

Botanical Survey of Lupine Meadows

Prepared for the Greenbelt Land Trust
By Institute for Applied Ecology
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density maps.

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Introduction

The Greenbelt Land Trust's (GLT) vision for its 58-acre Lupine Meadows property is to protect, restore and manage rare native habitats and rare species to provide low-impact education, recreation and ecological research. In addition, the GLT desires to use Lupine Meadows in partnership with public agencies and private landowners and organizations to promote restoration and management of native habitats in the Newton Creek area.

Upland and wetland prairie habitats are the most imperiled native habitats in the Willamette Valley and host most of the rare and listed plant and animal species in the ecoregion. The Lupine Meadows Management Plan (Kaye 2008) places the highest priority on restoration of these habitats and species, with emphasis on Fender's blue butterfly (*Plebejus icarioides fenderi* née *Icaricia icarioides fenderi*) and Kincaid's lupine (*Lupinus oregonus* née *L. sulphureus* ssp. *kincaidii*).

Kincaid's lupine, a federally listed threatened species, is found in native prairie remnants in the Willamette Valley, southwestern Washington, and forest openings in Douglas County, Oregon. In the Willamette Valley, Kincaid's lupine is the primary larval host plant for Fender's blue butterfly. Although this species preferentially uses Kincaid's lupine, it will occasionally lay its eggs on spurred lupine (*Lupinus arbustus*). Fender's blue butterfly is a federally listed endangered species, and is restricted to 16 populations found solely within the Valley (Hammond 2009). Eggs are deposited on the underside of the lupine leaves, which serve as a food source for the emerging caterpillars. The caterpillars overwinter in the soil at the base of the plant. The larvae feed on new lupine growth in February and early March of the following year, and then pupate in April. Adult butterflies emerge in May and June to continue the life cycle (Schultz and Crone 1998). Focusing conservation efforts on the lupine is a common strategy for success of both species.

A total of 191 plant species have been documented at Lupine Meadows, 114 of which are native species (Lawrence and Blakeley-Smith 2005). Grasses dominate the low vegetation of both upland and wetland prairies, and some portions of these habitats have high quality remnants of native vegetation. Trees provide extensive habitat structure in riparian and ash swale/savanna habitats. In addition to *L. oregonus*, wild populations of the federally endangered Nelson's checkermallow (*Sidalcea nelsoniana*) and candidate species, Howell's spring beauty (*Montia howellii*) are currently found on the property. In addition, Willamette daisy (*Erigeron decumbens*; USFWS endangered) and golden paintbrush (*Castilleja levisecta*; previously extirpated from Oregon) have been introduced to the site.

In spring 2011, we conducted vegetation surveys at Lupine Meadows to document the availability of host and nectar plants for Fender's blue butterfly and the distribution of exotic plant species. Specifically, the goals of this project are to:

1. Establish a permanent monitoring plot and protocol in the area of Lupine Meadows occupied by Kincaid's lupine and nectar species for Fender's blue butterfly.
2. Measure the amount of Kincaid's lupine at Lupine Meadows.
3. Describe the diversity, amount, and distribution of nectar species for Fender's blue butterfly.
4. Survey and map invasive species at Lupine Meadows, with particular attention to species that (a) have the potential to become problematic, and/or (b) could be

relatively easily managed. Obvious invasive species such as Himalayan blackberry and Scotch broom were not mapped.

Kincaid's lupine monitoring

Methods

Lupine was monitored on June 6-8, 2011. The main population of lupine is in the northern portion of upland prairie meadow. The lupine also extends along the roadside and roadcut. There are 5 additional smaller patches of lupine on the southern portion of the upland prairie (Figure 1).

The roadside population is 130 meters long and is marked with tagged rebar pounded flush with the ground and capped with a round orange plastic caps at meters 0, 30, 60, 100, and 130 (Table 1). The origin of the roadside transect is labeled #578 and is located 9.8 meters at a bearing of 322° from the base of the telephone pole at the top of the hill. The transect runs roughly parallel to West Hills Rd. and 19th St. Lupine was monitored in 10m segments going NW from the transect towards the road. Monitoring stopped at the top of the cut-bank.

The main population of lupine is marked with a 180m transect at the southern boundary of the population. The baseline transect of the main population intersects the boundary of the roadside population at approximately 80 meters on the roadside transect (**Figure 1**). Lupine in the main population was monitored in 10m belts running north-south until they hit the road or the roadside population. Each of the 10 meter wide belts was divided in 10 meter sections and lupine cover was estimated in each section. Between meters 120-138 of the baseline transect, there are plants on the south side of the transect. Any lupine to the east of the first monitoring belt (from 0-10 on the baseline transect), were included in the totals for the 0-10m belt.

The five remaining patches were marked with yellow capped rebar in the approximate center of the patch and lupine was measured in wedge-shaped sections to capture all plants present (Table 1). The patches varied 5-11m radius from the numbered rebar (Table 1).

Within each plot, we determined the abundance of Kincaid's lupine by measuring the foliar cover (Appendix A. Technique for measuring lupine cover, lupine data and lupine datasheets.) Each patch of Kincaid's lupine was visually manipulated into a rectangular shape, of which we recorded the length and width to the nearest centimeter. To create density maps of Kincaid's lupine and selected nectar species, we created modeled surfaces of species cover to interpolate a smooth estimate between observed measurements. The modeled surfaces were produced by non-parametric multiplicative regression (McCune 2006) based on local mean estimates of species cover as predicted by mapped coordinates. The neighborhood size tolerances of the coordinates were set to 1% of the range of coordinate values in order to over-estimate the modeled cover to the observed cover. We also chose a tolerance of 5% to generate a smoother estimate of cover for a more general map of species density.

Results

The approximate cover of Kincaid's lupine at Lupine Meadows was 184.6m² (Table 2). The density of lupine was greatest in the main population between meters 40-50 on the baseline transect and 90-120m (Figure 3). The area from 90-120m also has high cover of sweetbriar rose (*Rosa eglantheria*), which may pose a threat to the lupine if not controlled. All lupine cover data as well as example datasheets can be found in Appendix A. Technique for measuring lupine cover, lupine data and lupine datasheets..

Table 1. Tag numbers and plot descriptions of lupine plots established for lupine monitoring.

	Tag #	Meter	Plot size and description	Meter,Bearing	Coordinates (NAD 83, UTM 10N)
Roadside population	578	0		-	4933573 N 471812 E
"	579	30	130m baseline run roughly parallel to road, measured in 10m sections	0-30,220°	4933553 N 471793 E
"	580	60		30-60,222°	4933530 N 471771 E
"	581	100		60-100,205°	4933495 N 471752 E
"	582	130		100-130,202°	4933466 N 471739 E
Main Population	583	0			-
"	584	30	180m baseline, crosstapes run N/S and lupine monitored in 10m grid	0-30,274°	4933465 N 471898 E
"	585	60		30-60,274°	4933467 N 471867 E
"	586	100		60-100,274°	4933469 N 471827 E
"	587	140		100-140,300°	4933489 N 471794 E
"	588	180		140-180,300°	4933513 N 471762 E
Patch 1	597		11m radius	N/A	4933380 N 471830 E
Patch 2	598		6 m radius	N/A	4933345 N 471866 E
Patch 3	136		6 m radius, on old road	N/A	4933423 N 471880 E
Patch 4	599		7.5 m radius	N/A	4933418 N 471891 E
Patch 5	600		6m radius	N/A	4933453 N 471893 E

Summary

This monitoring protocol was established so that it could be replicated in the future in order to determine changes in lupine abundance through time. We recommend monitoring every three years if the site is only undergoing regular maintenance or yearly during periods of active restoration.

Table 2. Cover of Kincaid's lupine within each patch at Lupine Meadows.

Population	Cover (m²)
Roadside	16.3
Main Population	136.2
Patch 1	15.3
Patch 2	4.5
Patch 3	3.4
Patch 4	8.2
Patch 5	0.6
Total cover	184.6



Figure 1. Location of Kincaid’s lupine at Lupine Meadows. Numbers represent tag numbers for rebar pounded flush with the ground and capped with an orange cap.

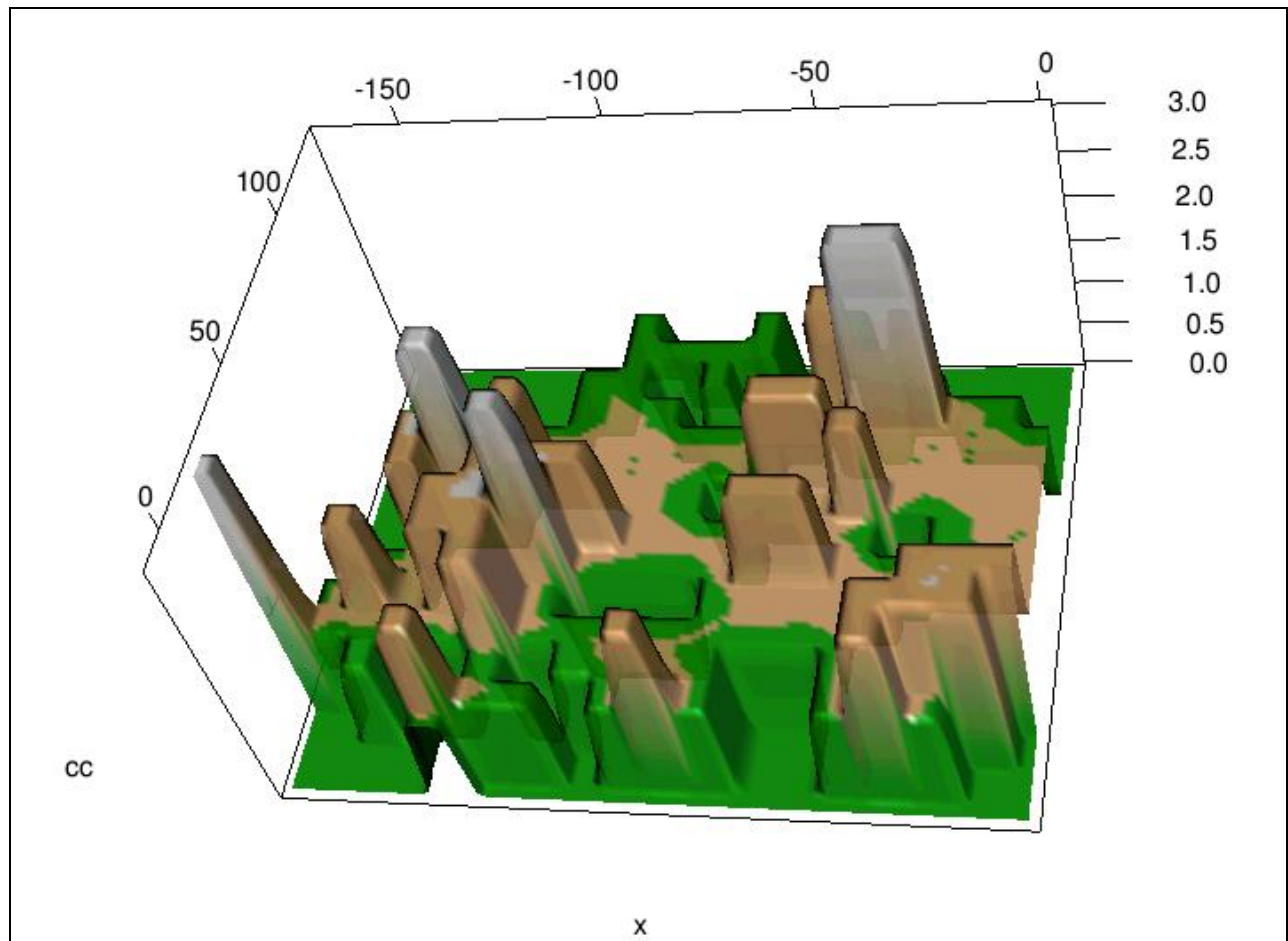
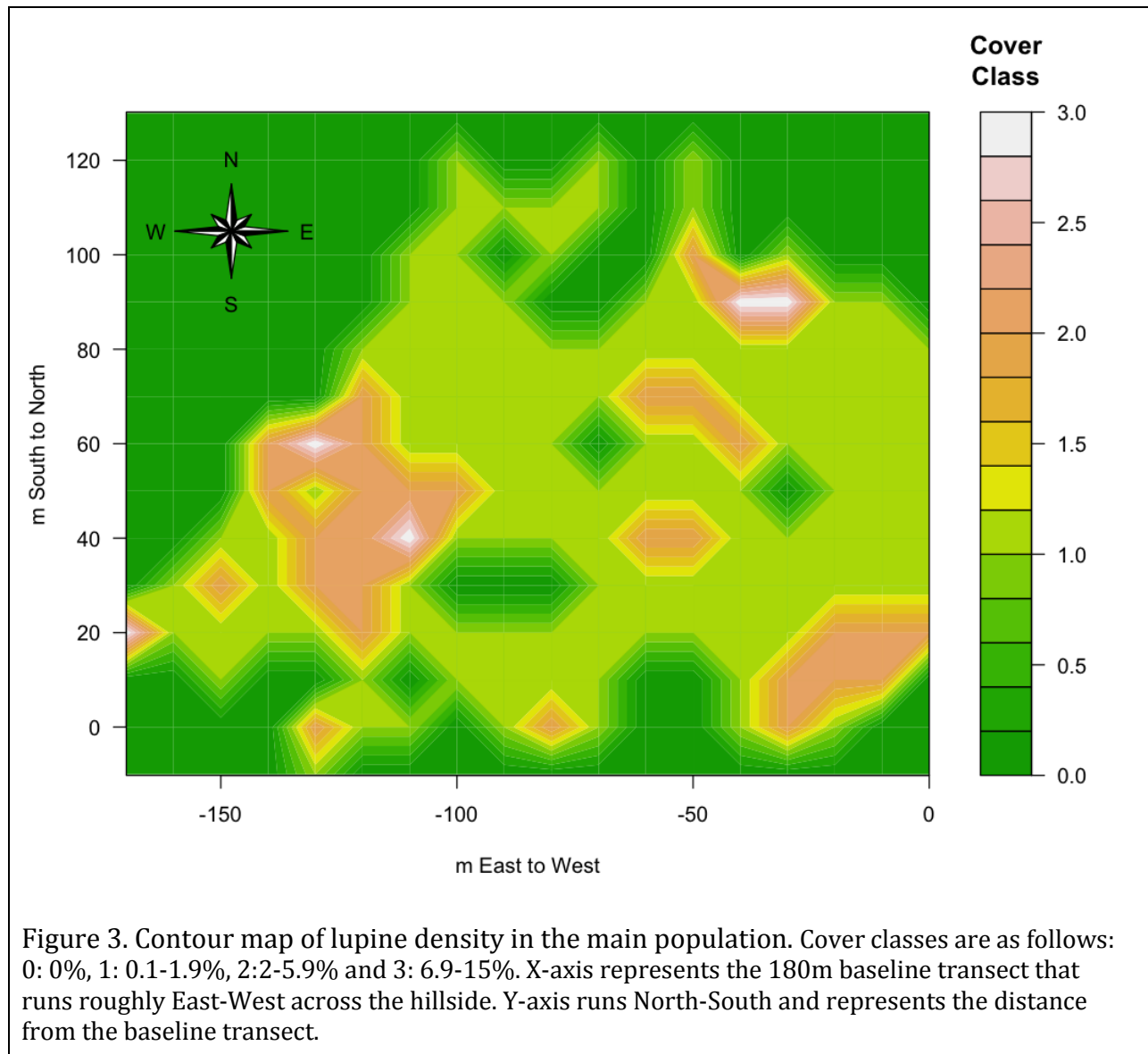


Figure 2. Lupine density in the main population. Cover classes are as follows: 0: 0%, 1: 0.1-1.9%, 2: 2-5.9% and 3: 6.9-15%. X-axis represents the 180m baseline transect that runs roughly East-West across the hillside. Y-axis runs North-South and represents the distance from the baseline transect.



Botanical surveys

Botanical surveys to generate species lists for the habitats at Lupine Meadows were completed in 2005 (Lawrence and Blakeley-Smith 2005). In 2011, we conducted additional surveys to assist with management. The primary goals of these surveys were to (1) determine the relative abundance and location of nectar species utilized by Fender’s blue, and (2) document the abundance and location of invasive species. The surveys were completed on June 6 and 7 and July 27, 2011.

Nectar species survey

The purpose of the nectar species survey was to map the distribution and estimate abundance of nectar species at Lupine Meadows. Multiple sources (USFWS 2010, Thomas and Schultz 2010, Cheryl Shultz *personal communication*) were used to generate a list of potential nectar species (Appendix B).

We surveyed for all nectar species throughout the open meadow, with particular attention to the northern portion of the meadow which contains a large patch of Kincaid's lupine. The dominant feature of the upland prairie north meadow is a large hill (hereafter referred to as "the hill"). Most of the lupine is located on the north side of a large hill in the meadow. The hill flattens out towards the south. Patches of nectar species were mapped and the abundance of plants was estimated. Searching for nectar is energetically expensive for Fender's blue butterfly, thus we used the more intensive monitoring method to determine nectar abundance where its presence (or absence) would have the greatest effects on the butterflies.

