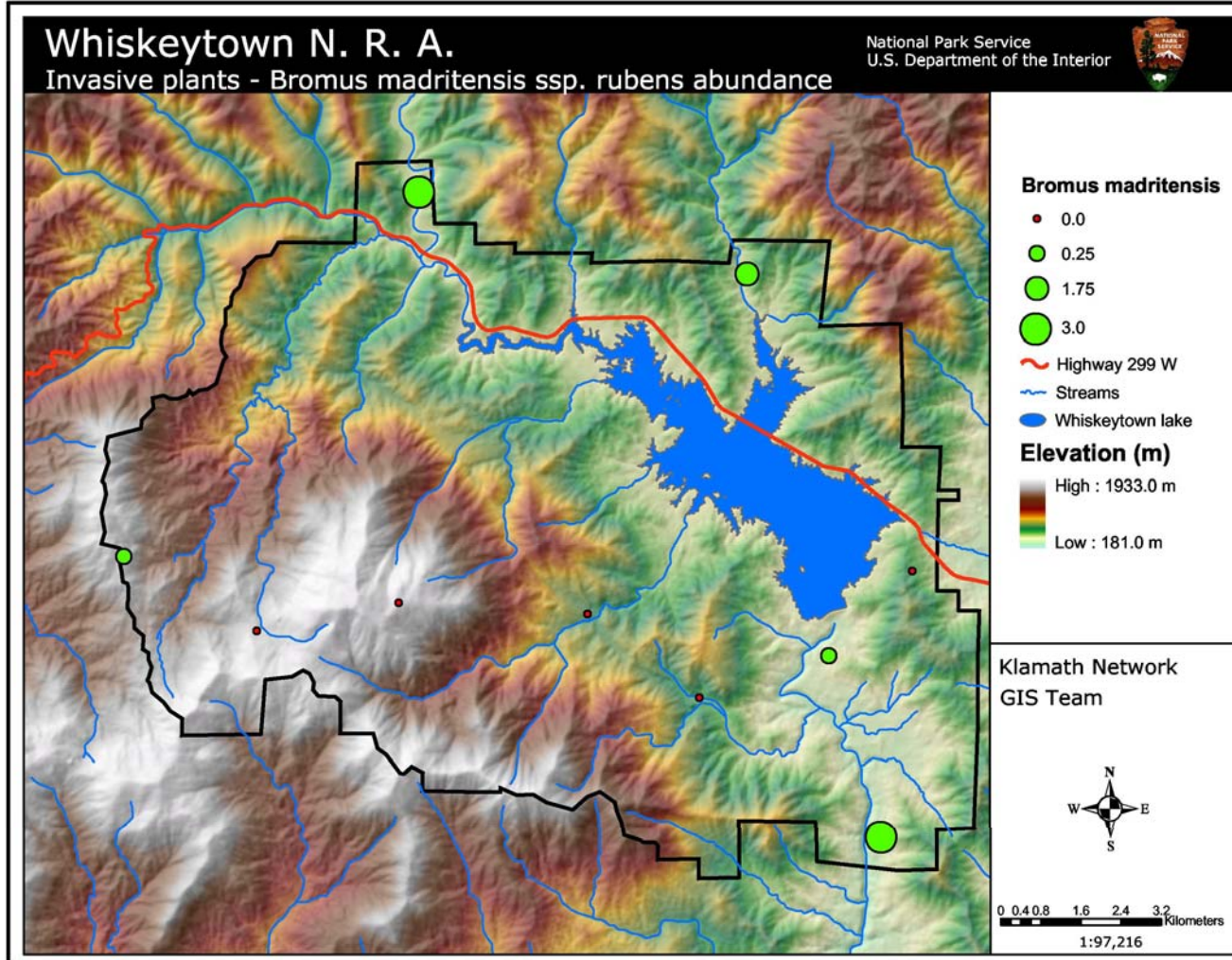


Figure 5. Abundance of *Bromus madritensis* ssp. *rubens* in quantitative belt plots at Whiskeytown National Recreation Area.

