Horse Rock Ridge Area of Critical Environmental Concern and Research Natural Area Restoration Plan

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Horse Rock Ridge Area of Critical Environmental Concern (ACEC)/Research Natural Area (RNA)

2. Legal Description

2.1. Legal description. Horse Rock Ridge ACEC/RNA is situated in T15S, R2W, Sec. 1.

2.2. Coordinates. A rectangle encompassing the BLM section of Horse Rock Ridge has the coordinates (UTM NAD 27):

NW corner: Easting: 508984, Northing: 4905076
SW corner: Easting: 508984, Northing: 4903691
NE corner: Easting: 510686, Northing: 4905076
SE corner: Easting: 510686, Northing: 4903691

This rectangle includes land not included in Horse Rock Ridge ACEC/RNA.

2.3. Maps. Maps of native and exotic plant communities are included in Appendix A.

3. Goal of the Restoration Plan

The over-all objectives of this restoration plan are to sustain or increase existing communities and populations of native plant species and decrease the abundance of exotic species. Specifically, the objectives include,

3.1. Invasive forbs occurring as individuals or in small populations: (Appendix A.4) Removal of these plants.

3.2. Mesic meadows characterized by high cover of the invasive forbs *Leucanthemum vulgare* and *Hypericum perforatum*: (Appendix A.11) Decrease the cover of invasive species and increase the cover of native species. Priority should be given to creating islands of high native cover and diversity that can serve as seed sources for surrounding untreated areas.

3.3. Remnant native grassland communities: (Appendix A.2) Increase the size of native-grass patches, focusing on expanding and connecting those dominated by *Danthonia californica*, *Stipa lemmonii*, *Elymus glaucus*, and *Festuca roemeri* (prioritizing high-quality patches).

3.4. Xeric grasslands currently dominated by the "matrix" community (dominant species include the invasive grasses *Bromus diandrus*, *Cynosurus echinatus*, *Vulpia bromoides*, and *Aira caryophyllea*). Decrease the cover of invasive species and increase the cover of native species. Priority should be given to creating islands of high native cover and diversity that can serve as seed sources for surrounding untreated areas.

3.5. Areas dominated by dense invasive grasses. (Appendix A.3) This invasive grass tends to occur in very dense patches to the exclusion of most native species. Priority should be given to creating islands of high native cover and diversity that can serve as seed sources for surrounding untreated areas.

4. Background

4.1. Site Description

Horse Rock Ridge ACEC/RNA is a 378-acre (153-ha) area located in Linn County within the Upper Willamette Resource Area (Appendix A, Horse Rock Ridge ACEC/RNA Location Map; Sawtelle 2006). Horse Rock Ridge was designated as an ACEC in January 1984 and an ACEC/RNA under the 1995 Eugene District Resource Management Plan (RMP), Record of Decision. In both instances the site was proposed for protection in order to preserve an example of a grassy bald (treeless area) and forest mosaic located on the western margin of the Cascade Mountains. The site fills the natural area cell or element described in the Oregon Natural Heritage Plan (2003) as *West Cascades Ecoregion/Shrub and Grassland Type/Blue wildrye or Roemer's fescue grass bald communities*.

Horse Rock Ridge is in the Coburg Hills on the divide between the Calapooya and Mohawk River drainages on the eastern edge of the Willamette Valley in western Oregon. The ACEC/RNA is part of the western slope of the Cascade Range physiographic province and is considered the best remaining example of a grassy bald with the associated botanical, wildlife and scenic values on the western margin of the Cascade Range. Approximately two-thirds of the ACEC/RNA has a southern exposure, and the rest of the area lies on the northslope. The topography is rugged with rock outcroppings and steep slopes. The RNA consists of a mosaic of open grasslands, young-growth forest and old-growth forest. The elevation of the ACEC/RNA ranges from 1,550 to 2,864 feet. The grassland balds are surrounded by old-growth *Pseudotsuga menziesii/Tsuga heterophylla* (Douglas-fir/western hemlock) forest. The site is recognized for the considerable diversity of plant species that includes plant species typical of the Willamette Valley, the montane zone of the Cascade Range, and east of the Cascade Range.

4.2. Ecological processes

4.2.1. *Soils*. One of the main processes that determines habitat availability for plants at Horse Rock Ridge is soil development. Soils in the grassland areas at Horse Rock Ridge are a complex of rock outcrop (60%) and Entisols (30%) on slopes of 55 – 70% (Curtis, 2003). These soils exhibit little or no development. At Horse Rock Ridge, the predominant basalt bedrock is very resistant and slopes are steep and actively eroding, inhibiting the development of soil horizons. Horizontal orientation of the basalt flows also may contribute to the fact that water is readily shed from the site as runoff and is not available for soil formation. Soils at Horse Rock Ridge are generally well drained and have loamy or sandy loam textures. Depth is variable, from 18 cm near exposed bedrock, 36 cm in depositional areas near drainages, and as deep as 91 cm on the less severe slopes along the main ridgeline where some old-growth *Pseudotsuga menzisii* occurs.

The meadows at Horse Rock Ridge have historically been divided into three communities defined by their dominant grass species: *Elymus glaucus* (blue wildrye) association; *Festuca roemeri* (Roemer's fescue; previously identified as *Festuca idahoensis*) association; and *Stipa lemmonii/Racomitrium canescens* (Lemmon's needlegrass/moss). *Festuca* communities tend to occupy the deepest soils, in areas that are often concave

and moister than surrounding areas. *Elymus* communities typically occur on convex slopes with moderate soil depths and are the most invaded of the community types. *Stipa* communities tend to occur on convex slopes and gravel substrate where there is little or no soil formation.

4.2.2. *Hydrology*. Water is readily shed from the steep slopes at Horse Rock Ridge and is likely limiting in the majority of the meadows most of the year. There are several small (0.5 – 1m^2) seasonal springs near the ridge top of Horse Rock Ridge. Although they dry-up completely in summer, they flow during storm events and support small populations of wetland plants. Many ephemeral stream channels are found on the lower reaches of the grasslands. These are eroded to bedrock and are typically 30 cm across. Lower slopes of the RNA are dissected by several stream channels, but they flow only during late fall, winter, and spring when storms bring adequate moisture.

4.2.3. *Grazing*. Although the extent is unknown, it is likely that Horse Rock Ridge was grazed by sheep in the early 1900's (Curtis, 2003). No grazing has occurred since the early 1960's. Sheep likely transported invasive plant species into the site and created disturbances that led to soil erosion and facilitated weed establishment. Native ungulates, including elk (*Cervus elaphus*) and blacktail deer (*Oedocoileus hemionus*) are expected to use the site. However, due to the minimal forage and water available at the site, it is unlikely that they would occupy the site long, and thus would have minimal impacts.

4.2.4. *Blowdown*. Blowdown of exposed trees along the grassland edges at Horse Rock Ridge primarily occurred during the 1962 Columbus Day Storm (Curtis, 2003). Many of these trees remain on the steep slopes where they could not be removed. In general, blowdown is expected to infrequently affect the meadows due to the low occurrence of trees.

4.2.5. *Fires*. There is no evidence of wildfire having occurred at Horse Rock Ridge (Curtis, 2003). There is a low chance of a wildfire carrying through the meadows. Although invasive annual grasses often increase fire frequency in invaded communities, their cover in the dry meadow communities is generally about 10% and cover of litter is <2%. Although litter cover is higher in the mesic meadows (25 – 35%), the dominant *Leucanthemum vulgare* remains green through much of the year (A.S. Thorpe, *unpublished data*), reducing the chance of a wildfire.

4.3. Plant communities and mapping units

Three primary communities have been defined at Horse Rock Ridge: grasslands, *Pseudotsuga menziesii/Tsuga heterophylla* forest community, and *Quercus garryana stands*. The grassland community was divided into three distinct plant associations: *Elymus glaucus* (blue wildrye); *Festuca roemeri* (Roemer's fescue); and *Stipa lemmonii/Racomitrium canescens* (Lemmon's needlegrass/moss) (Vanderschaff, 1993).

In 2006 – 2009, the grassland habitat at Horse Rock Ridge was mapped with the intent of characterizing native plant communities and invasive plant occurrences. Currently, only small remnants of the native grassland community remain (Appendix A.2). The majority of the grassland habitat at Horse Rock Ridge is now dominated by exotic grasses and forbs. Mapped categories include:

4.3.1. *Seeps and dry/rocky outcrops.* Seeps and dry/rocky outcrops are common at Horse Rock Ridge (Appendix A.1). Because of the shallow soils, the shape and orientation of the underlying rock strata dictate the overlying plant assemblages. Slopes that are flat to concave channel water; plant species indicating this subsurface topography include *Mimulus guttatus, Camassia leichtlinii, Plectritis congesta,* moss spp., *Mimulus alsinoides, Allium amplectens,* and *Trifolium microcephalum.* Convex slopes tend to shed water and cause the substrate to dry out quickly. Because the soils are thin and the slopes are steep at Horse Rock Ridge, topographic convexities often manifest as rocky outcrops with soil pockets dispersed within them. Plants typical of this habitat include *Poa scabrella, Allium acuminatum, Daucus pusillus, Lomatium utriculatum, Achnatherum lemmonii, Clarkia* spp., *Blepharipappus scaber, Brodiaea hyacinthina, Castilleja hispida, Castilleja tenuis,* and *Microsteris gracilis*.

While these are relatively distinct communities, there is overlap between community types. Seeps with shallower underlying concavities support annuals typical of xeric habitats, including all of the annual exotic grasses, when they dry out in summer. Conversely, dry rocky outcrops harbor mesic species, including *Mimulus guttatus* and *Trifolium microcephalum,* early in the spring before they dry out,

4.3.2. *Native grass communities.* Meadow communities were initially based on the associations defined by Vanderschaff (1993) and included: *Elymus glaucus, Festuca roemeri,* and *Achnatherum lemmonii* (*Stipa lemmonii*) associations (Appendix A.2). In general, *Elymus glaucus* was most abundant in mesic areas adjacent to the tree canopy. *Festuca roemeri* was found in sunnier habitats with deeper, richer soils. *Danthonia californica* and *Bromus carinatus* were commonly distributed throughout these habitats. Rocky outcrops and other areas with low soil depth tended to be dominated by the *Stipa lemmonii/Racomitrium canescens* (Lemmon's needlegrass/moss) associations, which commonly included *Poa scabrella* and *Koeleria cristata.* Soils and microsites intermediate in environmental characteristics harbored a mixture of these graminoids. When these species were found in dense patches, they were mapped individually. Areas dominated by *Festuca roemeri* were defined as low-, medium-, or high-quality (<10% cover, 10 – 50% cover, and >50% cover, respectively).

4.3.3. *The matrix community*. This community was dominated by several native annual grasses and a few native forbs (Table 4.1). This is now the dominant community at the site and occurs in areas with lower soil development and moisture levels. Any area that is not covered by a polygon should be assumed to the matrix community.

4.3.4. *Exotic grasses.* Although exotic grasses are ubiquitous at Horse Rock Ridge, particularly dense patches were mapped (Appendix A.3).

4.3.5. *Mesic meadows*. Meadows with shallower slopes, higher soil development, and higher soil moisture were characterized by a community dominated by the invasive forbs *Leucanthemum vulgare* and *Hypericum perforatum* (Appendix A.12). The native forb, *Eriophyllum lanatum,* frequently co-occurs with these species.

4.3.6. *Invasive forbs and shrubs occurring as individuals or in small populations*. Several invasive forb species occur at Horse Rock Ridge primarily as individuals or small populations (Appendices A.4 – A.17).

No listed, threatened or endangered plant species are currently known to occur in the ACEC/RNA. Two BLM Special Status plant species, *Juncus kellogii* (vascular plant) and *Lecidea dolodes* (lichen) occur within the ACEC/RNA. Historical sightings of golden eagles from near the ACEC/RNA have been reported, and it is likely that the site is within foraging range for northern spotted owls.

4.4. Site Threats

4.4.1. Off-trail recreation.

4.4.1.1. Off-trail use at horse Rock Ridge includes hiking off trials, camping, mountain biking, and off-highway vehicle (OHV) use. Off-trail recreation has resulted in numerous secondary routes. OHV and mountain bike use has widened and caused rutting in existing trails. OHV users have also repeatedly destroyed barriers intended to direct recreation use of Horse Rock Ridge.

4.4.1.2. *Consequences*. Off-trail recreation has a number of negative effects, including destroying native plant species, disturbing the soil (thus increasing soil erosion), compacting the soil, and transporting invasive plant species. Many of these activities are associated with moving/destroying trail barriers, creating secondary trails, and widening existing trails. Particularly due to the steep slopes, OHV and mountain bike use cause safety threats to both users and other ACEC/RNA visitors. Camping and open fires by visitors have resulted in an increase of garbage, cans, bottles, and other debris left within the boundary of the ACEC/RNA.

4.4.2. Invasion by exotic plant species.

4.4.2.1. *Consequences*. Invasive species are detrimental to native plant species through direct competition and indirect effects, such as changing soil chemistry and microbial communities. Invasive plant communities may also provide poor habitat for other native species (e.g. insects, birds, and fungi). By reducing native plant seed production, competition from invasive species can create a positive feedback loop eventually resulting in a near-elimination of native species.

4.4.2.2. *Invasive species at Horse Rock Ridge*.

4.4.2.2.1. Several invasive shrubs and forbs occur as isolated individuals or in small patches (Table 4.2; Appendices A.4 – A.17)

4.4.2.2.2. Invasive grasses and forbs co-occur with native plant species throughout the wet (Table 4.3) and dry (Table 4.1) meadow communities.

4.4.2.2.3. Although the invasive grasses *Aira caryphyllea, Bromus hordeaceous, Bromus rigidus, Cynosurus echinatus, Dactylis glomeratua, Holcus lanatus, Taeniatherum caput-medusae,* and

Vulpia spp. are ubiquitous at Horse Rock Ridge, particularly dense patches occur in numerous locations throughout Horse Rock Ridge (Appendix A.3).

4.5. Site Management History

4.5.1. *OHV incursions.* OHV incursions at Horse Rock Ridge ACEC/RNA have increased steadily since the mid-1980's. In order to minimize incursions, the the gate off BLM road 15-2-11.5 is kept locked. The vegetation and other barriers adjacent to the gate are also maintained in order to prevent passage. Numerous methods to prevent incursion off BLM road 15-2-11.5 have had to be implemented. Suspected OHV users have cut sections out of logs that were placed across the path to prevent access. A tall fence and large boulder pile have been placed at the entrance in order to prevent incursions. A variety of tools can be used to achieve closures including, but not limited to, signing, fencing, boulders, and brush piles.

4.5.2. *Long-term, permanent monitoring transects.* In 2000, the BLM established transects in the RNA to characterize existing vegetation and to monitor long-term vegetation changes in the grassland, forest, and the ecotone between them. Resampling of these transects is important as this data can be used to detect shifts in vegetation and potential management needs.

4.5.3. *Education.* One of the main purposes of RNAs is that they are used as an educational resource as outdoor laboratories and examples of undisturbed natural features. The RNA has been used for Botany field trips by local colleges (e.g. Lane Community College), universities, and organizations (e.g. Native Plant Society of Oregon) since the 1970's. While educational use continues to be important for management and restoration of Horse Rock Ridge, it is also critical that educational users are informed of the importance of staying on-trail and minimizing their impacts to the RNA.

4.5.4. *Seed Collection.* The Institute for Applied Ecology collected seed from native plant species in 2008 and 2009 (Table 4.4) for restoration in 2008 – 2012. Species were chosen to be representative of the flora in the mesic and xeric communities. Emphasis was placed on collecting native grasses, which are morphologically similar to invasive grasses and may offer higher resistance to reinvasion by exotic grasses, and "aggressive" native forbs (e.g. *Madia gracilis, Eriophyllum lanatum,* and *Clarkia* spp.) that typically germinate quickly, grow quickly, and produce copious seeds. Seeds were cleaned either by hand or using cleaning equipment at the USDA Natural Resources Conservation Service Native Plants Material Center located in Corvallis, Oregon.

The total number of seeds collected was estimated by multiplying the weight of the collected seeds by seed per pound data used by Beauty Beyond Belief (http://www.bbbseed.com/) and Heritage Seedlings Inc. (http://www.heritageseedlings.com/native.htm). As the purity of the collections is unknown, these numbers should be assumed to only be rough estimates.

A relatively small amount of seed was used in the experimental trials established in 2008. The remainder of the seed will be used in restoration activities in 2010 and 2011.

4.5.5. *Control of invasive weeds occurring in small patches*. Several invasive species, including *Cirsium* ssp., *Geranium dissectum,* and *Tragopogon dubius* were found only as scattered individuals or in small patches (Table 4.2). After we identified and mapped these individuals, we either manually removed them by pulling and/or grubbing or removed all of their aboveground biomass using loppers in both the spring and fall. Plant material was left onsite when appropriate; otherwise it was bagged and carried offsite for disposal. We will revisit these sites in 2010 to repeat treatments as necessary.

4.5.6. Mesic meadow restoration trial plots. Although mesic meadows retain a diverse assemblage of native species, at Horse Rock Ridge, they have been heavily invaded by exotic grasses and forbs. In contrast to the majority of the habitat at Horse Rock Ridge, these meadows are characterized by deeper soils and subsequently higher water and nutrient availability. In order to determine the most effective control methods for invasive species, the Institute for Applied Ecology established 30 - $1m^2$ experimental treatment plots in May 2008. Plots were randomly assigned one of four treatments: seed addition, clear plastic (solarization) + seed, carbon + seed addition, or no treatment (control).

4.5.6.1. Treatment summaries

4.5.6.1.1. Seed addition: Invasive weed species often produce higher amounts of seeds than native species. The low occurrence of native species may be due to a low number of native seeds compared to invasive seeds. To test this, we added 2.8 grams (equivalent to 25 pounds $acre^{-1}$) native seed (all seed was collected on site; Table 4.5) to five test plots in October 2008. Species and seed rates were selected based on recommendations for restoration using broadcast seeding in Willamette Valley prairies (Boyer 2008), the availability of seed, and with an emphasis on commonly occurring species. Seeds were collected throughout summer 2008 and cleaned either by hand or utilizing equipment at the NRCS Plant Materials Center in Corvallis, Oregon.

4.5.6.1.2. Clear plastic: Covering patches of vegetation with clear plastic kills any existing plants and stimulates germination from the seed bank. New germinants are subsequently killed by the treatment. We secured clear plastic to 10 plots using garden staples. The plastic was replaced one or two times on each plot because of weathering and damage by wildlife. After the plastic was removed in October 2009, each plot was seeded with 2.8 grams of the same mix used in the seed addition plots.

4.5.6.1.3. Carbon addition: Carbon addition limits the amount of soil nutrients available for plant growth (particularly nitrogen and

phosphorus) by stimulating microbial activity. Several studies have indicated that native species are more capable of tolerating low nutrient conditions than exotic species (Morgan, 1994; Zink and Allen, 1998; Reever Morghan and Seastedt, 1999; Alpert and Maron, 2000; Paschke et al., 2000; Blumenthal et al., 2003; Kirkpatrick *et al., unpublished data*). In fall 2008, we sprinkled 2 kg of carbon m^{-2} (in the form of sucrose) and 2.8 grams of the seed mix used above on ten plots.

4.5.6.1.4. No treatment: We also established five control plots in order to assess the effectiveness of the aforementioned treatments.

4.5.6.2. *Monitoring*. The percent cover of all plant species and four ground cover types (litter, moss, bare ground, and rock) were recorded in May 2008 and 2009.

4.5.6.3. *Results***.** An analysis of the effectiveness of the solarization treatment will not be available until 2010 as the plastic was not removed until fall 2009. Relative to the control plots, there was a decline in both exotic forbs and graminoids in the seed and seed + carbon plots (Thorpe et al. 2009). This effect was strongest with the carbon addition. Surprisingly, there was also a decline in native forbs in the treated plots compared to the control plots (though this effect was not significant with the carbon treatment). In contrast, the cover of native graminoids decreased in both the control and seed treatment plots, but increased slightly in the seed + carbon plots. Thus, one year after application, both treatments appeared to negatively impact exotic forbs and graminoids and have either no to slightly positive effects on native species. The majority of the species that we used in our seed mixes are perennials, which may take greater than one year to occupy a significant area. These plots will be surveyed again in 2010 in order to re-evaluate treatment effects.

4.5.7. *Matrix meadow restoration trial plots*. The majority of the meadow area at Horse Rock Ridge is covered by poorly developed, shallow soils on which exotic annual grasses are ubiquitous. This community type occurs throughout the site, with species density positively correlated with soil depth. Although this dry habitat can be dominated by exotic grasses, several native forbs are common, including *Eriophyllum lanatum, Clarkia gracilis*, and *Madia gracilis*. In order to determine the most effective control methods for the matrix species, the Institute for Applied Ecology established 30 - $1m^2$ experimental treatment plots in May 2008. Plots were randomly assigned one of three treatments: seed addition, carbon + seed addition, or no treatment (control). Treatments were applied as described above for mesic meadows, with two exceptions. First, there were ten plots for each experimental treatment. Second, a xeric meadow seed mix (Table 4.5) was used.

4.5.7.1. *Monitoring*. Several nails were found dislodged during the May 2009 monitoring. The corners for all but one plot were replaced by recreating the initial marcoplot grid. The percent cover of all plant

species and the four ground cover types (litter, moss, bare ground, and rock) was recorded in May 2008 and 2009.

4.5.7.2. *Results*. Similar to the mesic meadows, there was variability in the effects of the treatments on the different plant groups. Compared to the controls, there was no effect of either treatment on exotic forbs. However, both treatments caused a decline in the cover of exotic graminoids. Unfortunately, both treatments also caused a decline in the cover of native forbs. In contrast, both treatments resulted in a small increase in the cover of native graminoids. In summary, seed addition and seed + carbon addition had the desired negative effects on exotic grasses. However, these treatments also had negative effects on native forbs. The majority of the species that we used in our seed mixes are perennials, which may take greater than one year to occupy a significant area. These plots will be surveyed again in 2010 in order to re-evaluate treatment effects.

Table 4.1. Species found in the matrix community at Horse Rock Ridge listed in order of abundance (high to low).

Scientific name	Family	Growth form	Nativity
Cynosurus echinatus	Poaceae	Grass	Exotic
Trifolium tridentatum	Fabaceae	Forb	Native
Vulpia bromoides	Poaceae	Grass	Exotic
Aira caryophyllea	Poaceae	Grass	Exotic
Hypochaeris radicata	Asteraceae	Forb	Exotic
Eriophyllum lanatum	Asteraceae	Forb	Native
Bromus hordeaceus	Poaceae	Grass	Exotic
Holcus lanatus	Poaceae	Grass	Exotic
Poa scabrella	Poaceae	Grass	Native
Mimulus guttatus	Scrophulariaceae	Forb	Native
Madia gracilis	Asteraceae	Forb	Native
Linum usitatissimum	Linaceae	Forb	Exotic
Hypochaeris glabra	Asteraceae	Forb	Exotic
Lotus micranthus	Fabaceae	Forb	Native
Perideridia gairdneri	Apiaceae	Forb	Native
Castilleja tenuis	Scrophulariaceae	Forb	Native
Githopsis specularioides	Campanulaceae	Forb	Native
Bromus carinatus	Poaceae	Grass	Native
Galium aparine	Rubiaceae	Forb	Native
Minuartia tenella	Caryophyllaceae	Forb	Native
Daucus pusillus	Apiaceae	Forb	Native
Silene gallica	Caryophyllaceae	Forb	Exotic
Clarkia gracilis	Onagraceae	Forb	Native
Eriogonum nudum	Polygonaceae	Forb	Native
Trifolium microcephalum	Fabaceae	Forb	Native
Cerastium sp.	Caryophyllaceae	Forb	Exotic
Allium sp.	Liliaceae	Forb	Native
Triteleia hyacinthine	Liliaceae	Forb	Native

Table 4.2. All treatments listed are intended for individuals and small patches of invasive forbs and shrubs and require initial surveys. All documented locations of invasive species should be surveyed annually until the species has been noted as "not present" for five years. Previous Actions took place 2008 – 2009.

Threat	Growth form	Duration	Approx. area covered	Previous Actions	Map	Desired site condition
Alliaria petiolata	Forb	Annual/ Biennial	1 patch, <1m^2	Hand-pulled	Appendix A.6	Removal by 2012.
Cirsium vulgari and *Cirsium* spp.	Forb	Perennial	Infrequent individuals, small patches	Hand-pulled	Appendix A.7	Removal by 2012.
Crataegus monogyna	Shrub	Perennial	Infrequent individuals, small patches		Appendix A.8	Removal by 2012.
Cytisus scoparius	Shrub	Perennial	Infrequent individuals, small patches up to ~100 plants.		Appendix A.9	Removal by 2012.
Digitalis purpurea	Forb	Biennial	3 small patches	Hand-pulled	Appendix A.10	Removal by 2012.
Geranium dissectum	Forb	Annual/ Biennial	Somewhat distributed throughout; most dense near tree-line.	Hand-pulled	Appendix A.11	Removal by 2012.
Hypericum perforatum	Forb	Perennial	Relatively common in mesic meadows.	Experimental treatments, small patches hand-pulled.	Appendix A.12	Reduced cover through-out site by 2012.
Leucanthemum vulgare	Forb	Perennial	Relatively common in mesic meadows.	Experimental treatments.	Appendix A.12	Reduced cover through-out site by 2012.

Table 4.2, cont.

Threat	Growth form	Duration	Approx. area covered	Previous Actions	Map	Desired site condition
Rubus armeniacus	Shrub	Perennial	Mesic areas and just inside forest edges.	Pulled and lopped.	Appendix A.13	Removal by 2012.
Rubus laciniatus	Shrub	Perennial	Mesic areas and just inside forest edges.	Pulled and lopped.	Appendix A.13	Removal by 2012.
Rubus ursinus	Shrub	Perennial	Mesic areas and just inside forest edges.	Pulled and lopped.	Appendix A.13	Reduced cover if threatening meadow vegetation.
Rumex acetosella	Forb	Perennial	Infrequent individuals, small patches	Hand-pulled	Appendix A.14	Removal by 2012.
Rumex crispus	Forb	Perennial	Infrequent individuals, small patches	Hand-pulled	Appendix A.14	Removal by 2012.
Senecio jaobaea	Forb	Perennial	Infrequent individuals, small patches	Hand-pulled	Appendix A.15	Removal by 2012.
Sonchus asper	Forb	Annual	Several small patches (< 10 individuals each)	Hand-pulled	Appendix A.16	Removal by 2012.
Tragopogon dubius	Forb	Annual/ Biennial	Two small patches	Hand-pulled	Appendix A.16	Removal by 2012.
Vicia sativa	Forb	Annual	One small patch		Appendix A.17	Removal by 2012.

Table 4.3. Species found in mesic meadows community at Horse Rock Ridge listed in order of abundance (high to low).

Species	Family	Growth Form	Nativity
Eriophyllum lanatum	Asteraceae	Forb	Native
Leucanthemum vulgare	Asteraceae	Forb	Invasive
Hypochaeris radicata	Asteraceae	Forb	Invasive
Carex rossi	Cyperaceae	Grass	Native
Crepis capillaris	Asteraceae	Forb	Invasive
Fragaria vesca	Rosaceae	Forb	Native
Luzula multiflora multiflora	Juncaceae	Grass	Native
Rubus ursinus	Rosaceae	Shrub	Native
Elymus glaucus	Poaceae	Grass	Native
Cynosurus echinatus	Poaceae	Grass	Invasive
Danthonia californica	Poaceae	Grass	Native
Poa compressa	Poaceae	Grass	Invasive
Hypericum perforatum	Clusiaceae	Forb	Invasive
Lotus micranthos	Fabaceae	Forb	Native
Ranunculus occidentalis	Ranunculaceae	Forb	Native
Prunella vulgaris lanceolata	Lamiaceae	Forb	Native
*Allium*spp.	Liliaceae	Forb	Native
Cerastium nutans	Caryophyllaceae	Forb	Native
Symphoricarpos albus	Caprifoliaceae	Forb	Native
Irix tenax	Liliaceae	Forb	Native
Taraxacum officinale	Asteraceae	Forb	Invasive
Bromus hordeaceous	Poaceae	Grass	Invasive
Leptosiphon bicolor	Polemoniaceae	Forb	Native
Amelanchier alnifolia	Rosaceae	Forb	Native
Plantago lanceolata	Plantaginaceae	Forb	Invasive
Aquilegia formosa	Ranunculaceae	Forb	Native
Holodiscus discolor	Rosaceae	Forb	Native
Lomatium utriculatum	Apiaceae	Forb	Native
Rumex acetosella	Polygonaceae	Forb	Invasive
Microsteris gracilis	Polemoniaceae	Forb	Native
Bromus vulgaris	Poaceae	Grass	Native
Veronica arvensis	Scrophulariaceae	Forb	Invasive
Brodiaea hyacinthina	Liliaceae	Forb	Native

Table 4.3, cont.

Species	Family	Growth Form	Nativity
mustard spp.	Brassicaceae	Forb	Invasive
Holcus lanatus	Poaceae	Grass	Invasive
Maianthemum stellatum	Liliaceae	Forb	Native
Epilobium spp.	Onagraceae	Forb	Native
Vicia americana	Fabaceae	Forb	Native

Table 4.4. Seeds of native plant species collected at Horse Rock Ridge in 2008 and 2009. The number of seeds for some species could not be estimated and was labeled unknown ("unk.").