Site-wide surveys

Maps of species included in the nectar species surveys are included in Appendix C. Maps of nectar species documented at Lupine Meadows.

Oxeye daisy (*Leucanthemum vulgare*; exotic) was the most common nectar species found at Lupine Meadows. It is especially abundant on the south side on the bottom of the hill where it reaches an approximate percent cover of about 5% for the entire bottom section, about 50 plants per 1m². Cover was about 1% for the rest of the meadow. At the time of our surveys, approximately 80% of plants were in bloom or had buds while 20% were vegetative.

Virginia strawberry (*Fragaria virginiana*; native) was the second most common nectar species. It was mainly on the top and sides of the large hill, especially on the west side. On the hill (top and sides) cover was approximately 25%; cover in other areas was about 0.5%. Most plants were in the fruiting stage although a trace amount still had flowers.

Slender cinquefoil (*Potentilla gracilis*; native) was the third most common nectar species and was found throughout the meadow. Abundance of this species increased near the tree line and was especially high on the bottom of the hill in the northeast corner. About 5% were in flower.

Garden vetch (*Vicia sativa*; exotic) was common throughout the site, predominantly in trace amounts although cover in localized areas occasionally increased to 5%. It was most common on the sides and bottom of the hill and about 70% were in flower.

Hairy vetch (*Vicia hirsuta*; exotic) was found throughout the site in trace amounts. Cover of this species was particularly high on east and south hill sides. About 90% of this species was in bloom.

Smooth tare (*Vicia tetrasperma*; exotic) was the least common vetch and was found in trace amounts throughout the site. All that were identified were in flower.

Oregon sunshine (*Eriophyllum lanatum*; native) was mainly found on the hill top and sides in trace amounts. Cover of this species was very sparse on the east side of hill. About 1% were in flower.

Tolmie's mariposa lily (*Calochortus tolmiei*; native) was most common on the hill top and the west side of hill. Cover was much less than 1% for the site, but reached 1% cover in patches. 90% of this species was in bloom.

Pale flax (*Linum bienne*; exotic) was very common on the south and west hill side and somewhat throughout the top. Due to its small size, overall cover was less than 1% for the site, although some areas were more dense. All identified plants were in bloom.

Small camas (*Camassia quamash*; native) was prevalent on the tree line for the entire eastern and southern portions of the meadow in areas that are wet. Cover in these areas was less than 1%. About 50% were in bloom and the other 50% were fruiting.

Rose checkermallow (*Sidalcea virgata*; native) was not common at Lupine Meadows. We found several dense patches on the northeast side of hill, a few sparse patches on top and on the south and west sides, and a few plants near the southern tree line. About 15% of these plants were in bloom.

Yellow and blue forget-me-not (*Myosotis discolor*; native) was common throughout the site at trace levels. All identified were in bloom.

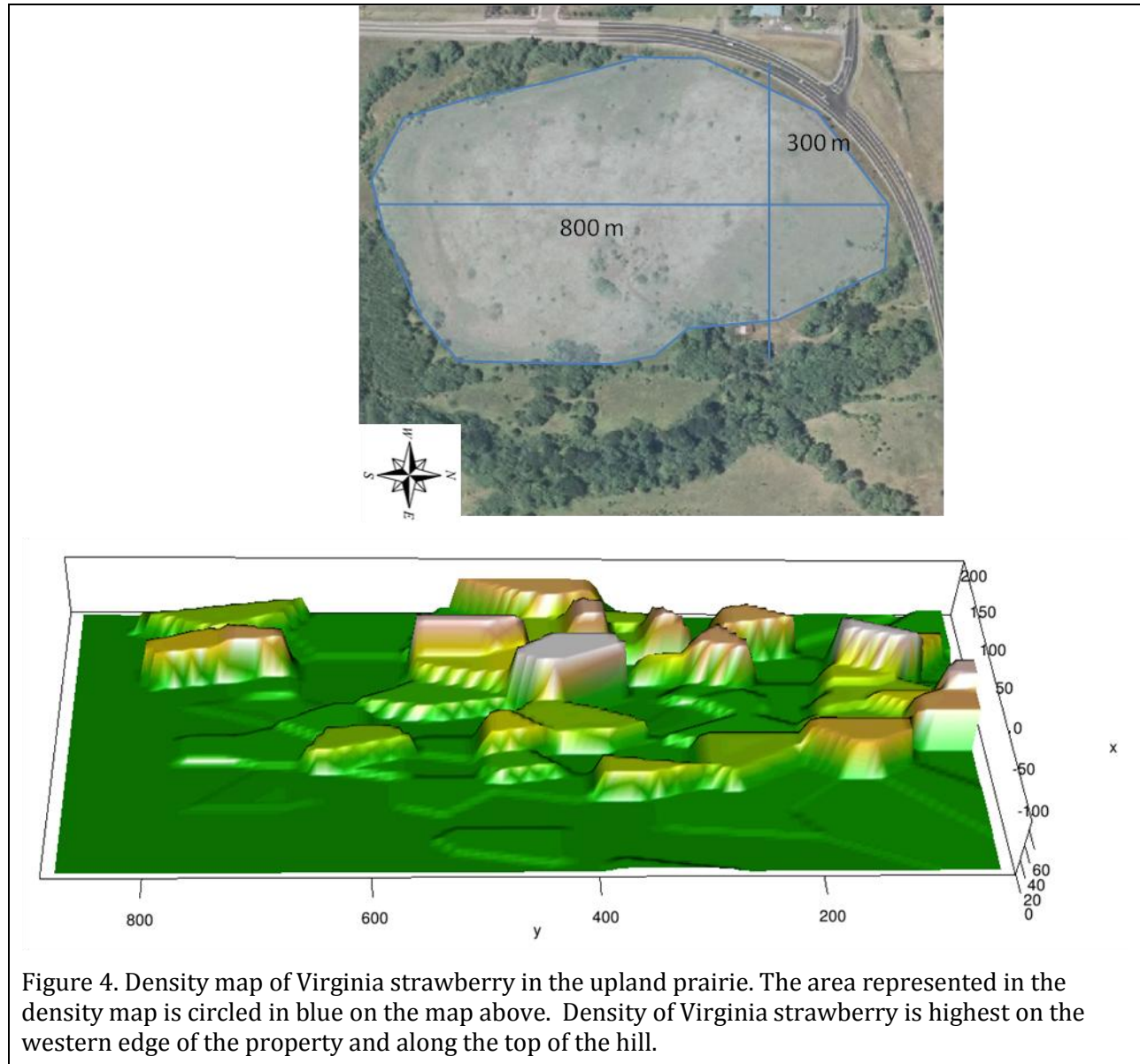
Cluster lily (*Dichelostemma congesta*; native) was found throughout the site but was uncommon; there were one or two plants every 20 meters. All identified cluster lilies were in bloom.

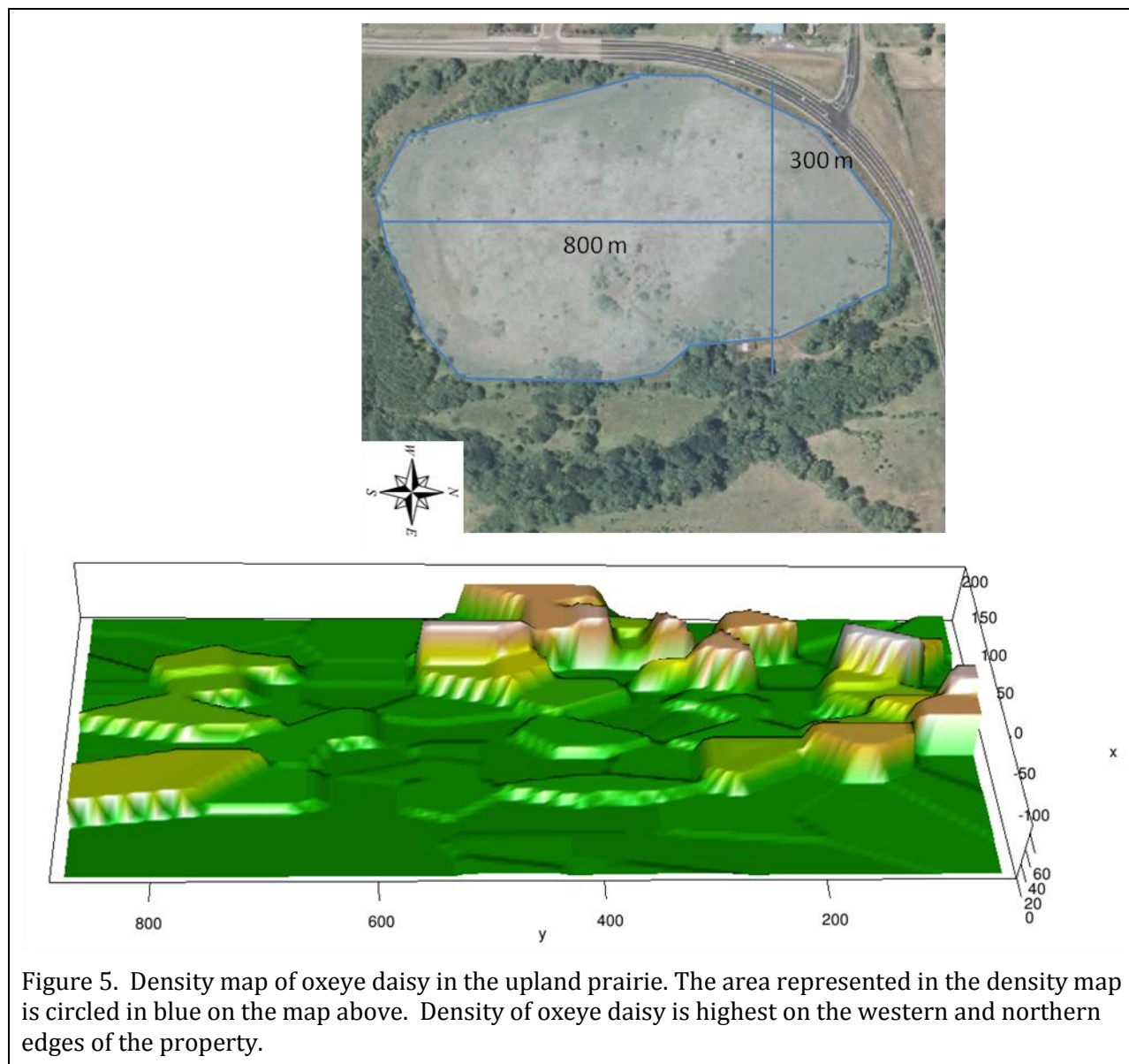
Summary: Nectar species

Lupine Meadows has a good diversity of nectar species. This is particularly important as the abundance of nectar from each of these species persists for only a short fraction of the Fender's blue butterfly flight season (Thomas and Schultz 2010). The most abundant nectar species at Lupine Meadows was the exotic species, oxeye daisy; several other nectar species were found in smaller amounts. Due to their importance to the butterfly, control of these exotic species should be paired with increasing the abundance of native nectar species, particularly those with similar flowering phenology. For example, both garden vetch (exotic) and common camas (native) provide the earliest nectar (camas is occasionally in fruit by the time the first butterflies emerge in the spring) (Tomas and Schultz 2010). Oxeye daisy provides late season nectar and control of this species should be paired with increasing native late-season blooming species, such as slender cinquefoil.

The dominant nectar species found in the lupine monitoring grid include, Virginia strawberry, oxeye daisy, slender cinquefoil, Oregon sunshine, and Tolmie's mariposa lily. Remaining nectar species were found in trace amounts throughout the lupine area. Density

maps of the two most common nectar species in the upland prairie meadow, oxeye daisy and Virginia strawberry, were created following the same method used in making the lupine density map. Both species tended to have similar dispersal patterns (Figure 4, Figure 5).





Invasive species survey

We surveyed for invasive plant species throughout Lupine Meadows, with a focus of those species that can be easily managed, or haven't yet become widespread. The locations of invasive species were marked with a GPS unit, and habitat type and distributional trends were noted. Scotch broom (*Cytisus scoparius*) and Himalayan blackberry (*Rubus armeniacus*) were excluded from these surveys due to their pervasive nature throughout the Willamette Valley and the ease of managers and volunteers to identify these species. First, we describe the distribution and abundance of weeds with more localized distributions and high management concern. Next, we describe the distribution and abundance of widespread weeds grouped by habitat type (Figure 6). Maps of all invasive species surveyed can be found in Appendix C.

Priority weeds

The invasive species of greatest concern found at Lupine Meadows are false-brome (*Brachypodium sylvaticum*), meadow knapweed (*Centaurea pratensis*), and reed canarygrass (*Phalaris arundinacea*). False-brome and meadow knapweed are classified as B list noxious weeds by the Oregon Department of Agriculture (ODA 2011). Although not a state-listed noxious weed, reed canarygrass can quickly form a monoculture throughout wet areas, displacing native vegetation. Several large patches and scattered individuals of false-brome were found within the boundaries of the ash swale (Figure 7) and there were four small patches in the northern portion of the meadow (Figure 8). Meadow knapweed was found along the western border of the property, extending to the southern edge of the north meadow (Figure 9). Reed canarygrass was along the fencerow in the wetland prairie to the south (Figure 10). Several patches of meadow knapweed and reed canarygrass were located in the roadside right-of-way along N. 19th St, and have serious potential to invade the property. A table of GPS coordinates of target weed species can be found in Appendix E.

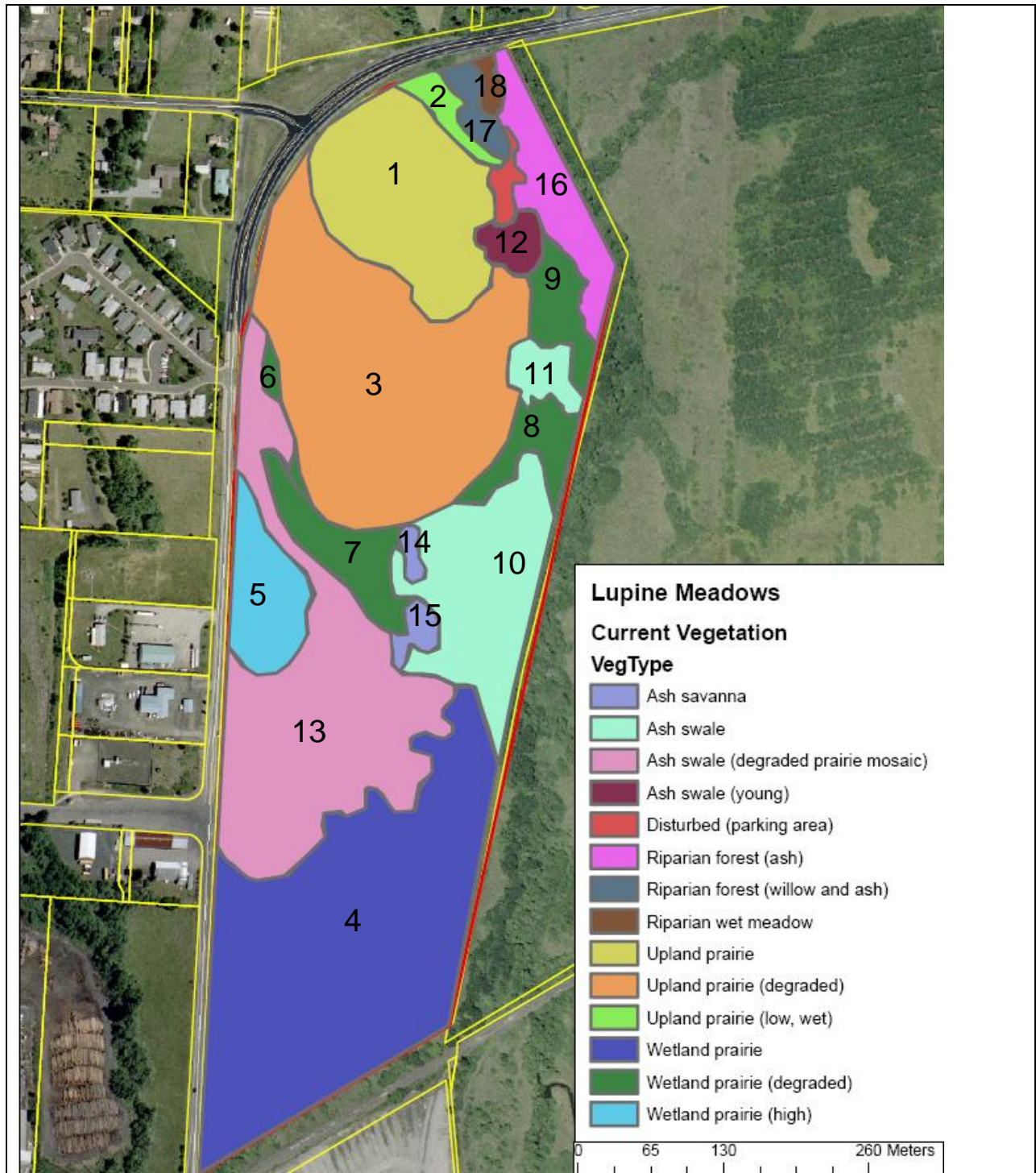


Figure 6. Map of habitat types at Lupine Meadows (Kaye 2008).