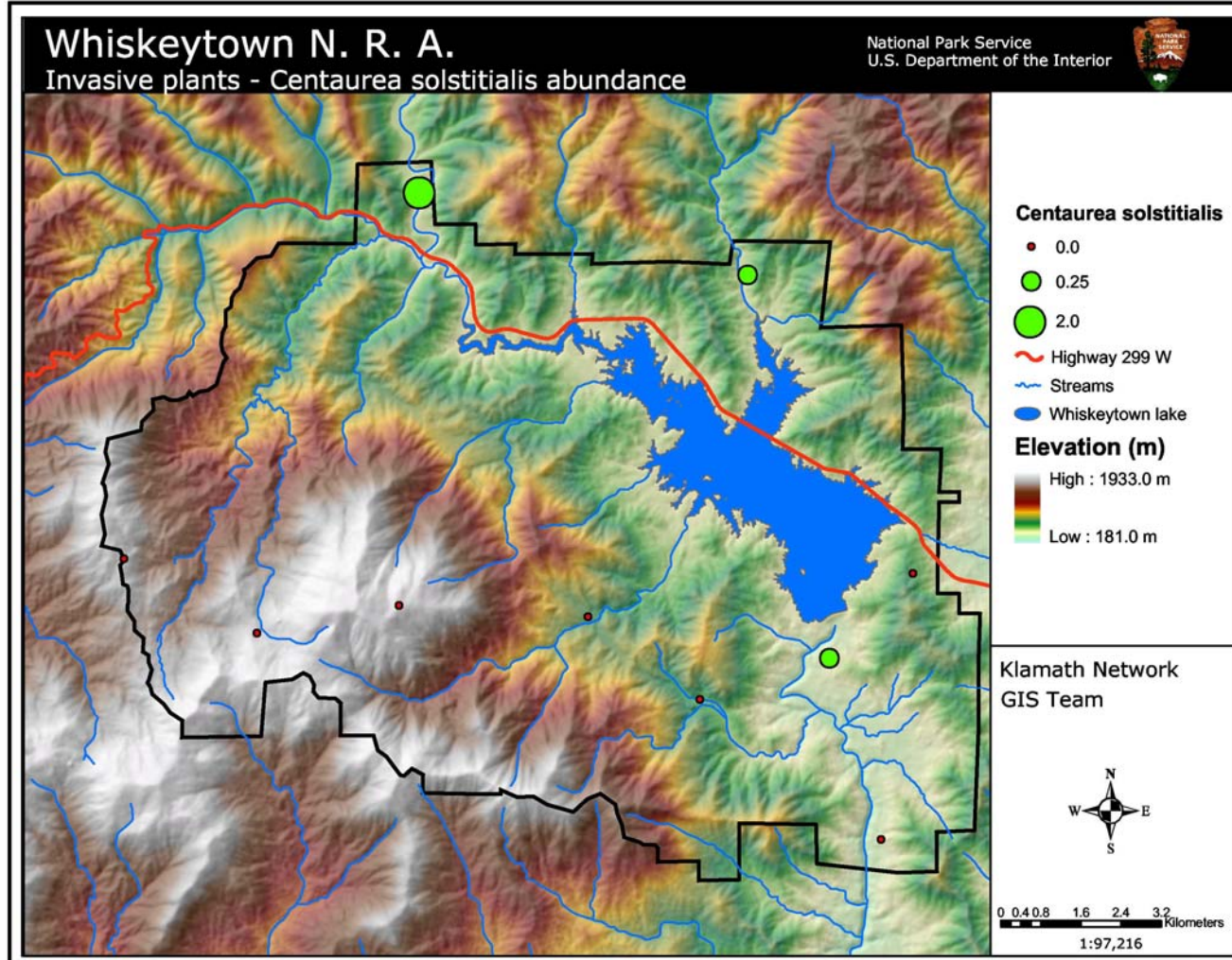


Figure 6. Abundance of *Centaurea solstitialis* in quantitative belt plots at Whiskeytown National Recreation Area.

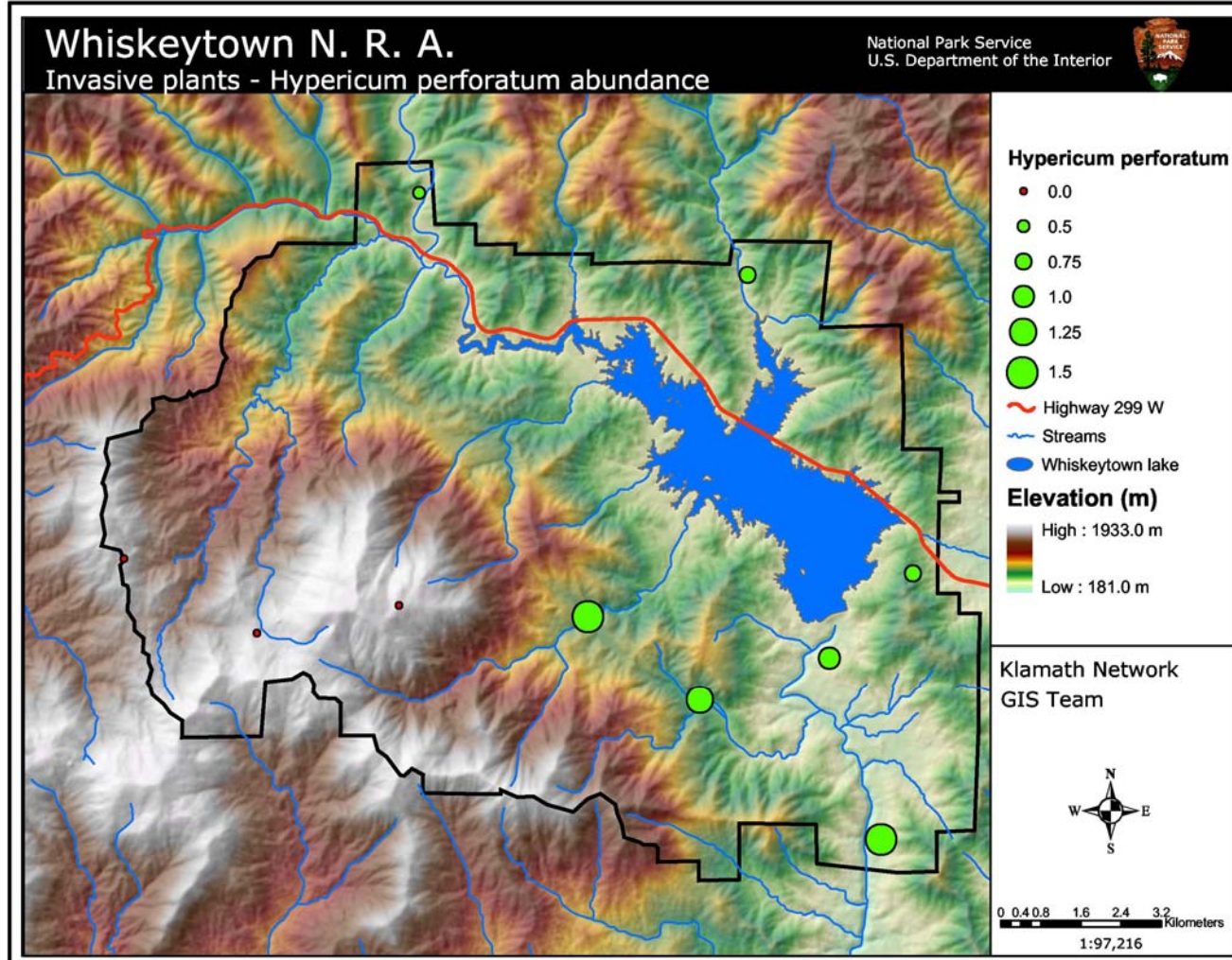


Figure 7. Abundance of *Hypericum perforatum* in quantitative belt plots at Whiskeytown National Recreation Area.