Scientific Name	Family	Form	Collection date	Clean grams	# seeds (rough)
Agoseris grandiflora	Asteraceae	Forb	8/6-7/08, 7/23-24/08	3.80	2,085
Allium acuminatum	Liliaceae	Forb	7/3/2009	0.05	35
Allium amplectens	Liliaceae	Forb	8/6-8/7	2.80	1,973
Allium crenulatum	Liliaceae	Forb	8/6-7/08, 7/23-24/08	6.10	4,280
Balsamorhiza deltoidea	Asteraceae	Forb	7/11/08, 7/23-24/08	120.70	1,040
Triteleia hyacinthina	Liliaceae	Forb	8/6-7/08	3.10	unk.
Bromus carinatus	Poaceae	Grass	7/23-24/08, 7/23/2009	760.71	108,269
Calochortus tolmiei	Liliaceae	Forb	8/6-7/08	1.40	1,193
Camassia leichtlinii	Liliaceae	Forb	8/6-7/08	4.90	1,572
Clarkia gracilis	Onagraceae	Forb	8/6-7/08, 7/23-24/08	6.90	15,768
Clarkia spp.	Onagraceae	Forb	7/23/09, 8/12/09	2.03	4,639
Danthonia californica	Poaceae	Grass	7/23-24/08, 8/6-7/08, 7/23/09, 8/12/09	99.42	27,902
Daucus pusillus	Apiaceae	Forb	8/6-7/08, 7/23/2009	40.86	36,695
Delphinium menziesii var. *pyramidale*	Ranunculaceae	Forb	8/6-7/08, 7/23-24/08	1.50	451
Dodecatheon pulchellum var. *pulchellum*	Primulaceae	Forb	8/6-7/08, 7/23-24/08	7.50	4,910
Elymus glaucus	Poaceae	Grass	8/6-7/08, 7/23/09, 8/12/09	190.05	27,459
Erigeron compositus var. *glabratus*	Asteraceae	Forb	7/23-24/08, 7/3/2009	3.48	6,278
Eriogonum nudum	Polygonaceae	Forb	8/6-7/08, 7/23-24/08	10.70	1,930
Eriophyllum lanatum	Asteraceae	Forb	7/23-24/08, 9/2-3/08, 7/3/09, 7/23/09, 8/12/09	118.75	278,287
Erythronium spp.	Liliaceae	Forb	8/6-7/08	4.00	617
Festuca roemeri	Poaceae	Grass	8/6-7/08, 7/23-24/08, 7/23/09, 8/12/09	300.62	301,311
Gilia capitata ssp. *capitata*	Polemoniaceae	Forb	8/6-7/08	1.20	2,427
Koeleria cristata	Poaceae	Grass	8/6-7/08, 9/2-3/08, 8/12/2009	99.45	461,513
Lomatium utriculatum	Apiaceae	Forb	8/6-7/08, 7/23-24/08, 7/3/2009	16.59	9,237
Madia gracilis	Asteraceae	Forb	7/23-24/08, 7/3/2009	7.54	11,034
Microsteris gracilis	Polemoniaceae	Forb	7/3/2009	0.67	559

Table 4.4. cont.

Scientific Name	Family	Form	collection date	clean grams	# seeds (rough)
Mimulus guttatus	Scrophulariaceae	Forb	7/23-24/08, 7/3/2009	4.75	76,175
Orthocarpus hispidus	Scrophulariaceae	Forb	8/6-7/08, 7/23-24/08, 7/3/2009	6.07	45,630
Perideridia gairdneri ssp. *borealis*	Apiaceae	Forb	8/6-7/08	19.80	18,754
Plectritis congesta	Valerianaceae	Forb	8/6-7/08, 7/23-24/08	5.70	14,988
Poa scabrella	Poaceae	Grass	8/6-7/08, 7/23-24/08, 9/2-3/08, 7/23/2009	183.00	384,069
Potentilla glandulosa	Rosaceae	Forb	8/6-7/08, 9/2-3/08	3.60	8,191
Saxifraga cf. *integrifolia*	Saxifragaceae	Forb	9/2-3/08	1.10	unk.
Sedum spathulifolium	Crassulaceae	Forb	9/2-9/3	2.40	unk.
Stipa lemmonii	Poaceae	Grass	7/23-24/08, 7/3/09, 7/23/09	136.52	29,195
Trifolium microcephalum	Fabaceae	Forb	8/6-7/08, 7/23-24/08, 7/3/2009	10.85	4,350
Trifolium triternatum	Fabaceae	Forb	7/23-24/08, 7/3/09, 7/23/09	29.52	18,920
Zigadenus venenosus var. *venenosus*	Liliaceae	Forb	8/6-7/08	23.00	13,832

Table 4.5. Plant species used in seedmixes for treatment plots in mesic and xeric meadows at Horse Rock Ridge.

			Community type	
			Mesic	Xeric
Family	Scientific Name	Common Name	Percent of mix	Percent of mix
Asteraceae	*Agoseris grandiflora*	bigflower agoseris		1.0%
Asteraceae	*Balsamorhiza deltoidea*	deltoid balsamroot		1.0%
Liliaceae	*Camassia leichtlinii*	Leichtlin/large camas	2.0%	
Onagraceae	*Clarkia gracilis*	slender godetia	2.0%	1.0%
Primulaceae	*Dodecatheon pulchellum* var. *pulchellum*	darkthroat shooting star	2.0%	
Asteraceae	*Erigeron compositus* var. *glabratus*	cut-leaved daisy	1.0%	1.0%
Asteraceae	*Eriophyllum lanatum*	woolly sunflower	8.0%	8.0%
Apiaceae	*Lomatium utriculatum*	common lomatium		2.5%
Asteraceae	*Madia gracilis*	slender tarweed	3.5%	2.0%
Scrophulariaceae	*Mimulus guttatus*	yellow monkeyflower		3.5%
Scrophulariaceae	*Orthocarpus hispidus*	hairy indian paintbrush		2.0%
Apiaceae	*Perideridia gairdneri* ssp. *borealis*	Gairdner's yampah	4.0%	
Valerianaceae	*Plectritis congesta*	rosy plectritis		3.0%
Rosaceae	*Potentilla glandulosa*	sticky cinquefoil	2.5%	
Fabaceae	*Trifolium microcephalum*	woolly clover		2.0%
Fabaceae	*Trifolium tridentatum*	sand clover		2.0%
Liliaceae	*Zigadenus venenosus* var. *venenosus*	meadow deathcamas	5.0%	1.0%
Poaceae	*Bromus carinatus*	California brome	12.0%	12.0%
Poaceae	*Danthonia californica*	California oatgrass	10.0%	12.0%
Poaceae	*Elymus glaucus*	blue wildrye	12.0%	
Poaceae	*Festuca roemeri*	Roemer’s fescue	12.0%	12.0%
Poaceae	*Koeleria cristata*	prairie junegrass	12.0%	12.0%
Poaceae	*Poa scabrella*	pine bluegrass	12.0%	12.0%
Poaceae	*Stipa lemmonii*	Lemmon’s needlegrass		10.0%

5. Restoration Needs

5.1. Issue. Recreation creates disturbances that facilitate exotic weed spread, introduces exotic weed seeds, and damages sensitive native species.

5.1.1. *Desired condition*. Reduced movement of invasive weed species into and through site.

5.1.2. Action needed.

5.1.2.1. Sign the existing trail that traverses the meadows and post informational signs at both ends of the trail articulating both educational and regulatory information. Subsequent signing along the trail should be considered where users deviate from the designated route because of increased visitation or confusion about the location of the trail. Some areas may currently need clarification on the ground as is evidenced by multiple trails in key areas.

5.1.2.2. Keep the gate off of BLM road 15-2-11.5 locked. Maintain the vegetation or erect other barriers adjacent to the gate to prevent passage. Maintain the fence, boulders, and other deterrents to OHV and bike use at BLM road 15-2-11.5.

5.1.2.3. As required, use signing, fencing, boulders, brush piles, etc. to close secondary routes and prevent use by OHVs.

5.1.2.4. Educate user groups (e.g. educational and community groups such as Lane Community College classes and Native Plant Society of Oregon fieldtrip groups) about the important of staying on-trail and minimizing recreational impacts.

5.1.2.5. Install informational signs about RNA habitats and species and ways to prevent invasive weed spread at the entry points to the site.

5.1.3. *Responsibility*. Eugene BLM

5.2. Issue. Invasive forb species occurring throughout Horse Rock Ridge as individuals or small patches (Table 4.2).

5.2.1. *Desired condition*. Elimination of invasive forb species occurring as individuals or small patches within 10 years of sign-off on the plan. To be considered "eliminated" a previously occupied area must be documented free of the invasive weed for at least 3 years.

5.2.2. *Action needed*.

5.2.2.1. Manual removal of individuals using methods and timing as appropriate for each species (Table 5.1).

5.2.2.2. Treatment with herbicides as appropriate for each species. Due to the low rates of success of manual treatments, herbicide treatment is particularly recommended for *Crataegus monogyna*, green *Cytisus scoparius* that are too large to hand-pull and are green at the base of the stem, *Rubus* spp., and any other species where manual removal following suggested guidelines is not possible (e.g. due to soil conditions, root crowns cannot be fully removed).

5.2.3. *Responsibility*. The Institute for Applied Ecology is under Assistance Agreement with the Eugene BLM to conduct treatments in 2010 and 2011, and will continue to pursue funding in 2012 and beyond.

5.3. Issue. Mesic meadows have been invaded by several weeds, including *Leucanthemum vulgare* and *Hypericum perforatum*.

5.3.1. *Desired condition*.

5.3.1.1. Greater than 90% cover of native species and less than 10% cover of invasive species (relative to other vegetation).

5.3.1.2. Native species produce relatively large quantities of seed.

5.3.2. *Action needed.* Follow treatments as described in Table 5.2.

5.3.3. *Responsibility*. The Institute for Applied Ecology is under Assistance Agreement with the Eugene BLM to conduct treatments in 2010 and 2011, and will continue to pursue funding in 2012 and beyond.

5.4. Issue. Remnant patches of native grass communities have been degraded by invasion, particularly by invasive annual grasses.

5.4.1. *Desired condition*.

5.4.1.1. Within patches, greater than 90% cover of native species and less than 10% cover of invasive species (relative to other vegetation).

5.4.1.2. Native species produce relatively large quantities of seed.

5.4.1.3. Increased connectivity between patches.

5.4.2. *Action needed***.** Follow treatments as described in Table 5.3.

5.4.3. *Responsibility*. The Institute for Applied Ecology is under Assistance Agreement with the Eugene BLM to conduct treatments in 2010 and 2011, and will continue to pursue funding in 2012 and beyond.

5.5. Issue. Dry meadow communities are highly degraded due to high cover of invasive plants, particularly annual grasses, and low cover of native plants. Using the same treatment at once over the entire site is not recommended due to the expense and currently unpredictable results. It is recommended that treatments be initially applied using an experimental approach, then expanded if determined to be successful.

5.5.1. Desired condition.

5.5.1.1. Within patches, greater than 90% cover of native species and less than 10% cover of invasive species (relative to other vegetation).

5.5.1.2. Native species produce relatively large quantities of seed.

5.5.2. Action needed.

5.5.2.1. If grass specific herbicides are available, follow the treatments as in Table 5.4.

5.5.2.2. If grass specific herbicides are not available for use, it is recommended that the priority be on focusing efforts on small areas to improve cover and seed production of native species (Table 5.5). Given sufficient funding and if these methods have been successful, in Spring 2013, new patches should be selected for treatment and the treatment cycle repeated. If there is not sufficient funding to continue treatments, seed collection and plug production in 2012 is not recommended.

5.5.3. *Responsibility*. The Institute for Applied Ecology is under Assistance Agreement with the Eugene BLM to conduct treatments in 2010 and 2011, and will continue to pursue funding in 2012 and beyond.

5.6. Issue. Areas dominated by dense invasive grasses

5.6.1. Desired condition.

5.6.1.1. Within patches, greater than 90% cover of native species and less than 10% cover of invasive species (relative to other vegetation).

5.6.1.2. Native species produce relatively large quantities of seed.

5.6.2. Action needed.

5.6.2.1. If grass specific herbicides are available, follow the treatments as in Table 5.4.

5.6.2.2. If grass specific herbicides are not available for use, it is recommended that the priority be on focusing efforts on increasing cover of native grasses and forbs (Table 5.5). It is recommended that this be given a lower priority than treatments for other issues.

5.6.3. *Responsibility*. The Institute for Applied Ecology is under Assistance Agreement with the Eugene BLM to conduct treatments in 2010 and 2011, and will continue to pursue funding in 2012 and beyond.

Table 5.1. All treatments listed are intended for individuals and small patches of invasive forbs and require initial surveys. All documented locations of invasive species should be surveyed annually until the species has been noted as "not present" for three years. Prior to chemical application, The Pacific Northwest Weeds Handbook should be consulted for current herbicide recommendations. Chemical treatments may be particularly effective and cost efficient for larger (>30 individuals) infestations of invasive forbs.

Species	Non-chemical	Chemical	Map
Alliaria petiolata	Pull, removing at least 3" of taproot.	1 - 2% solution of glyphosate to foliage during late fall or early spring. 2,4-D, triclopyr, and crossbow may also be effective.	Appendix A.6
Cirsium vulgari and *Cirsium* spp.	Pull, removing at least 3" of taproot.	If patch exceeds 30 individuals; spray with glyphosate if feasible.	Appendix A.7
Crataegus monogyna	Young plants: pull, removing >4" of root.	Mature plants: cut to the ground and paint with a solution of 25% triclopyr (as Garlon 4) and 75% cottonseed or other light cooking oil as surfactant and inert ingredient. Glyphosate (Roundup at label-recommended strength) may be substituted for triclopyr, but results are less certain. A 2 – 3% solution of triclopyr or glyphosate has been sprayed on the foliage for control, but overall spraying has not generally been reliable.	Appendix A.8
Cytisus scoparius	Young plants: pull, removing >4" of root. Mature plants (brown stems): cut to the ground; if feasible, apply herbicides to cut stumps.	Foliar herbicide application is most effectve after full leaf development and before fall senescence. Basal and cut stump treatments also effective. Glyphosate, 2% solution, is most effective if applied to actively growing plants. 2,4-D also effective.	Appendix A.9
Digitalis purpurea	Pull, removing at least 4" of taproot.		Appendix A.10
Geranium dissectum	Pull at or before onset of flowering, removing root crown.	1.5 – 2% solution of broadleaf selective herbicide (e.g. Triclopyr) or non-selective herbicide (e.g. glyphosate).	Appendix A.11

Table 5.1, cont.

Species	Non-chemical	Chemical	Map
Hypericum perforatum	If <20 individuals, hand-pull, removing >2" taproot and all lateral roots. If a larger patch that is interspersed with desirable native species, follow treatments as in Table 5.2.	If not interspersed with desired native species, apply 2,4-D at 2 lb ae/A in 50 gal of water. Apply before any blossoms open, preferably on new seedlings after germination.	Appendix A.12
Leucanthemum vulgare	If <20 individuals, hand-pull, removing >2" taproot and all lateral roots. If a larger patch that is interspersed with desirable native species, follow treatments as in Table 5.2.	2,4-D, dicamba, clopyralid, and imazapyr can be effective. For best results, spot-spray when in the rosette stage. Effects can be seen in one day, allowing plants that were missed to be easily detected and treated. Clopyralid persists in the soil for one to two years and will damage or destroy sensitive native species (e.g., composites and legumes), so it should be very carefully spot-sprayed.	Appendix A.12
Rubus armeniacus & R.laciniatus	Grub, removing >4" root and transporting material off-site.	Garlon 3A and Roundup: spraying of foliage is more effective during summer, spot application on cut canes, injection into canes, and spraying newly emergent plants more effective in fall.	Appendix A.13
Rubus ursinus	*If* a threat to native meadow forbs, grub, removing >4" root and transporting material off-site. If threat, pull, removing all material or, if feasible, apply herbicides as for other *Rubus*.	If a threat to native meadow forbs, apply herbicides as for other Rubus.	Appendix A.13
Rumex acetosella	Pull, removing all rhizomes and root fragments.	Dicamba: 0.5 lb ae/A, apply when there is new foliage, usually Nov 15 - March 15. Spring application controls spring-germinating seedlings better than sprays applied earlier.	Appendix A.14

Table 5.1, cont.

Species	Non-chemical	Chemical	Map
Rumex crispus	Pull, removing >2" root	2,4-D, dicamba, or picloram at 1 lb ae/50 gal of water for spot treatments. Apply before flower elongation.	Appendix A.14
Senecio jaobaea	Pull, removing at least 3 inches of taproot, after bolting, but before flowering (May - June). Dispose of off-site (flowers can mature after pulled).	1 to 2 lb ae/A 2,4-D LV ester or 2,4-D amine; 0.25 lb ae/A picloram; 1 lb ae/A dicamba; 2 quarts/A Weedmaster; or 1.5 to 2 quarts/A Crossbow. Apply 2,4-D in spring before any flowers appear; the earlier the application in relation to plant growth, the better the control. Picloram and dicamba can be used at the flowering stage with good results. Fall applications after rains begin seed germination have proven effective also.	Appendix A.15
Sonchus asper	Pull, removing at least 3" of taproot.	2,4-D: apply at 2 lb ae/A at bud stage and to regrowth 8 to 10 inches high. Curtail: apply 1 - 5 qts/A after most rosettes have emerged, but before bud stage. Aminopyralid: apply 0.75 - 1.25 oz ae/A to actively growing plants before the bud stage.	Appendix A.16
Tragopogon dubius	Pull, removing at least 3" of taproot.	Clopyralid + 2,4-D & chlorsulfuron + metsulfuron are effective.	Appendix A.16
Vicia sativa	Pull, removing at least 3" of taproot.	2,4-D, glyphosate: apply in early spring at 1 - 2% solution; triclopyr: apply 2% sln; clopyralid: apply 0.25% sln + 0.5% surfactant.	Appendix A.17

Table 5.2. Schedule of treatments in mesic meadows. The Institute for Applied Ecology is under Assistance Agreement with the Eugene BLM to conduct treatments in 2010 and 2011, and will continue to pursue funding in 2012 and beyond.

	2010				2011				2012				Future years[2]			
	Spr.	**Su.**	**Fall**	**Win.**	**Spr.**	**Su.**	**Fall**	**Win.**	**Spr.**	**Su.**	**Fall**	**Win.**	**Spr.**	**Su.**	**Fall**	**Win.**
Select patches for treatment	X												X[2]			
Manually remove invasive plants	X	X			X	X			X	X			X	X		
Broadcast carbon (2 kg m^{-2})[1]			X													
Broadcast native seed			X				X				X				X	
Plant native plugs			X				X				X				X	
Assess success of prior treatments	X				X				X				X			
Collect seeds as needed		X				X				X				X		
Propagate plugs for restoration				X	X			X	X			X	X			X

[1]After one-year of research, carbon addition has been successful at inhibiting invasive species in favor or native species, however, this treatment should continue to be applied using an experimental approach as it has not yet been tested in all communities at Horse Rock Ridge, it is currently unknown what the long-term effects of this treatment are, and it would be very expensive to use on a large scale. However, we recommend using it on a small-scale in order to create patches of particularly high native cover that could serve as a source of seeds for neighboring areas.

[2]Once the condition of existing patches of native grasses has been improved to the point that relative cover of native species is >90% and the relative cover of invasive species is <10%, connectivity between patches can be improved by using the same techniques used within patches on patch edges.

Table 5.3. Restoration techniques to use in patches of native grasses (Appendix A.2). The Institute for Applied Ecology is under Assistance Agreement with the Eugene BLM to conduct treatments in 2010 and 2011, and will continue to pursue funding in 2012 and beyond.

	2010				2011				2012				Future years[2]			
	Spr.	**Su.**	**Fall**	**Win.**	**Spr.**	**Su.**	**Fall**	**Win.**	**Spr.**	**Su.**	**Fall**	**Win.**	**Spr.**	**Su.**	**Fall**	**Win.**
Select patches for treatment	X												X[2]			
Manually remove invasive plants	X	X			X	X			X	X			X	X		
Broadcast carbon (2 kg m^{-2})[1]			X													
Broadcast native seed			X				X				X				X	
Plant native plugs			X				X				X				X	
Assess success of prior treatments					X				X				X			
Collect seeds as needed		X				X				X				X		
Propagate plugs for restoration				X	X			X	X			X	X			X
Solarization (if appropriate)[3]																
Apply plastic							X									
Remove plastic											X					
Broadcast native seed			X				X				X				X	
Plant native plugs			X				X				X				X	

[1]After one-year of research, carbon addition decreased cover of invasive species and increased cover of native species, however, this treatment should continue to be applied in an experimental approach as it has not yet been tested in all communities at Horse Rock Ridge, the long-term effects of carbon addition are unknown, and it would be very expensive to use on a large scale. However, on a small-scale this treatment has potential to create patches of particularly high native cover to serve as a source of seeds for neighboring areas.

[2]Once the condition of treatment patches has been improved to the point that relative cover of native species is >90% and the relative cover of invasive species is <10%, treatments should be replicated in new patches.

[3]Solarization is being tested as a method at Horse Rock Ridge; at the time of preparation of this plan, it was effective at removing invasive weeds, however, it is not known how effectively native plants can become established after this treatment. If this treatment is determined to be successful after monitoring in 2011, it should be applied to small plots to create "islands" of relatively high native cover.

Table 5.4. If grass-specific herbicides are available for use. In areas with low (<10%) cover of native grasses, trial plots should be established to test the effectiveness of using grass-specific herbicides to control invasive grasses. The Institute for Applied Ecology is under Assistance Agreement with the Eugene BLM to conduct treatments in 2010 and 2011, and will continue to pursue funding in 2012 and beyond.

Schedule	Action
Year 1, spring	Establish test plots (e.g. 20 5mx5m plots), spray plots with grass-specific herbicide per recommendations (generally during the boot-stage of development).
Year 1, fall	Broadcast and plant forbs.
Year 2, spring	Spray with grass-specific herbicide.
Year 2, spring	Evaluate cover of exotic grasses.
Year 2, fall	Broadcast and plant forbs.
Year 3, spring	Spray with grass-specific herbicide.
Year 3, spring	Evaluate cover of exotic grasses.
Year 3, fall	If exotic forb cover < 10%, broadcast and plant native grasses. If not, continue previous treatment cycles.
Year 4, spring	Evaluate effectiveness of treatments; adapt management of plots as necessary (e.g. repeat native grass additions). If treatments were successful, repeat in new plots.

Table 5.5. Restoration techniques to use in degraded dry meadow ("matrix") communities if grass-specific herbicides are unavailable for use. The Institute for Applied Ecology is under Assistance Agreement with the Eugene BLM to conduct treatments in 2010 and 2011, and will continue to pursue funding in 2012 and beyond.

	2010				2011				2012			
	Spr.	**Su.**	**Fall**	**Win.**	**Spr.**	**Su.**	**Fall**	**Win.**	**Spr.**	**Su.**	**Fall**	**Win.**
Select patches for treatment	**X**											
Broadcast carbon (2 kg m^{-2})[1]			**X**									
Broadcast native seed			**X**				**X**				**X**	
Plant native plugs			**X**				**X**				**X**	
Assess success of prior treatments	**X**				**X**				**X**			
Collect seeds as needed		**X**				**X**				**X**[2]		
Propagate plugs for restoration				**X**	**X**			**X**	**X**			**X**[2]

[1]After one-year of research, carbon addition decreased cover of invasive species and increased cover of native species, however, this treatment should continue to be applied in an experimental approach as it has not yet been tested in all communities at Horse Rock Ridge, the long-term effects of carbon addition are unknown, and it would be very expensive to use on a large scale. However, on a small-scale this treatment has potential to create patches of particularly high native cover to serve as a source of seeds for neighboring areas.

[2]Given sufficient funding and if these methods have been successful, in Spring 2013, new patches should be selected for treatment and the treatment cycle repleated. If there is not sufficient funding to continue treatments, seed collection and plug production in 2012 is not recommended.

6. Adaptive Management

6.1. Monitoring protocols

Small patches and individuals of invasive forbs and shrubs. After removal of invasive forbs and shrubs occurring as individuals and small patches, areas should be monitored annually in order to determine if new individuals have recruited from root fragments or the seed bank. All documented locations of invasive species should be surveyed annually until the species has been noted as "not present" for three years.

Monitoring: The "Invasive species treatment and monitoring at Horse Rock Ridge" form should be completed.

6.1.1. *Mesic meadow communities*. Treatments in mesic meadow communities should be applied in experimental plots that are monitored each year to document the cover of all species.

Minimum monitoring: The cover of native and invasive species in each functional group should by monitored. See "Horse Rock Ridge - Mesic meadow weed treatment plots monitoring form".

Preferred monitoring: The cover of each species should be estimated in order to determine changes between years. The "Horse Rock Ridge - Mesic meadow weed treatment plots monitoring form" should be completed

6.1.2. *Remnant patches of native grass communities*. Before and for at least three years after removal of invasive species in remnant patches of native grasses, patches should be monitored to document the approximate area treated and the change in cover of native and invasive species.

Minimum monitoring: The cover of native and invasive species in each functional group should by monitored. See "**Horse Rock Ridge - Grass community treatment and monitoring form**".

Preferred monitoring: The cover of each species should be estimated in order to determine changes between years. The "**Horse Rock Ridge - Grass community treatment and monitoring form**" should be completed

6.1.3. *Xeric meadow communities*. Treatments in xeric meadow ("matrix") communities should be applied in experimental plots that are monitored each year to document the cover of all species.

Minimum monitoring: The cover of native and invasive species in each functional group should by monitored. See "**Horse Rock Ridge - Xeric meadow weed treatment plots monitoring form**"

Preferred monitoring: The cover of each species should be estimated in order to determine changes between years. The "**Horse Rock Ridge - Xeric meadow weed treatment plots monitoring form**" should be completed

6.1.4. *Dense invasive grasses*. Before and for at least three years after removal of invasive species in remnant patches of native grasses, patches should be monitored to document the approximate area treated and the change in cover of native and invasive species.

Minimum monitoring: The cover of native and invasive species in each functional group should by monitored. See "**Horse Rock Ridge - Grass community treatment and monitoring form**".

Preferred monitoring: The cover of each species should be estimated in order to determine changes between years. The "**Horse Rock Ridge - Grass community treatment and monitoring form**" should be completed

6.2. Site assessment.

6.2.1. To be considered successful, the relative cover of native species should be greater than 90% and the cover of invasive species less than 10%, relative to total vegetation cover. If treatments are not successful, they should be repeated or altered until goals are achieved. See "**Maintenance monitoring form"**.

6.2.2. Once treatment goals have been achieved, previously treated areas should be monitored using the "**Maintenance monitoring form".**

6.2.3. If previously treated areas no longer meet treatment goals, treat again as prescribed in Restoration Needs.

6.3. Monitoring summary

6.3.1. High monitoring effort.

6.3.1.1. Document the presence/absence of previously removed individuals and small patches of invasive forbs/shrubs using the "**Invasive species treatment and monitoring at Horse Rock Ridge**" form.

6.3.1.2. Document the cover of all species and ground cover in treatment plots using the "**Horse Rock Ridge - Mesic meadow weed treatment plots monitoring",** "**Horse Rock Ridge - Xeric meadow weed treatment plots monitoring**", and "**Horse Rock Ridge - Grass community treatment and monitoring**" forms. Continue monitoring until restoration goals are achieved.

6.3.1.3. Once treatment goals have been achieved, previously treated areas should be monitored using the "**Maintenance monitoring form".**

6.3.2. Moderate monitoring effort.

6.3.2.1. Document the presence/absence of previously removed individuals and small patches of invasive forbs/shrubs using the "**Invasive species treatment and monitoring at Horse Rock Ridge**" form.

6.3.2.2. In Treatment plots, document the cover of native and invasive species in each functional group using the "**Horse Rock Ridge - Mesic meadow weed treatment plots monitoring",** "**Horse Rock Ridge - Xeric meadow weed treatment plots monitoring**", and "**Horse Rock Ridge - Grass community treatment and monitoring**" forms. Continue monitoring until restoration goals are achieved.

6.3.2.3. Once treatment goals have been achieved, previously treated areas should be monitored using the "**Maintenance monitoring form".**

6.3.3. Low monitoring effort.

6.3.3.1. Document the presence/absence of previously removed individuals and small patches of invasive forbs/shrubs using the "**Invasive species treatment and monitoring at Horse Rock Ridge**" form.

6.3.3.2. Document the relative cover of invasive and native species in previously treated plots using the "**Maintenance monitoring form".**

Invasive species treatment and monitoring at Horse Rock Ridge

Name_____ **Date**_____

Instructions: For each location of an invasive shrub or forb, document presence or absence, the number of individuals, life stage(s) (e.g. seedling, rosette, flowering, or fruiting) if present, and control methods used. Attach a copy of a site map with the area surveyed delineated.

Species	GPS locations	Presence (+)/ Absence (-)	# individuals	Life Stage(s)	Control method	Notes

Horse Rock Ridge - Mesic meadow weed treatment plots monitoring form (page 1 of 2)

Names Date:

Instructions: record aerial cover for each group (minimum) and species.
Total ground cover + Total functional groups cover ≥ 100%. Total ground cover + Total species cover ≥ 100%.

Coordinates (NW corner)											
Plot											
Ground cover											
bare ground											
rock											
litter											
moss											
lichen											
Functional Groups											
Native trees											
Invasive trees											
Native shrubs											
Invasive shrubs											
Native forbs											
Invasive forbs											
Native graminoids											
Invasive graminoids											
Species											
Bromus hordeaceous											
Bromus vulgaris											
Carex rossi											
Cynosurus echinatus											
Danthonia californica											
Elymus glaucus											
Festuca roemeri											
Holcus lanatus											
Luzula multiflora											
Poa compressa											
Allium sp.											

***Horse Rock Ridge - Mesic meadow weed treatment plots* (page 2 of 2)**

Amelanchier alnifolia											
Boraginaceae sp.											
Cerastium nutans											
Crepis sp.											
Epilobium sp.											
Eriophyllum lanatum											
Fragaria vesca											
Fragaria virginiata											
Holodiscus discolor											
Hypericum perforatum											
Hypochaeris radicata											
Irix tenax											
Leptosiphon bicolor											
Leucanthemum vulgare											
Lomatium utriculatum											
Lotus sp.											
Maianthemum stellatum											
Microsteris gracilis											
Montia sp.											
Plantago lanceolata											
Potentilla gladulosa											
Prunella vulgaris											
Ranunculus occidentalis											
Rosa sp.											
Rubus sp.											
Rumex acetosella											
Symphoricarpos albus											
Taraxacum officinale											
Thalictrum occidentale											
Triteleia hyacinthia											
Veronica arvensis											
Vicia sp.											
Zigadenus venenosus											

Horse Rock Ridge - Xeric meadow weed treatment plots monitoring form (page 1 of 2)

Names Date:

Instructions: record aerial cover for each group (minimum) and species.
Total ground cover + Total functional groups cover ≥ 100%. Total ground cover + Total species cover ≥ 100%.

Coordinates (NW corner)											
Plot											
Ground cover											
bare ground											
rock											
litter											
moss											
lichen											
Functional Groups											
Native trees											
Invasive trees											
Native shrubs											
Invasive shrubs											
Native forbs											
Invasive forbs											
Native graminoids											
Invasive graminoids											
Species											
Aira caryophylla											
Bromus carinatus											
Bromus hordeaceus											
Cynosurus echinatus											
Danthonia californica											
Festuca roemeri											
Holcus lanatus											
Poa scabrella											
Vulpia bromoides											
Allium sp.											
Castilleja tenuis											

Horse Rock Ridge - Xeric meadow weed treatment plots (page 2 of 2)

Clarkia gracilis											
Delphinium menziesii											
Eriophyllum lanatum											
Hypochaeris glabra											
Hypochaeris radicata											
Linum bienne											
Lomatium utriculatum											
Lotus sp.											
Madia gracilis											
Microsteris gracilis											
Mimulus guttatus											
Minuartia tenella											
Perideridia gairdneri											
Sherardia arvensis											
Silene gallica											
Trifolium microcephalum											
Trifolium tridentatum											
Triteleia hyacinthia											

Horse Rock Ridge: Grass community treatment & monitoring form (page 1 of 2)

Names Date:

Instructions: record aerial cover for each group (minimum) and species.
Total ground cover + Total functional groups cover ≥ 100%. Total ground cover + Total species cover ≥ 100%.
Attach a copy of a site map with the area surveyed delineated.