Figure 7. False-brome (*Brachypodium sylvaticum*; "BRSY") in the southern portion of the property can be found in at least 10 small patches ranging in size from single plants to areas as large as 7m x 5m.



Figure 8. False-brome (*Brachypodium sylvaticum*; “BRSY”) patches located in the northern meadow can be found in 4 small patches marked with pin flags.



Figure 9. Meadow knapweed (*Centaurea pratensis*; "CEPR") is found near the roadside in the seven mapped patches; six are near the roadside and one has established in the southern portion of the meadow.



Figure 10. Reed canarygrass (*Phalaris arundinacea*; “PHAR”) occurs in the southern tip of the property near the roadside.

Wet prairie

The wet prairie habitat at Lupine Meadows dominates the southern meadow, but is also to the east of the north meadow. In the southern meadow, the most commonly encountered invasive shrubs were one-seeded hawthorn (*Crataegus monogyna*) and sweetbriar rose (*Rosa eglantheria*). Distribution ranged from scattered individuals to very dense patches. Most rose and hawthorn plants were shrubs less than 3' in height, although there were several hawthorn trees 7' tall or higher. The most common invasive forbs were Canada thistle (*Cirsium arvense*), bull thistle (*Cirsium vulgare*), common St. Johnswort (*Hypericum perforatum*), Fuller's teasel (*Dipsacus fullonum*), tansy ragwort (*Senecio jacobaea*), and prickly sowthistle (*Sonchus asper*). Both thistles, teasel and tansy ragwort were scattered in patches of 2-3 individuals. St. Johnswort was found in clumps up to several meters in width. These same weeds were located along the tree line in the eastern meadows (Figure 12). These species co-occurred throughout the entire southern meadow (Figure 13). Several patches of pennyroyal (*Mentha pulegium*) were found in streams exiting to the south of the ash swale, and in several isolated patches at the southern end of the property (Figure 14, Figure 15).



Figure 11. Wet prairie at the southern end of Lupine Meadows. Red circles indicate bull thistle, Canada thistle, one-seeded hawthorn, sweetbriar rose and teasel.

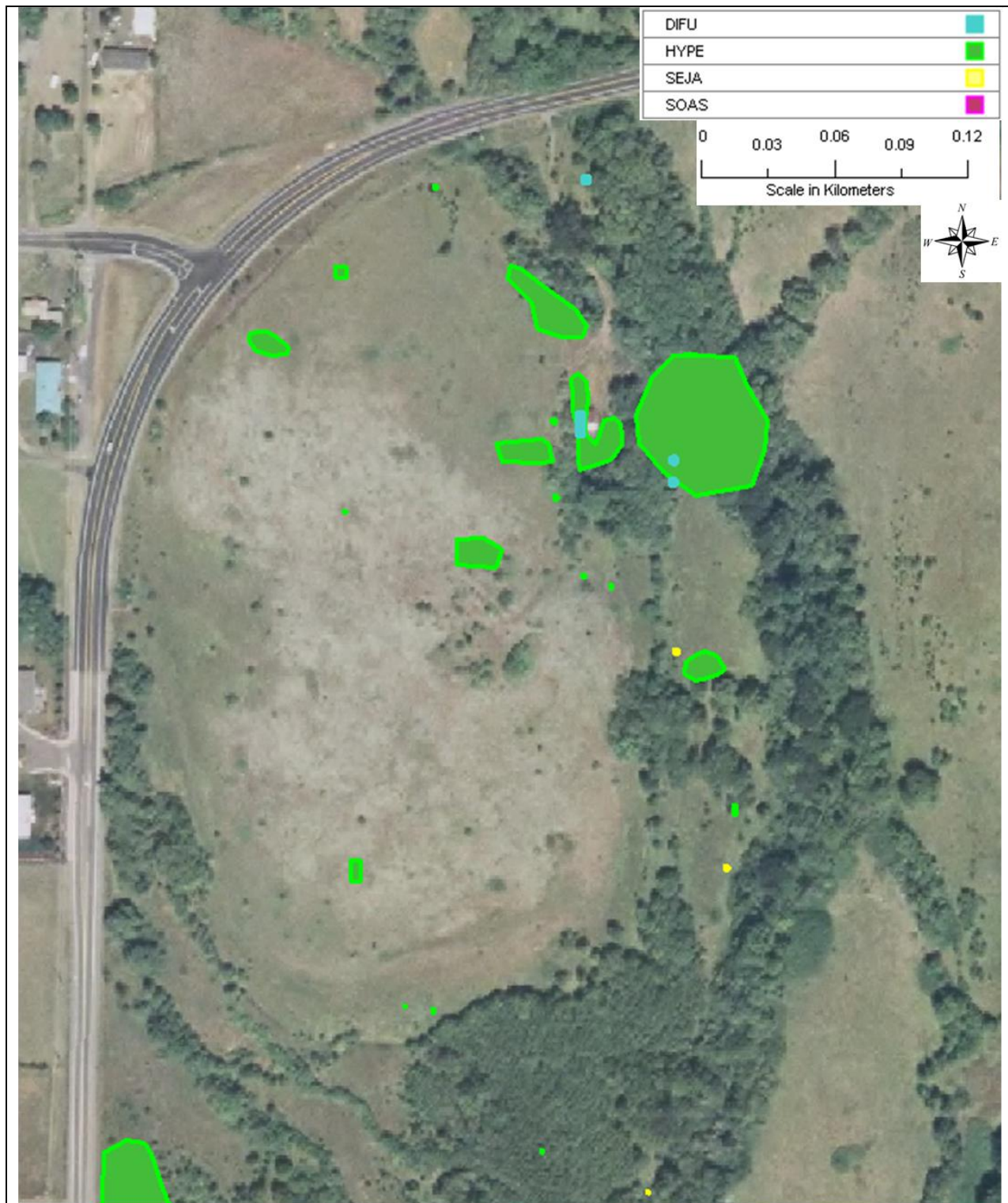
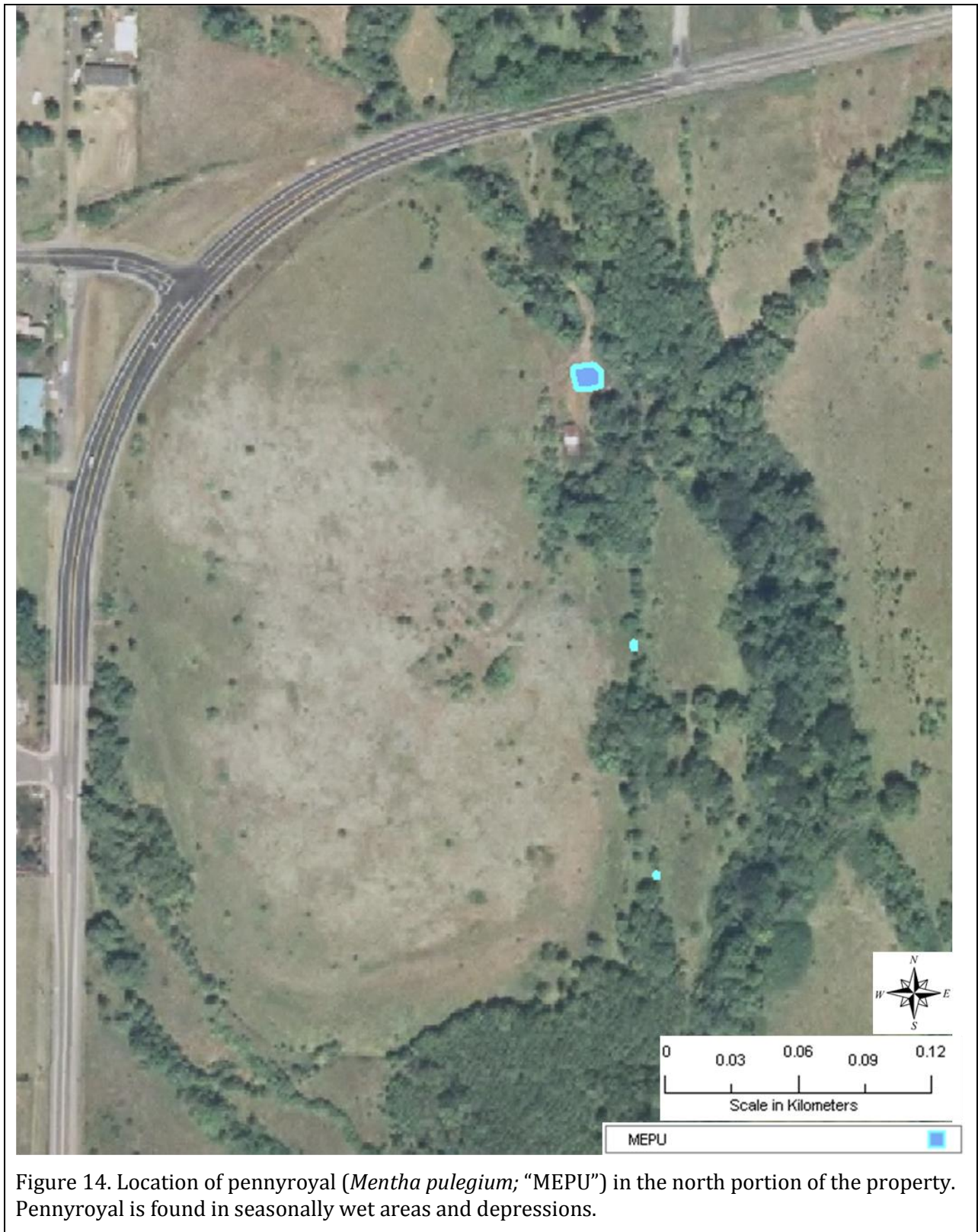


Figure 12. Locations in the northern meadow of common St. Johnswort (*Hypericum perforatum*; "HYPE"), Fuller's teasel (*Dipsacus fullonum*; "DIFU"), tansy ragwort (*Senecio jacobaea*; "SEJA"), and prickly sowthistle (*Sonchus asper*; "SOAS").



Figure 13. Mapped locations in the southern area of common St. Johnswort (*Hypericum perforatum*; "HYPE"), Fuller's teasel (*Dipsacus fullonum*; "DIFU"), tansy ragwort (*Senecio jacobaea*; "SEJA"), and prickly sowthistle (*Sonchus asper*; "SOAS").



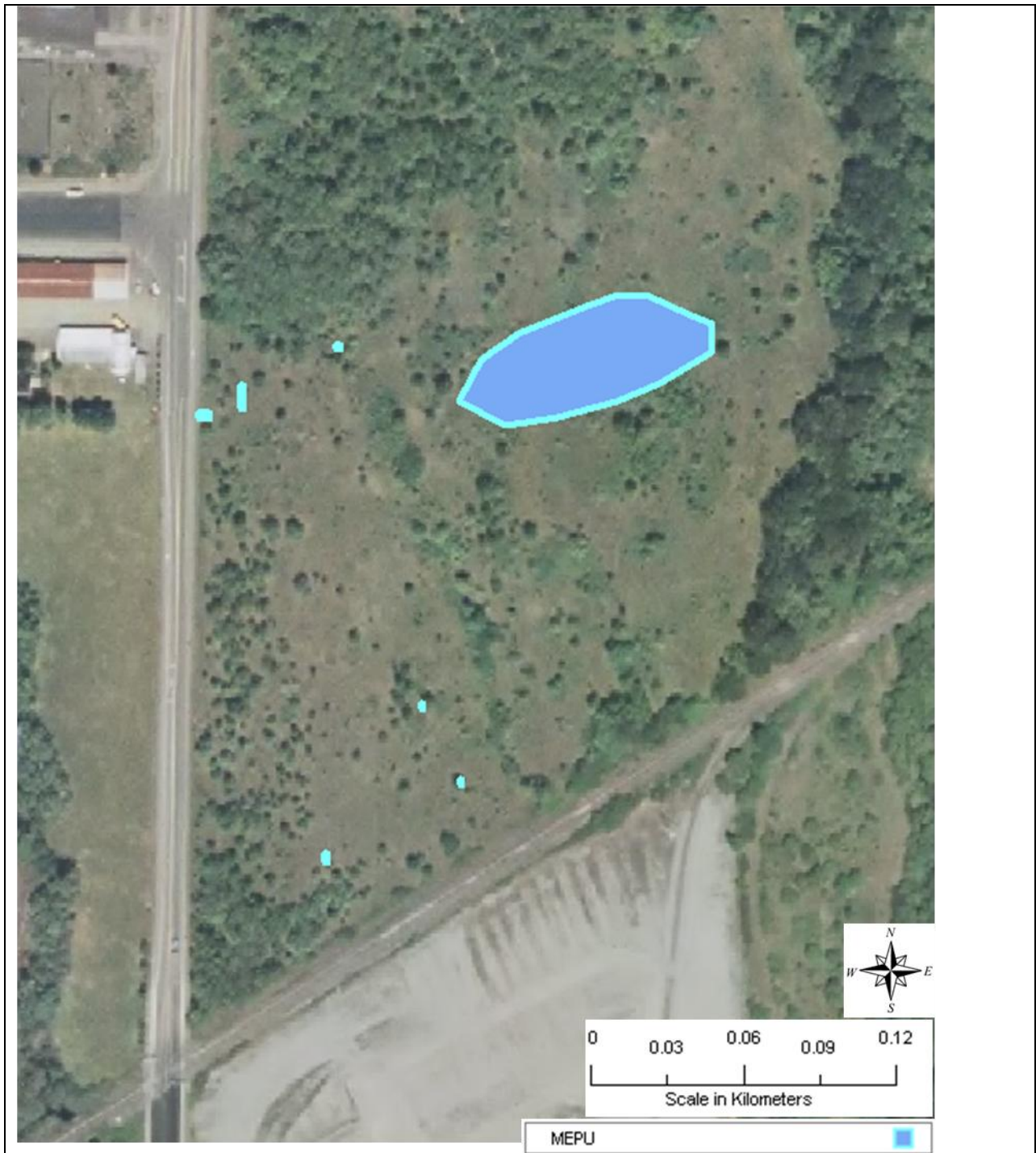


Figure 15. Location of pennyroyal (*Mentha pulegium*; “MEPU”) patches in the southern portion of the property. Pennyroyal can be found in seasonally wet areas and depressions.

Upland prairie

Upland prairie is the dominant habitat type of the northern meadow. One-seeded hawthorn and sweetbriar rose occurred throughout the meadow in patches ranging from a few small shrubs to several large shrubs and trees. A large swath of hawthorn and rose started underneath the power lines at the northern part of the hill, and extended to the southeast across the hillside (Figure 16). Several areas in this swath were particularly dense, and coincided with what may be areas of earlier tree removal. St. Johnswort was also found among these patches. The southeastern part of the hill had a “tree island”, with several large rose shrubs and hawthorn trees. Sweetbriar rose and hawthorn were also found along the tree lines bordering each meadow. Tansy ragwort and bull and Canada thistles were found in scattered patches extending into the meadow from the tree line.