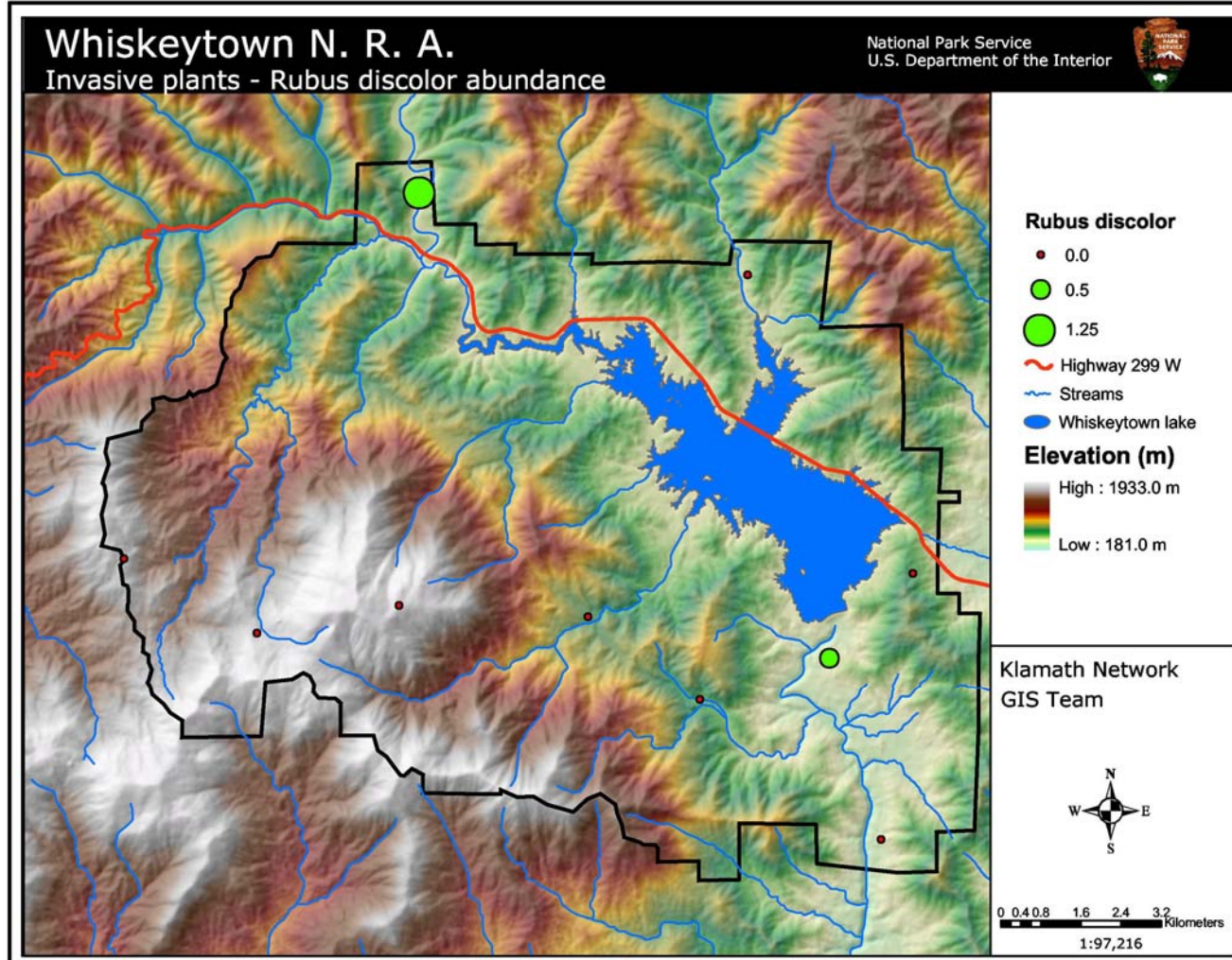


Figure 8. Abundance of *Rubus discolor* in quantitative belt plots at Whiskeytown National Recreation Area.