Coordinates					
Treatment description and notes					
Ground cover					
bare ground					
rock					
litter					
moss					
lichen					
Functional Groups					
Native trees					
Invasive trees					
Native shrubs					
Invasive shrubs					
Native forbs					
Invasive forbs					
Native graminoids					
Invasive graminoids					

Horse Rock Ridge - Grass community treatment & monitoring form (page 2 of 2)

Species					
Aira caryophylla					
Bromus carinatus					
Bromus hordeaceus					
Cynosurus echinatus					
Danthonia californica					
Festuca roemeri					
Holcus lanatus					
Poa scabrella					
Vulpia bromoides					
Allium sp.					
Castilleja tenuis					
Clarkia gracilis					
Delphinium menziesii					
Eriophyllum lanatum					
Hypochaeris glabra					
Hypochaeris radicata					
Linum bienne					
Lomatium utriculatum					
Lotus sp.					
Madia gracilis					
Microsteris gracilis					
Mimulus guttatus					
Minuartia tenella					
Perideridia gairdneri					
Sherardia arvensis					
Silene gallica					
Trifolium microcephalum					
Trifolium tridentatum					
Triteleia hyacinthia					

Maintenance monitoring at Horse Rock Ridge

Name_____ **Date**_____

Instructions: For each area previously treated, document the location, type of treated area (e.g. species of invasive forb, matrix community, remnant *Festuca* community), the relative cover of invasive and native species, the dominant plant species, and any additional notes. Attach a copy of a site map with the area surveyed delineated.

GPS location	Treated area type	Relative invasive & native cover	Dominant species	Notes

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8. Preparer:

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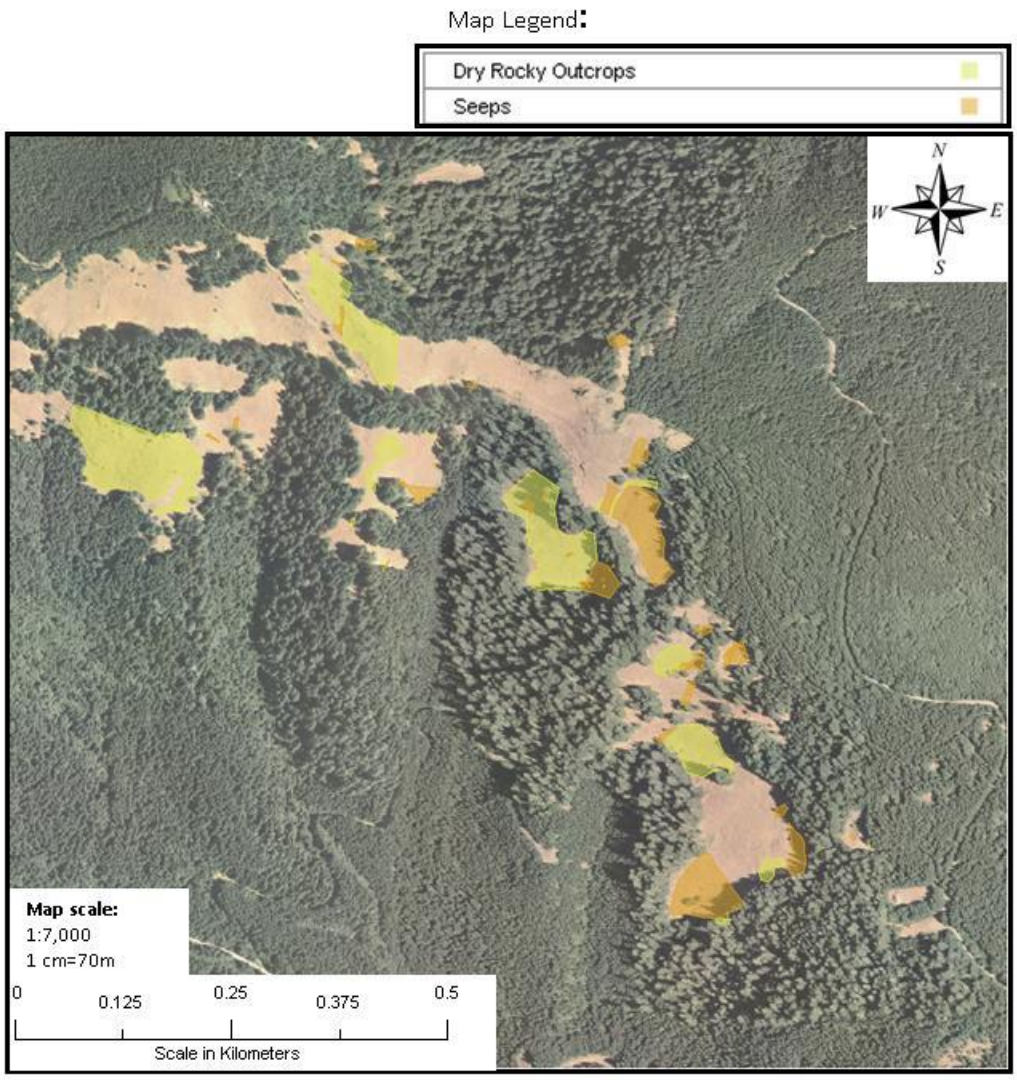
9. Date Completed: 30 March, 2010

10. Appendix A. Community and habitat maps of Horse Rock Ridge ACEC/RNA.

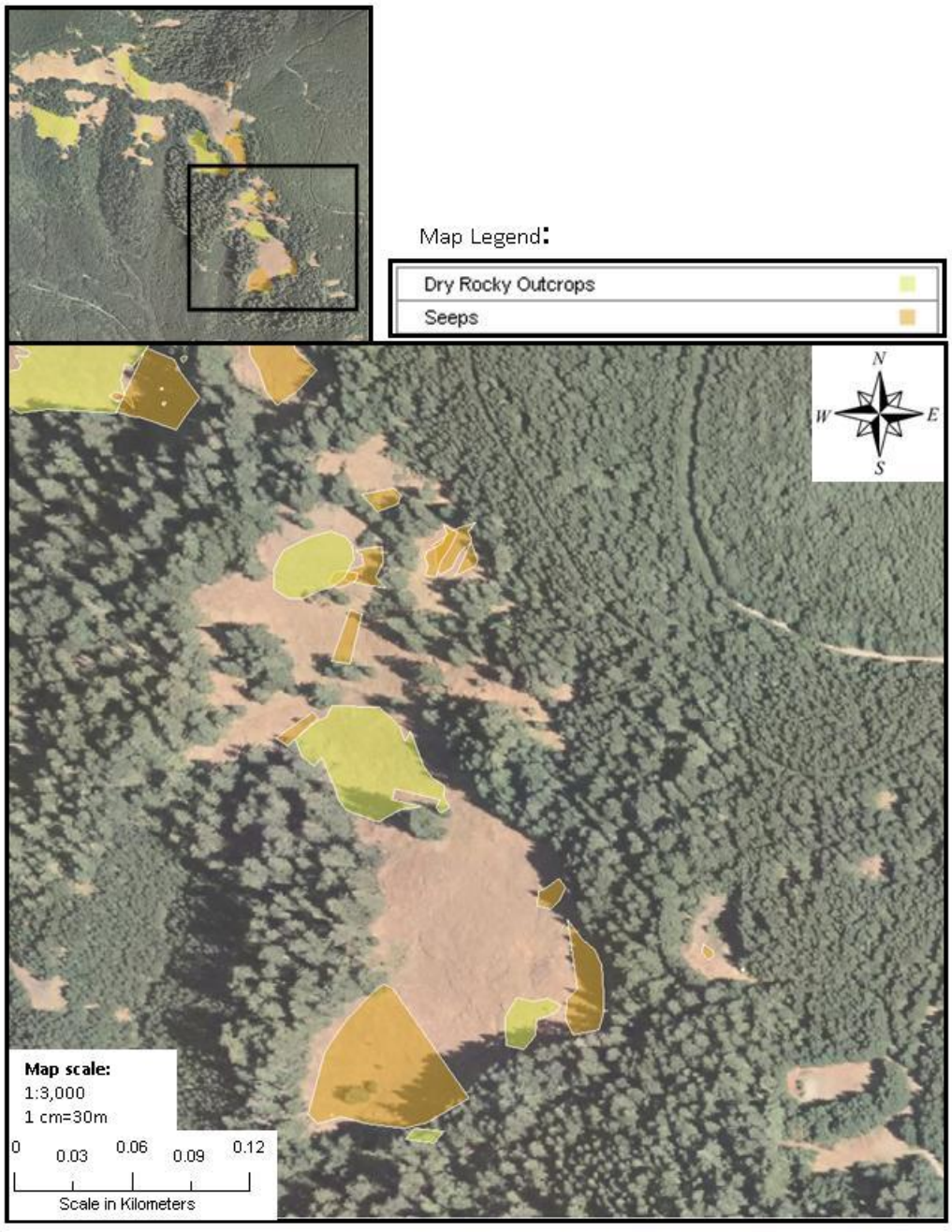
Appendix A.1. Horse Rock Ridge Native Areas.

Overview map
Southeast Meadows
Central Meadows
Northwest Meadows

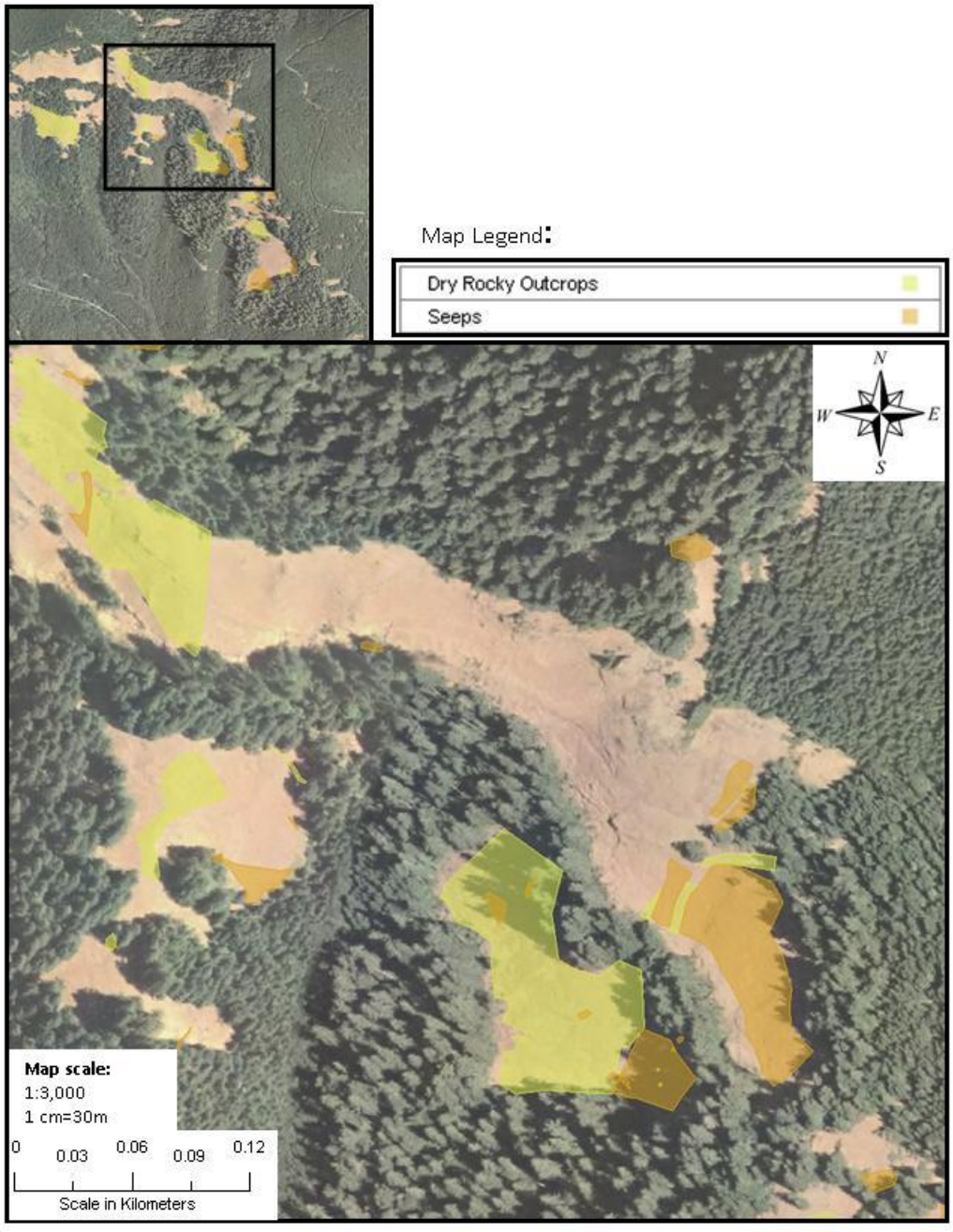
Horse Rock Ridge:
Native Areas



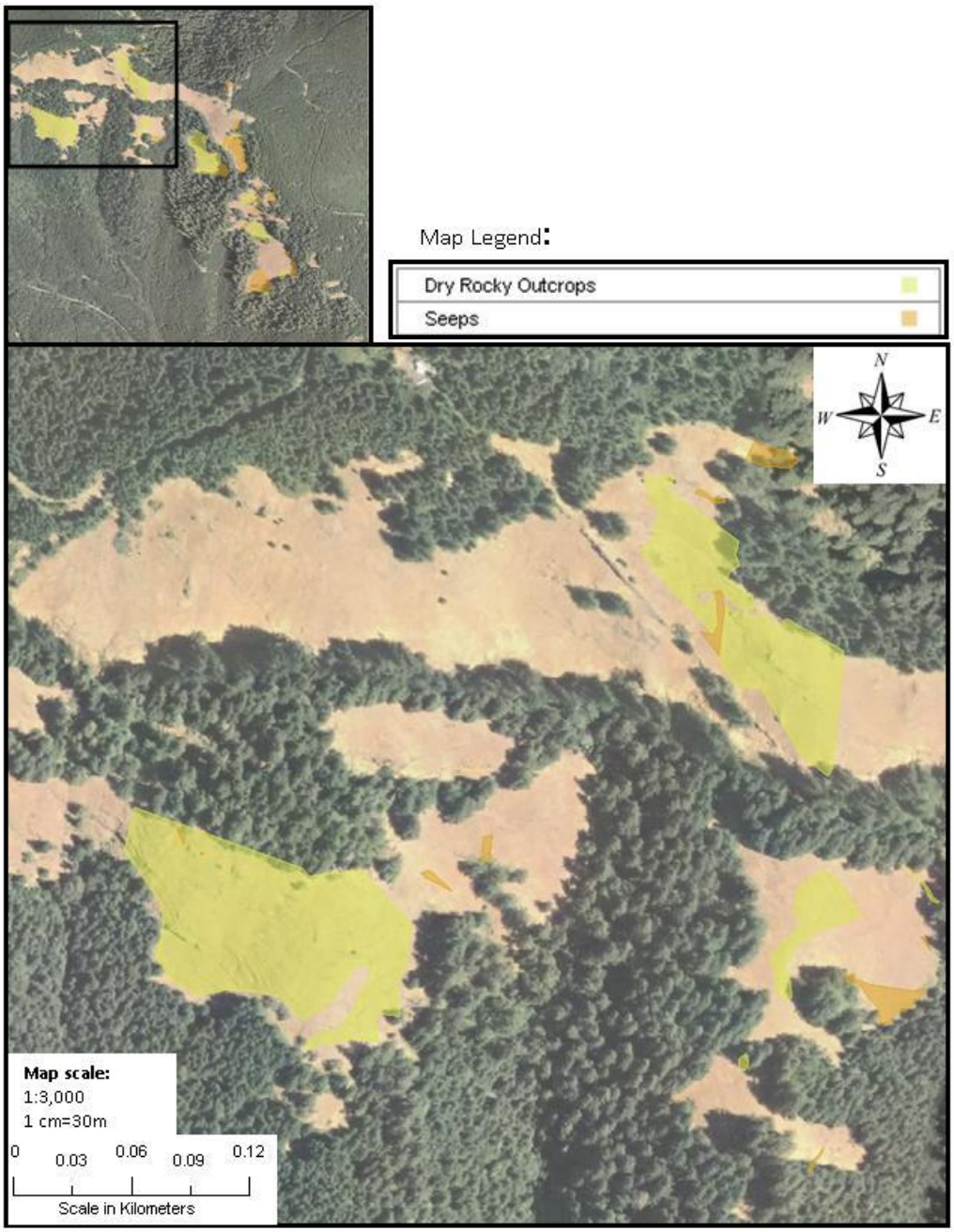
Horse Rock Ridge:
Southeast Meadow, Native Areas



Horse Rock Ridge:
Native Areas, Central Meadows



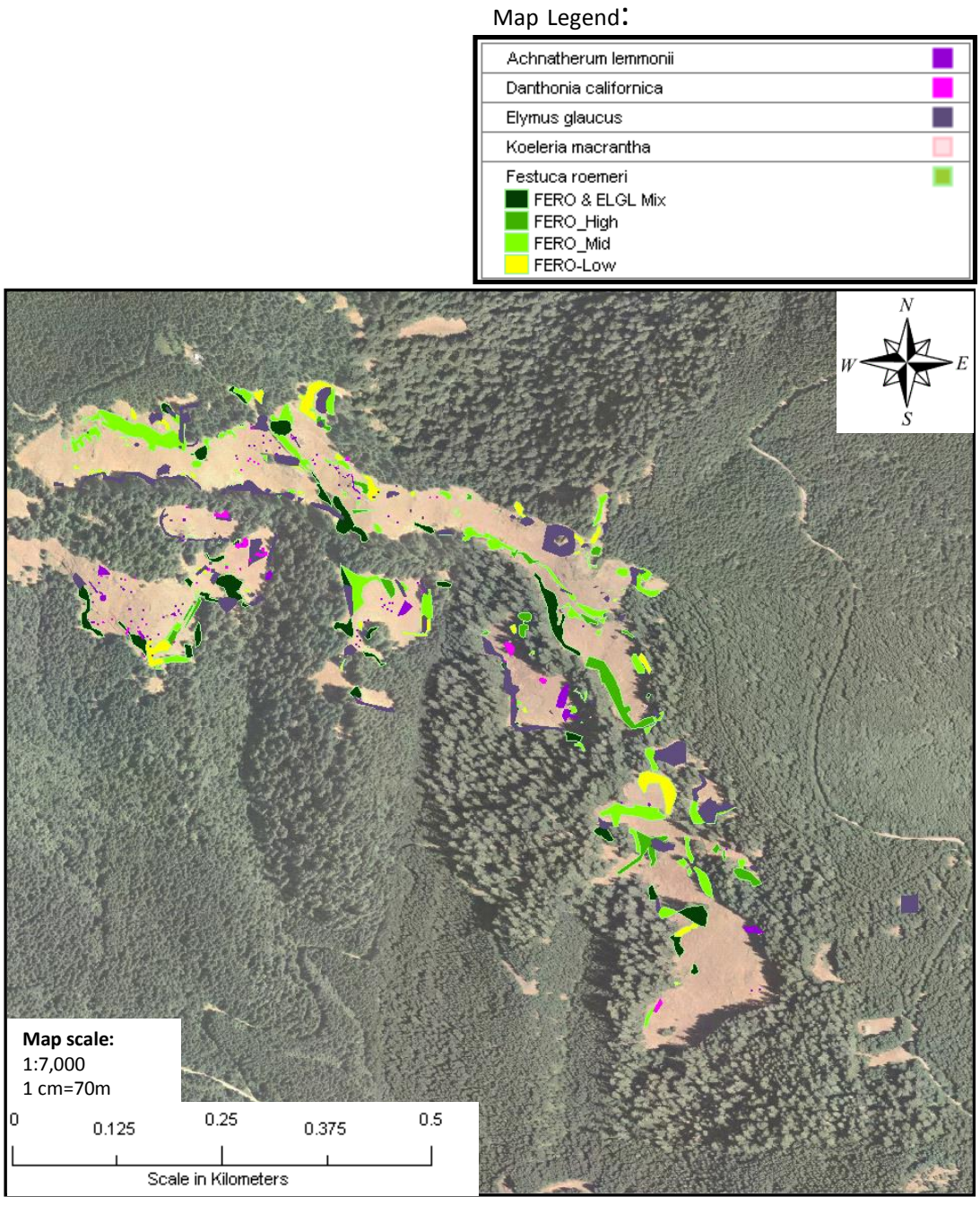
Horse Rock Ridge:
Native Areas, Northwest Meadows



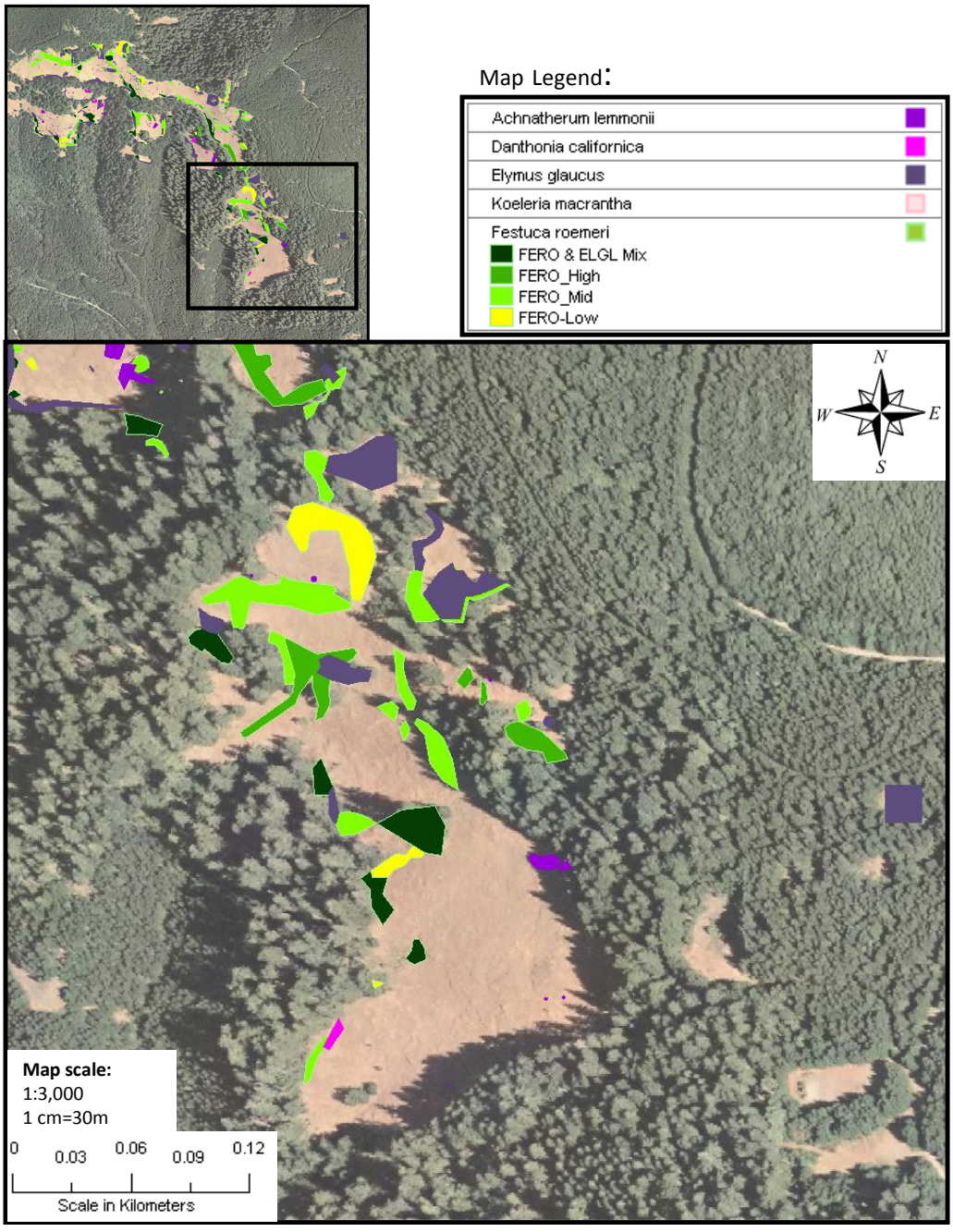
Appendix A.2. Horse Rock Ridge Native Grass communities

Overview map
Southeast Meadows
Central Meadows
Northwest Meadows

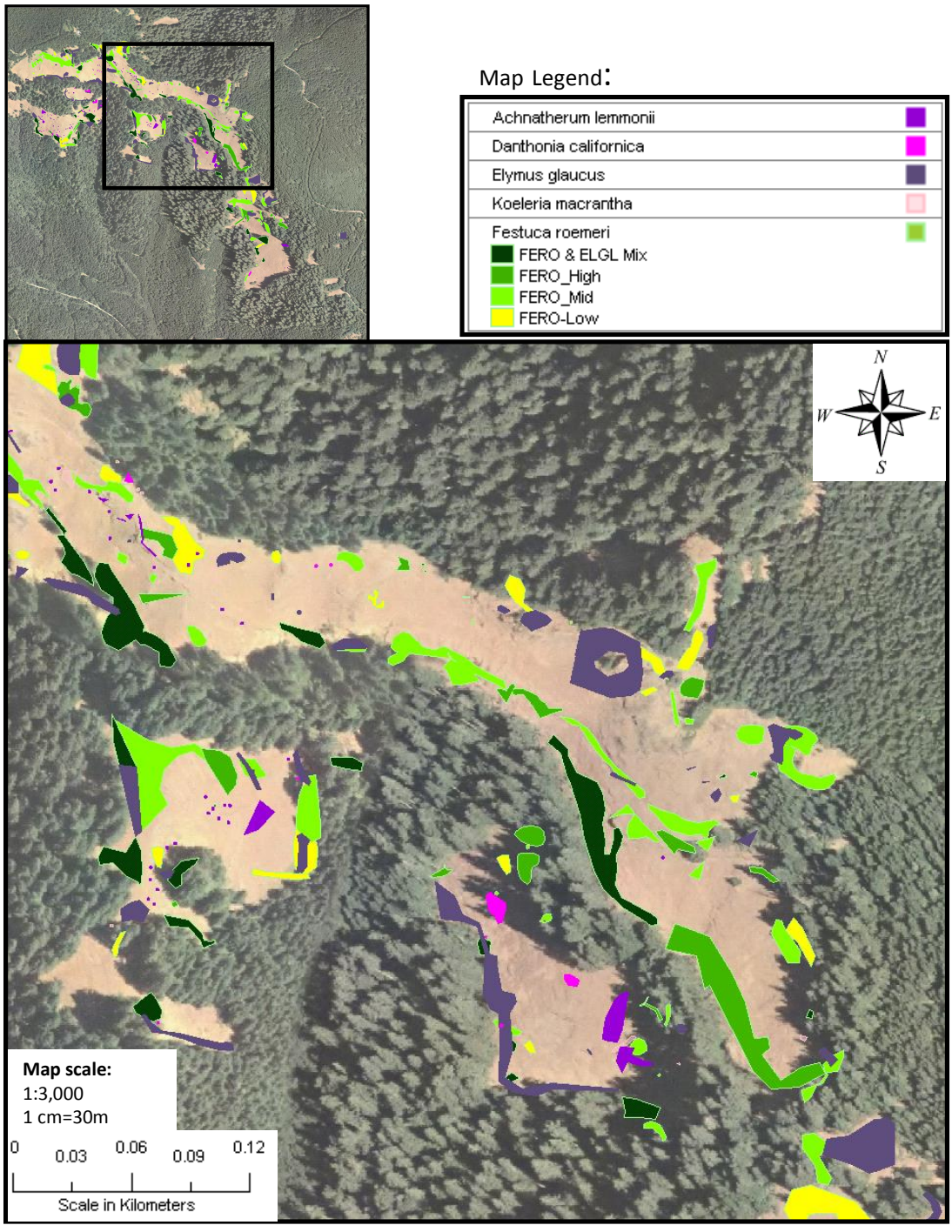
Horse Rock Ridge:
Native Grasses



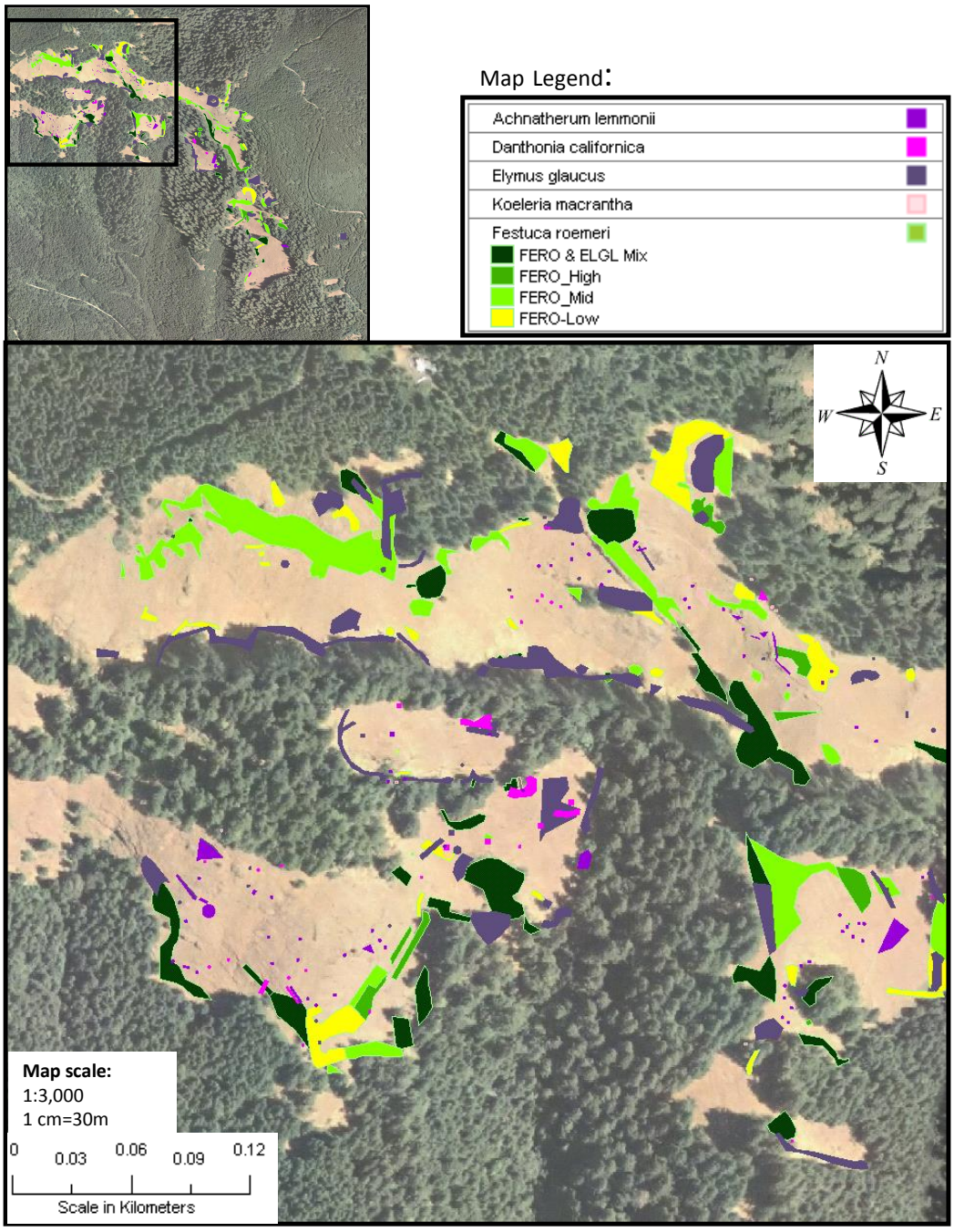
Horse Rock Ridge:
Native Grasses, Southeast Meadow