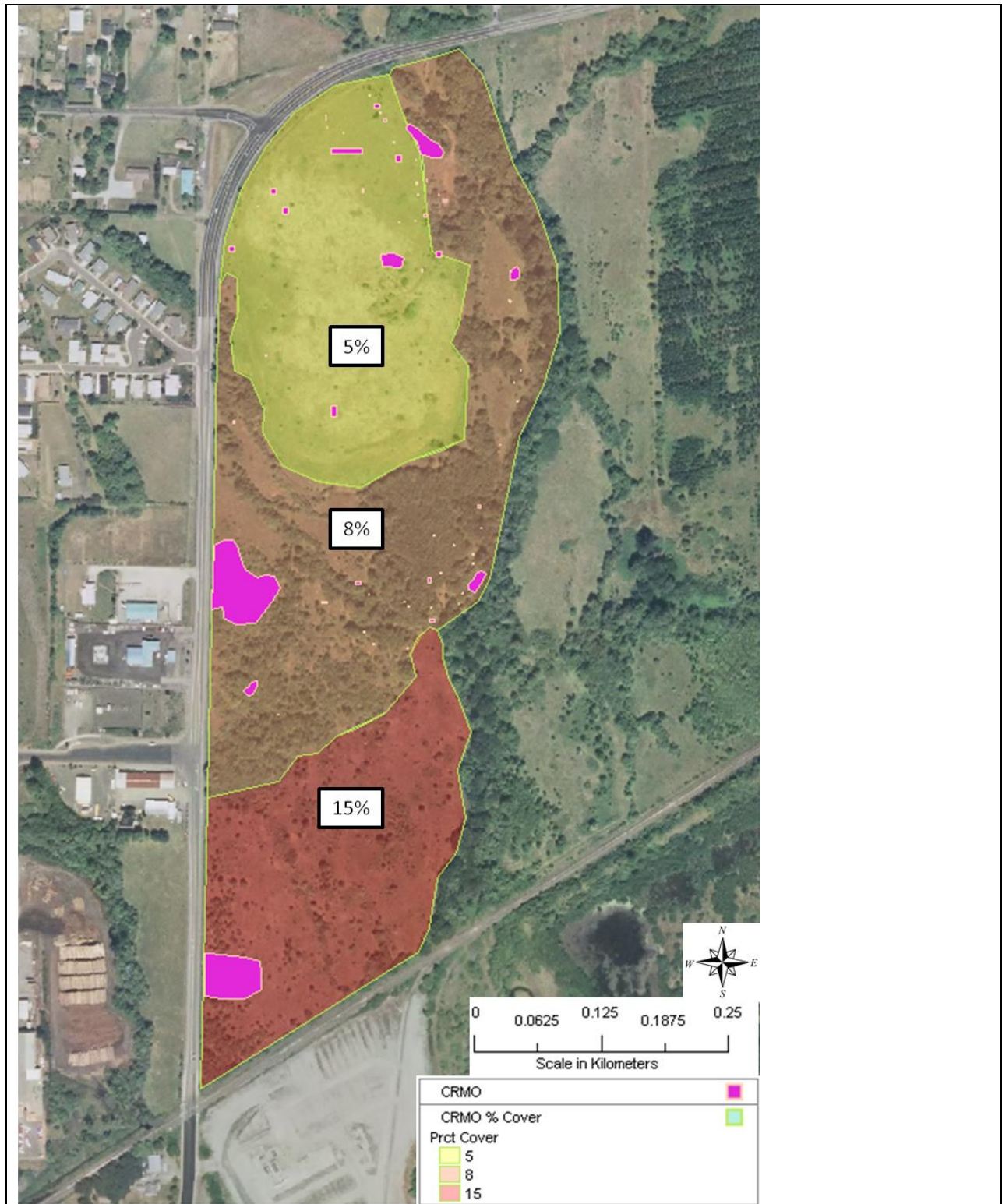


Figure 16. One-seeded hawthorn (*Crataegus monogyna*; "CRMO") was found throughout the property with increasing cover to the south, with an average cover of ~5% in the upland prairie, ~8% in the wetland prairie and ~15% in the ash swales. Pink areas indicate areas of dense concentration, or exceptionally tall or robust individuals.

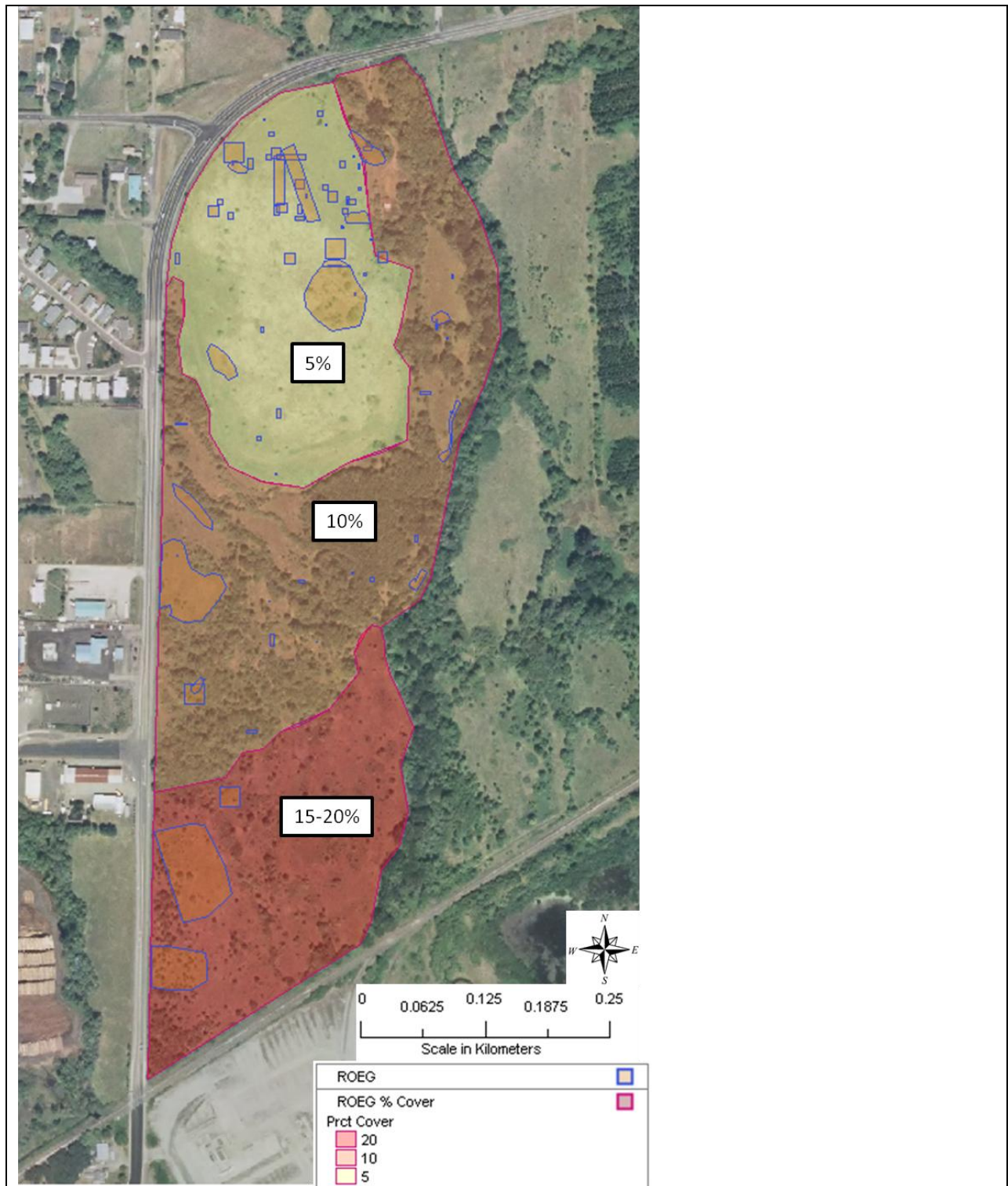


Figure 17. Sweetbriar rose (*Rosa eglantheria*; “ROEG”) was found throughout the property with increasing cover to the south. There was an average cover of ~5% in the upland prairie, ~10% in the wetland prairie and 15-20% in the ash swales. Areas outlined in blue represent areas of dense concentration.

Ash swale

The middle portion of the Lupine Meadows property is ash swale habitat. The same invasive species found in the wetland prairie were present here, although with different distribution patterns. Forest edges had higher densities of bull and Canada thistles, sweetbriar rose and one-seeded hawthorn. The Oregon ash (*Fraxinus latifolia*) canopy had areas of complete closure, so most weeds were in light gaps dotting the forest. Scattered clumps of St. Johnswort were found in areas of deep shade (Figure 18). Bittersweet nightshade (*Solanum dulcamara*) was found in isolated patches associated with cattail (*Typha latifolia*) within the swale's interior (Appendix D).



Figure 18. Ash swale at Lupine Meadows. Common weeds in this habitat include false-brome and common St. Johnswort.

Riparian forest

The riparian forest at Lupine Meadows is along the creek at the property's entrance. Canada thistle and St. Johnswort were within the forest proper, and extended to the nearby meadow. Weeds in this area included bull and Canada thistles, sweetbriar rose and hawthorn.

Summary and management recommendations

Kincaid's lupine

In 2011, cover of Kincaid's lupine at Lupine Meadows was 185 m². There is substantial unoccupied habitat at the site into which the species could spread. The monitoring protocol used in 2011 should be used to track changes in population size and the effects of management treatments through time. If new patches of lupine occur outside of the established grid and patches currently marked with rebar, the grid could be expanded or additional monitoring grids added.

Nectar species

We identified thirteen species of nectar plants for Fender's blue butterfly at Lupine Meadows. Although most of these species occurred in trace amounts, there was significant cover of three species (oxeye daisy, Virginia strawberry, and slender cinquefoil); in some areas, these species occupied greater than 25% cover. Nectar species that flower throughout the flight-time of Fender's blue butterfly were present. Several of the nectar sources were exotic species; control of these species should be paired with increasing the abundance of nectar species with similar flowering phenologies (e.g. with targeted management and/or seeding).

Weed surveys

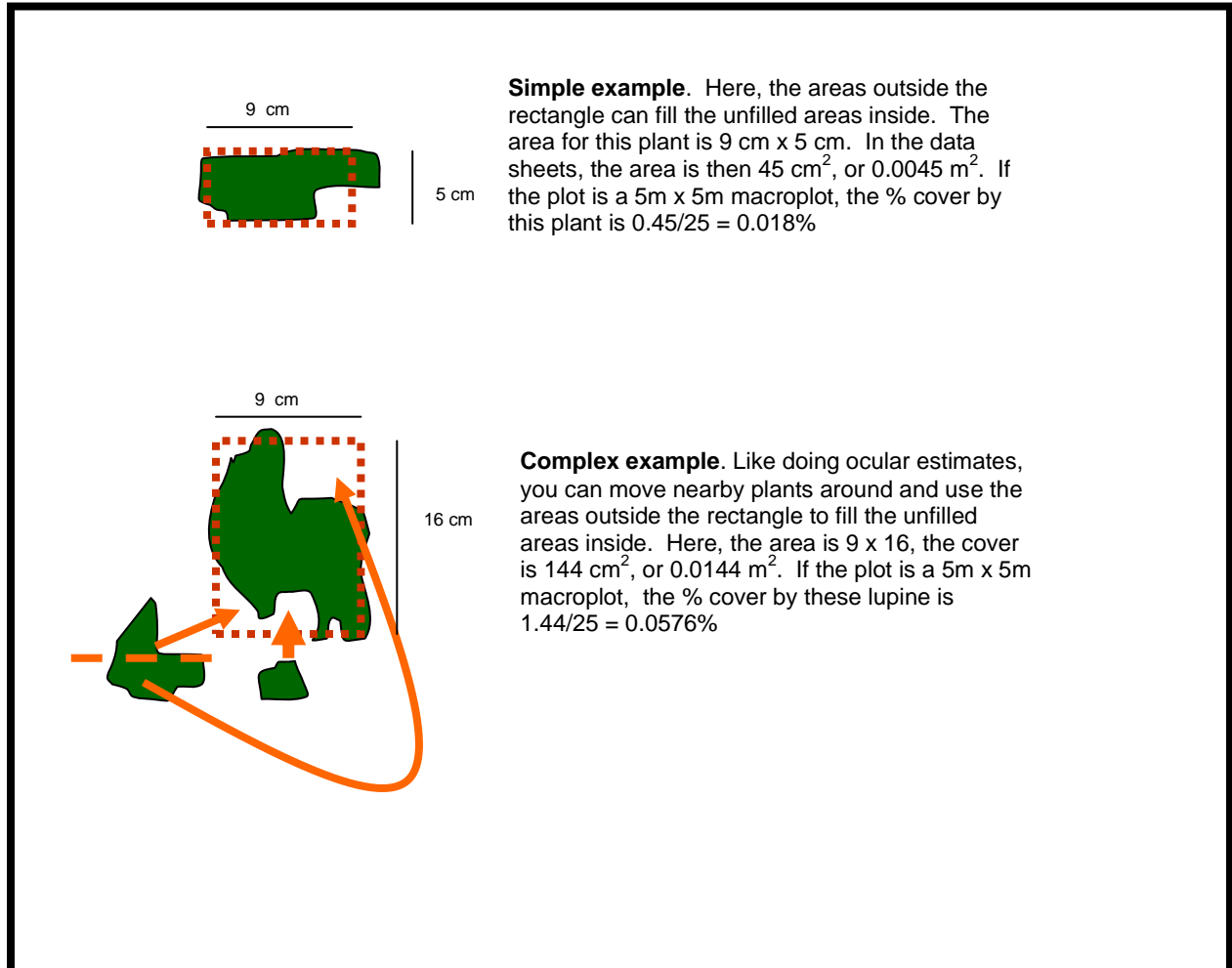
Although there were many more exotic plant species found at the site (e.g. vetch species, [*Vicia* spp.] and hairy cat's ear [*Hypochaeris radicata*]), our surveys focused on documenting those species presenting the greatest threat and/or occurring in patches that could be controlled with a concentrated effort. In general, we found a greater abundance of invasive species in the southern portion of the site. Our recommendations for prioritizing weed control are as follows:

- Remove shrubs near nectar species and Kincaid's lupine. The shrubs not only compete with Kincaid's lupine, but may also decrease the apparency of larval host and nectar species of Fender's blue butterfly (Severns 2008).
- Remove false-brome, meadow knapweed, and reed canarygrass as these species have the highest potential of rapidly spreading through the site.
- False-brome should either be pulled or culms clipped and removed before any brush hogging, mowing, or other activities that could spread seeds.

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Appendix A. Technique for measuring lupine cover, lupine data and lupine datasheets.



Lupine cover data for all populations at Lupine Meadows.

Population	Cover (m2)
Roadside	16.3
Main Population	136.2
Patch 1	15.3
Patch 2	4.5
Patch 3	3.4
Patch 4	8.2
Patch 5	0.6

Total *184.6*

	Location on tape	Cover (m2)
Roadside	0-30	2.4922
	30-60	11.9313
	60-100	0
	100-130	1.8851
	130-160	0

Main Population	0-10	1.5993
	10-20	4.2015
	20-30	2.954
	30-40	4.6635
	40-50	26.9122
	50-60	35.9895
	60-70	6.3369
	70-80	3.6353
	80-90	3.7755
	90-100	4.5033
	100-110	7.5259
	110-120	13.1526
	120-130	9.1653
	130-140	2.6047
	140-150	2.1443
150-160	0.3162	

160-170	0.148
170-180	0.0126
Outside of tape (120-138)	6.534

Patch 1	15.3273
Patch 2	4.5025
Patch 3	3.4019
Patch 4	8.2074
Patch 5	0.6434

Lupine Cover Class data taken in 10m sections in the main population.

**Each block is 10m x 10m;
1m² is equal to 1%**

Cover Classes:

0%	0
0-1.9%	1
2-5.9%	2
6-15.9%	3
16-25.9%	4
26-50.9%	5
51-75.9%	6
76-100%	7

Location on Baseline	Location in Lane	Cover Class
0	0	0
0	10	0
0	20	2
0	30	1
0	40	1
0	50	1
0	60	1
0	70	1
0	80	1
0	90	0
10	0	0
10	10	2

Cover classes for main population

Location on Baseline	Location in Lane	Cover Class
10	20	2
10	30	1
10	40	1
10	50	1
10	60	1
10	70	1
10	80	1
10	90	1
10	100	0
20	0	1
20	10	2
20	20	2
20	30	1
20	40	1
20	50	1
20	60	1
20	70	1
20	80	1
20	90	1
20	100	0
20	110	0
30	0	2
30	10	2
30	20	1
30	30	1
30	40	1
30	50	0
30	60	1
30	70	1
30	80	1
30	90	3
30	100	1
30	110	0
30	120	0
30	130	0
40	0	1
40	10	1
40	20	1
40	30	1

Cover classes for main population

Location on Baseline	Location in Lane	Cover Class
40	40	1
40	50	1
40	60	2
40	70	1
40	80	1
40	90	3
40	100	0
40	110	0
40	120	0
40	130	0
50	0	0
50	10	0
50	20	1
50	30	1
50	40	2
50	50	1
50	60	1
50	70	2
50	80	1
50	90	1
50	100	2
50	110	1
50	120	1
50	130	0
60	0	0
60	10	0
60	20	1
60	30	1
60	40	2
60	50	1
60	60	1
60	70	2
60	80	1
60	90	1
60	100	0
60	110	0
60	120	0
60	130	0
70	0	1

Cover classes for main population

Location on Baseline	Location in Lane	Cover Class
70	10	1
70	20	1
70	30	1
70	40	1
70	50	1
70	60	0
70	70	1
70	80	1
70	90	0
70	100	0
70	110	1
70	120	1
70	130	0
80	0	2
80	10	1
80	20	1
80	30	0
80	40	1
80	50	1
80	60	1
80	70	1
80	80	1
80	90	0
80	100	1
80	110	1
80	120	0
80	130	0
90	0	1
90	10	1
90	20	1
90	30	0
90	40	1
90	50	1
90	60	1
90	70	1
90	80	1
90	90	1
90	100	0
90	110	1

Cover classes for main population

Location on Baseline	Location in Lane	Cover Class
90	120	0
90	130	0
100	0	0
100	10	1
100	20	1
100	30	0
100	40	1
100	50	2
100	60	1
100	70	1
100	80	1
100	90	1
100	100	1
100	110	1
100	120	1
110	0	1
110	10	0
110	20	1
110	30	1
110	40	3
110	50	2
110	60	1
110	70	1
110	80	1
110	90	1
110	100	1
120	0	1
120	10	1
120	20	2
120	30	2
120	40	2
120	50	2
120	60	2
120	70	2
120	80	1
120	90	0
120	100	0
130	0	2
130	10	0