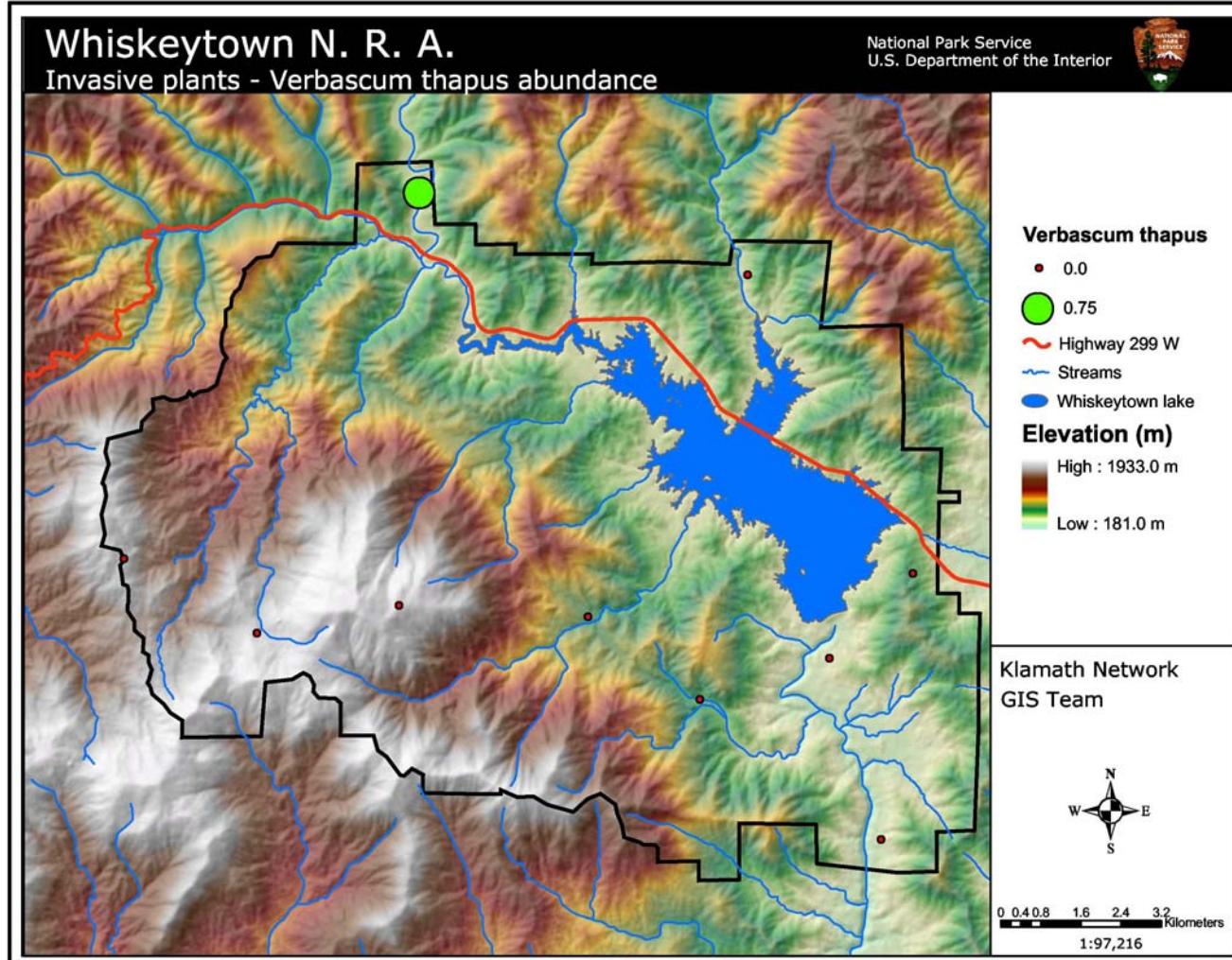


Figure 9. Abundance of *Verbascum thapsus* in quantitative belt plots at Whiskeytown National Recreation Area.

APPENDIX B. LABE MAPS

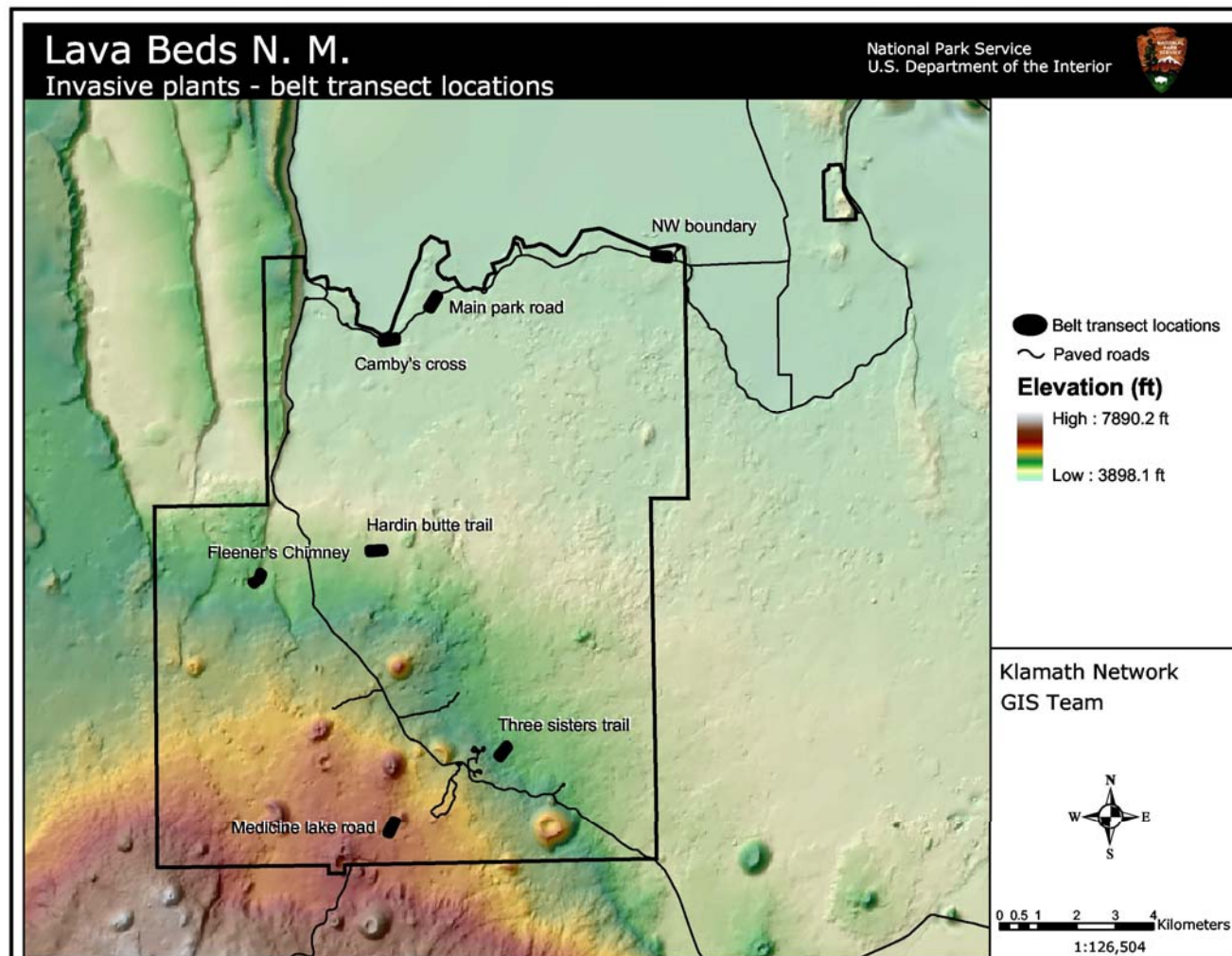


Figure 1. Location and name of quantitative belt plots in Lava Beds National Monument.