Horse Rock Ridge:
Native Grasses, Central Meadows



Horse Rock Ridge:
Native Grasses, Northwest Meadows

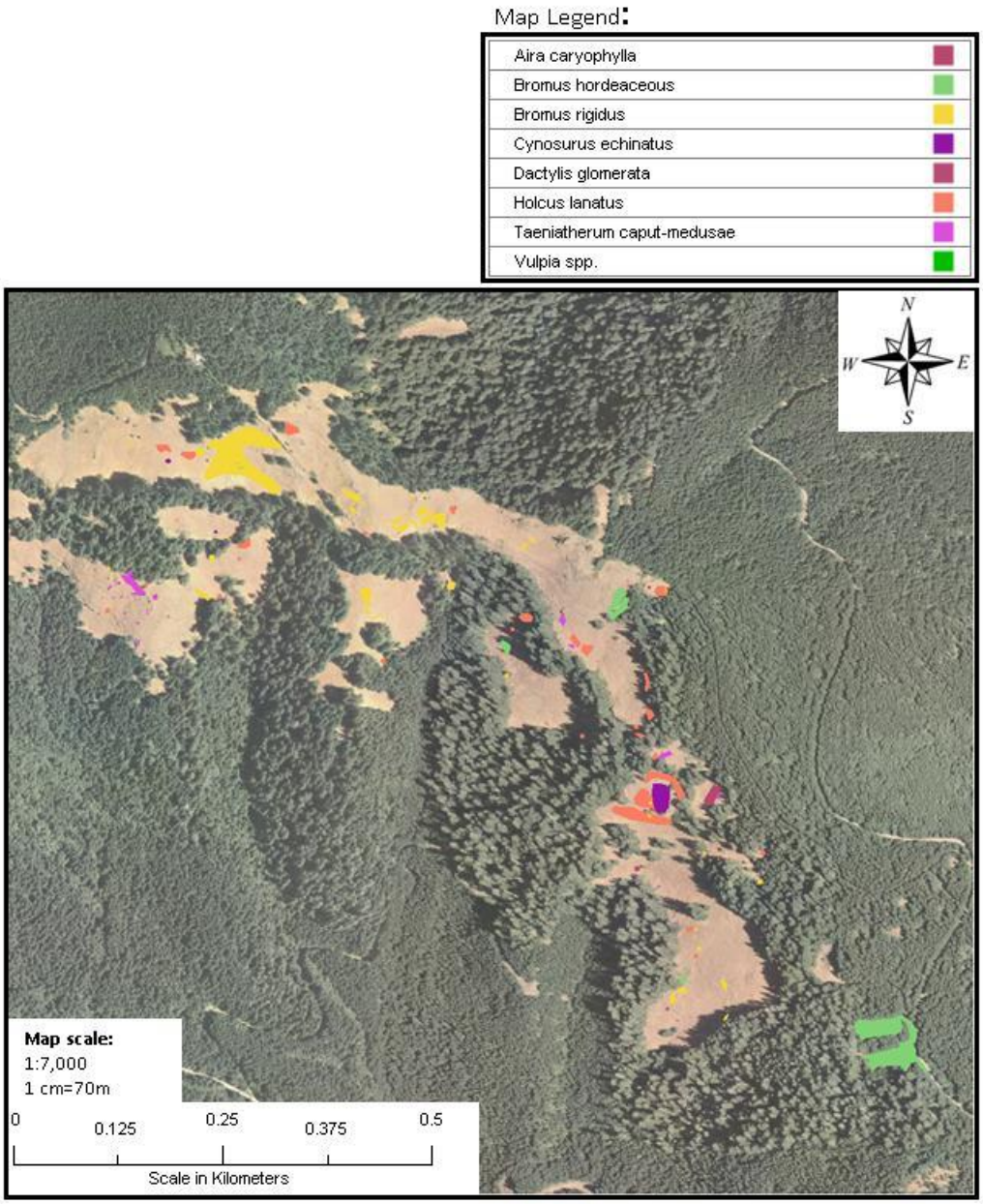


Appendix A.3. Horse Rock Ridge Exotic Grasses

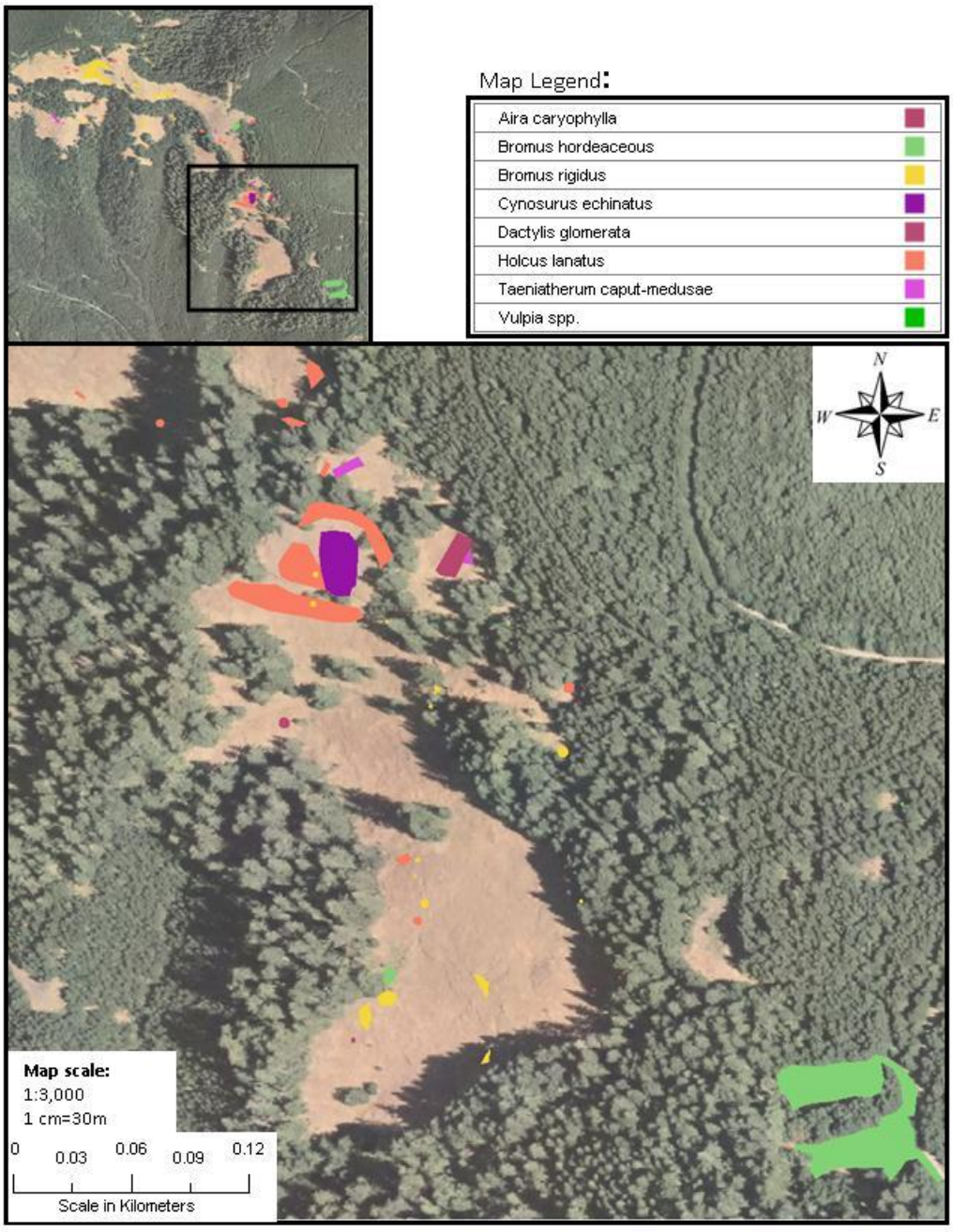
(*note*: most of these grasses are ubiquitous at Horse Rock Ridge; only particularly dense patches have been mapped)

Overview map
Southeast Meadows
Central Meadows
Northwest Meadows

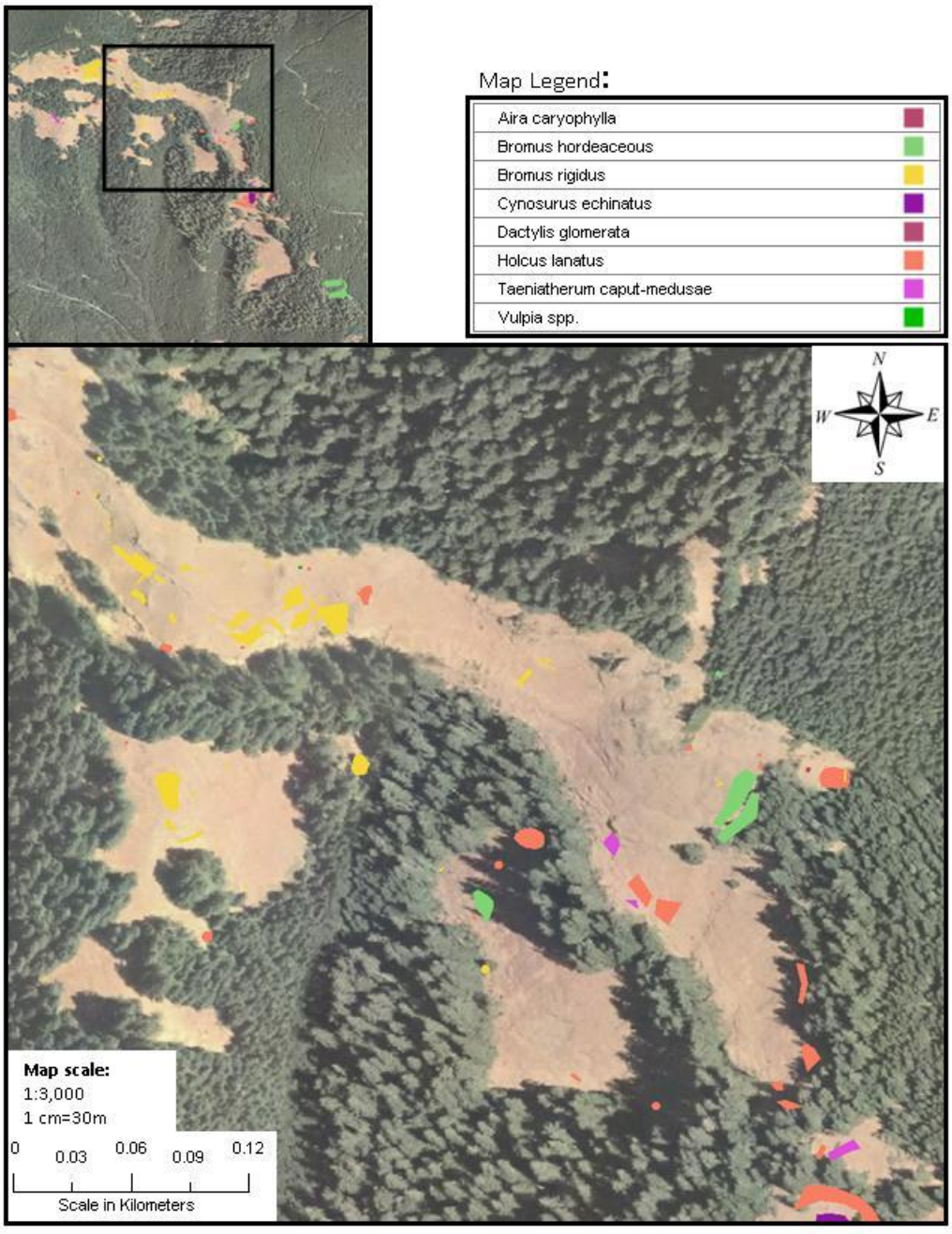
Horse Rock Ridge:
All Exotic Grasses



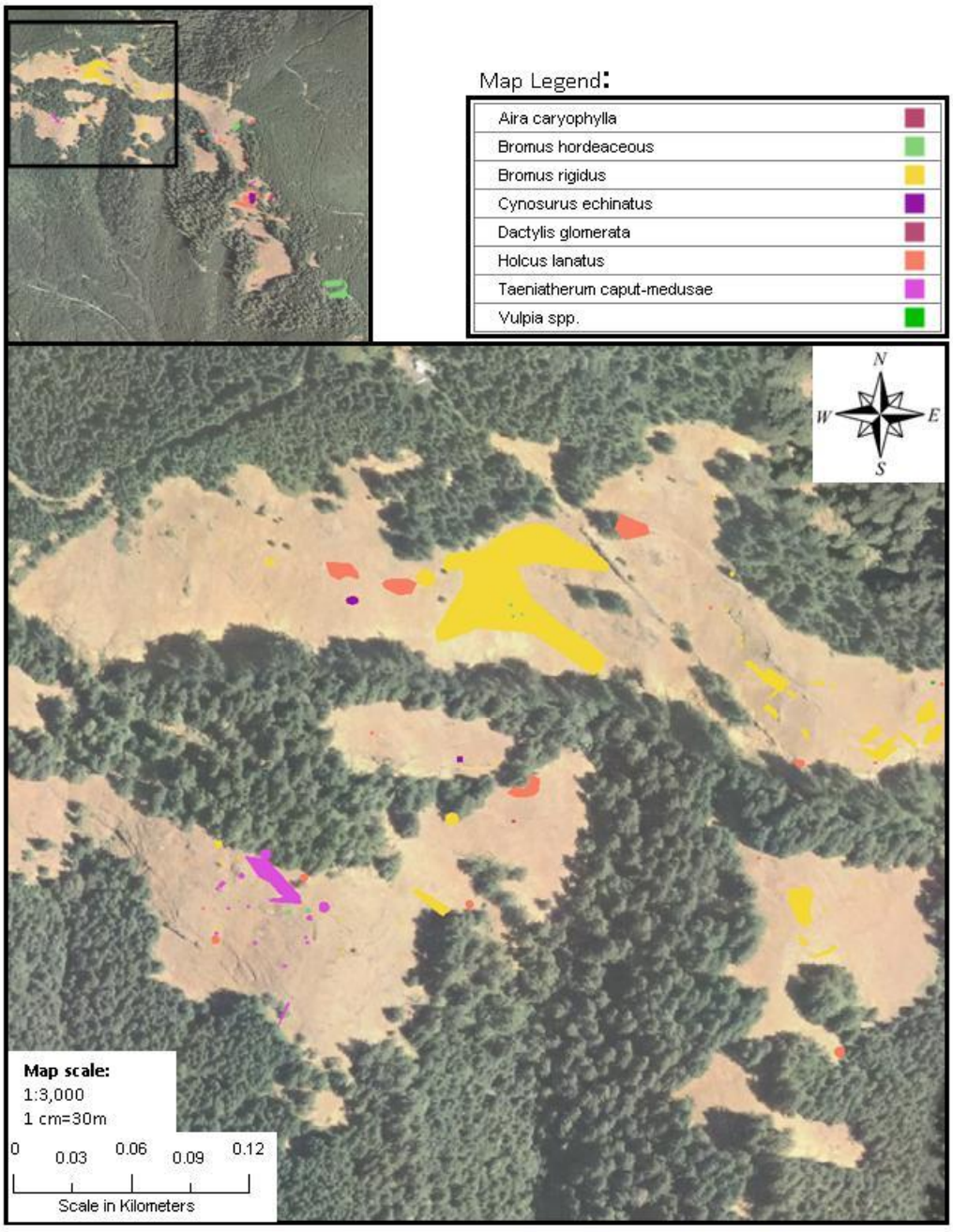
Horse Rock Ridge:
Southeast Meadow,
All Exotic Grasses



Horse Rock Ridge:
Central Meadows ,
All Exotic Grasses



Horse Rock Ridge:
Northwest Meadows,
All Exotic Grasses

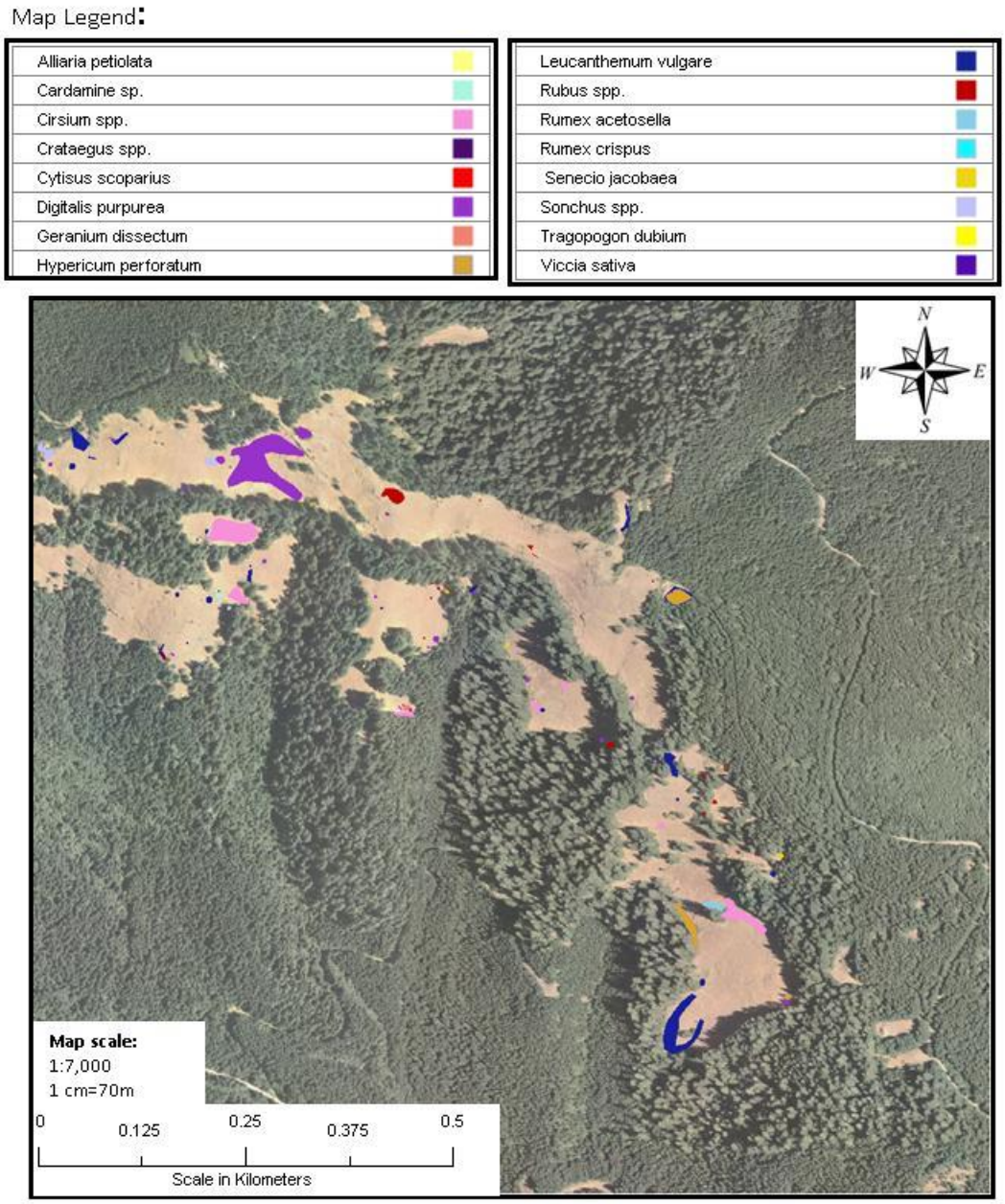


Appendix A.4. Horse Rock Ridge Exotic Forbs and Shrubs

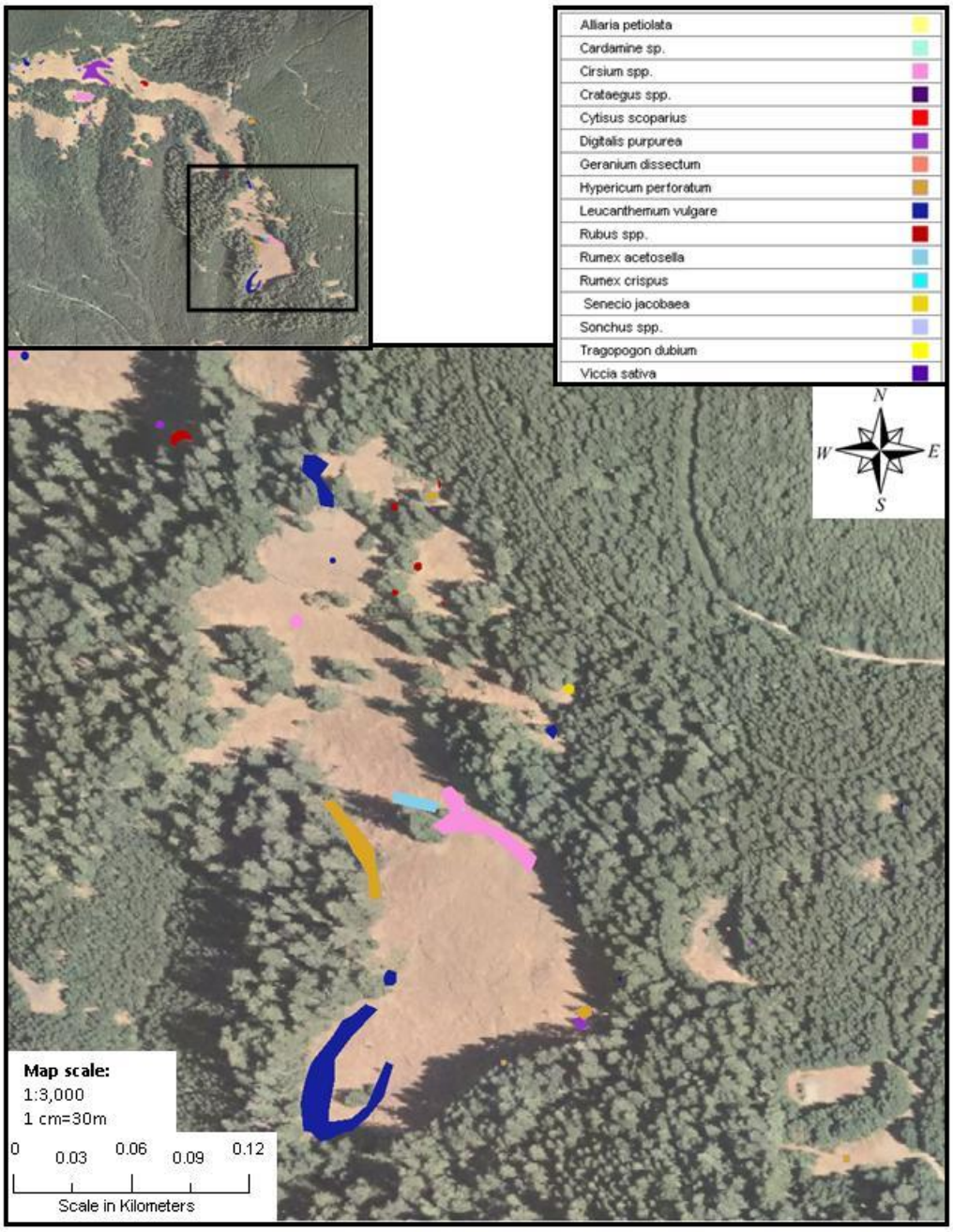
(*note*: these maps illustrate only those exotic forbs that are present in small patches; some exotic species such as *Hypochaeris radicata* occur throughout the site.)

Overview map
Southeast Meadows
Central Meadows
Northwest Meadows

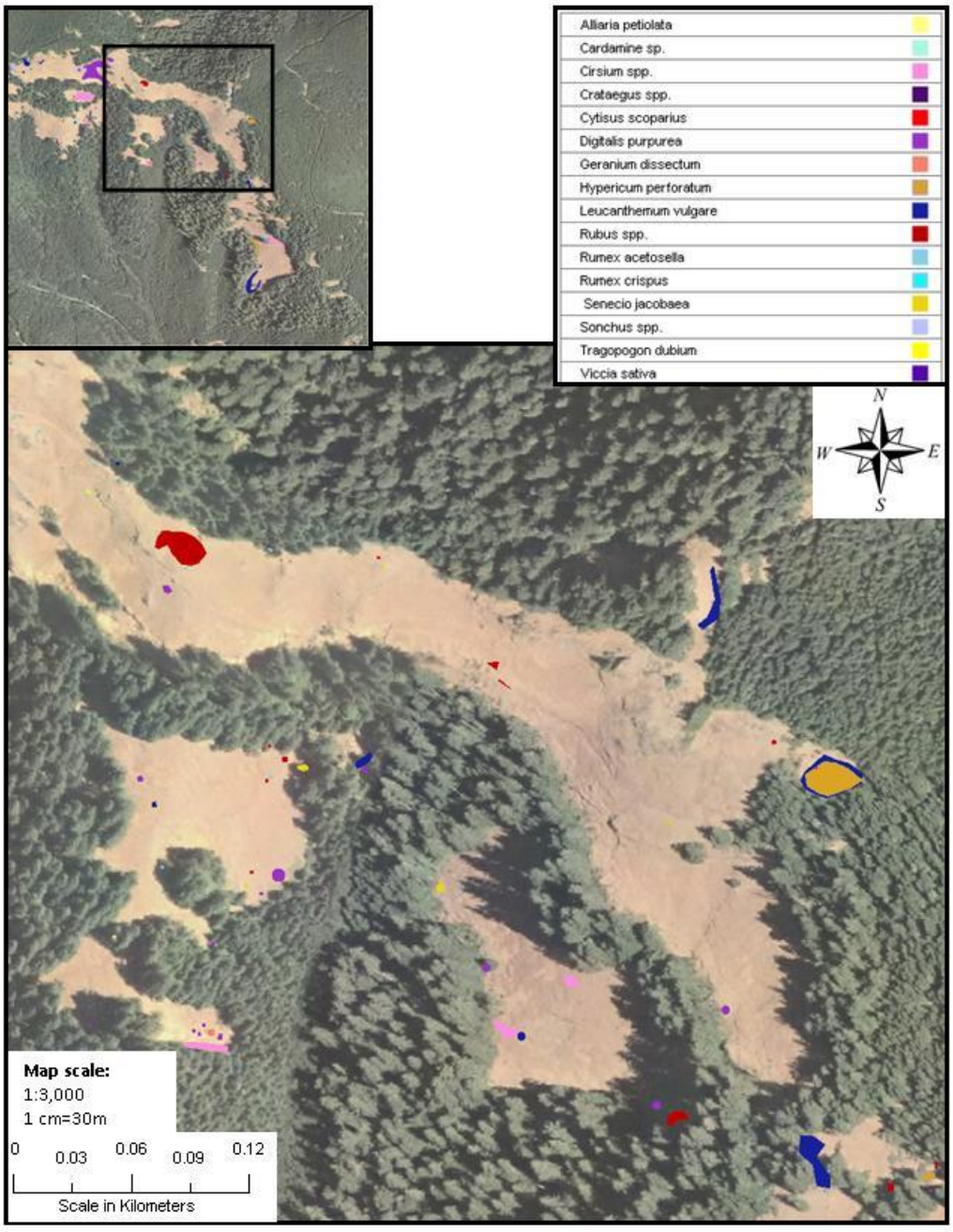
Horse Rock Ridge:
All Exotic Forbs and Shrubs



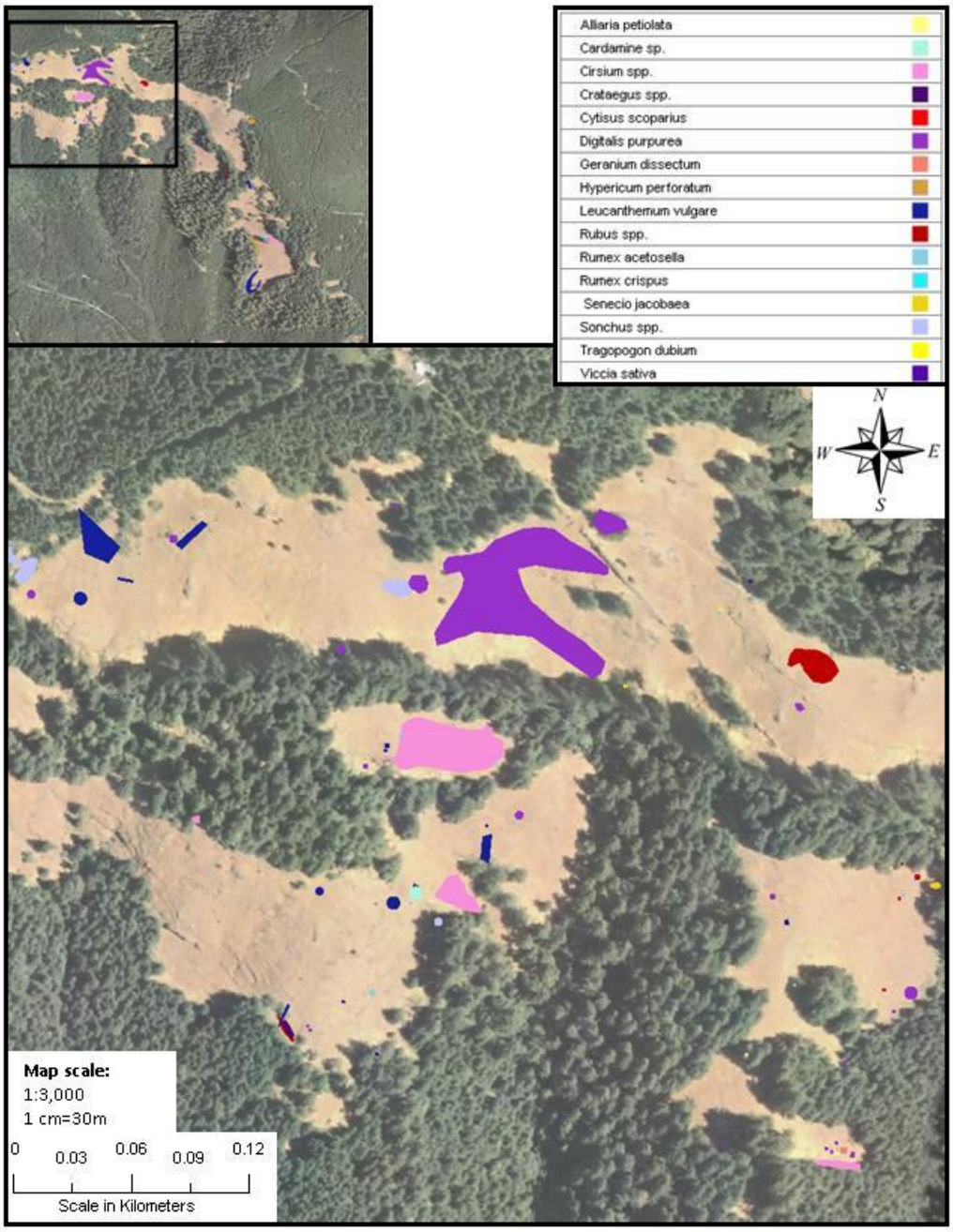
Horse Rock Ridge:
Southeast Meadow,
All Exotic Forbs and Shrubs