Cover classes for main population

Location on Baseline	Location in Lane	Cover Class
130	20	1
130	30	2
130	40	2
130	50	1
130	60	3
130	70	0
140	0	0
140	10	0
140	20	1
140	30	1
140	40	1
140	50	2
140	60	2
150	0	0
150	10	1
150	20	1
150	30	2
150	40	1
150	50	0
160	0	0
160	10	0
160	20	1
160	30	1
170	0	0
170	10	0
170	20	3

Lupine Cover Class Data for the Roadside Population

Roadside Population

Cover Classes:

0%	0
0-1%	1
2-5%	2
6-15%	3
16-25%	4
26-50%	5
51-75%	6
76-100%	7

0-10	1
10-20	1
20-30	3
30-40	2
40-50	1
50-60	2
60-70	1
70-80	0
80-90	0
90-100	0
100-110	0
110-120	0
120-130	1
130-140	1

Lupine Monitoring Datasheets

Roadside population:

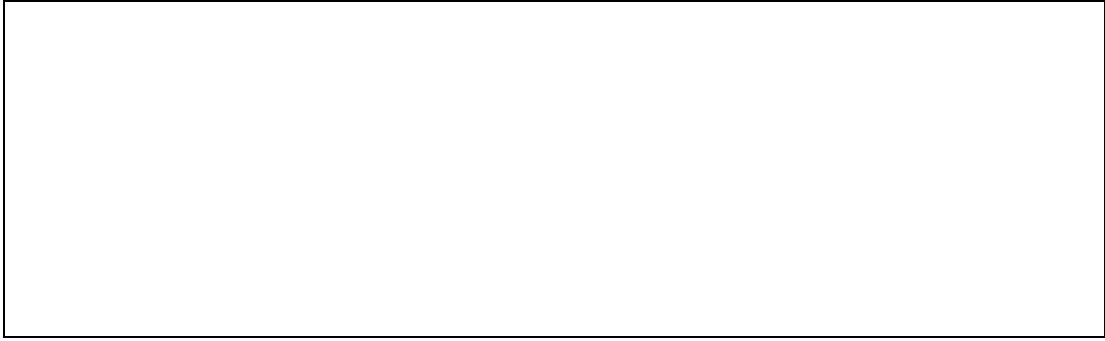
Date:

Names:

location Cover (cm x cm)

0-30	
30-60	
60-100	
100-130	
130-160	

Outside
of tape



Main Population

Date:

Names:

Location Cover (cm x cm)

0-10	
10-20	
20-30	

30-40	
40-50	
50-60	
60-70	
70-80	

80-90	
90-100	
100-110	
110-120	
120-130	

Outside 120-138	
130-140	
140-150	
150-160	
160-170	

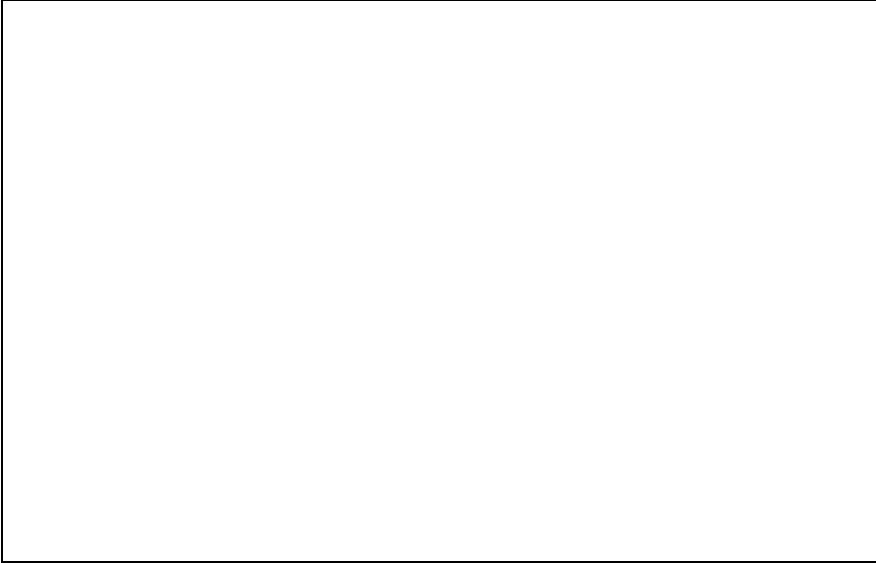
170-180	
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Patch ##

Date:

Names:

Cover (cm x cm)



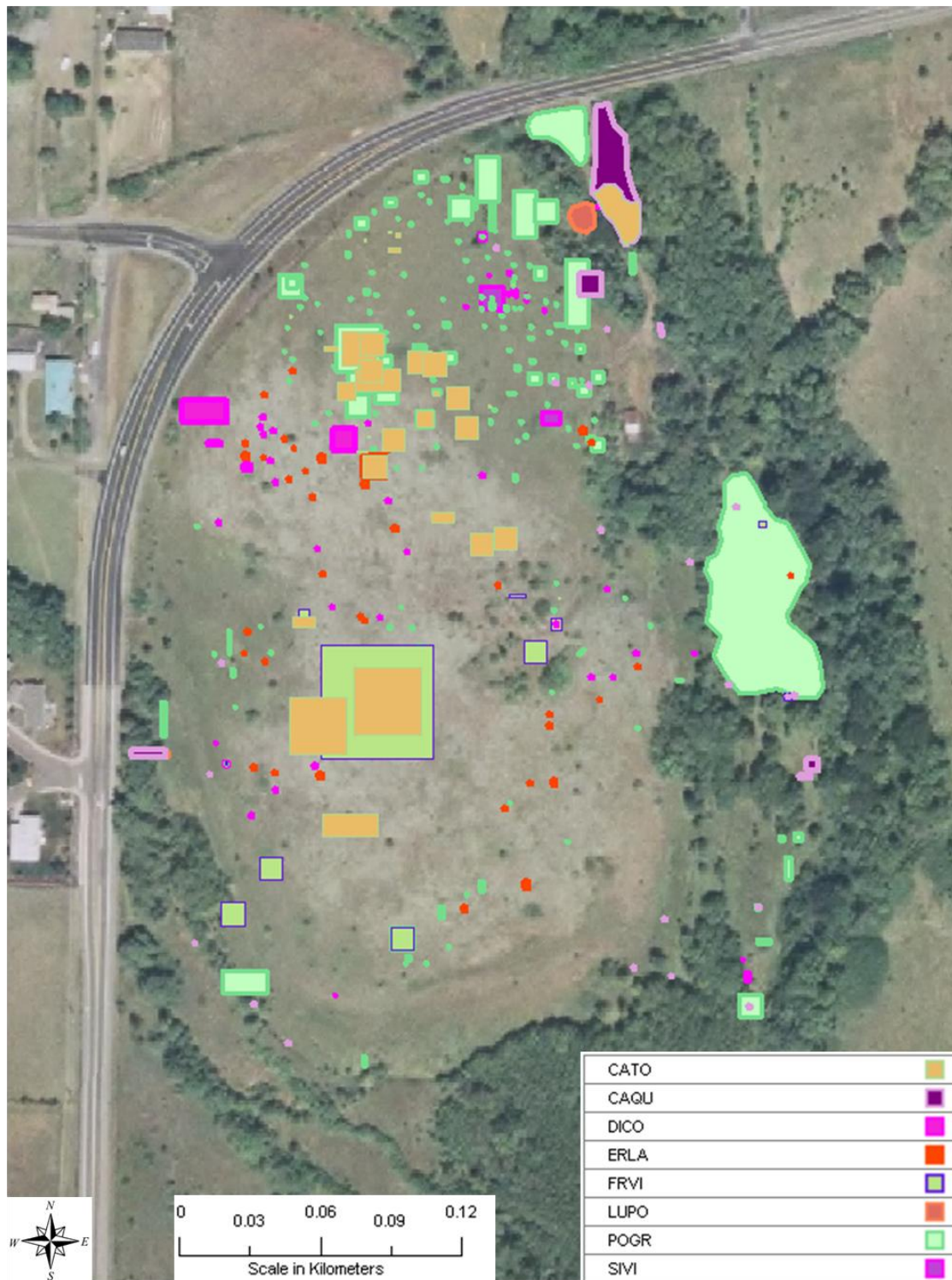
Appendix B. Nectar species included in surveys at Lupine Meadows.

Species	Common name	U.S. Nativity	Use
<i>Allium acuminatum</i>	tapertip onion	native	nectar
<i>Allium amplexans</i>	narrowleaf onion	native	nectar
<i>Aquilegia formosa</i>	western columbine	native	nectar
<i>Brodiaea coronaria</i>	crown brodiaea	native	nectar
<i>Brodiaea elegans</i>	Elegant cluster lily	native	nectar
<i>Calochortus tolmiei</i>	Tolmie star tulip	native	nectar
<i>Camassia leichtlinii</i>	Large camas	native	nectar
<i>Camassia quamash</i>	Common camas	native	nectar
<i>Cryptantha intermedia</i>	clearwater cryptantha	native	nectar
<i>Dichelostemma congestum</i>	ookow	native	nectar
<i>Eriophyllum lanatum</i>	Oregon sunshine, woolly sunflower	native	nectar
<i>Fragaria vesca</i>	strawberry	native	nectar
<i>Fragaria virginiana</i>	strawberry	native	nectar
<i>Geranium oreganum</i>	Oregon geranium	native	nectar
<i>Heracleum lanatum</i>	cow parsnip	native	nectar
<i>Iris tenax</i>	toughleaf iris	native	nectar
<i>Lathyrus sphaericus</i>	grass pea	exotic	nectar
<i>Leucanthemum vulgare</i>	oxeye daisy	exotic	nectar
<i>Linum bienne</i>	pale flax	exotic	nectar
<i>Lupinus albicaulis</i>	sickle-keeled lupine	native	larval host, nectar
<i>Lupinus arbustus</i>	spur lupine	native	larval host, nectar
<i>Lupinus oreganus</i>	Kincaid's lupine	native	preferred larval host, nectar
<i>Myosotis discolor</i>	changing forget-me-not	exotic	nectar
<i>Plagiobothrys figuratus</i>	fragrant popcorn flower	native	nectar
<i>Plagiobothrys scouleri</i>	Scouler's popcornflower	native	nectar
<i>Potentilla gracillis</i>	slender cinquefoil	native	nectar
<i>Sidalcea campestris</i>	meadow checkerbloom	native	nectar
<i>Sidalcea virgata</i>	dwarf checkermallow	native	nectar
<i>Triteleia hyacinthina</i>	Hyacinth brodiaea	native	nectar
<i>Vicia americana</i>	American vetch	native	nectar
<i>Vicia cracca</i>	bird vetch	exotic	nectar
<i>Vicia hirsuta</i>	tiny vetch	exotic	nectar
<i>Vicia sativa</i>	garden vetch	exotic	nectar
<i>Vicia tetrasperma</i>	lentil vetch	exotic	nectar

Appendix C. Maps of nectar species documented at Lupine Meadows.

Native Nectar Species

All native nectar species found in the north meadow. Maps of individual species follow.



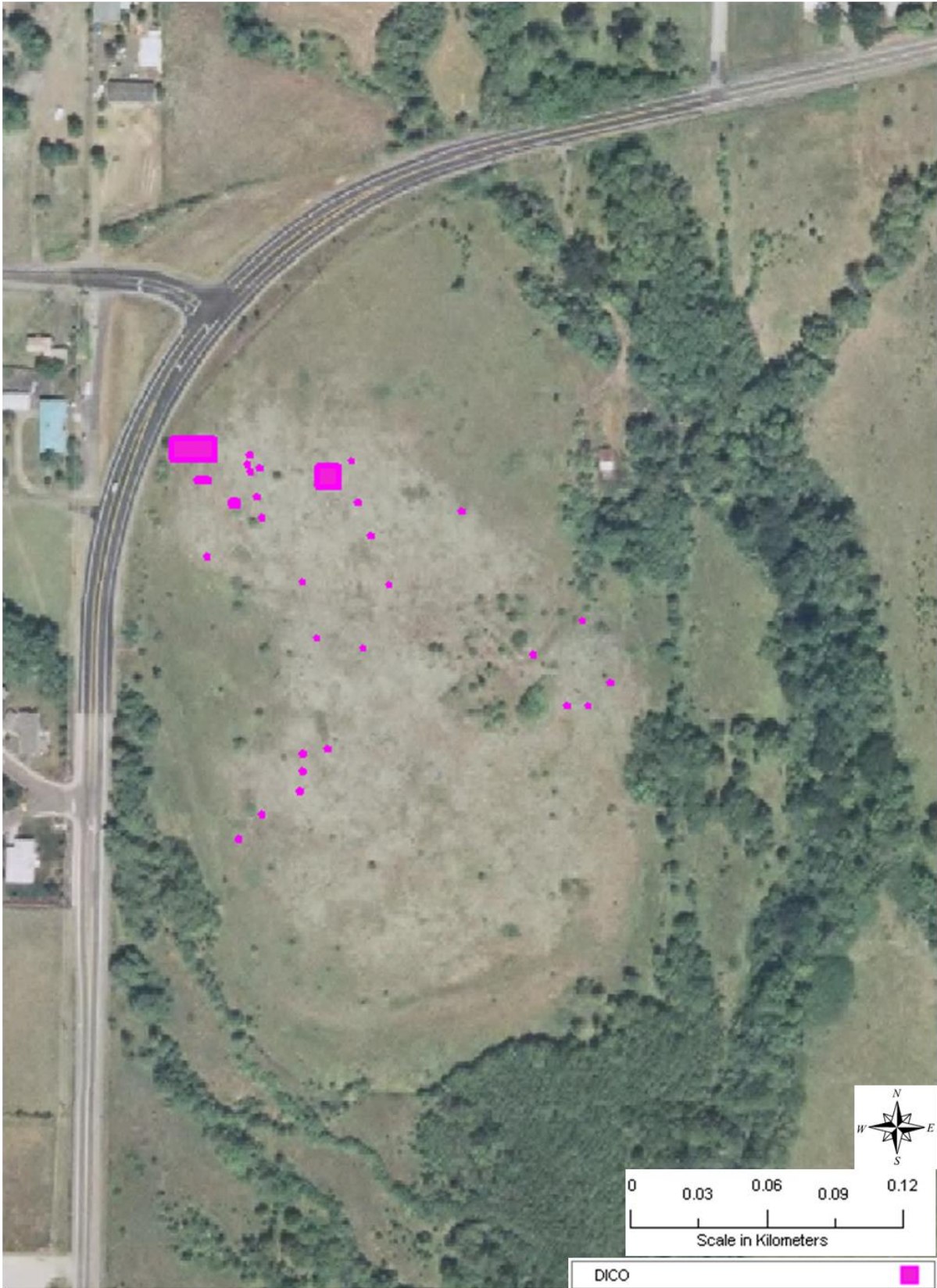
Tolmie's mariposa lily (*Calochortus tolmiei*; "CATO")



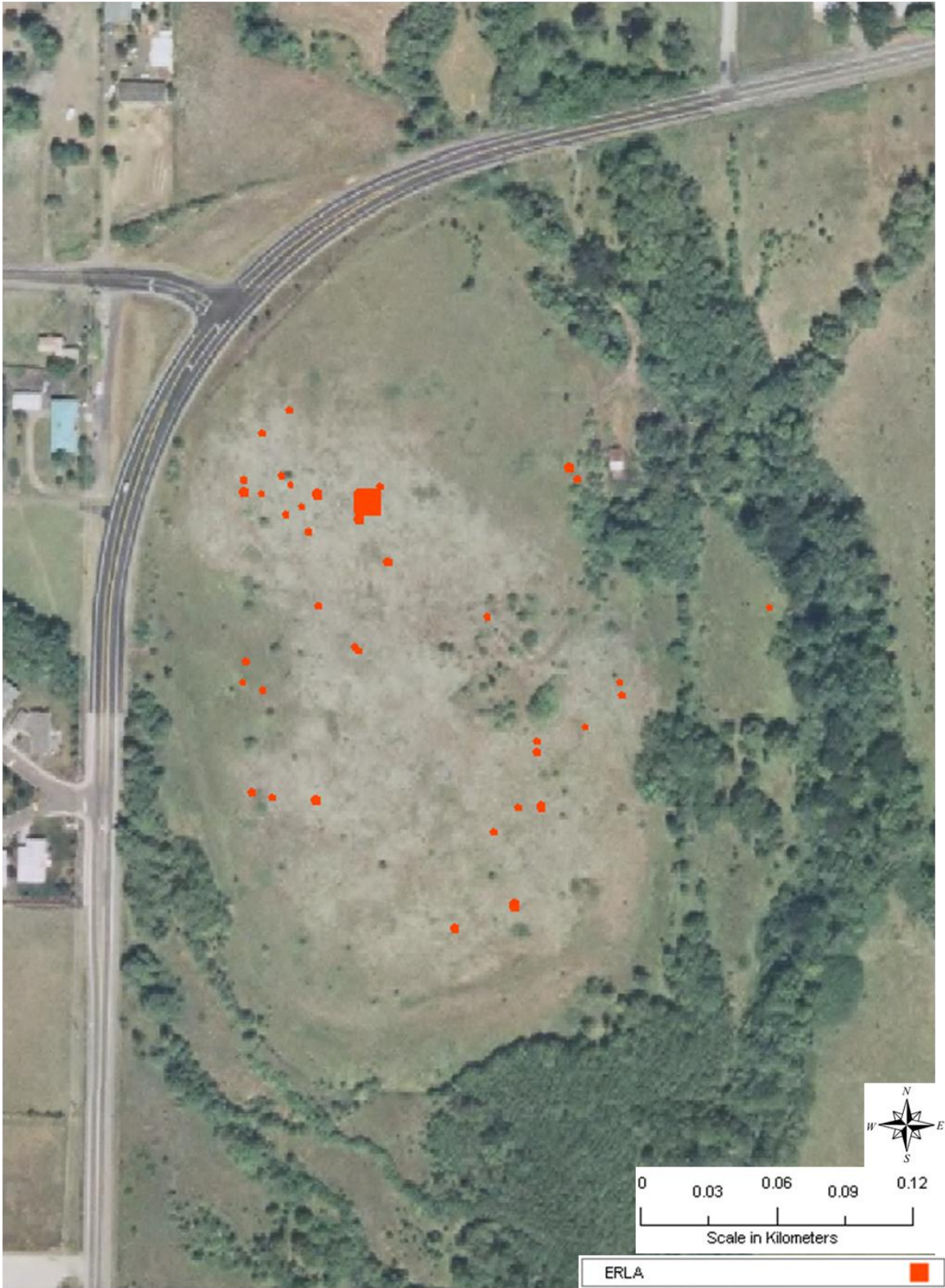
Small camas (*Camassia quamash*; "CAQU")