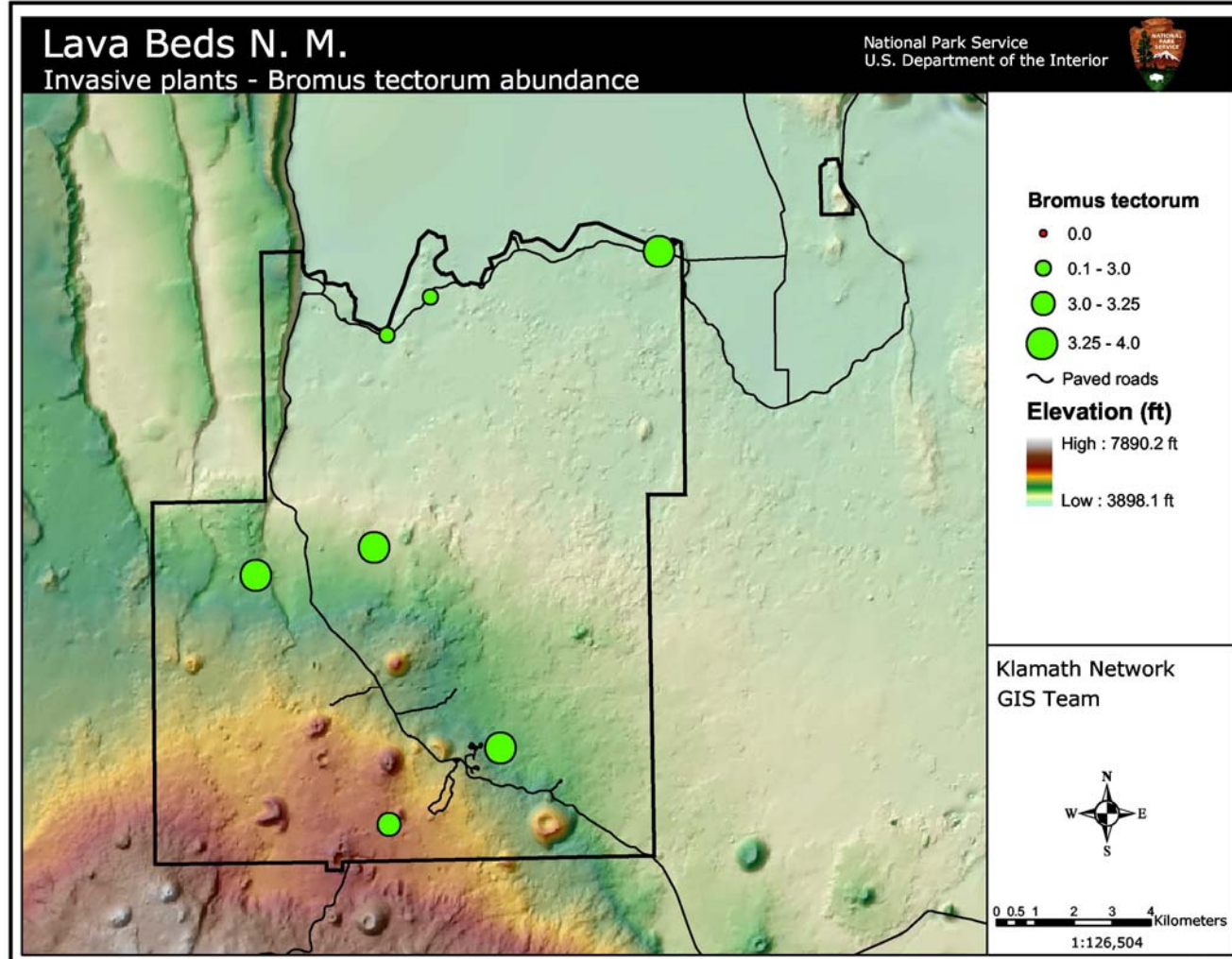


Figure 2. Abundance of *Bromus tectorum* in quantitative belt plots at Lava Beds National Monument

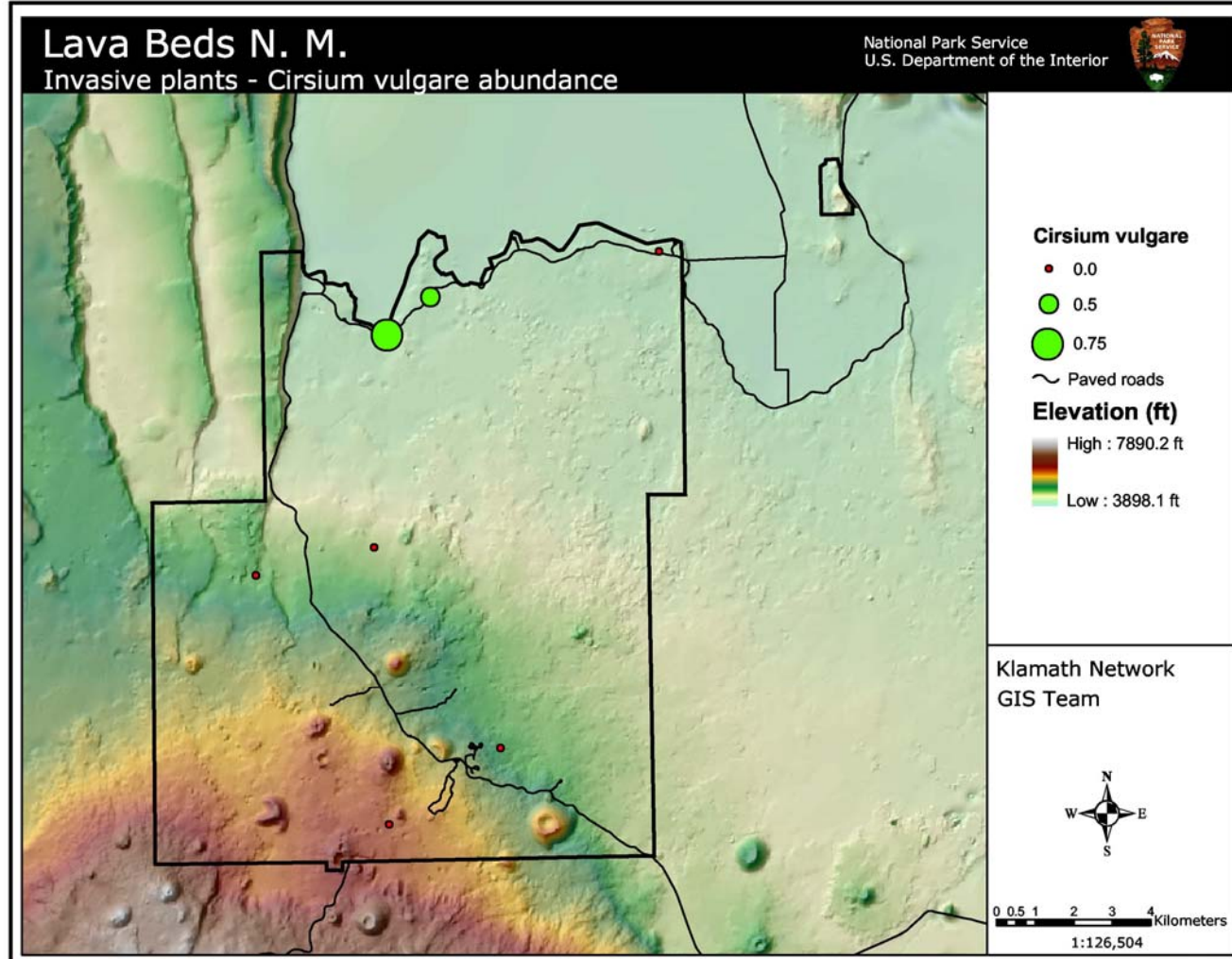


Figure 3. Abundance of *Cirsium vulgare* in quantitative belt plots at Lava Beds National Monument