Horse Rock Ridge:
Central Meadows
All Exotic Forbs and Shrubs



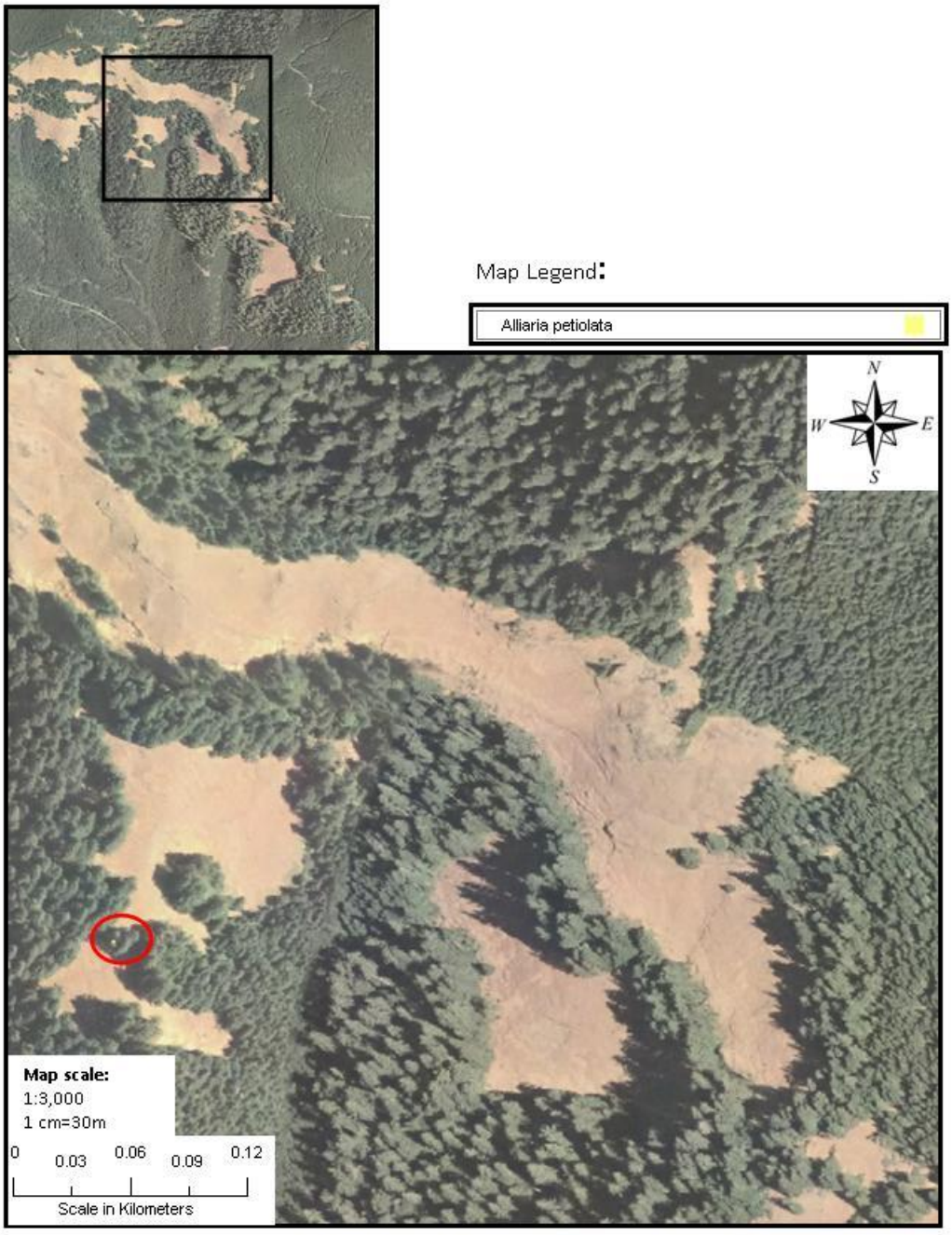
Horse Rock Ridge:
Northwest Meadows,
All Exotic Forbs and Shrubs



Appendix A.5. Horse Rock Ridge *Alliaria petiolata*

Note: only one patch has been located. A red circle indicates the location of the polygon.

Horse Rock Ridge:
Exotic Forb, Allaria petiolata (Garlic Mustard), Central Meadows



Appendix A.6. Horse Rock Ridge *Cirsium* spp.

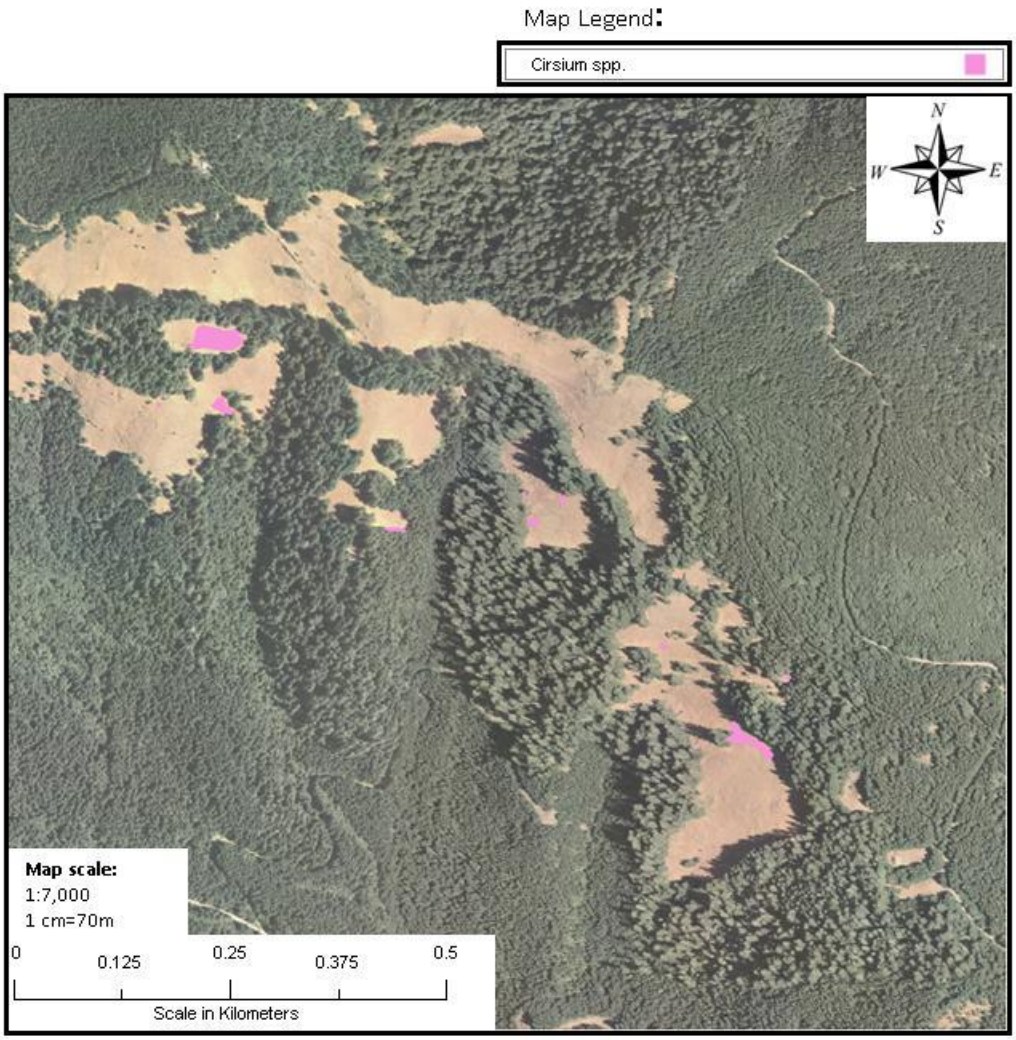
Overview map

Southeast Meadows

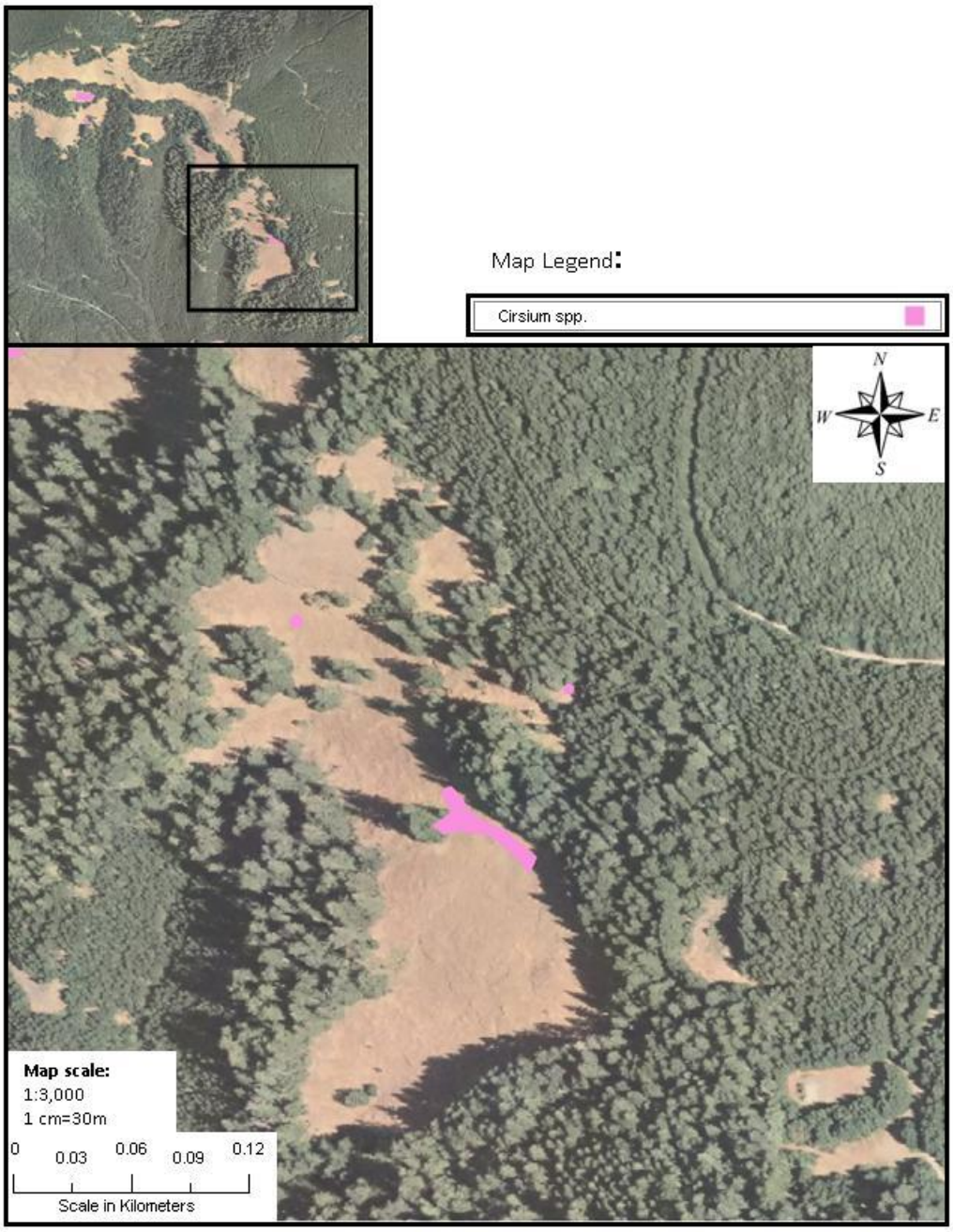
Central Meadows

Northwest Meadows

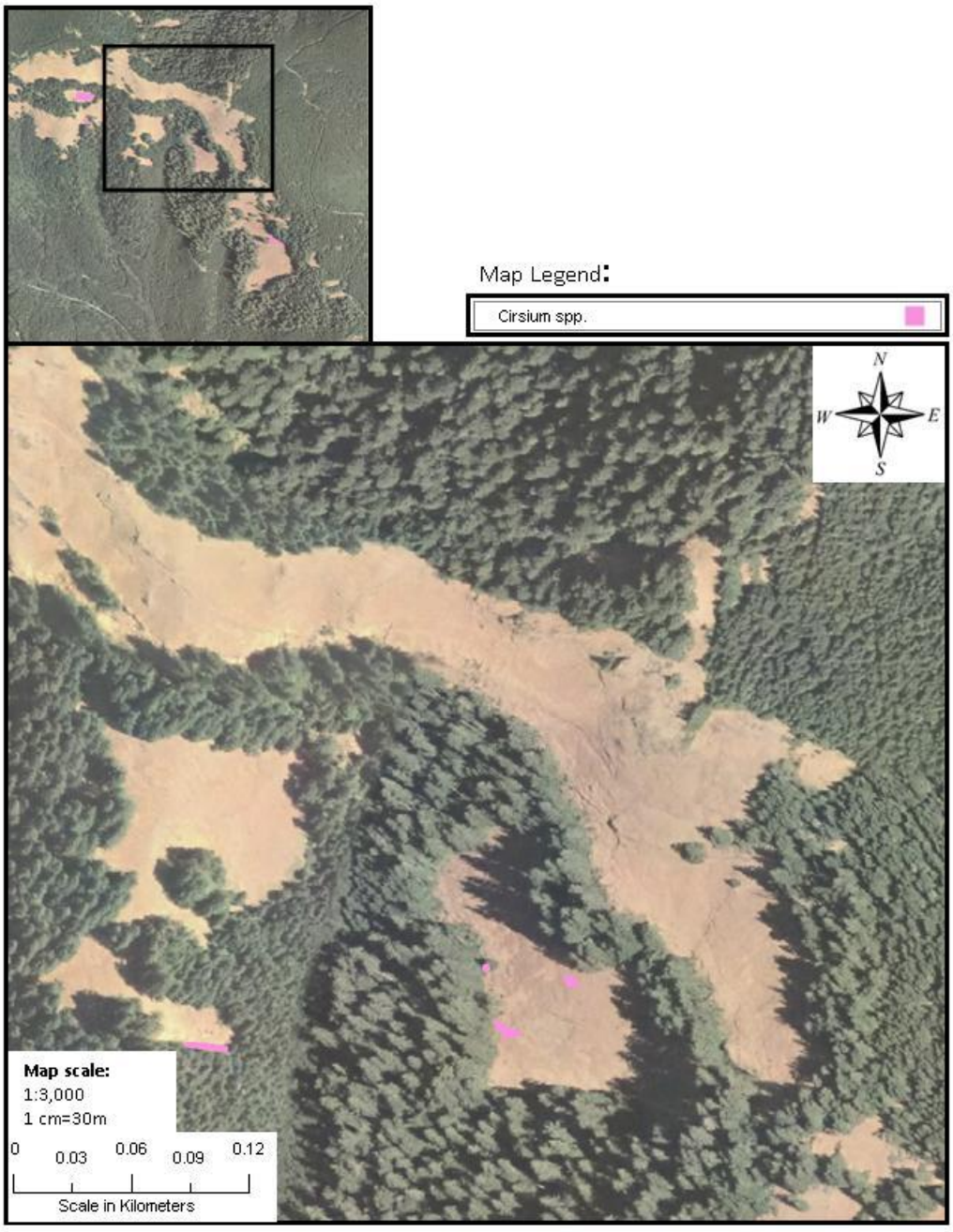
Horse Rock Ridge:
Cirsium spp.



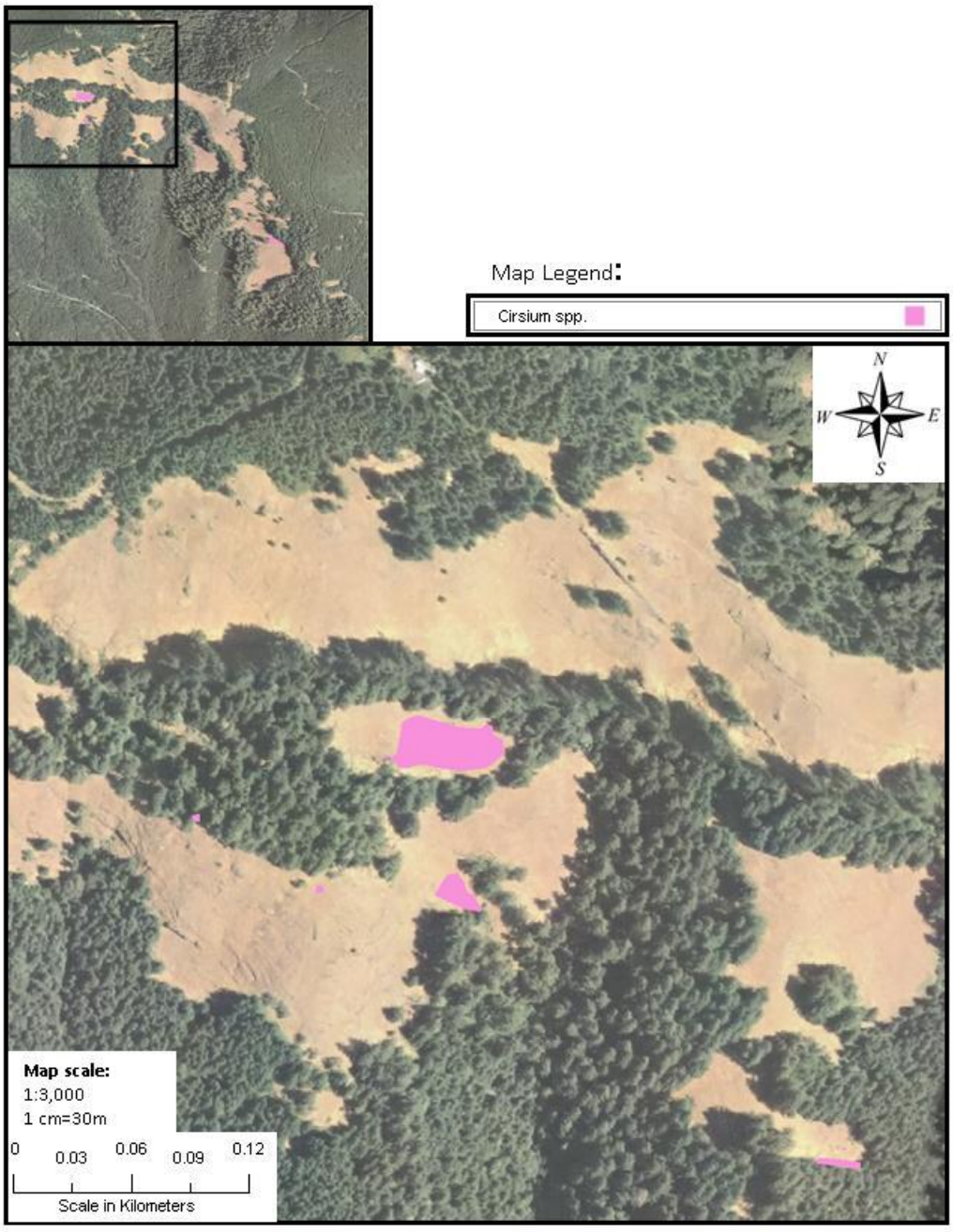
Horse Rock Ridge:
Southeast Meadow, Cirsium spp.



Horse Rock Ridge:
Central Meadows, Cirsium spp.



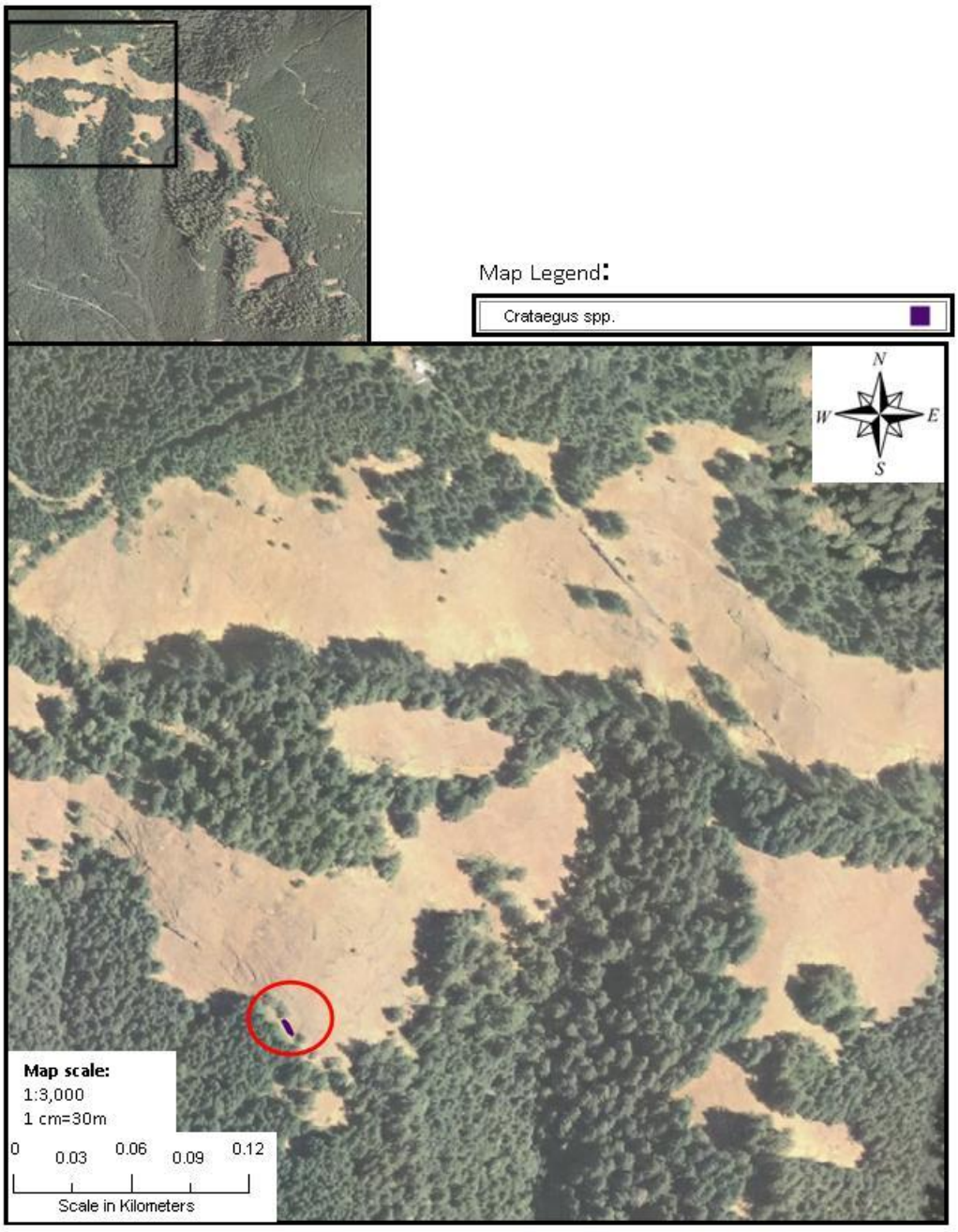
Horse Rock Ridge:
Northwest Meadows, Cirsium spp.



Appendix A.7. Horse Rock Ridge *Crataegus* spp.

Note: only one patch has been located. A red circle indicates the location of the polygon.

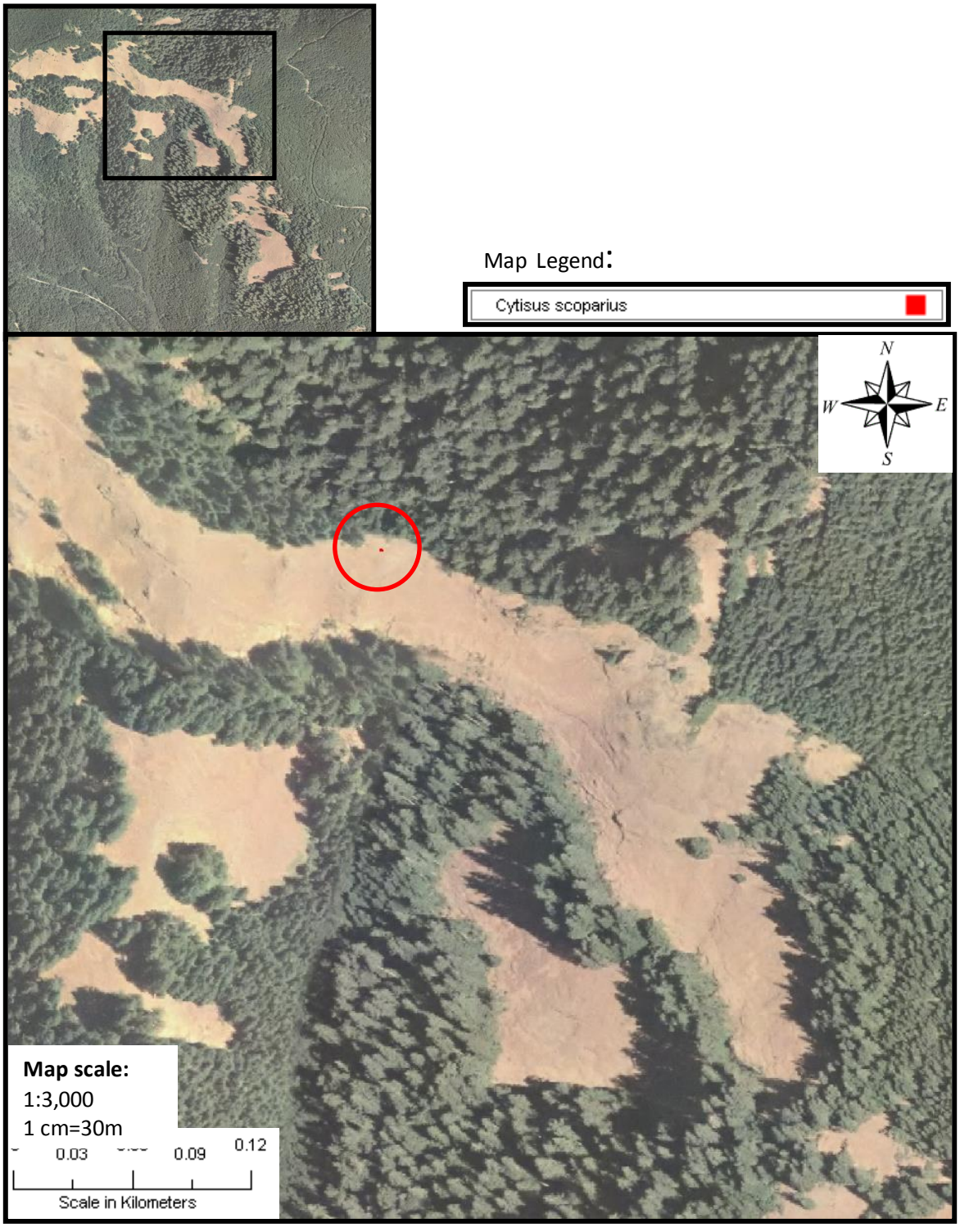
Horse Rock Ridge:
Northwest Meadows, Crataegus spp.



Appendix A.8. Horse Rock Ridge *Cytisus scoparius* spp.

Note: only one patch has been located. A red circle indicates the location of the polygon.