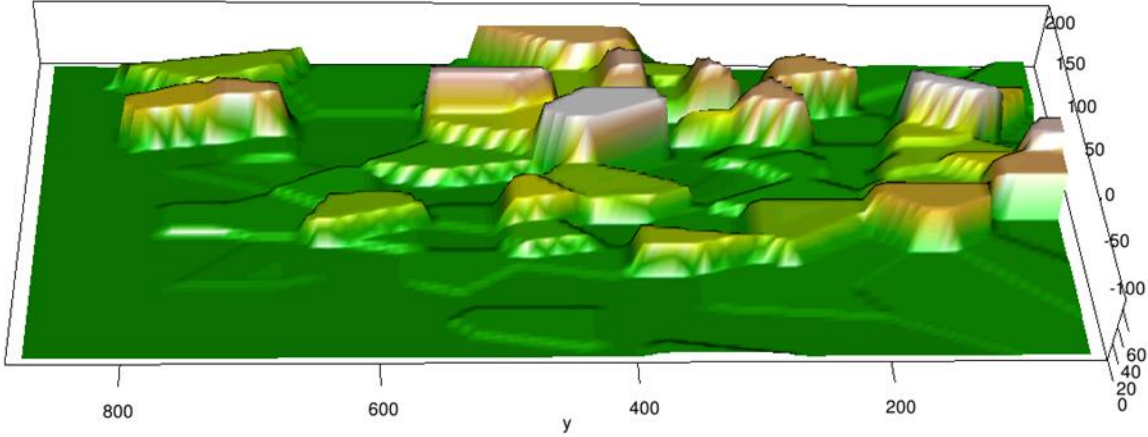
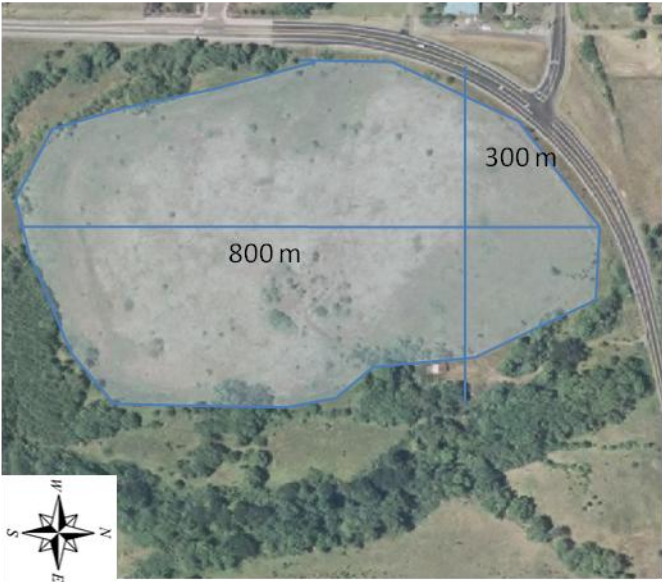
Cluster lily (*Dichelostemma congestum*; "DICO")



Oregon sunshine (*Eriophyllum lanatum*; "ERLA")



Virginia strawberry (*Fragaria virginiana*; "FRVI")



Slender cinquefoil (Potentilla gracilis; "POGR")

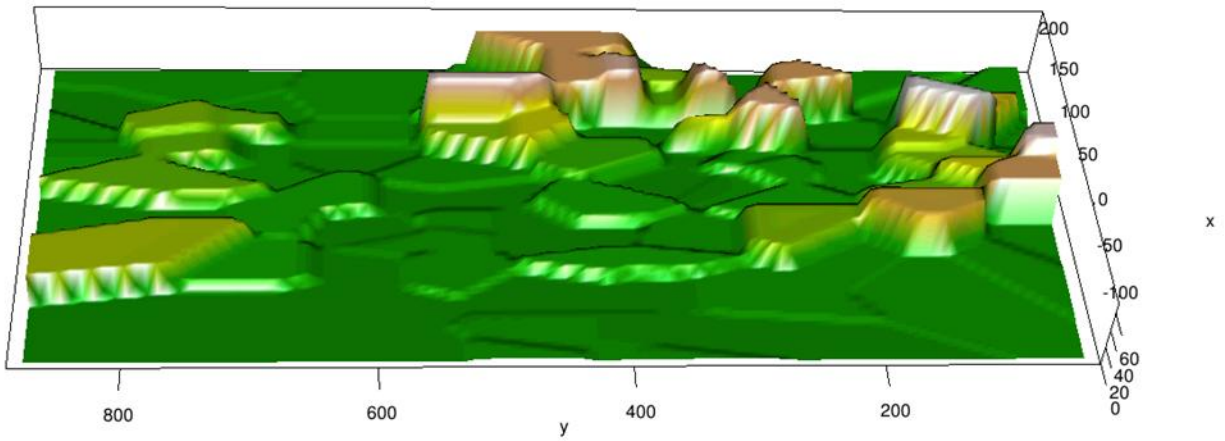
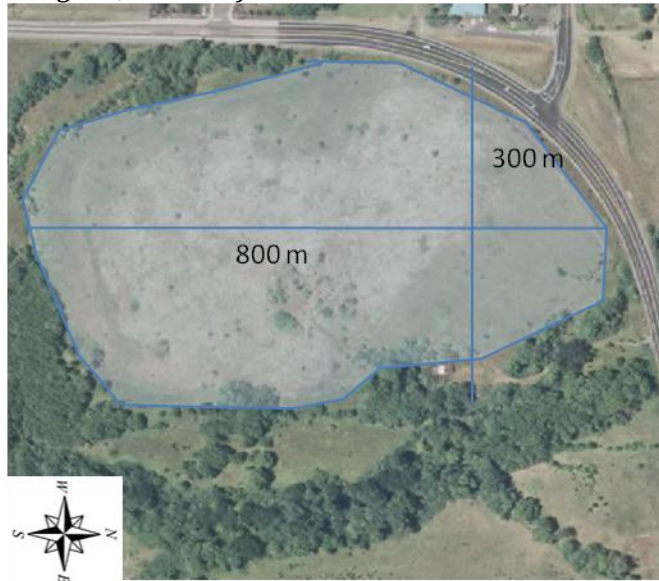


Rose checkermallow (*Sidalcea virgata*; "SIVI")

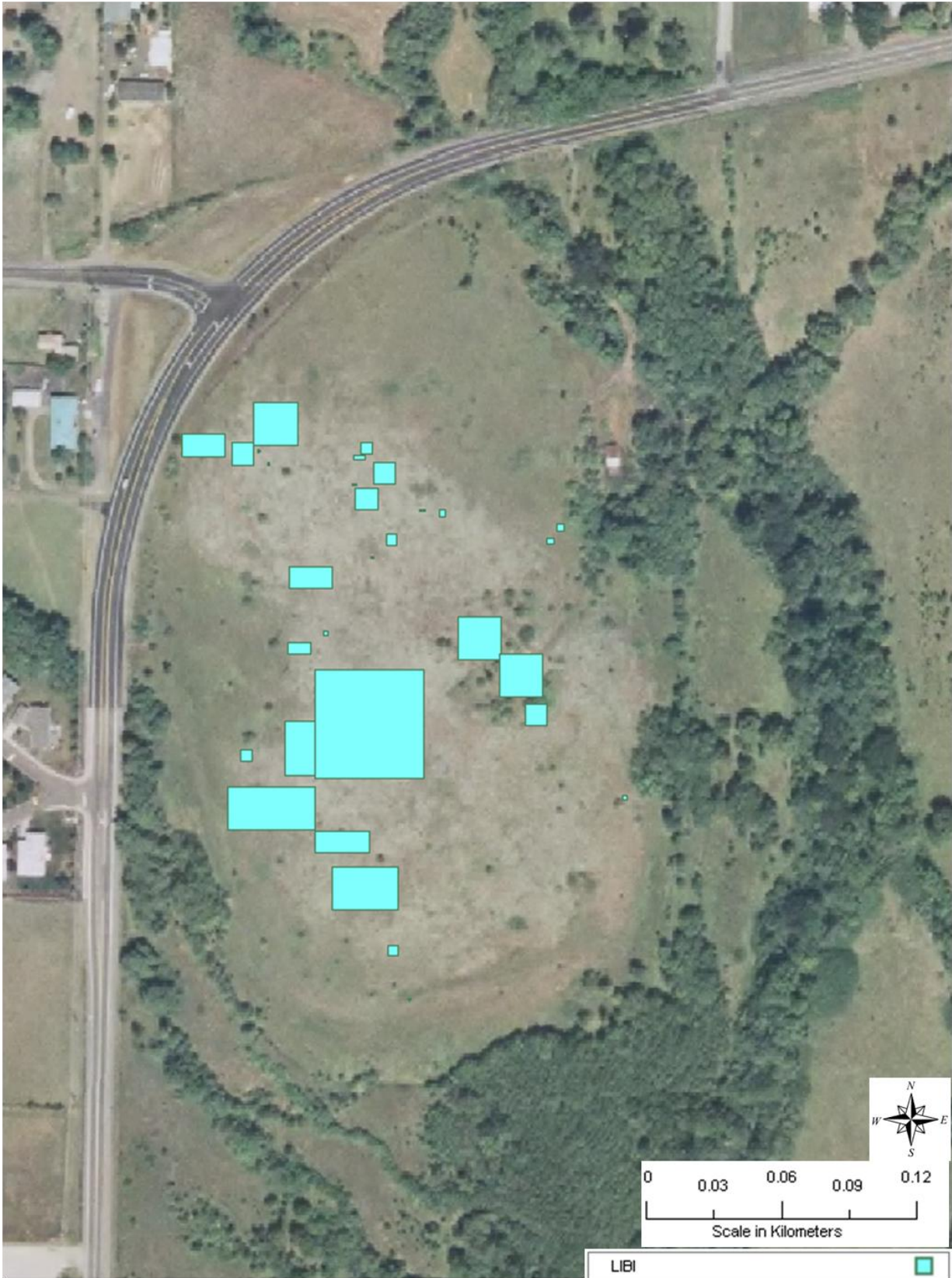


Maps of Invasive Nectar Species

Oxeye daisy (*Leucanthemum vulgare*; "LEVU")



Pale flax (*Linum bienne*; "LIBI")

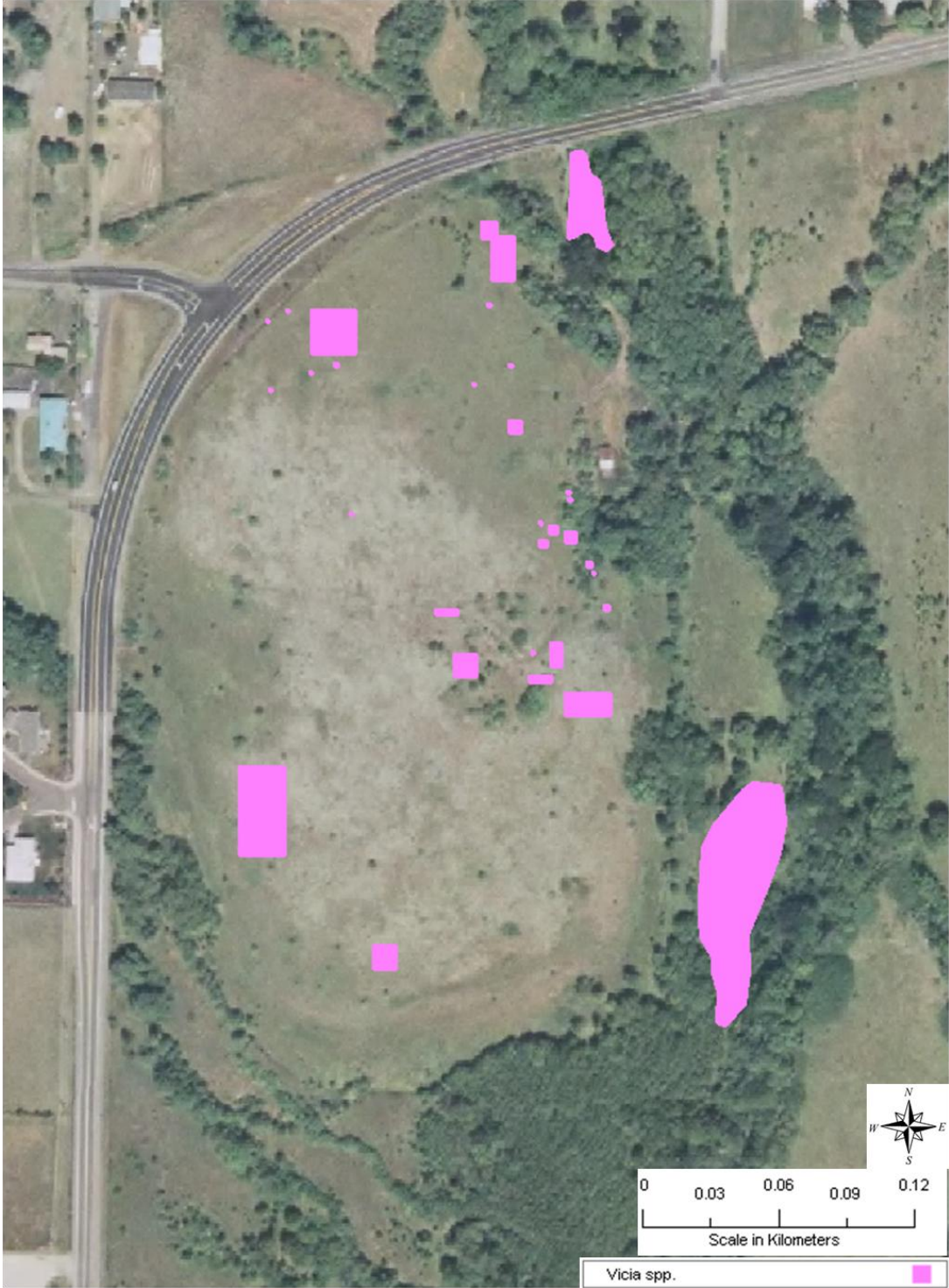


Yellow and blue forget-me-not (*Myosotis discolor*; "MYDI")

Yellow and blue forget-me-not (*Myosotis discolor*; "MYDI") is found in trace amounts (0.1% cover) throughout the site.



Several species of vetch [hairy vetch (*Vicia hirsuta*), garden vetch (*V. sativa*), and smooth tare (*V. tetrasperma*)] are found throughout the site. Areas outlined indicate areas of higher concentration of these species.