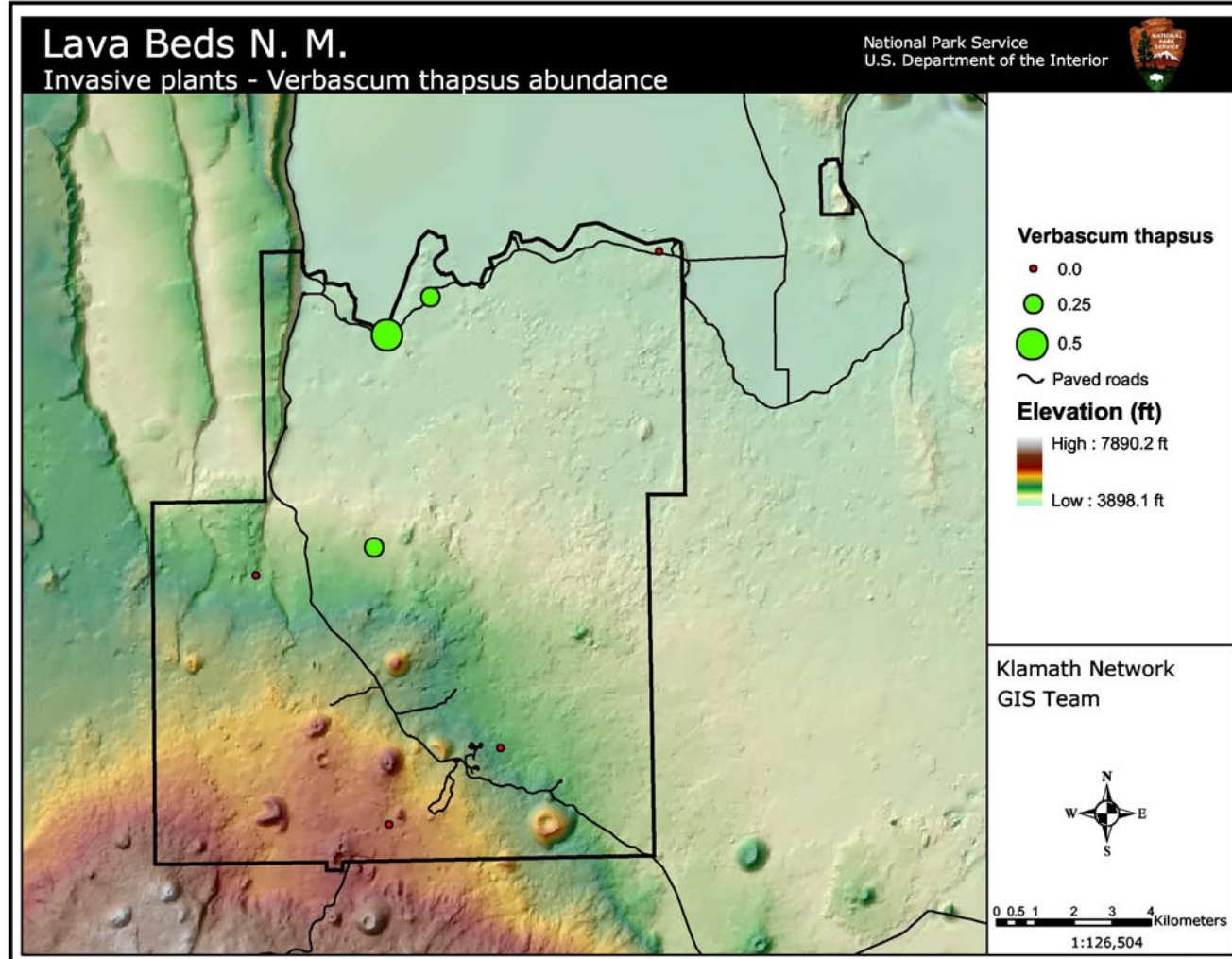


Figure 4. Abundance of *Verbascum thapsus* in quantitative belt plots at Lava Beds National Monument