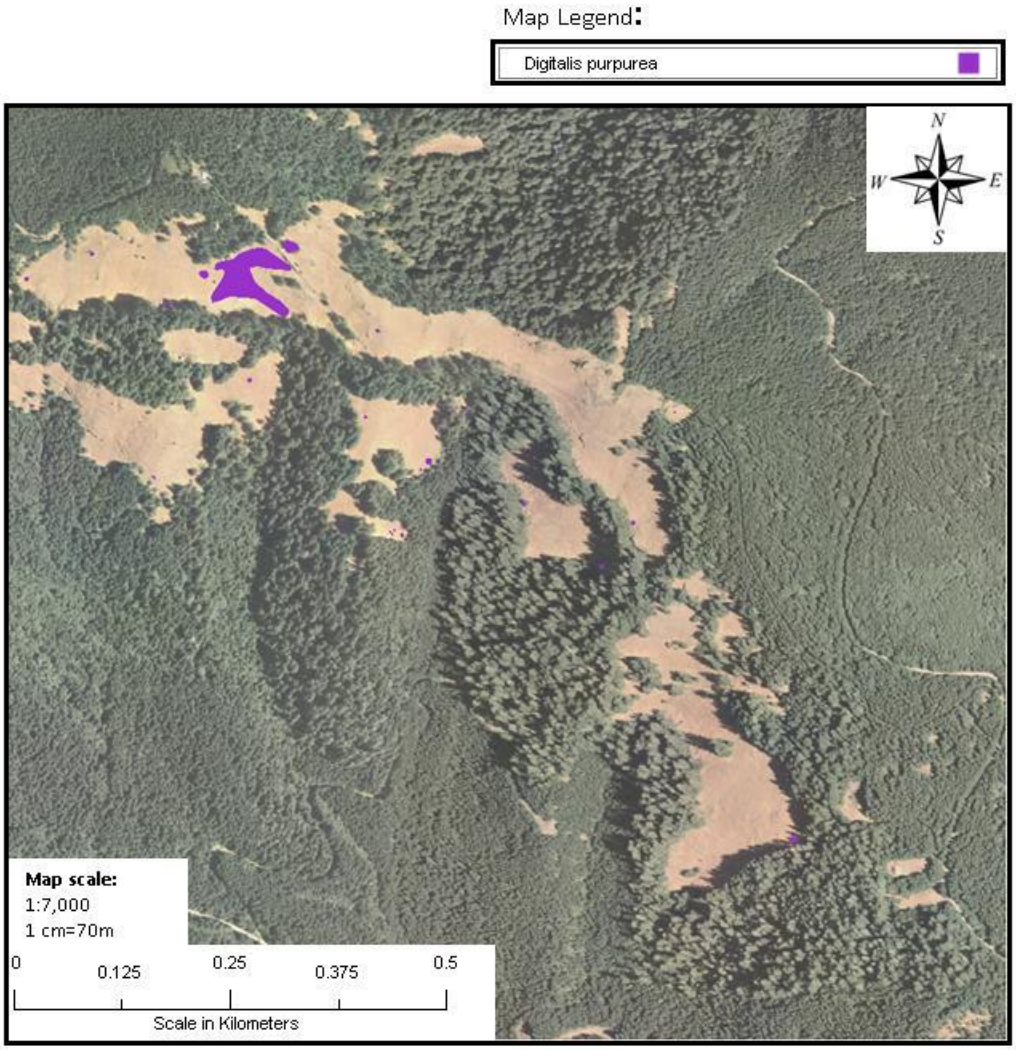
Horse Rock Ridge:
Exotic Forb, Cytisus scoparius,
Central Meadows



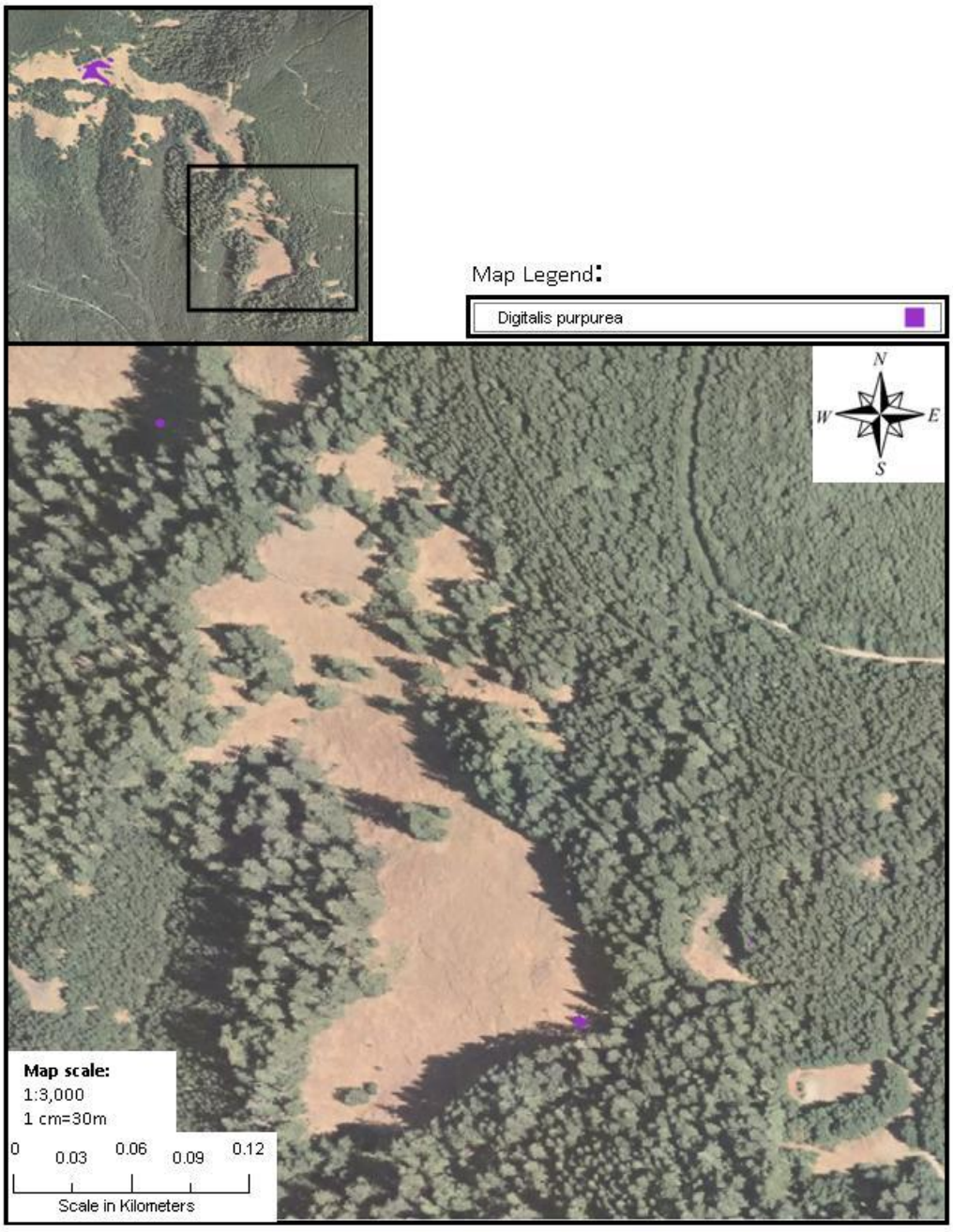
Appendix A.9. Horse Rock Ridge *Digitalis purpurea* spp.

Overview map
Southeast Meadows
Central Meadows
Northwest Meadows

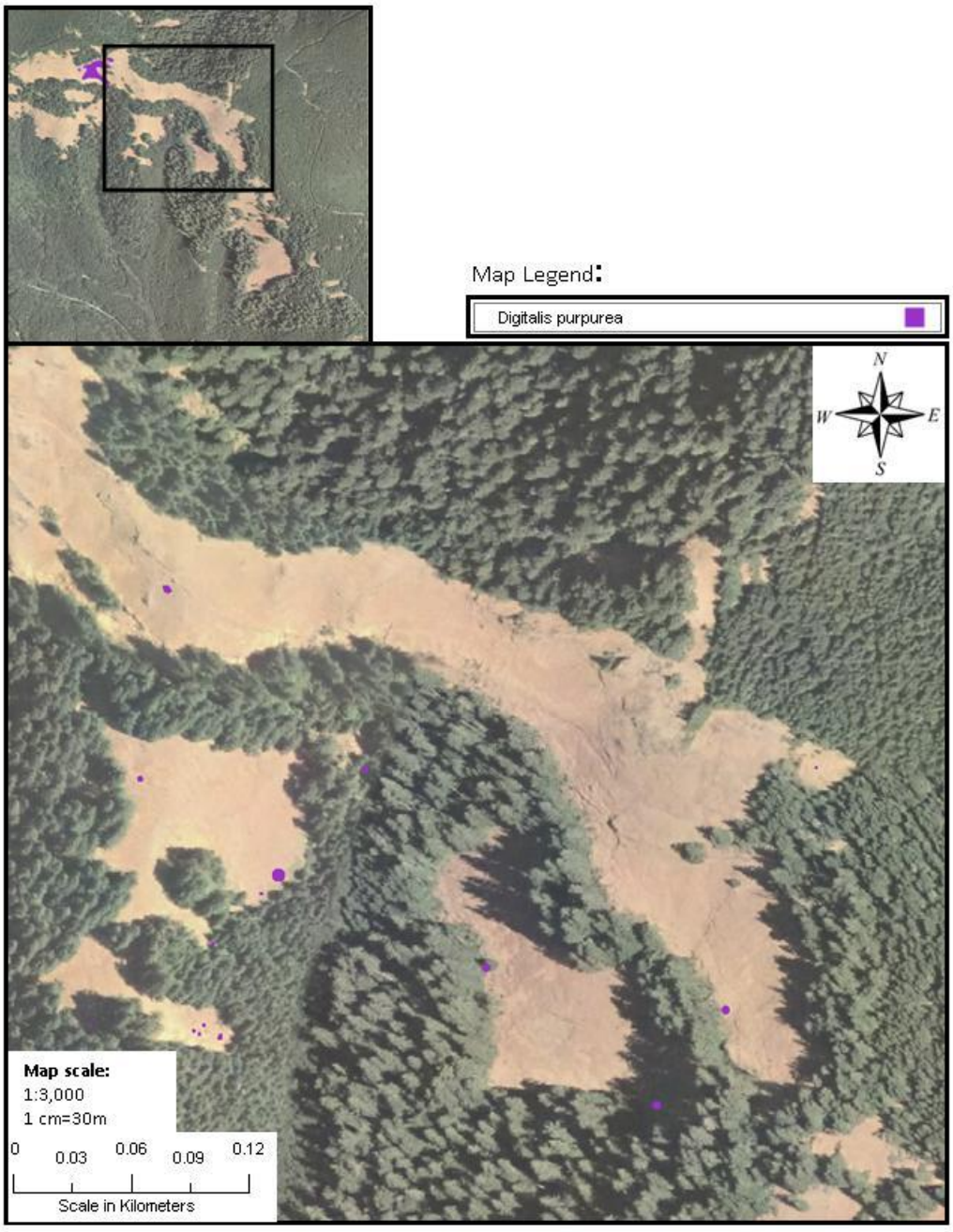
Horse Rock Ridge:
Exotic, Digitalis purpurea



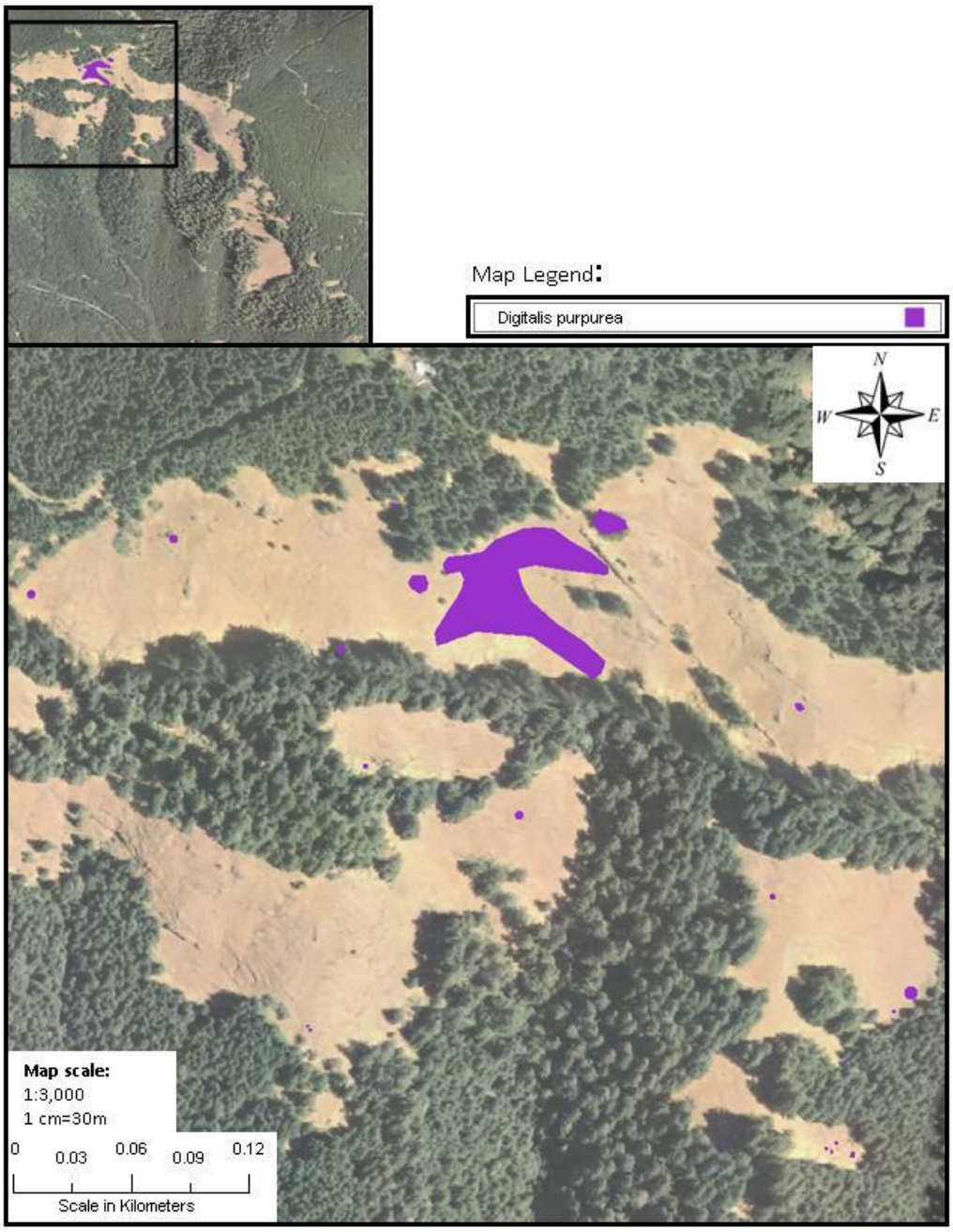
Horse Rock Ridge:
Southeast Meadow,
Exotic, Digitalis purpurea



Horse Rock Ridge:
Central Meadows
Exotic, Digitalis purpurea

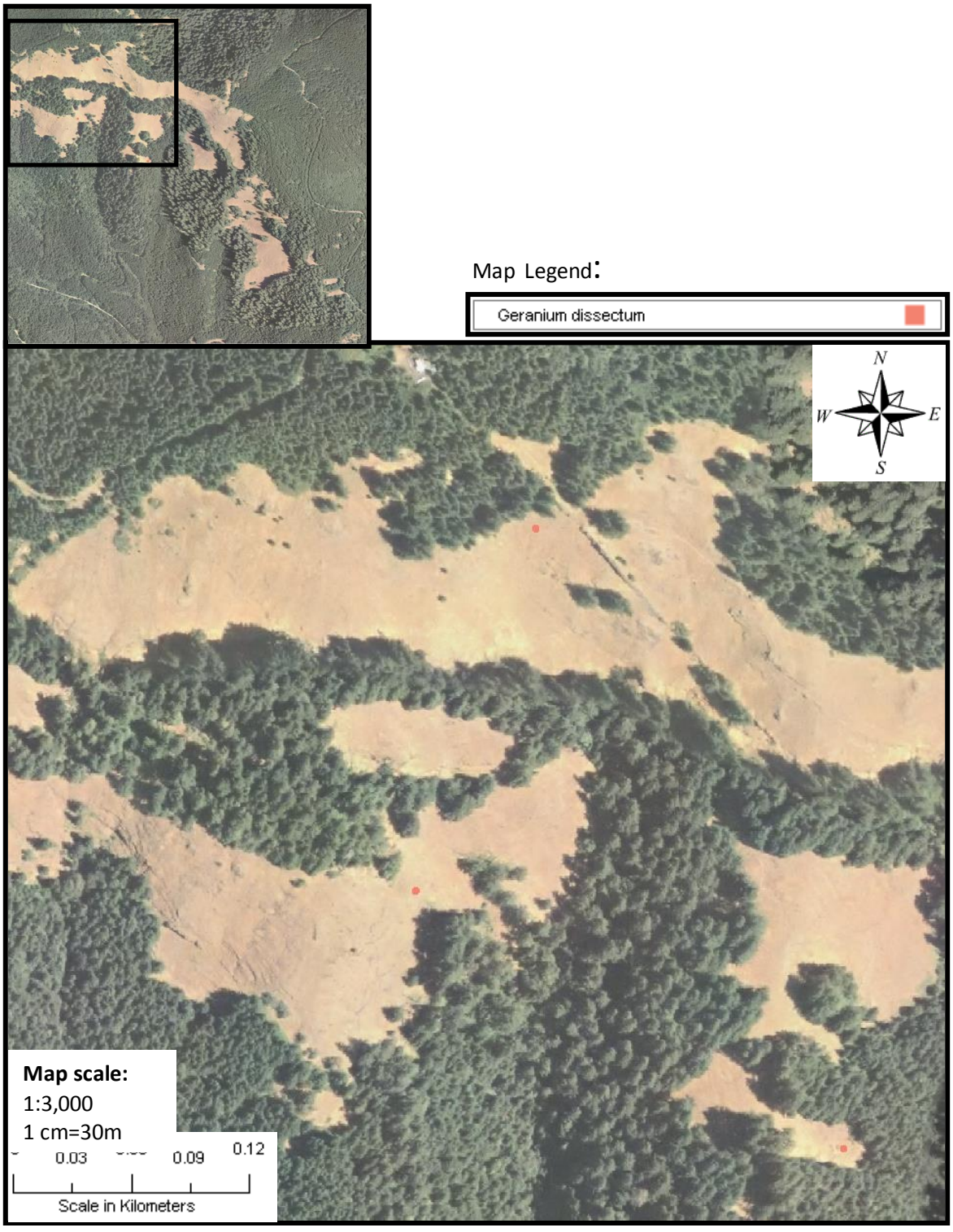


Horse Rock Ridge:
Northwest Meadows,
Exotic, Digitalis purpurea



Appendix A.10. Horse Rock Ridge *Geranium dissectum*
Note: this species has only been found in the northwest meadows

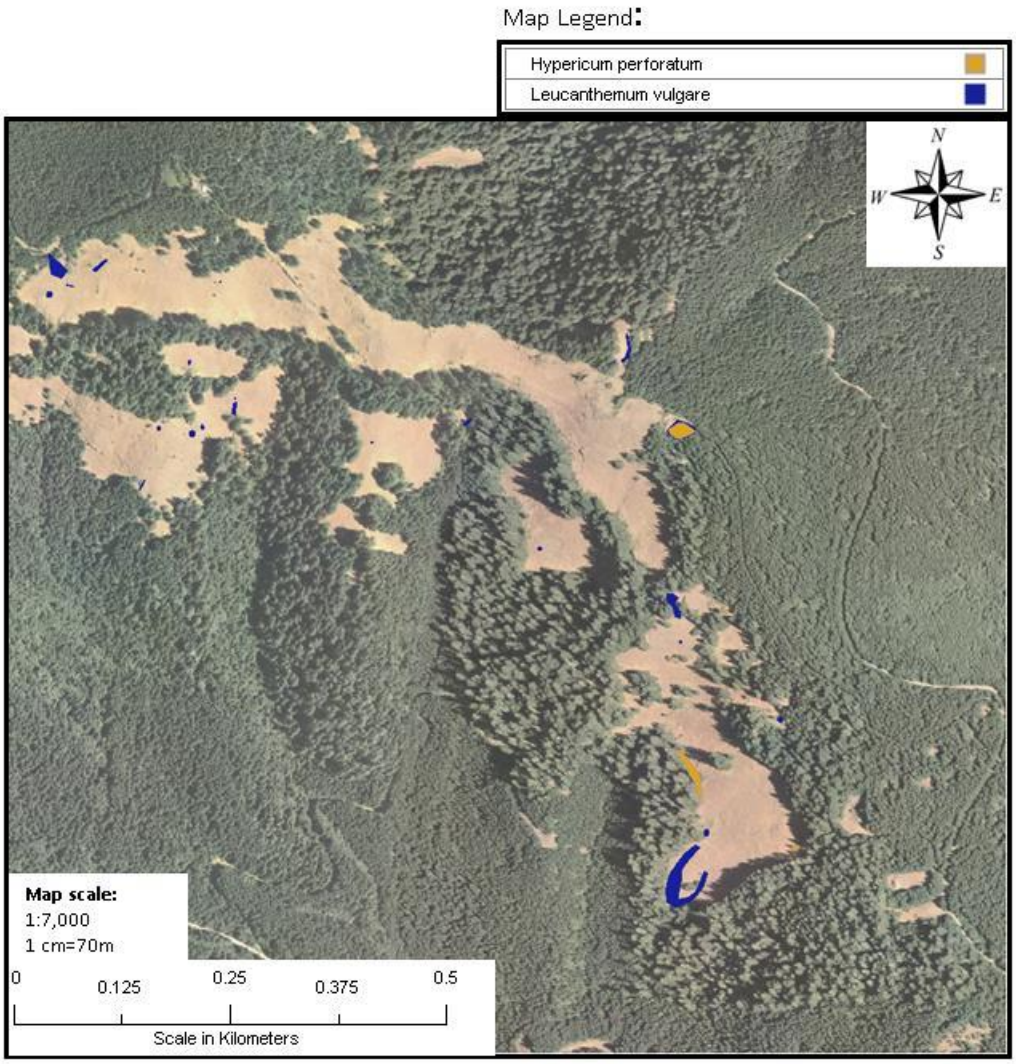
Horse Rock Ridge:
Northwest Meadows,
Exotic, Geranium dissectum



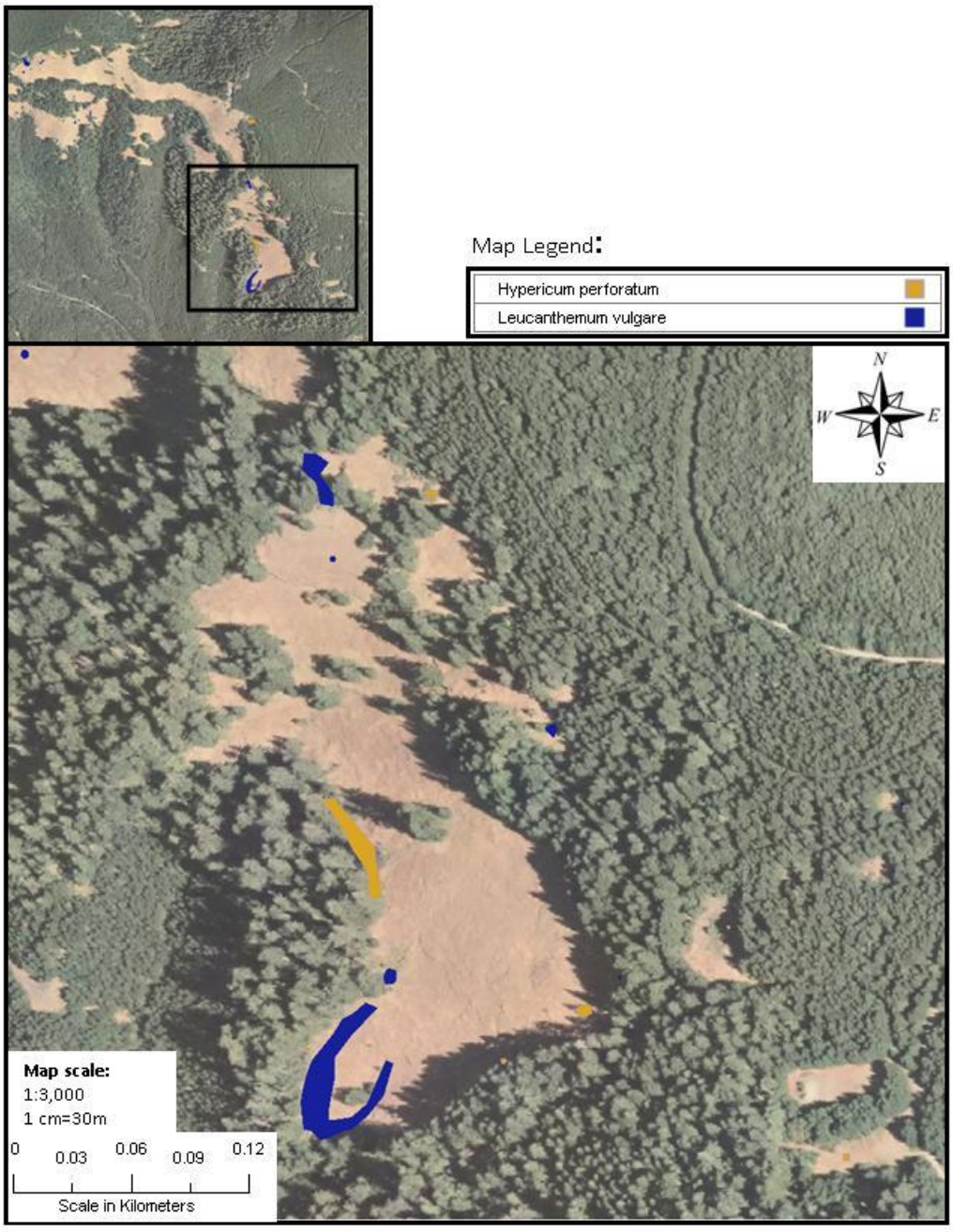
Appendix A.11. Horse Rock Ridge *Hypericum perforatum* and *Leucanthemum vulgare*
note: These species often co-occur and thus were mapped together. Some polygons may overlap.

Overview map
Southeast Meadows
Central Meadows
Northwest Meadows

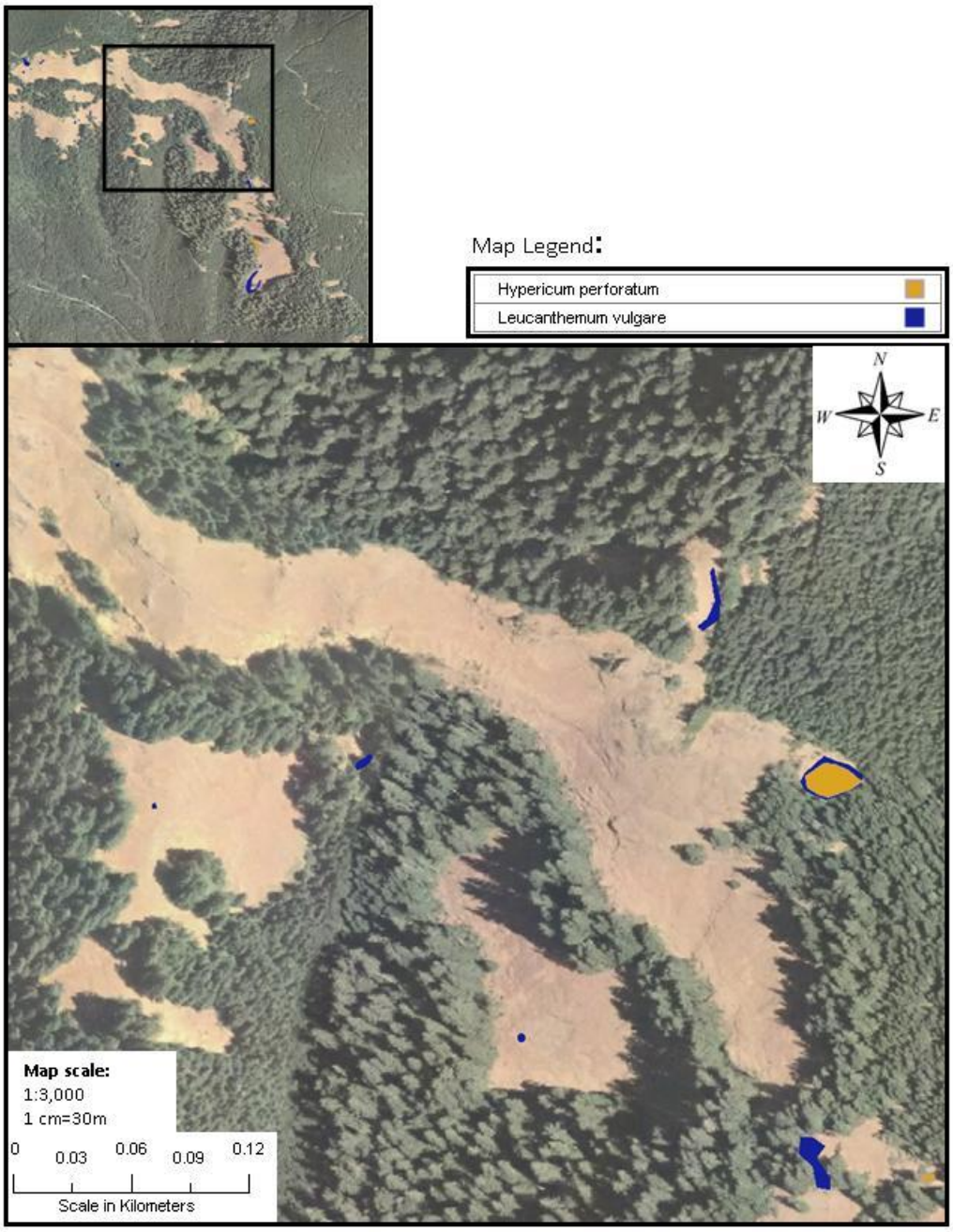
Horse Rock Ridge:
Exotic
Hypericum perforatum and Leucanthemum vulgare



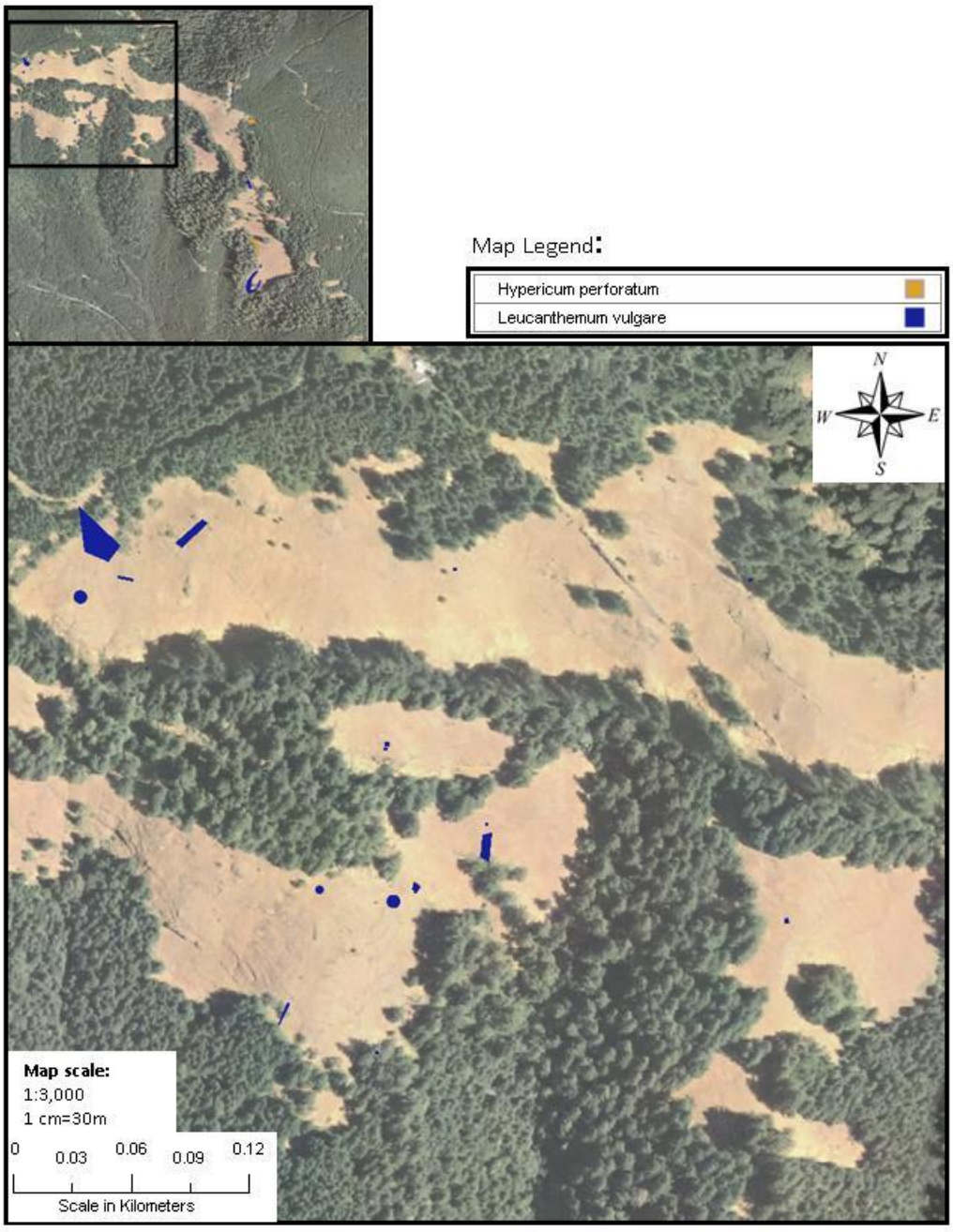
Horse Rock Ridge:
Southeast Meadow, Exotic
Hypericum perforatum and Leucanthemum vulgare