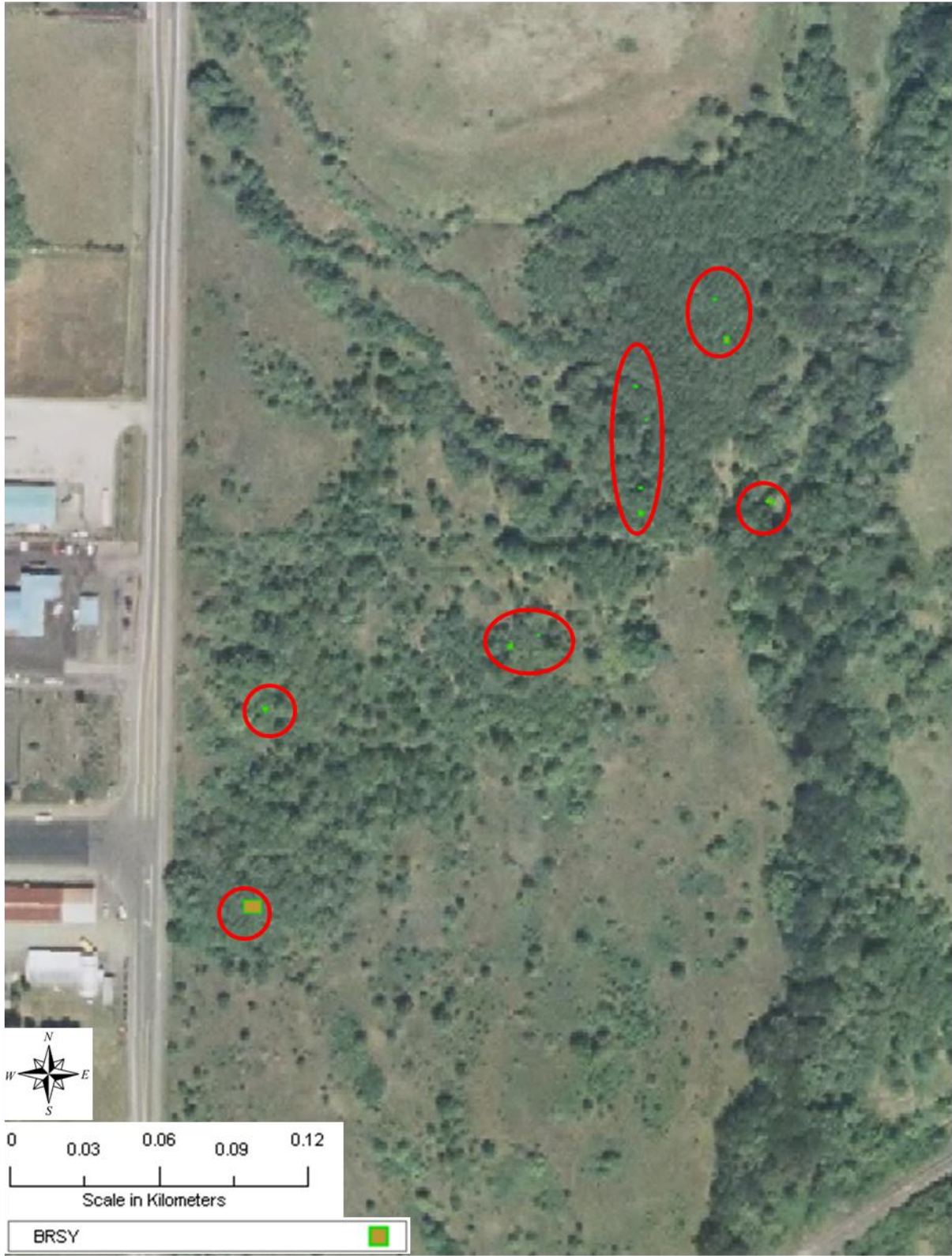
Appendix D. Maps of invasive species documented at Lupine Meadows

False-brome (*Brachypodium sylvaticum*; "BRSY"), north meadow

False-brome in the northern portion is isolated to four small patches. These have been treated but should be monitored to prevent any new seedling establishment.



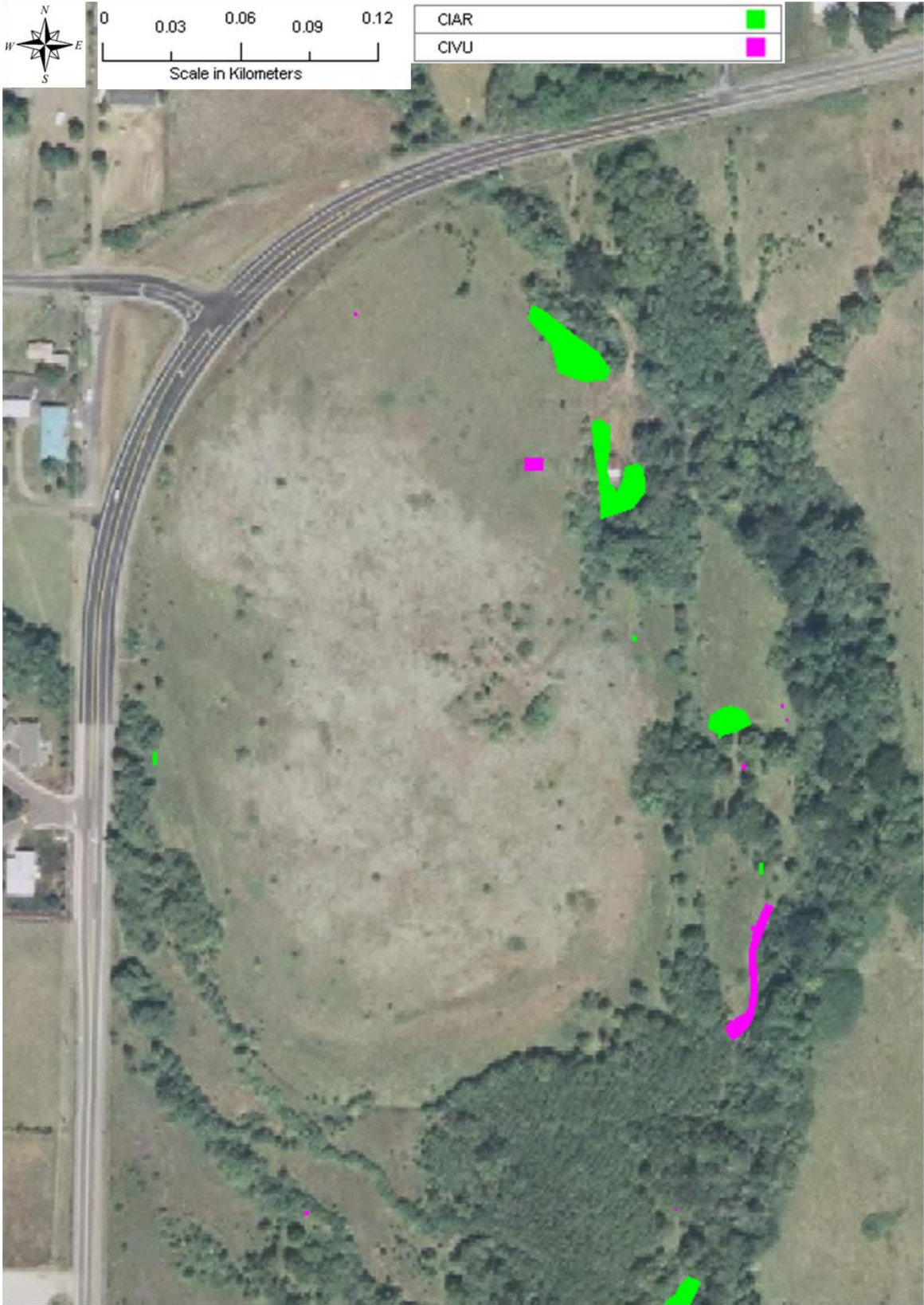
False-brome (*Brachypodium sylvaticum*; "BRSY"), south meadow



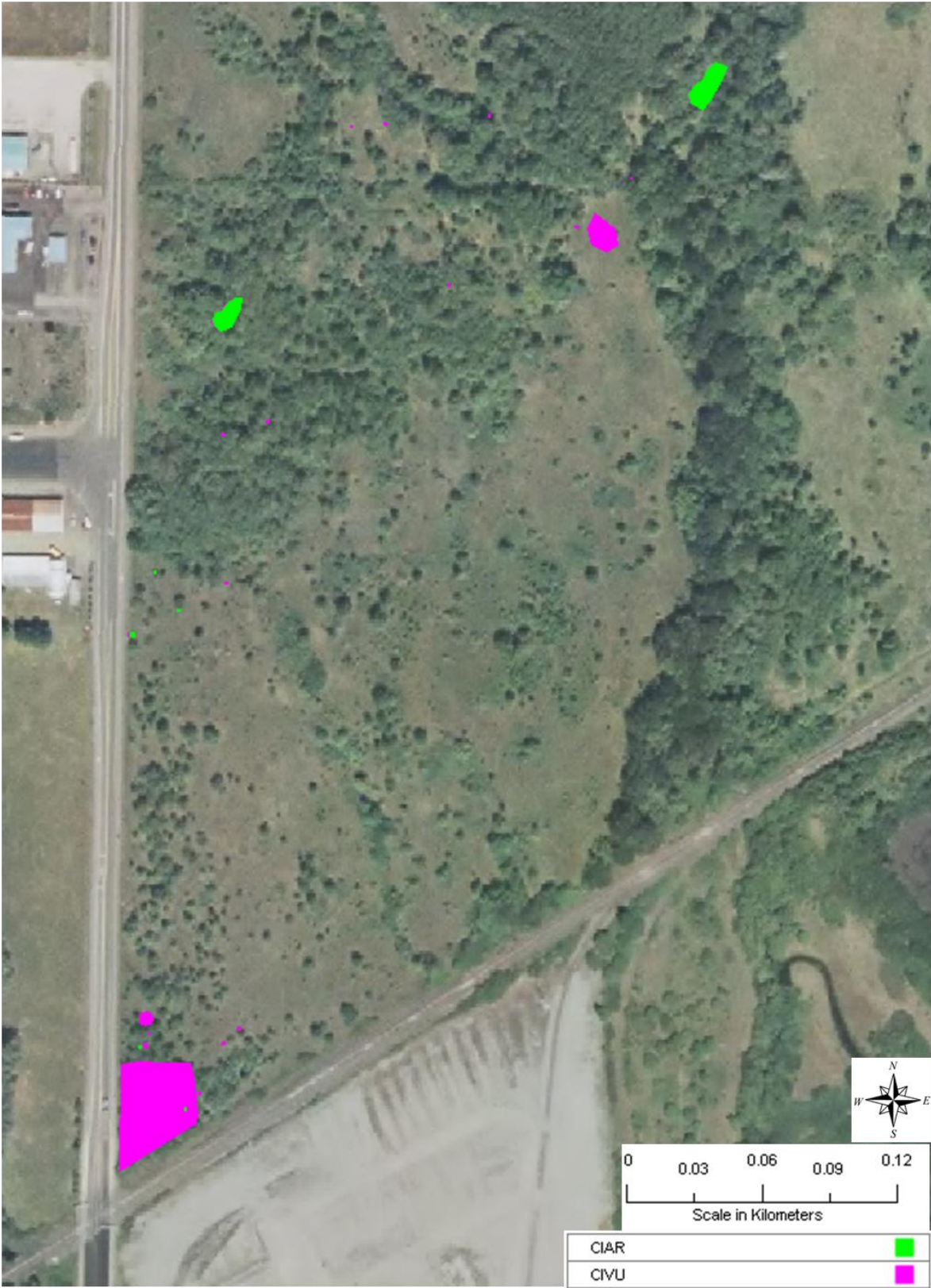
Meadow knapweed (*Centaurea pratensis*; "CEPR"), south meadow



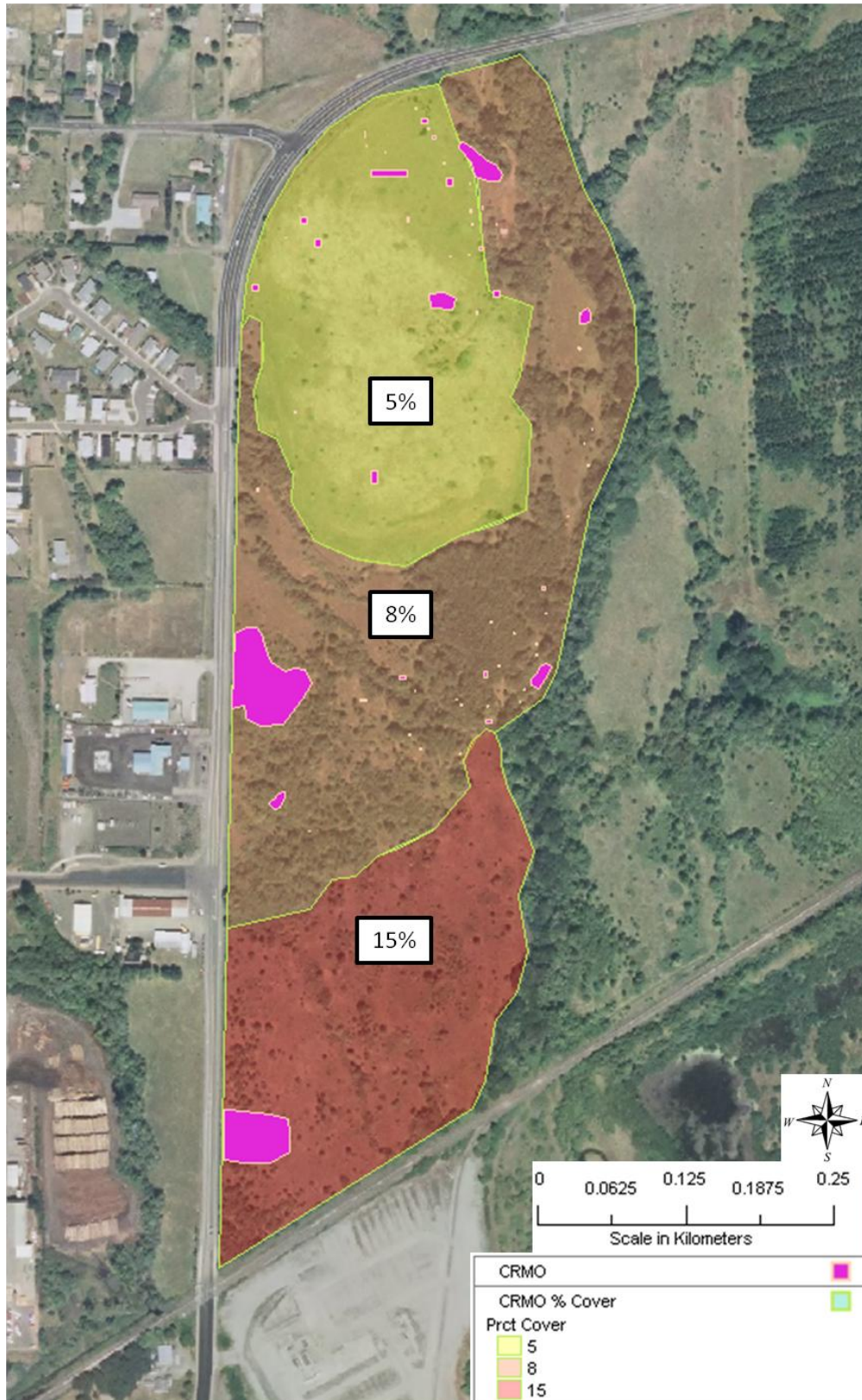
Canada thistle (*Cirsium arvense*; "CIAR") and bull thistle (*C. vulgare*; "CIVU"), north meadow



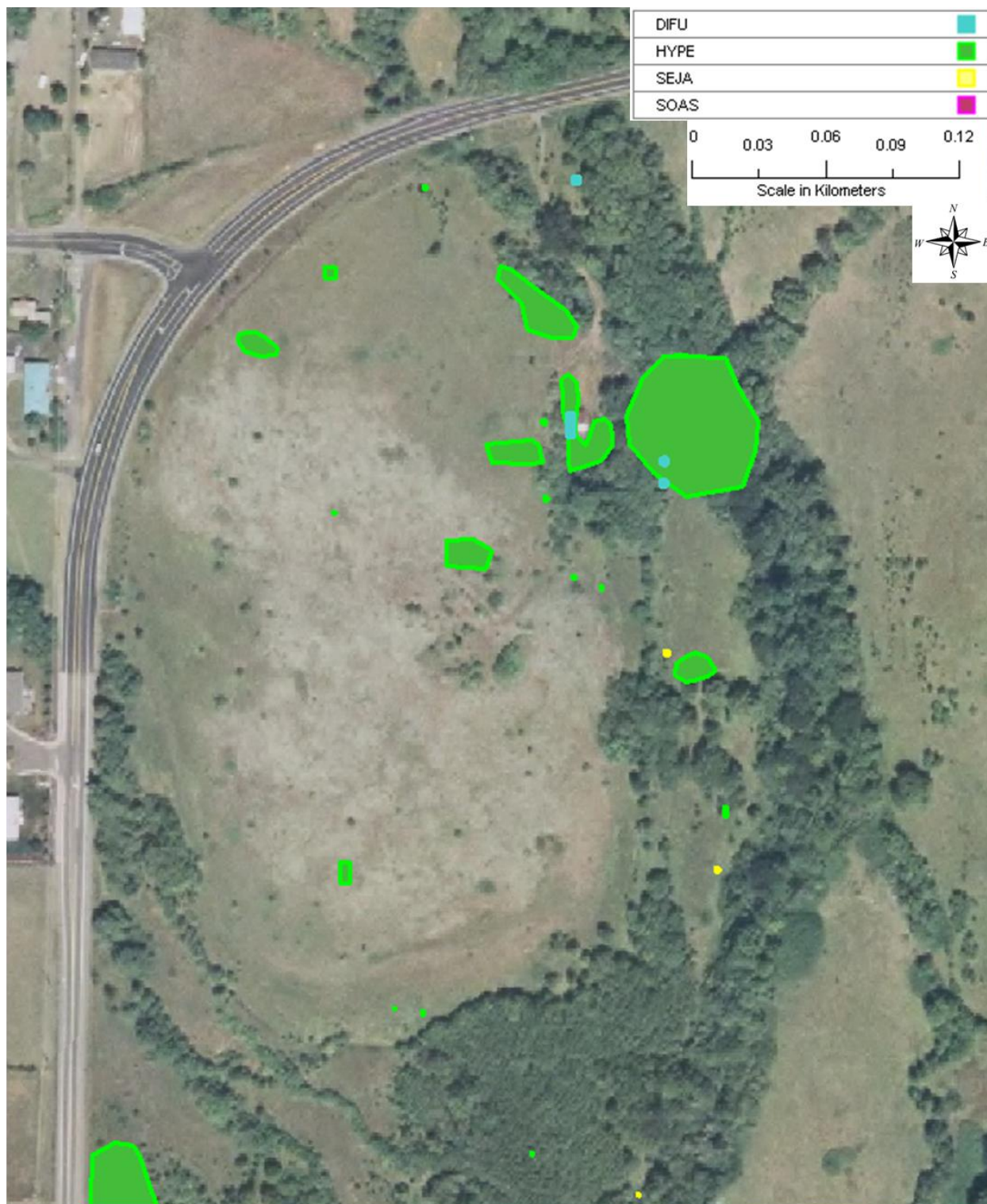
Canada thistle (*Cirsium arvense*; "CIAR") and bull thistle (*C. vulgare*; "CIVU"), south meadow