APPENDIX C. ORCA MAPS

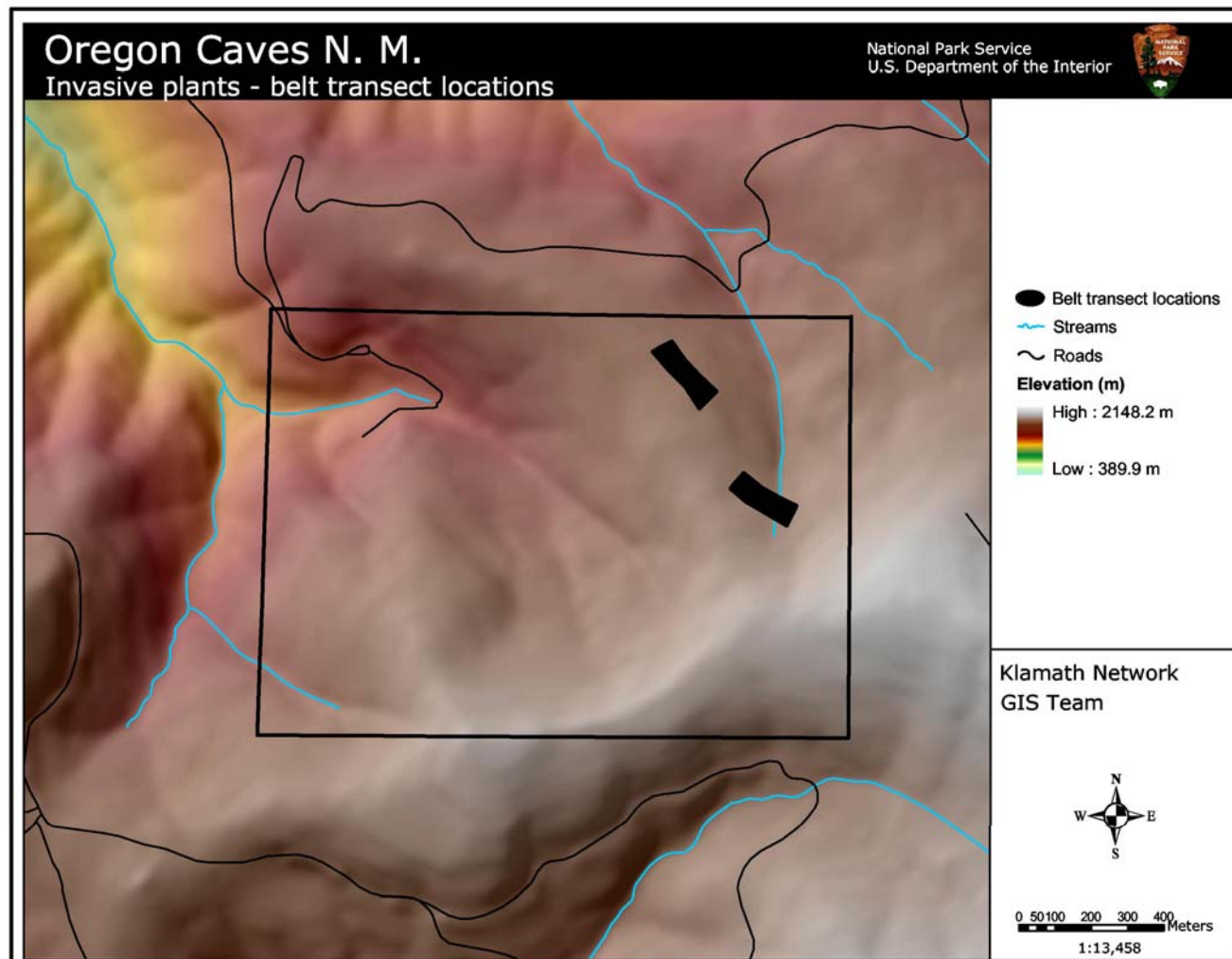


Figure 1. Location of quantitative belt plots in Oregon Caves National Monument.

APPENDIX D. LAVO MAPS

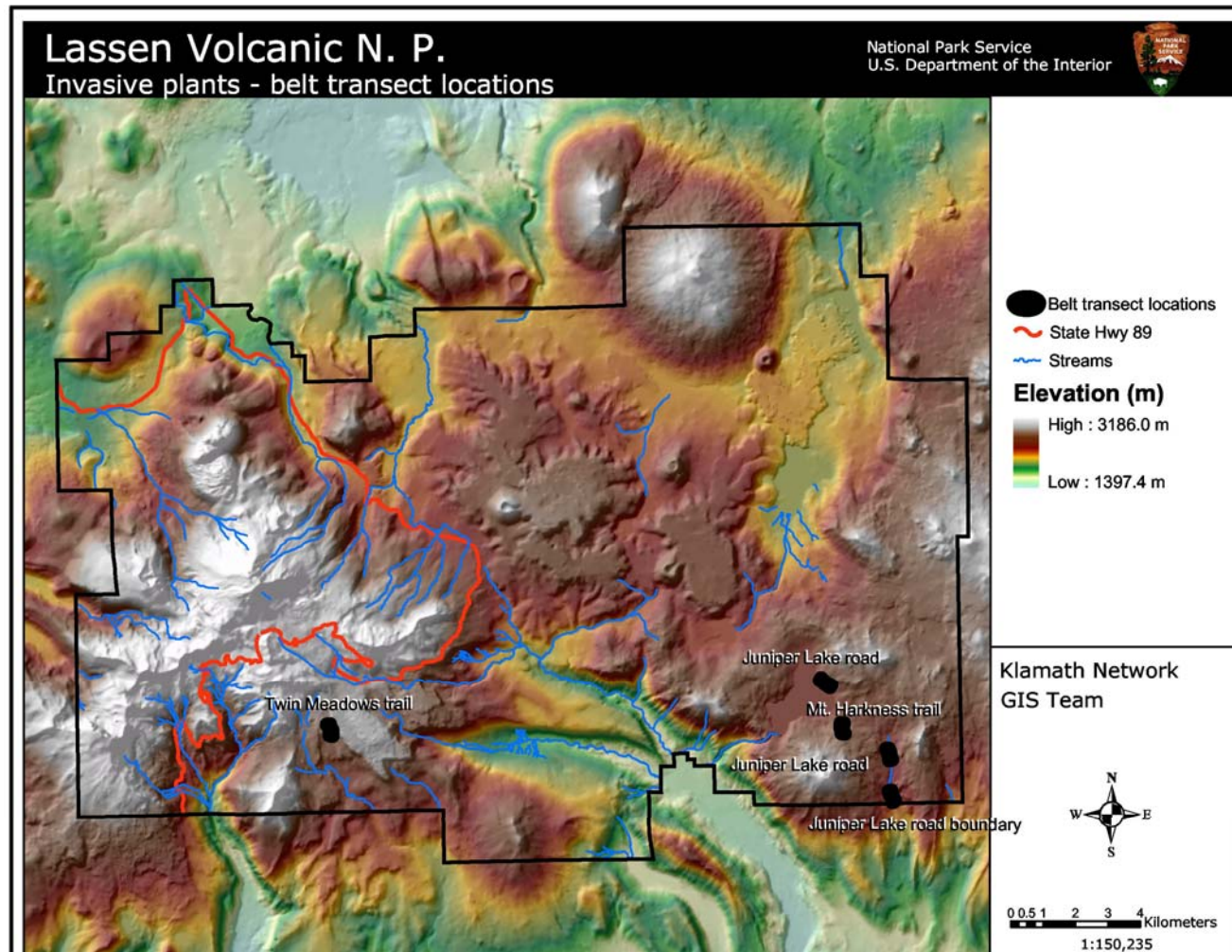


Figure 1. Location of Quantitative belt plots in Lassen Volcanic National Park.