Horse Rock Ridge:
Central Meadows ,Exotic,
Hypericum perforatum and Leucanthemum vulgare



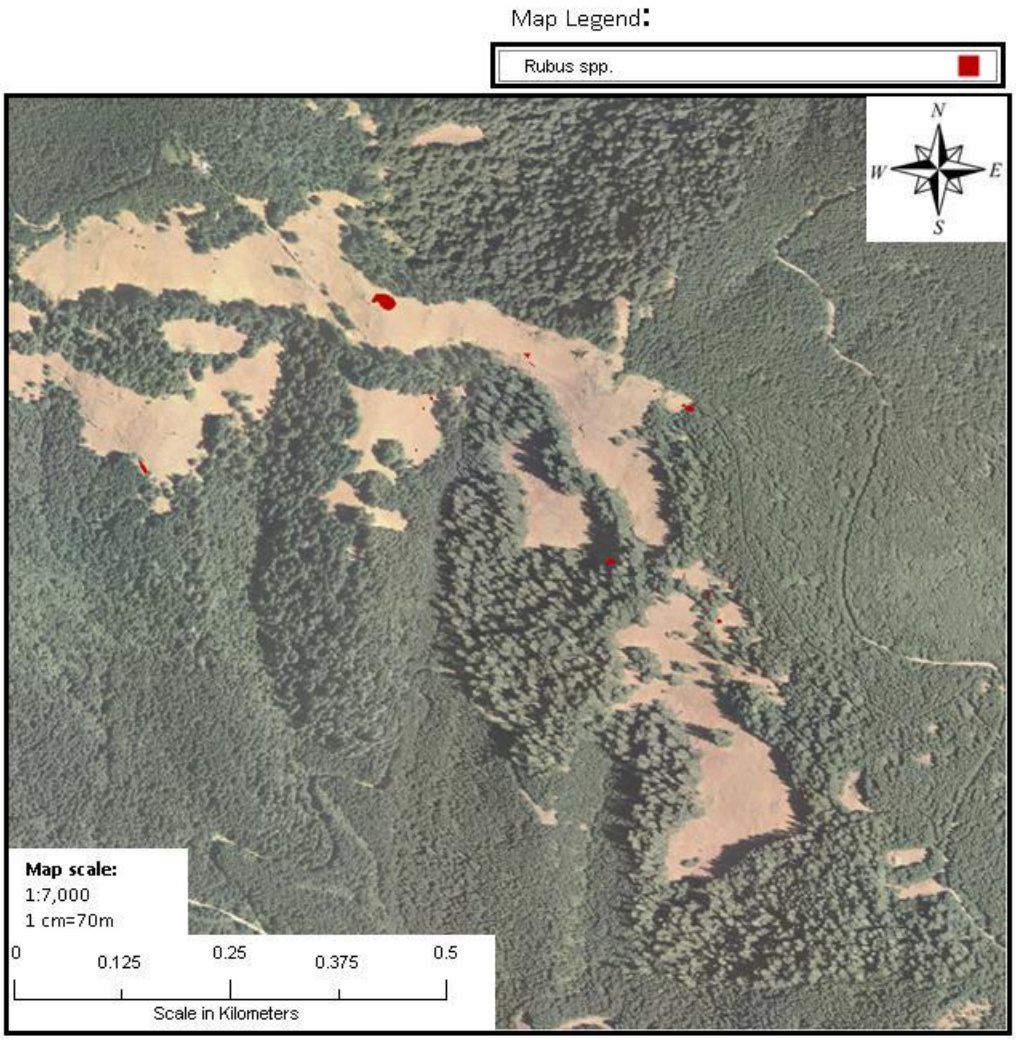
Horse Rock Ridge:
Northwest Meadows, Exotic
Hypericum perforatum and Leucanthemum vulgare



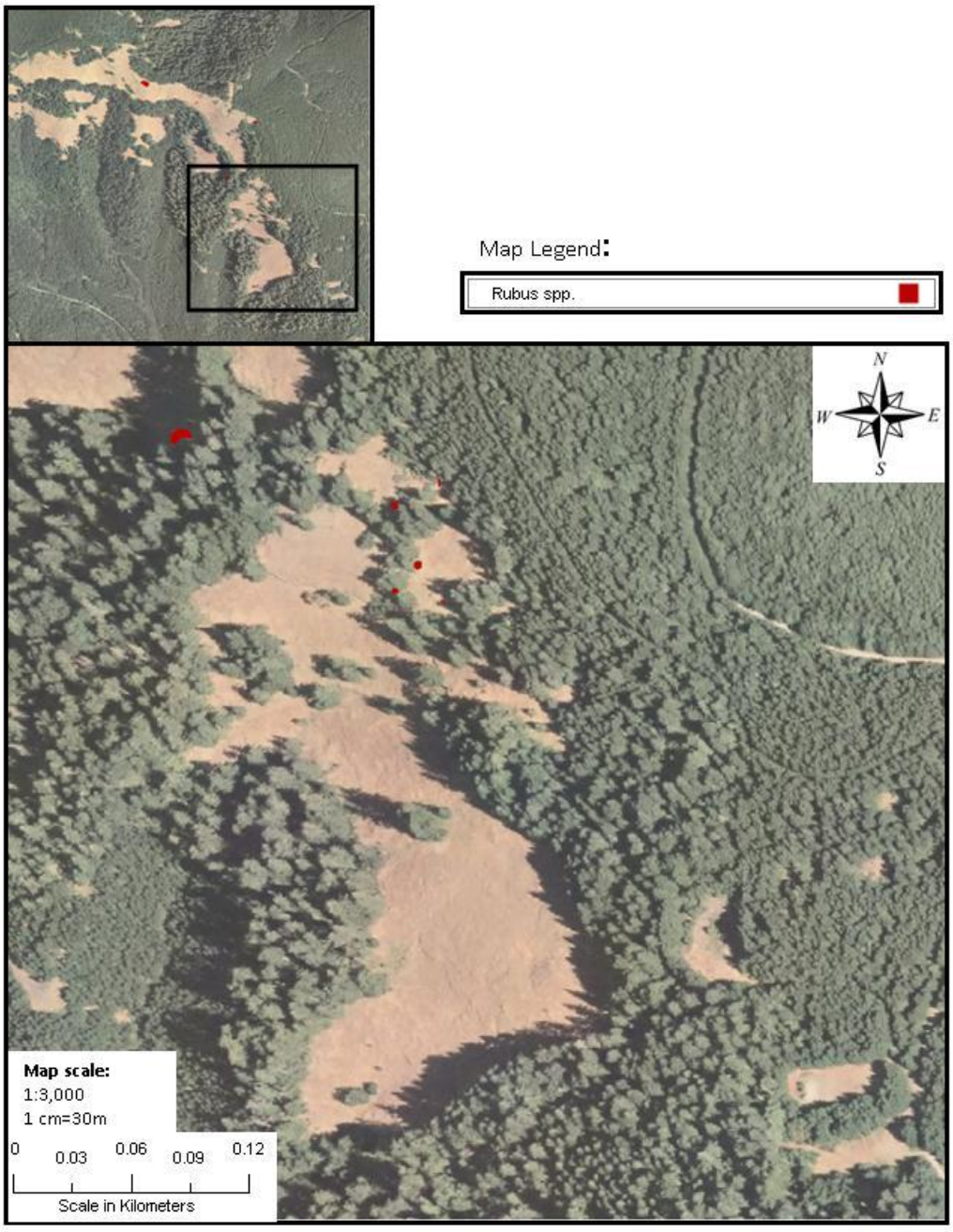
Appendix A.12. Horse Rock Ridge *Rubus* spp.

Overview map
Southeast Meadows
Central Meadows
Northwest Meadows

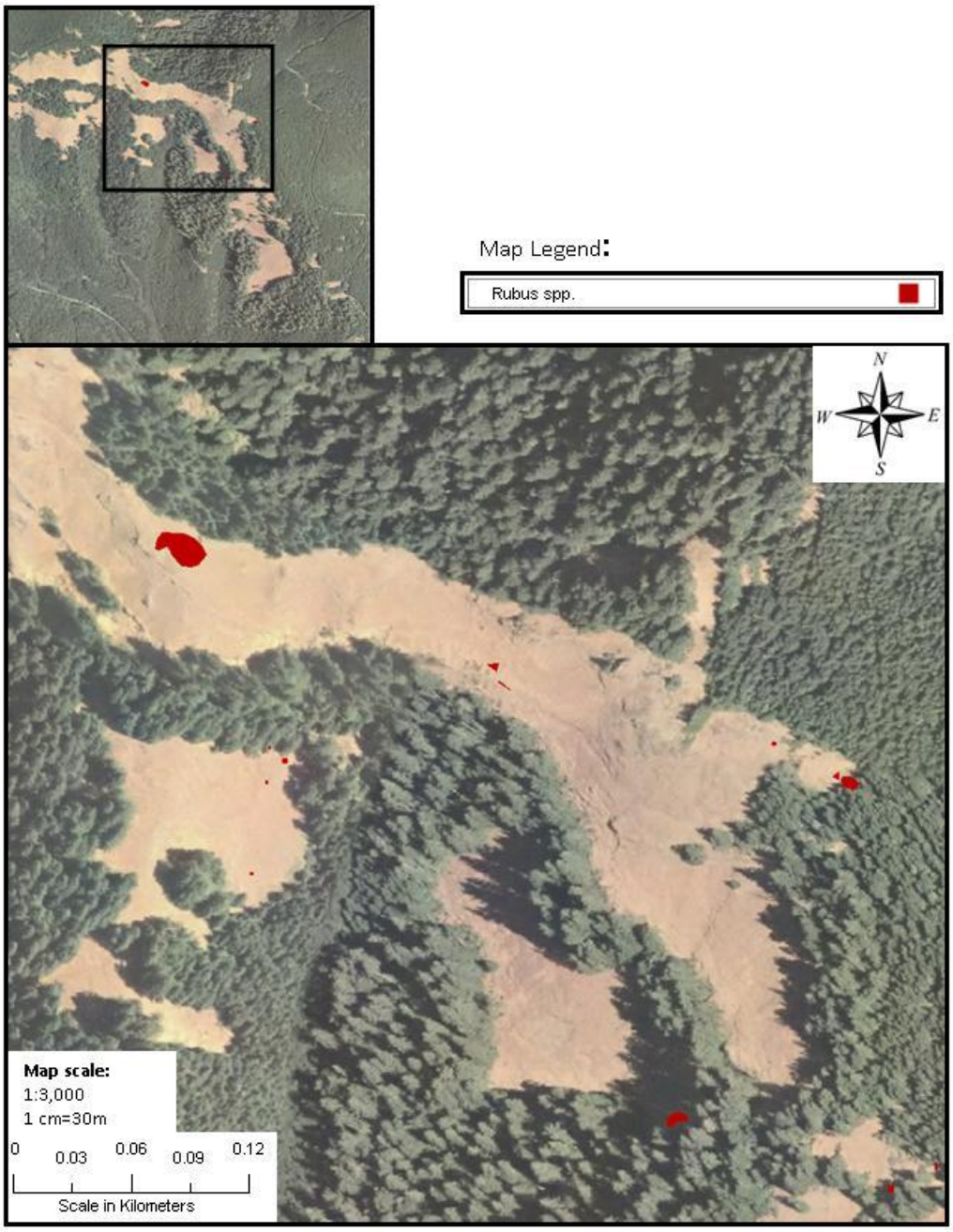
Horse Rock Ridge:
Exotic Forb, Rubus spp.



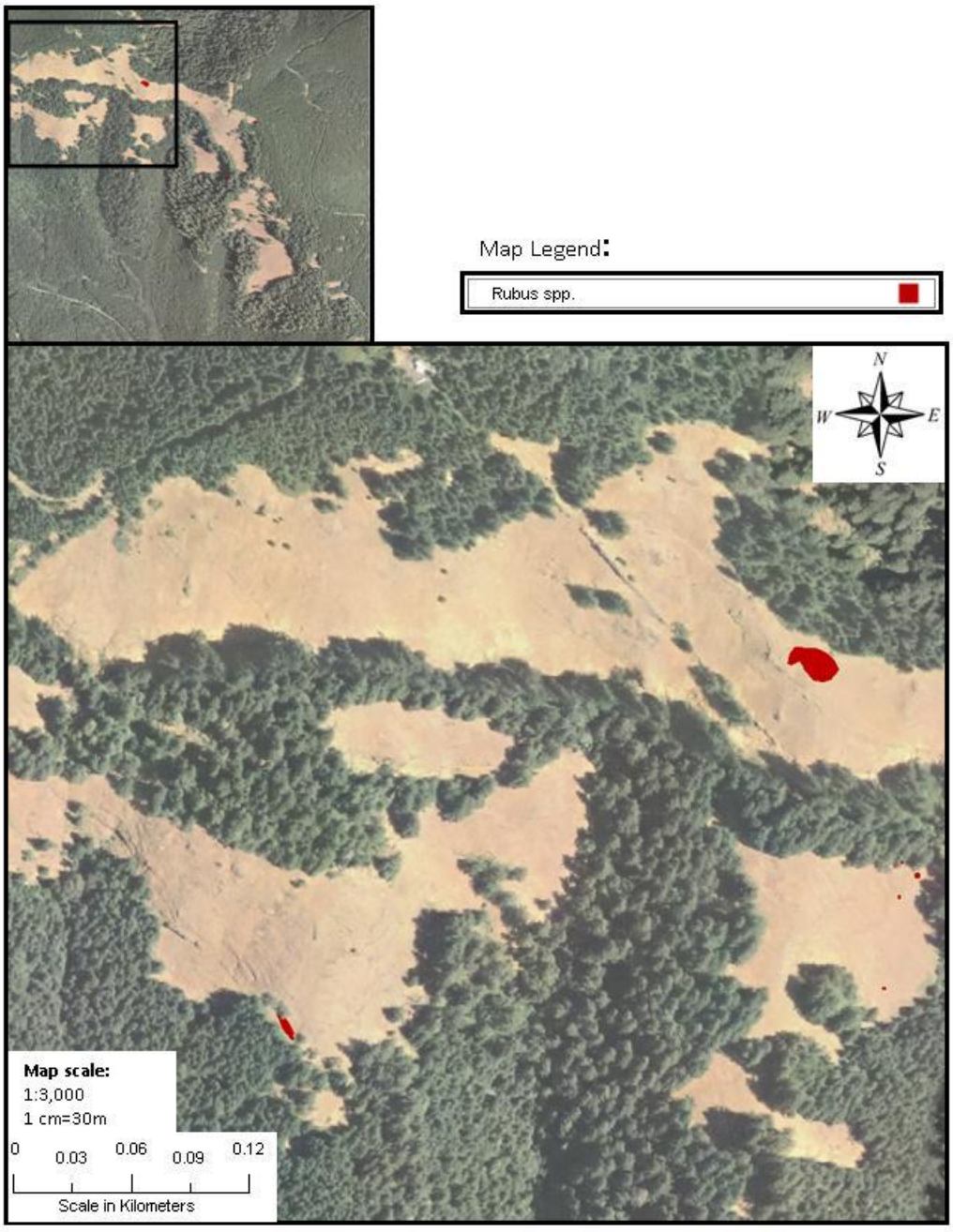
Horse Rock Ridge:
Southeast Meadow, Exotic Forb, Rubus spp.



Horse Rock Ridge:
Exotic Forb, Rubus spp., Central Meadows



Horse Rock Ridge:
Native Areas, Northwest Meadows



Appendix A.13. Horse Rock Ridge *Rumex acetosella* and *Rumex crispus*

Note: due to the small size and color, the polygons for Rumex crispus *locations are difficult to see; we have circled them to indicate their location.*

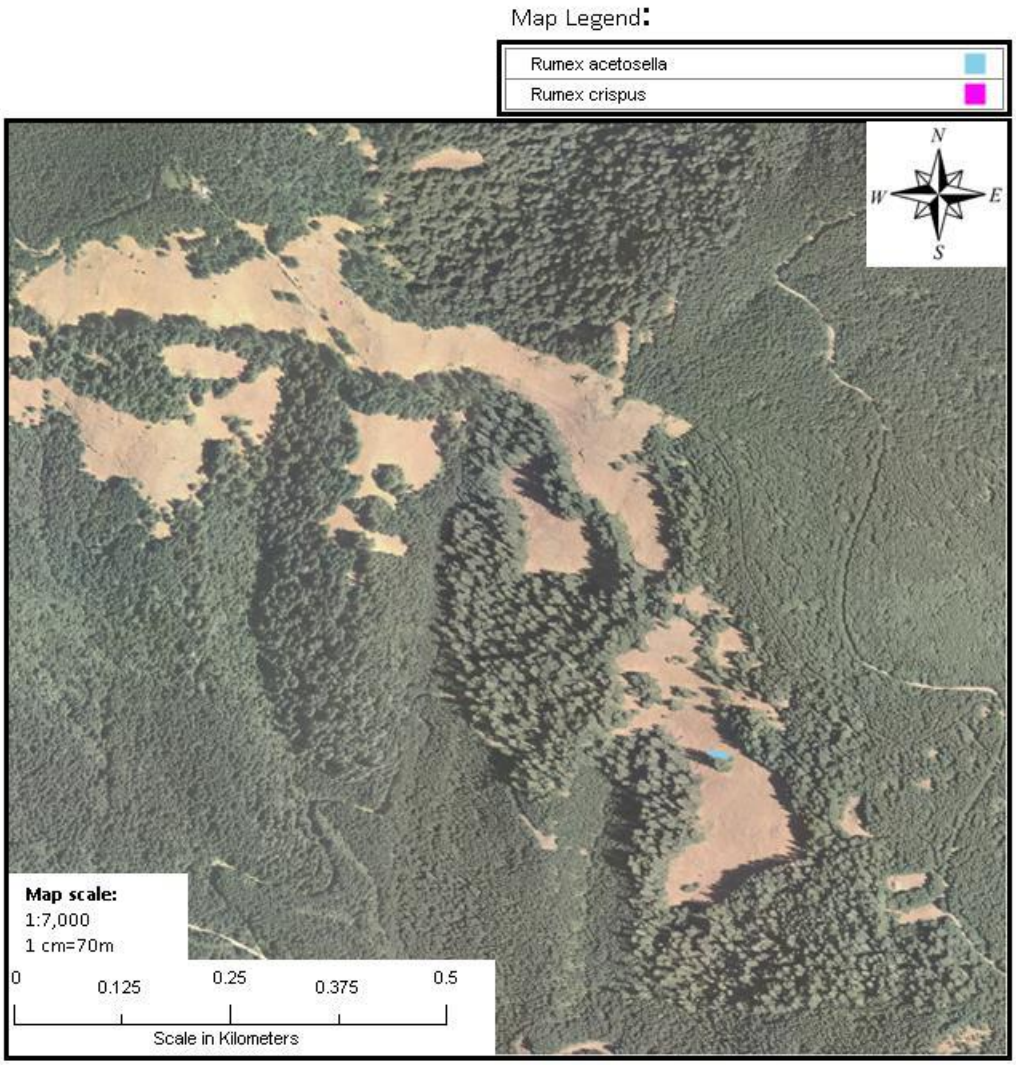
Overview map

Southeast Meadows

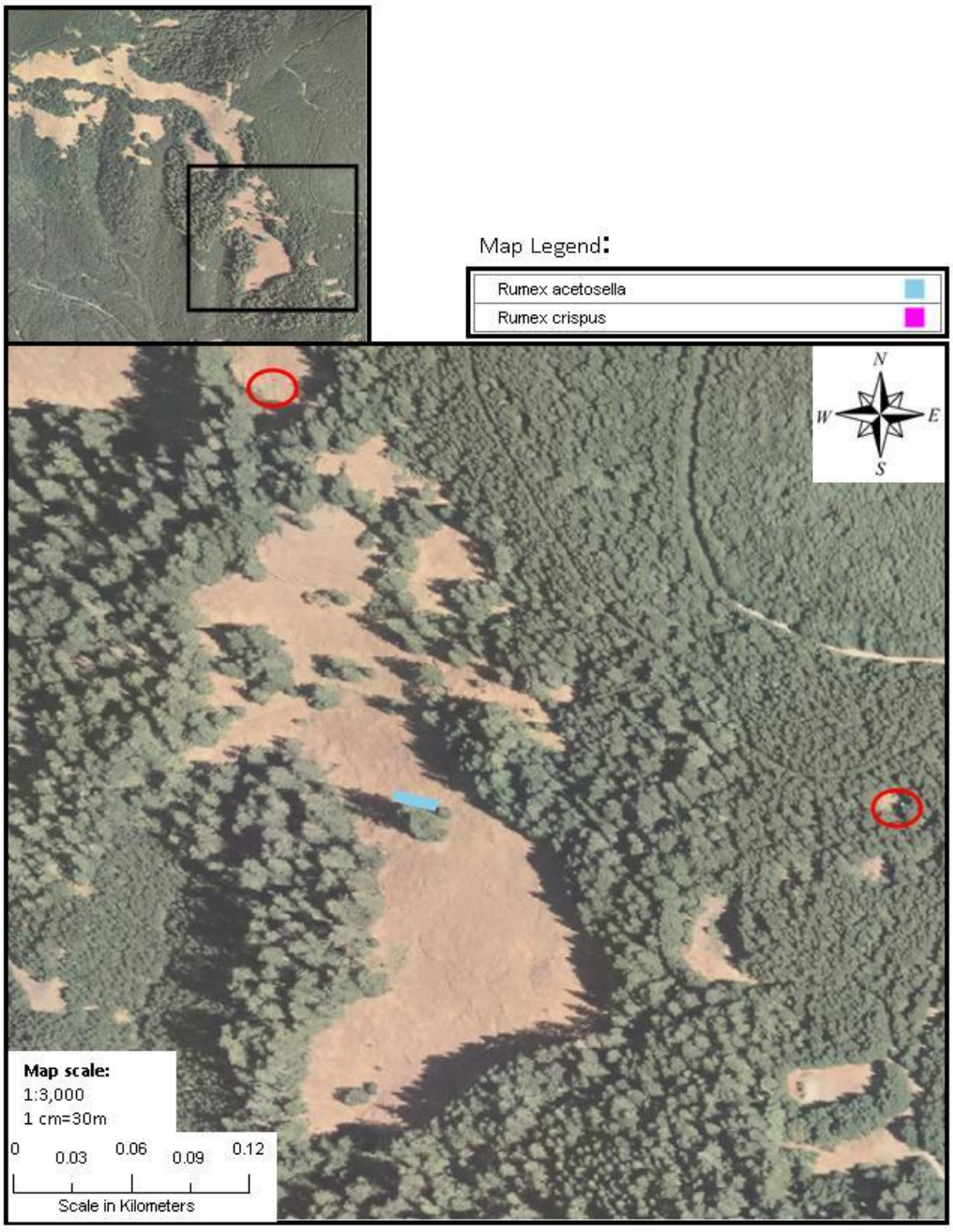
Central Meadows

Northwest Meadows

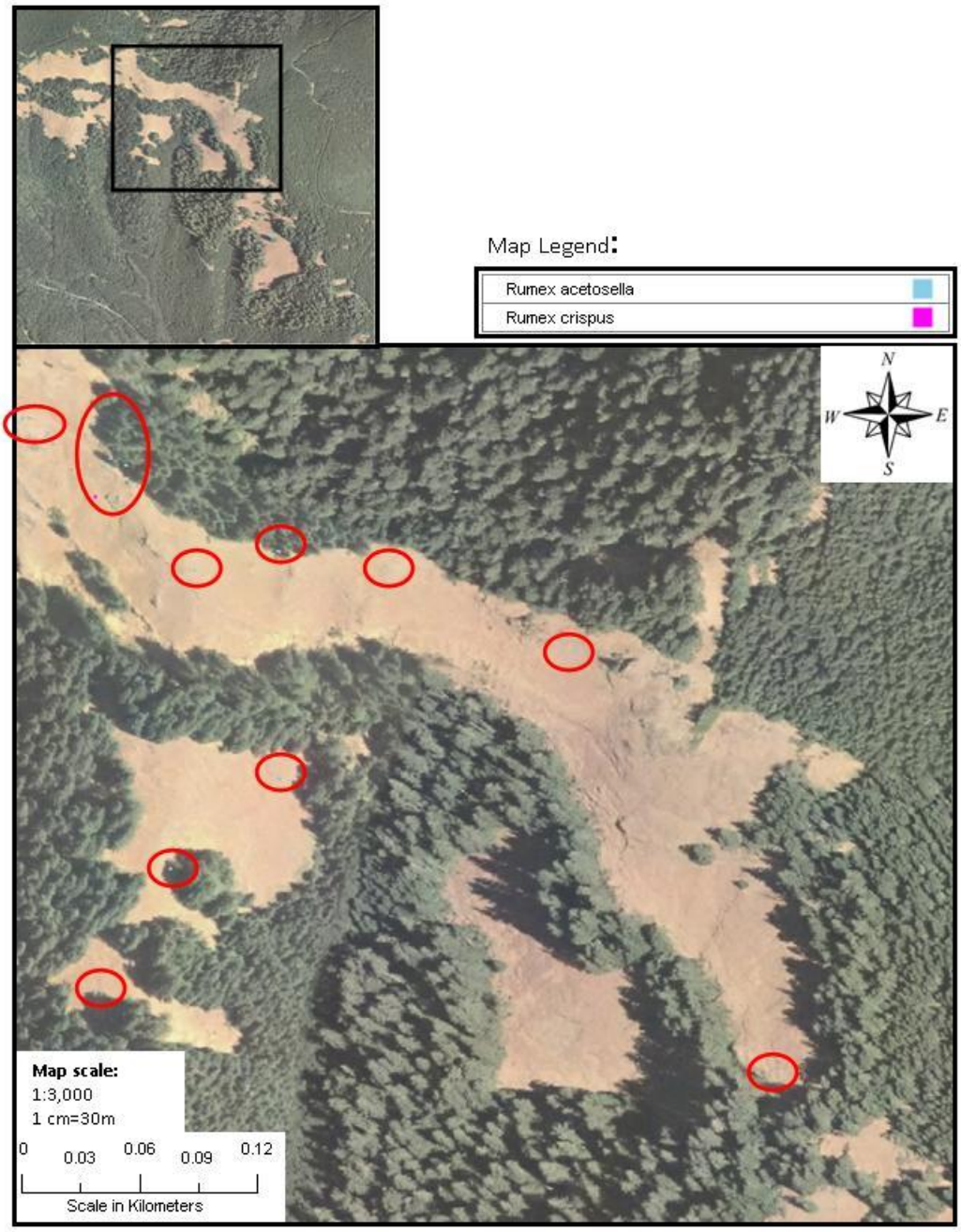
Horse Rock Ridge:
Rumex spp.



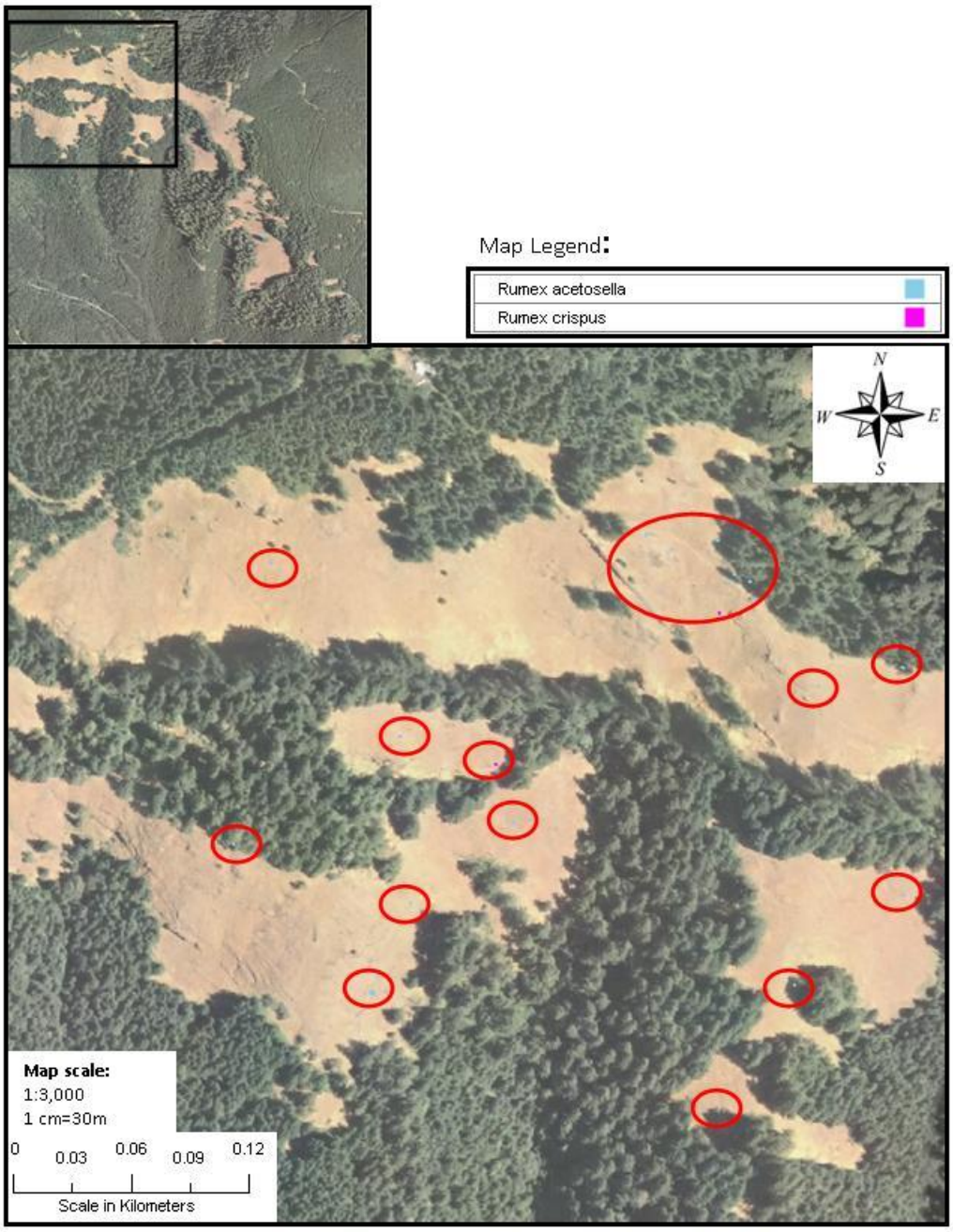
Horse Rock Ridge:
Southeast Meadow, Rumex spp.