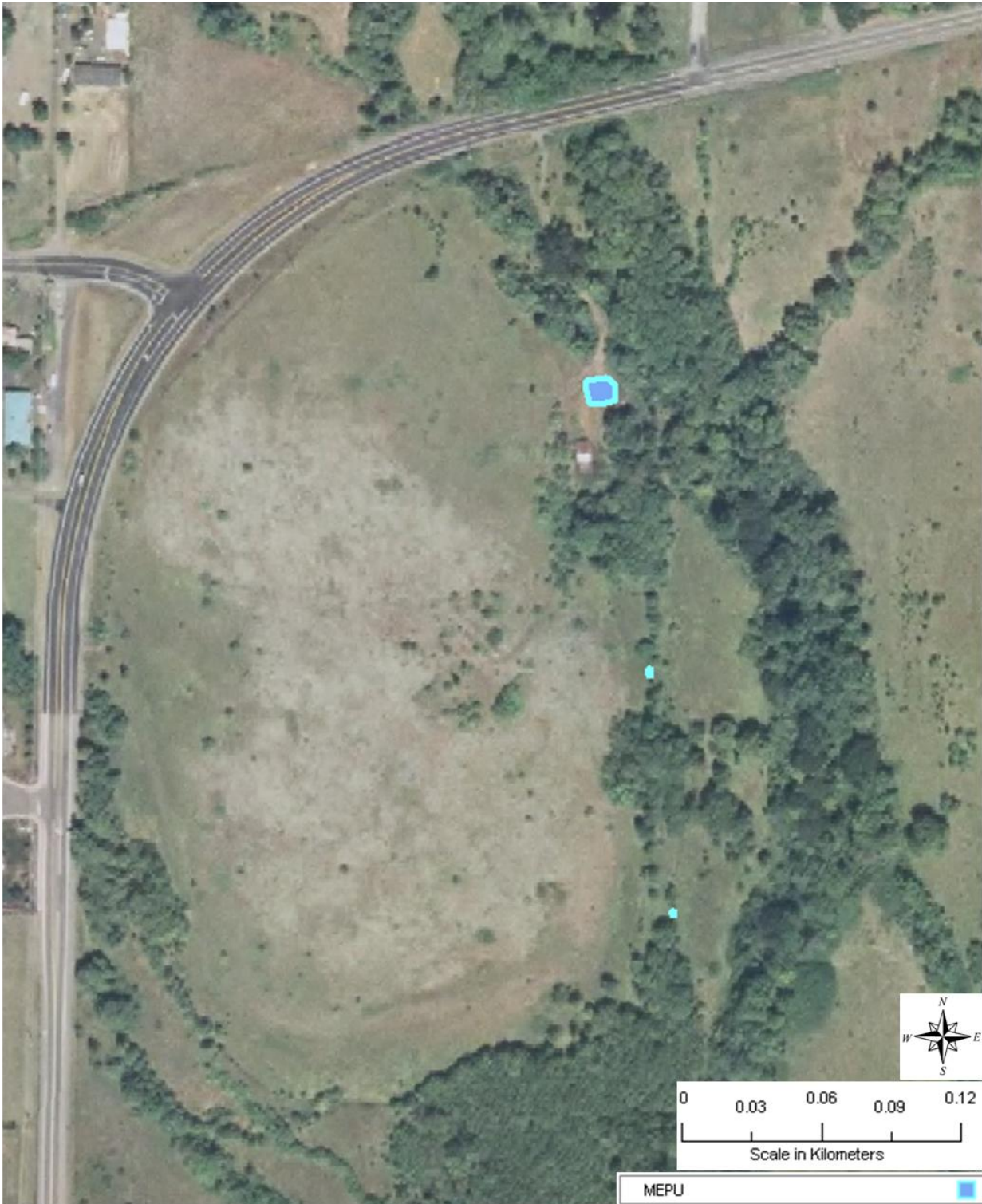
One-seeded hawthorn (*Crataegus monogyna*; "CRMO"), entire site



Fuller's teasel (*Dipsacus fullonum*; "DIFU"), *common St. Johnswort* (*Hypericum perforatum*; "HYPE"), *tansy ragwort* (*Senecio jacobaea*; "SEJA") and *prickly sowthistle* (*Sonchus asper*; "SOAS"), north meadow



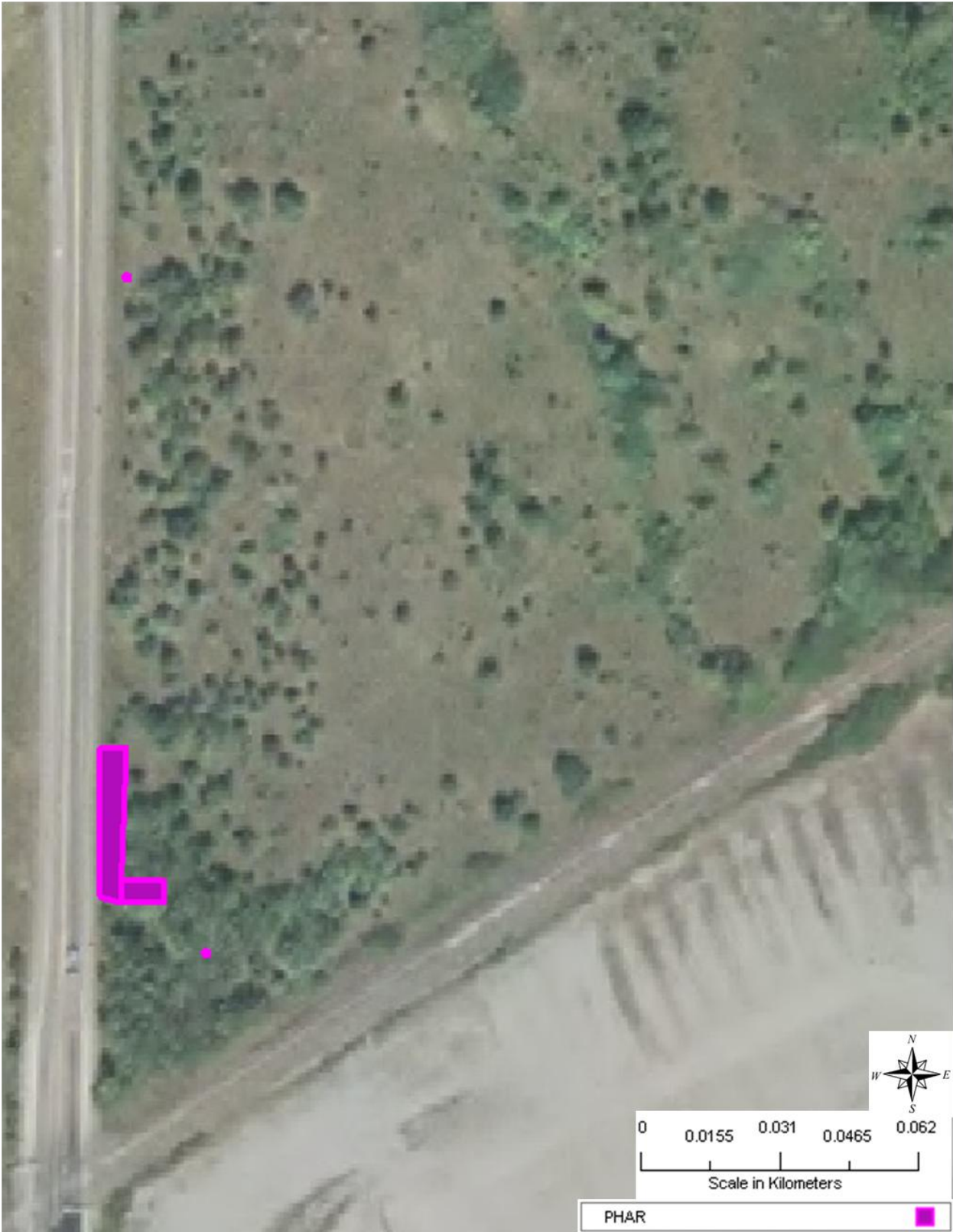
Pennyroyal (*Mentha pulegium*; "MEPU"), north meadow



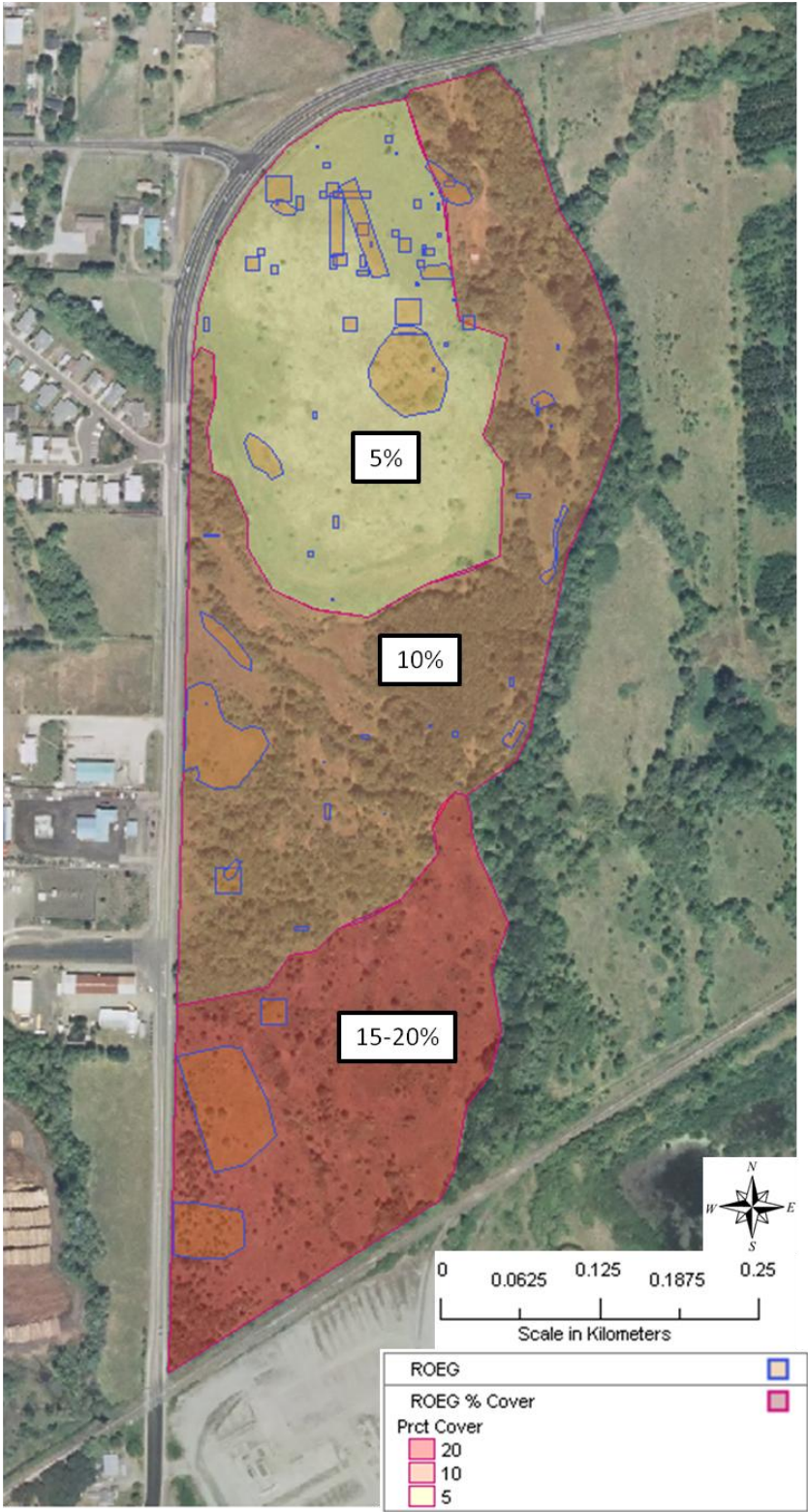
Pennyroyal (Mentha pulegium; "MEPU"), south meadow



Reed canarygrass (*Phalaris arundinacea*; "PHAR"), south meadow



Sweetbriar rose (*Rosa eglantheria*; "ROEG"), entire site



Bittersweet nightshade (*Solanum dulcamara*; "SODU"), south meadow



Appendix E. Table of Target Weed Species with Coordinates

Common Name	Scientific Name	Code	Latitude	Longitude	Northing	Easting	Approximate Patch Size (m)
False brome	<i>Brachypodium sylvaticum</i>	BRSY	44.549039	-123.355845	4932917	471736	7 x 5
False brome	<i>Brachypodium sylvaticum</i>	BRSY	44.550600	-123.353106	4933090	471954	5 x 5
False brome	<i>Brachypodium sylvaticum</i>	BRSY	44.550892	-123.353751	4933122	471903	1 x 1
False brome	<i>Brachypodium sylvaticum</i>	BRSY	44.551181	-123.353325	4933154	471937	1 x 1
False brome	<i>Brachypodium sylvaticum</i>	BRSY	44.551345	-123.353391	4933173	471932	2 x 3
False brome	<i>Brachypodium sylvaticum</i>	BRSY	44.550635	-123.353777	4933094	471901	1 x 1
False brome	<i>Brachypodium sylvaticum</i>	BRSY	44.550081	-123.354312	4933033	471858	1 x 1
False brome	<i>Brachypodium sylvaticum</i>	BRSY	44.550030	-123.354457	4933027	471847	1 x 1
False brome	<i>Brachypodium sylvaticum</i>	BRSY	44.550540	-123.353778	4933083	471901	1 x 1
False brome	<i>Brachypodium sylvaticum</i>	BRSY	44.549796	-123.355751	4933001	471744	1 x 1
Reed canarygrass	<i>Phalaris arundinacea</i>	PHAR	44.546746	-123.356182	4932663	471708	4 x 8
Reed canarygrass	<i>Phalaris arundinacea</i>	PHAR	44.546622	-123.356002	4932649	471722	1 x 1
Reed canarygrass	<i>Phalaris arundinacea</i>	PHAR	44.547990	-123.356231	4932801	471705	1 x 1
Bittersweet nightshade	<i>Solanum dulcamara</i>	SODU	44.549415	-123.355612	4932959	471755	2 x 5
Meadow knapweed	<i>Centaurea pratensis</i>	CEPR	44.548566	-123.356249	4932865	471704	0.5 x 0.5
Meadow knapweed	<i>Centaurea pratensis</i>	CEPR	44.550174	-123.356192	4933043	471709	0.5 x 0.5
Meadow knapweed	<i>Centaurea pratensis</i>	CEPR	44.550330	-123.356085	4933061	471718	4 x 4
Meadow knapweed	<i>Centaurea pratensis</i>	CEPR	44.550515	-123.355951	4933081	471728	6 x 2
Meadow knapweed	<i>Centaurea pratensis</i>	CEPR	44.551675	-123.356144	4933210	471713	2 x 2
Meadow knapweed	<i>Centaurea pratensis</i>	CEPR	44.551920	-123.356049	4933238	471720	5 x 5
Meadow knapweed	<i>Centaurea pratensis</i>	CEPR	44.551959	-123.355194	4933242	471788	5 x 5