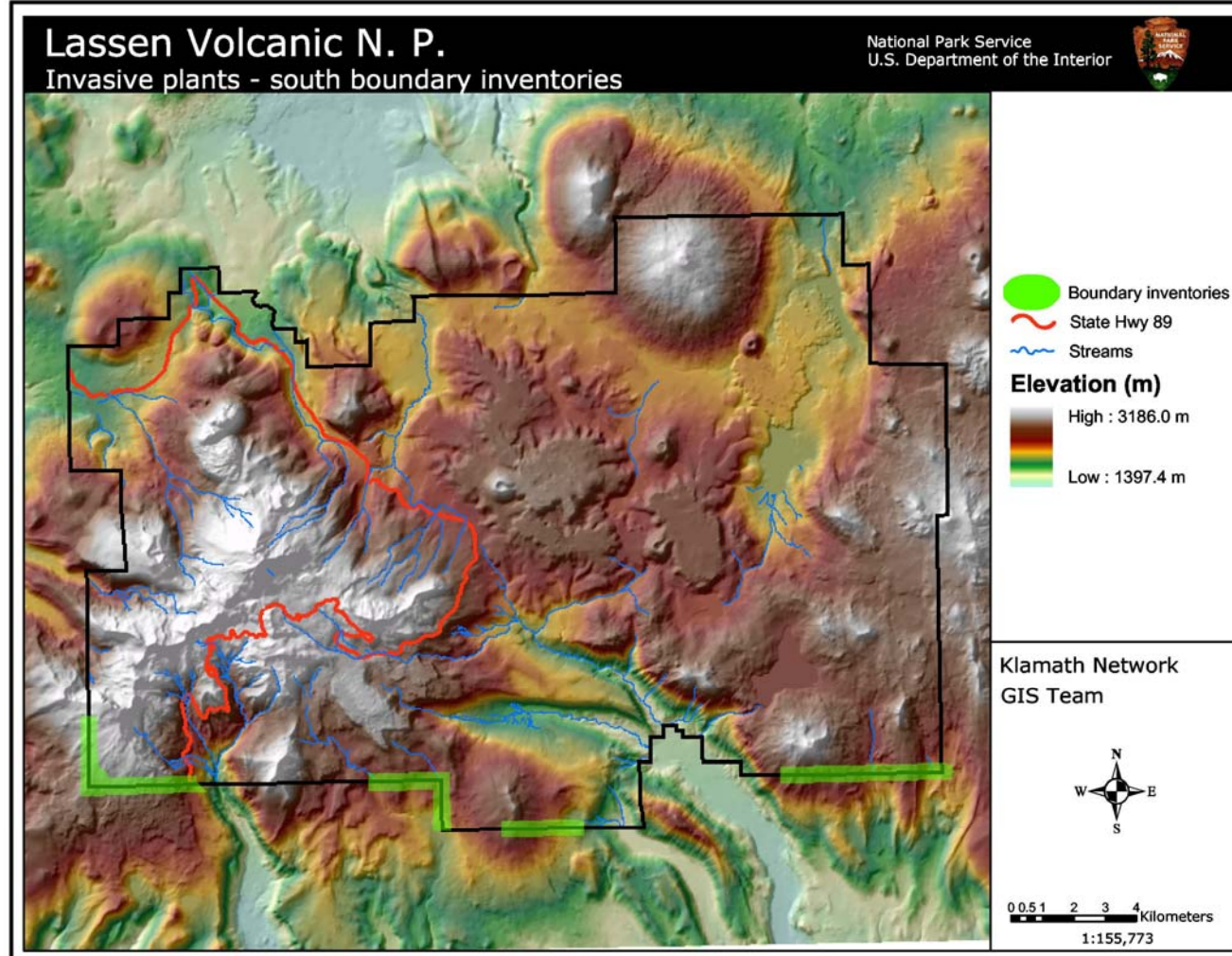


Figure 2. Location of south boundary non-native weed inventories in Lassen Volcanic National Park.

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Appendix 1. Klamath Network Site information form.

Site Information Form										SKETCH AREA
Park: _____		Date: _____		Time: _____		SampleRecordID: _____				
Crew: _____										
WxCloudCover: C P O		WxPrecip: _____		WxWind: C L G S		WxTempAir: _____				
		WxRelHumidity: _____				WxTempSoil: _____				
EncounterClass (circle one)										
Survey Plot(polygon) Time-Constrained Search Transect Survey(line) Point Site(point) Incidental Sighting Other (explain): _____										
StratumClass:1 _____			StratumClass:2 _____			StratumClass:3 _____				
StratumClass:4 _____			StratumClass:5 _____			StratumClass:6 _____				
UTM_Zone: _____		UTM_Datum: _____		UTM_Error: _____		UTMcorrected: Y N				
UTM_E: _____				UTM_N: _____						
Quad_Township: _____		Quad_Range: _____		Quad_Section: _____		Quad_1/4: _____				
Description to Site: _____										
PlotShape: _____ PlotLength: _____ PlotWidth: _____ PlotRadius: _____ PlotOther: _____										
Elevation: _____		Slope: _____		Aspect: _____		%SurfaceWater: _____				
Topography (circle one)										
Level ToeSlope LowerSlope MidSlope UpperSlope Escarpment/Face Ledge Crest Depression Draw										
SlopeShape (circle one)										
Concave/Concave Concave/Straight Concave/Convex Straight/Straight Straight/Convex Convex/Concave Convex/Straight Convex/Convex										
Hydrology (circle one)										
FloodedPermanently SemiPermanently Seasonally/Temp Intermittently Seep Upland										
Ground Cover (should sum to 100%)										
BedrockBoulder: _____		GravelCobble: _____		SandSoil: _____		Talus: _____				
HerbsForbs: _____		GrassLitter: _____		Mosses: _____		Ferns: _____				
LeafLitter: _____		WoodyDebris: _____				Lichen: _____				
Cover Classes 1:<1% 2:1-5% 3:5-25% 4:25-50% 5:50-100%										
Descrip_GeneralSite: _____										
Site Vegetation										
Leaf Phenology (of uppermost stratum having >10% cover)										
TreesShrubs: Evergreen _____					Herbs: Annual _____					
Deciduous _____					Perennial _____					
Mix (Evergreen/Deciduous) _____					Unknown _____					
Physiognomic Class (circle one)										
Forest Woodland SparseWoodland Shrubland SparseShrubland Herbaceous SparseVegetation										
Vegetation Strata										
	Height Class		% Cover		3 most Dominate Species in each Category					
Canopy:	1	2	3	4	5	6	A	B	C	D
SubCanopy:	1	2	3	4	5	6	A	B	C	D
Shrub:	1	2	3	4	5	6	A	B	C	D
Herb:	1	2	3	4	5	6	A	B	C	D
Vegetation Descrip: _____										
General Comments: _____										

Map: Y/N		Image: Y/N		Sketch: Y/N						