Horse Rock Ridge:
Central Meadows, Rumex spp.



Horse Rock Ridge:
Northwest Meadows, Rumex spp.



Appendix A.14. Horse Rock Ridge *Senecio jacobaea*

Note: due to the small size and color, the polygons for Senecio jacobaea, *locations are difficult to see; we have circled them to indicate their location.*

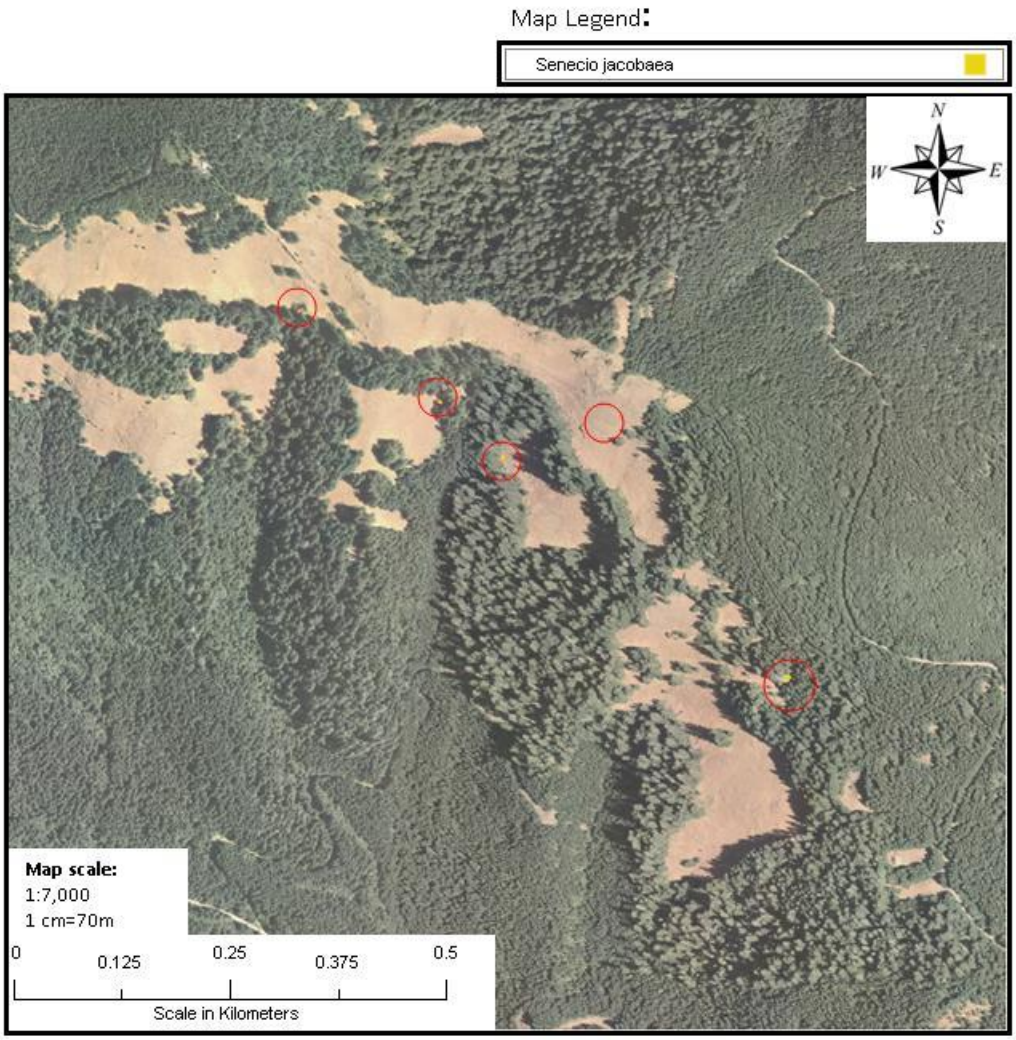
Overview map

Southeast Meadows

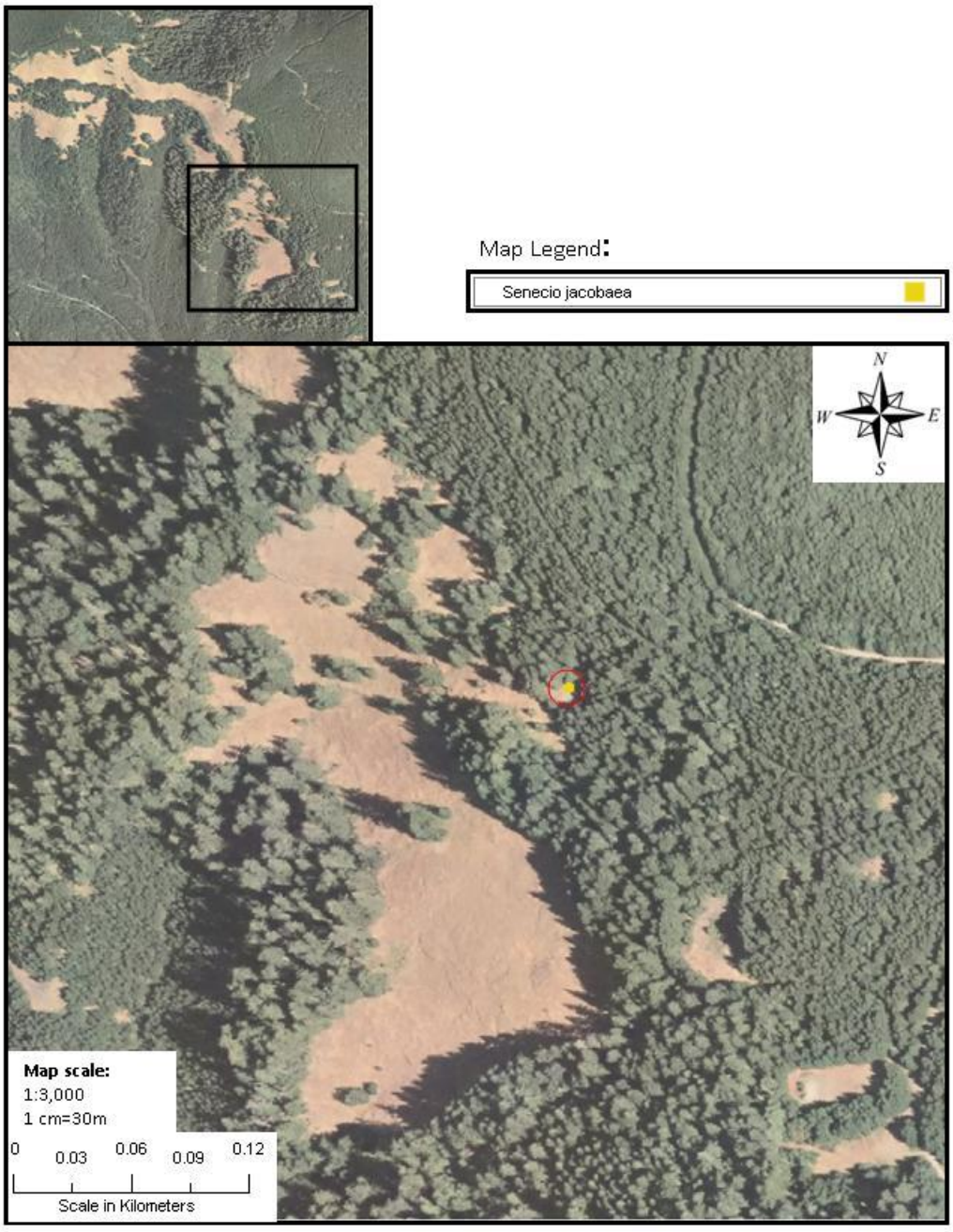
Central Meadows

Northwest Meadows

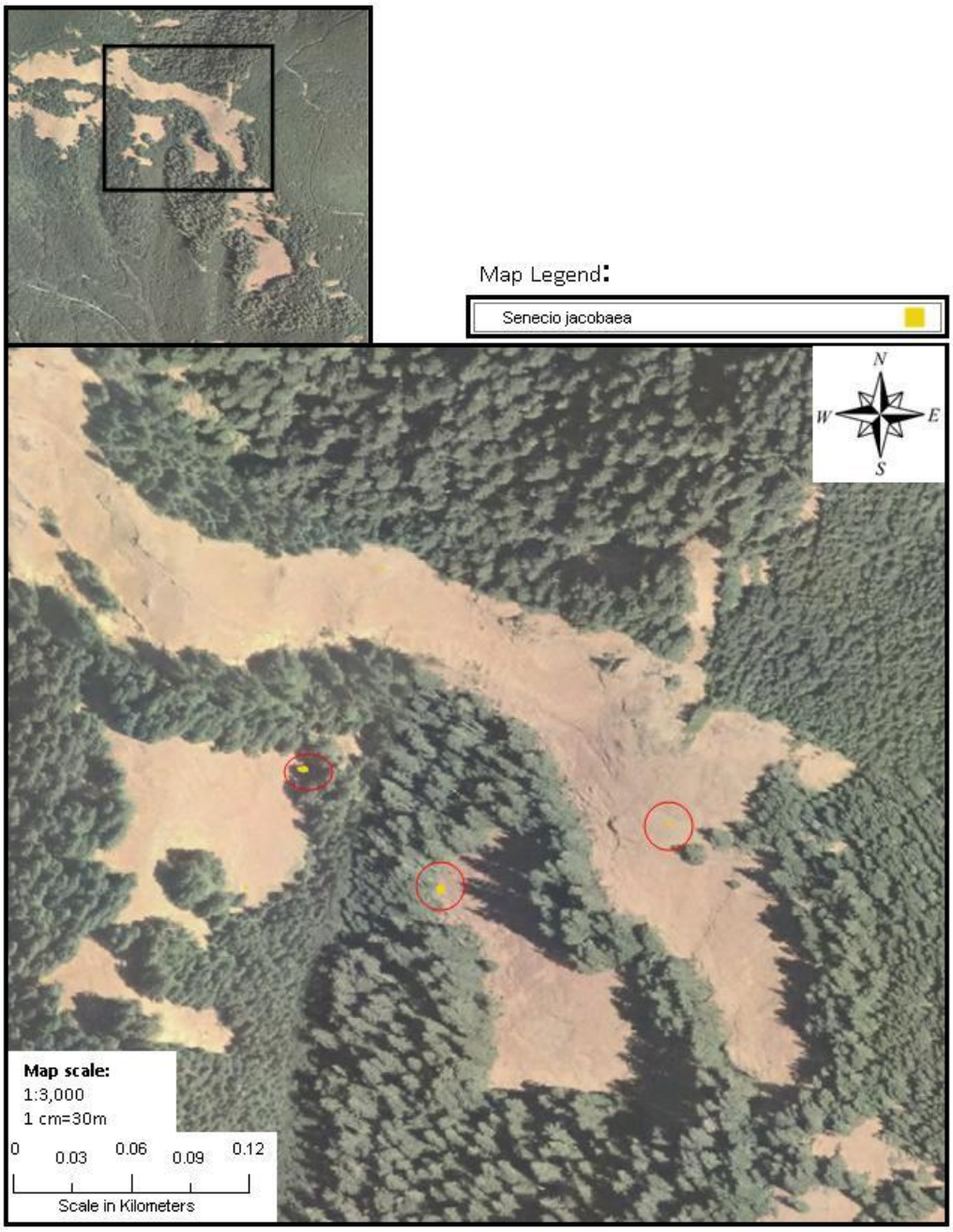
Horse Rock Ridge:
Senecio jacobaea



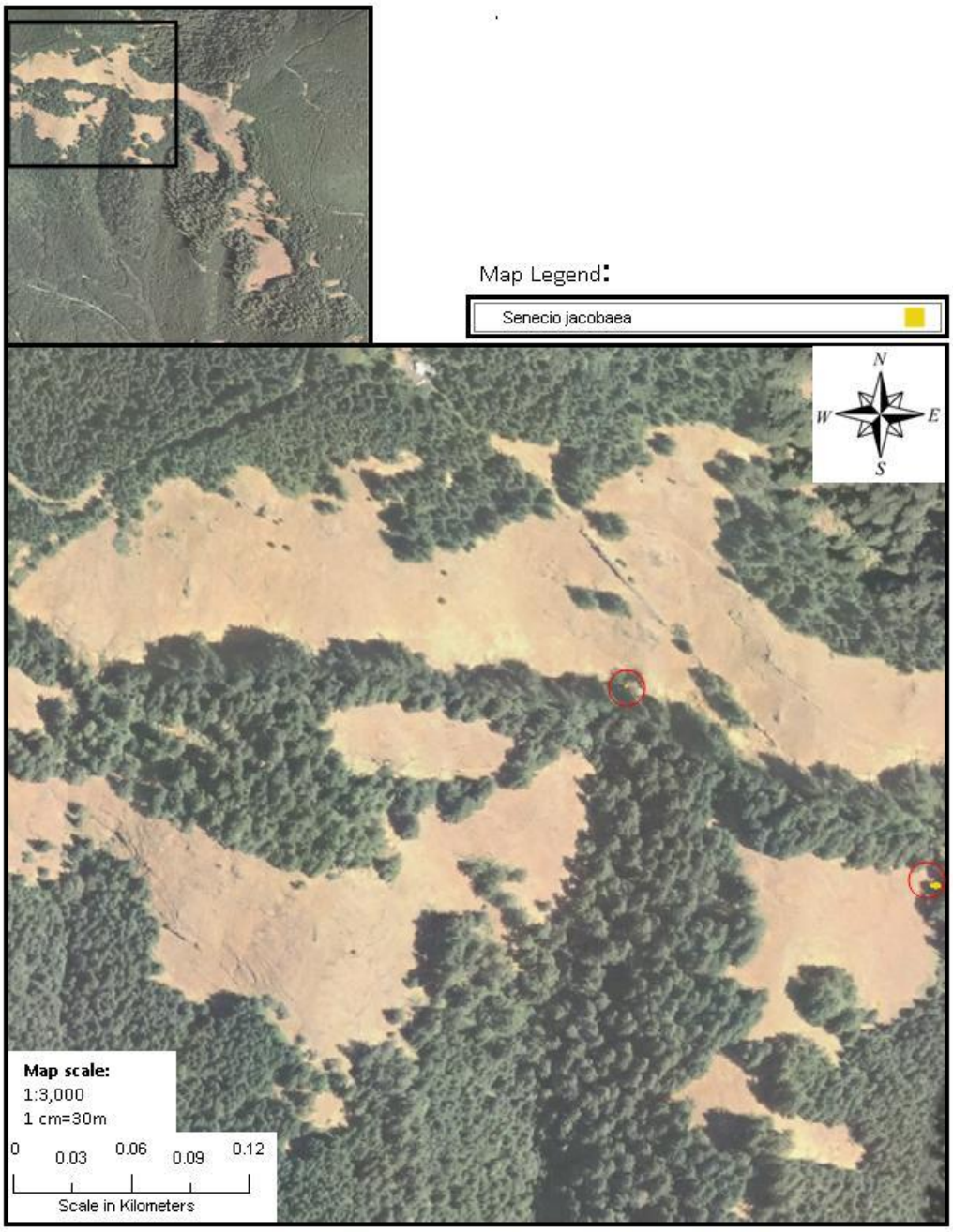
Horse Rock Ridge:
Southeast Meadow, Senecio jacobaea



Horse Rock Ridge:
Central Meadows, Senecio jacobaea



Horse Rock Ridge:
Northwest Meadows, Senecio jacobaea



Appendix A.15. Horse Rock Ridge *Sonchus asper* and *Tragopogon dubius*

Note: due to the small size and color, the polygons for Tragopogon dubius, *locations are difficult to see; we have circled them to indicate their location.*

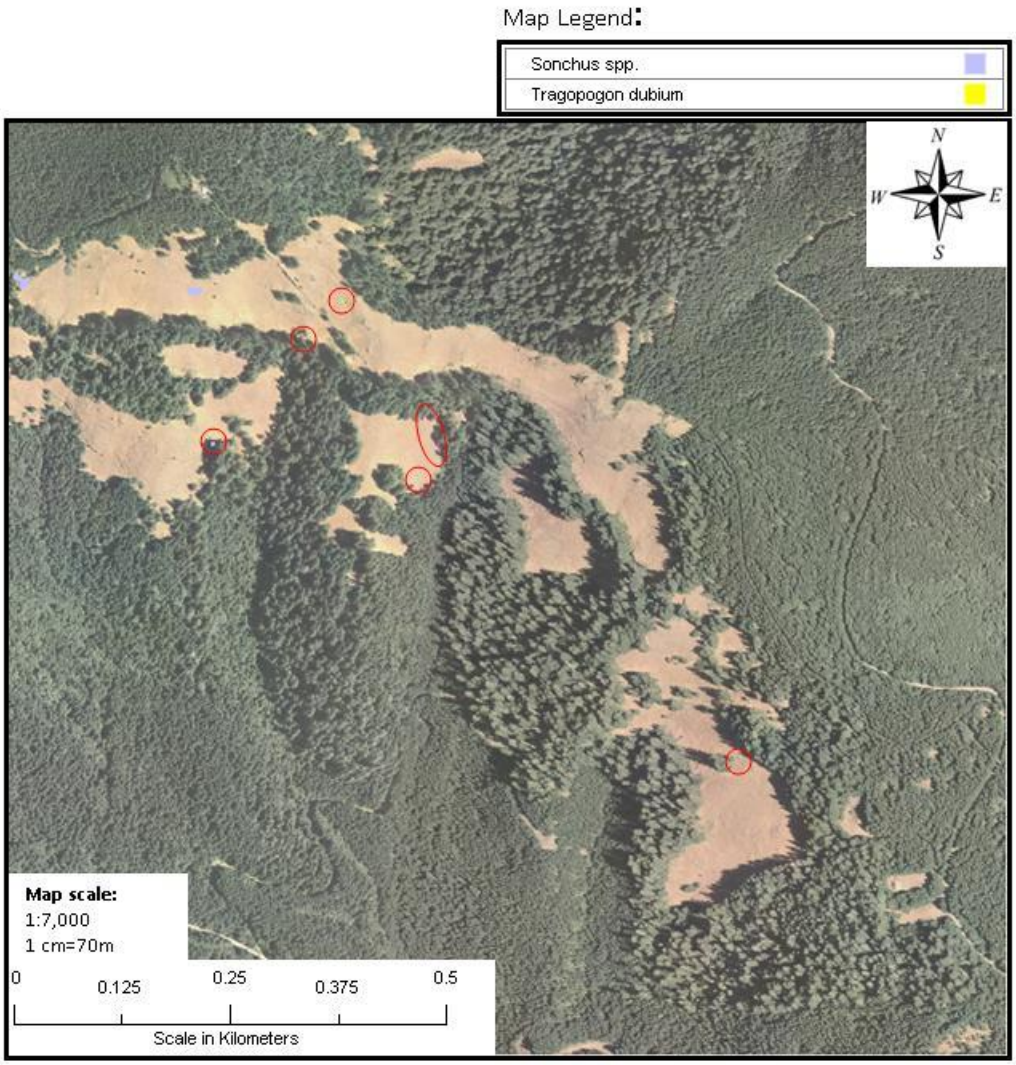
Overview map

Southeast Meadows

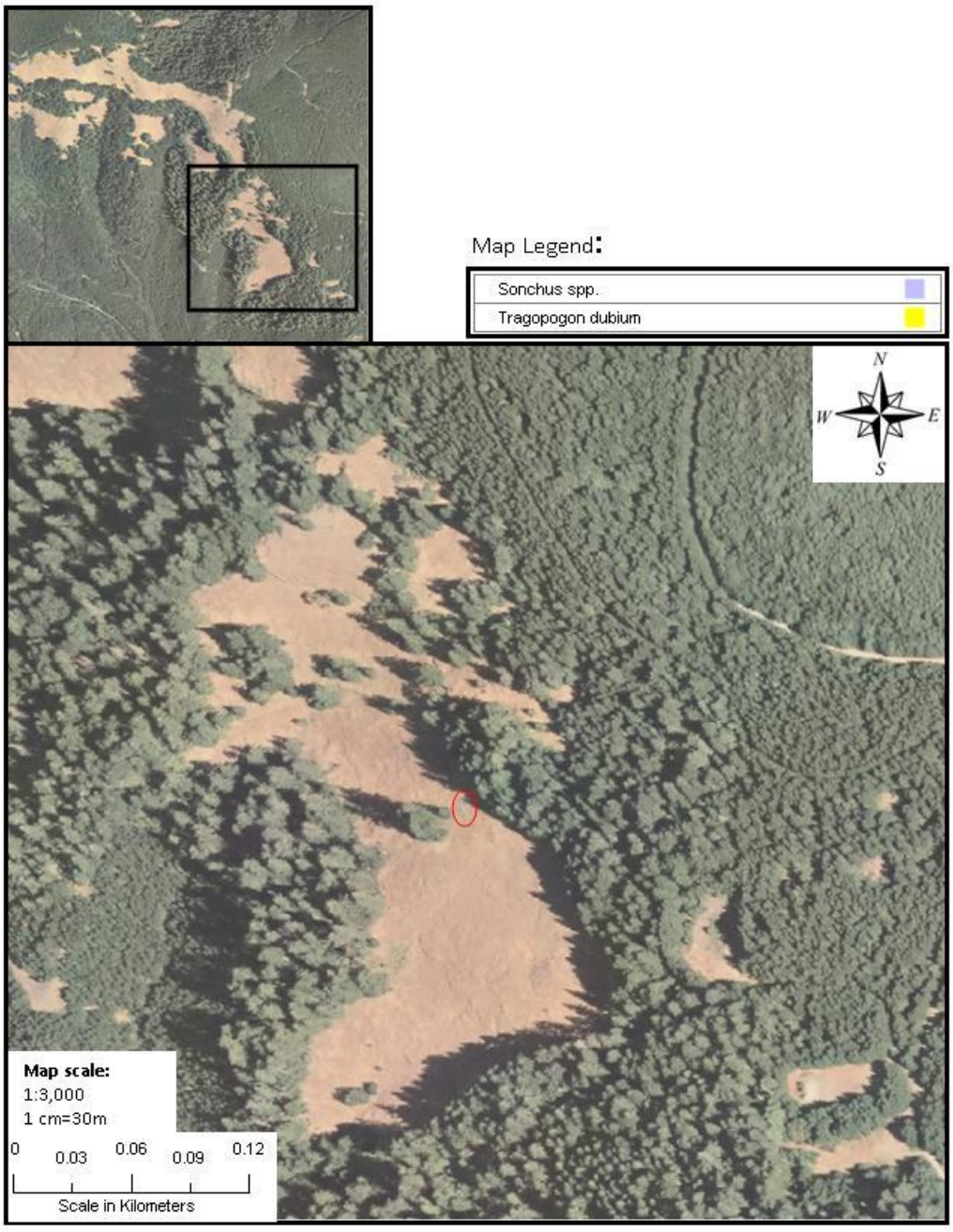
Central Meadows

Northwest Meadows

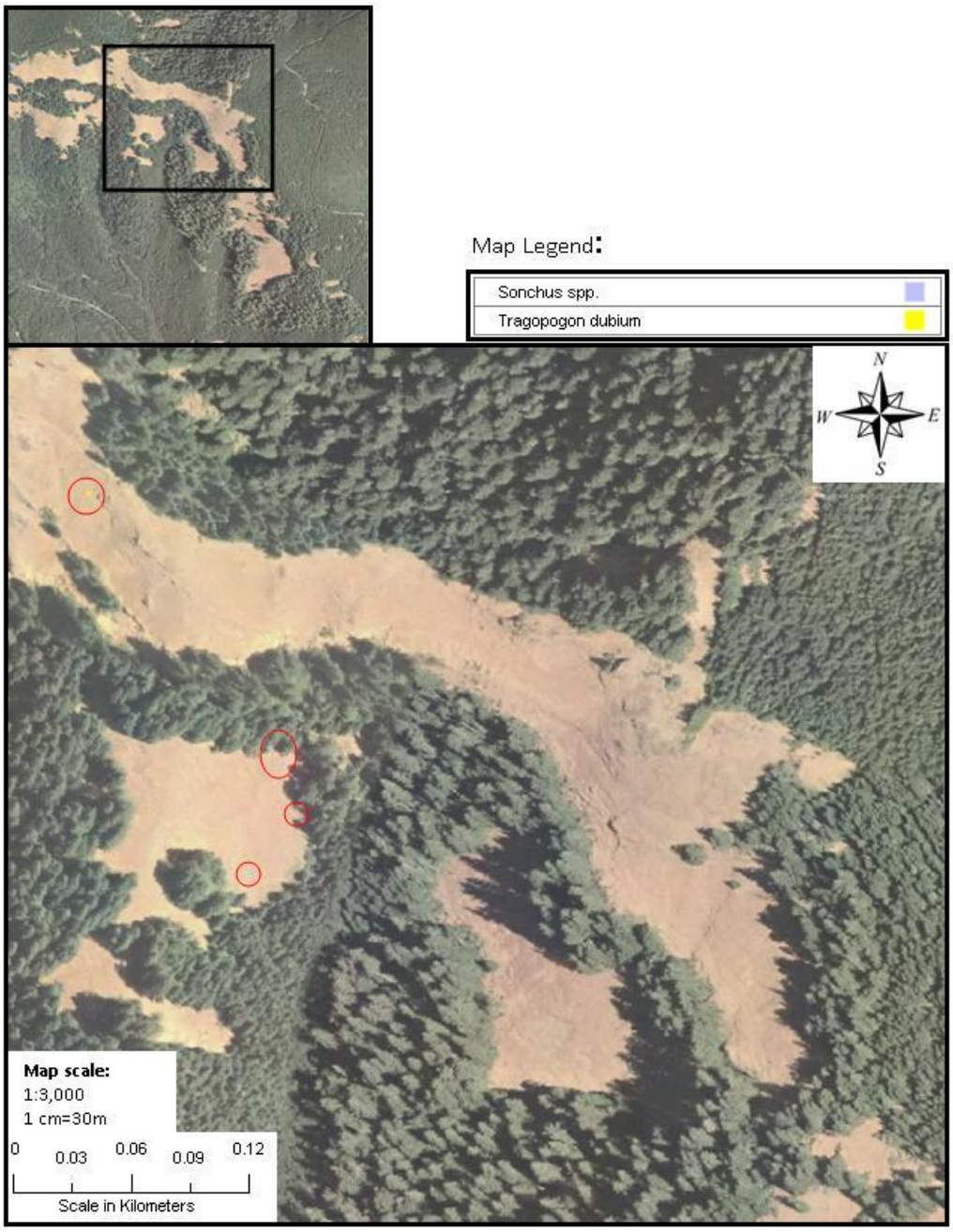
Horse Rock Ridge:
Sonchus asper and Tragopogon dubius



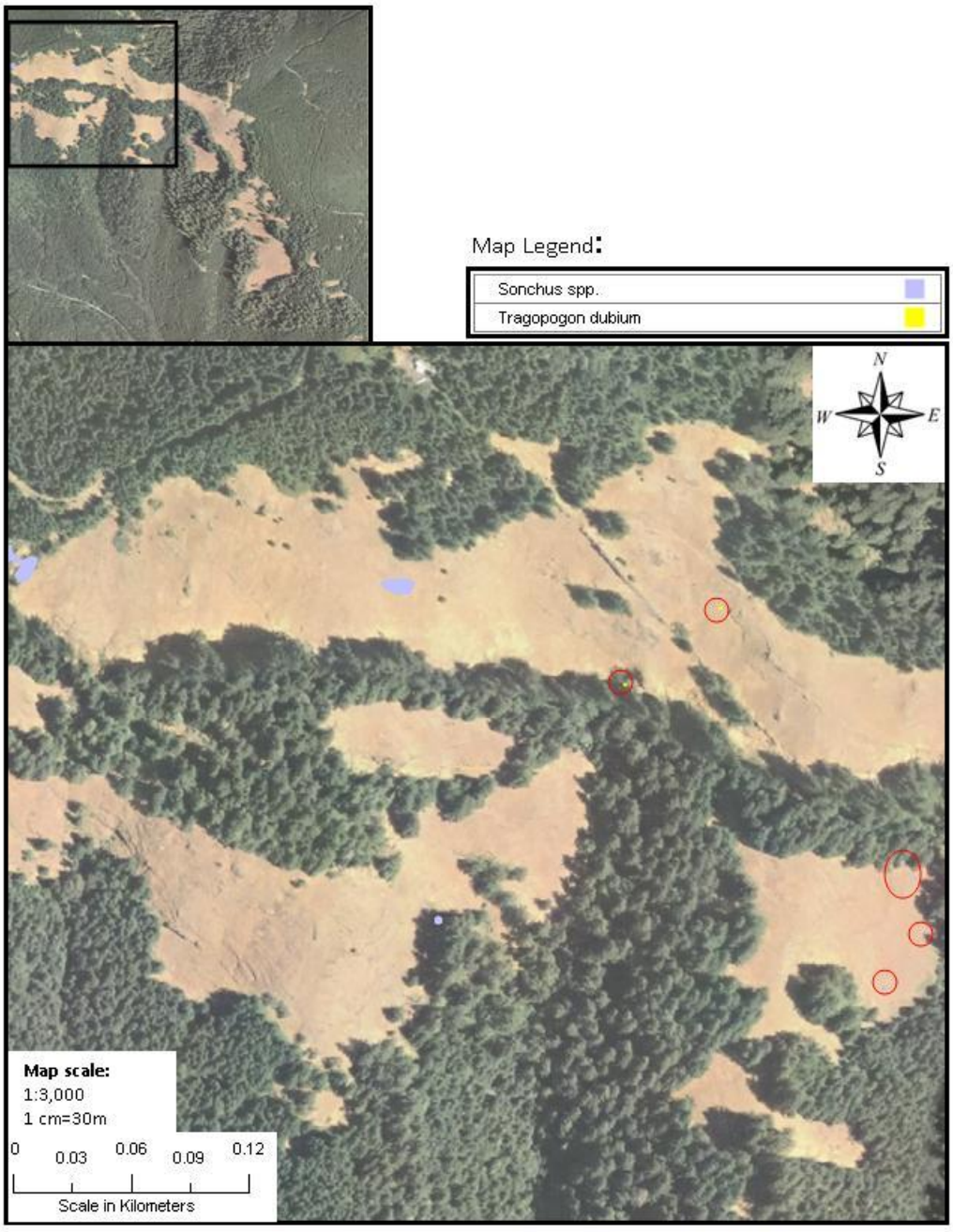
Horse Rock Ridge:
Southeast Meadow,
Sonchus asper and Tragopogon dubius



Horse Rock Ridge:
Central Meadows,
Sonchus asper and Tragopogon dubius



Horse Rock Ridge:
Northwest Meadows,
Sonchus asper and Tragopogon dubius



Appendix A.16. Horse Rock Ridge *Viccia sativa*.
Note: this species has only been found in the northwest meadows. A red circle as been added to aid locating the polygon.

Horse Rock Ridge:
Northwest Meadows,
Viccia sativa