Population monitoring for *Lupinus oreganus* (Kincaid's lupine) at Eagle's Rest

2012

Report to the Bureau of Land Management, Eugene District

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Institute for Applied Ecology

PREFACE

This report is the result of a cooperative Challenge Cost Share project between the Institute for Applied Ecology (IAE) and a federal agency. IAE is a non-profit organization dedicated to natural resource conservation, research, and education. Our aim is to provide a service to public and private agencies and individuals by developing and communicating information on ecosystems, species, and effective management strategies and by conducting research, monitoring, and experiments. IAE offers educational opportunities through 3-4 month internships. Our current activities are concentrated on rare and endangered plants and invasive species.

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Cover photograph: Eagle's Rest and *Lupinus oreganus* (Kincaid's lupine).

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REPORT TO THE BUREAU OF LAND MANAGEMENT, EUGENE DISTRICT

INTRODUCTION

This report documents the tenth year of monitoring for the *Lupinus oreganus* (Kincaid's lupine) population located at Eagle's Rest, managed by the Eugene District of the Bureau of Land Management (BLM). Monitoring will provide the BLM with information on population status and long-term trends and supply baseline data to help understand and predict the response of the population to habitat changes caused by natural forces, human-induced threats, and prescribed management actions.

Species status and background information

Lupinus oreganus (cover photo) is native to prairies in southwestern Washington and the Willamette Valley and forest openings and grassy balds in Douglas County, Oregon. Many of the largest and most significant *L. oreganus* populations occur on lands managed by the BLM in western Oregon. Habitat loss and population declines caused by land-use conversion, exotic weed invasion, and other threats have led *L. oreganus* to be listed as a threatened species by the Oregon Department of Agriculture (ODA) and the USFWS. Kincaid's lupine is also of great conservation importance because it is the primary larval host plant for the endangered Fender's blue butterfly (*Icaricia icarioides fenderi*).

Lupinus oreganus is an herbaceous perennial that reproduces by seed. Plants form clumps of basal leaves and produce one or more flowering stems. Although this species is capable of vegetative growth, the extent to which vegetative growth might result in clonal spread remains unknown. *Lupinus oreganus* requires insects for successful fertilization and seed formation (Kaye 1999).

Study site

Eagle's Rest is one of the few remaining upland prairie remnants in the Cascade foothills of the southern Willamette Valley that while containing some non-native species also contains a substantial native plant community. It is characterized as a forest opening harboring a diverse native upland prairie plant community (Figure 1). Conservation threats in this meadow include encroachment of shrubs, invasion by exotic plant species and damage by outdoor recreation vehicle (ORV) use.

Objectives

The objectives of this project are to:

1) Evaluate the effectiveness of using cover as a surrogate for counting leaves to determine lupine abundance.
2) Document population trends of Kincaid's lupine at Eagle's Rest.
3) Assess impacts of ORV use, and any other anthropogenic impacts.

FIGURE 1. THE EAGLE'S REST *LUPINUS OREGANUS* SITE IN 2004.

FIGURE 2. AERIAL PHOTO (TAKEN JUNE 2000) OF THE LOCATION OF EAGLE'S REST (INDICATED BY RED POLYGON AND BLACK ARROW).

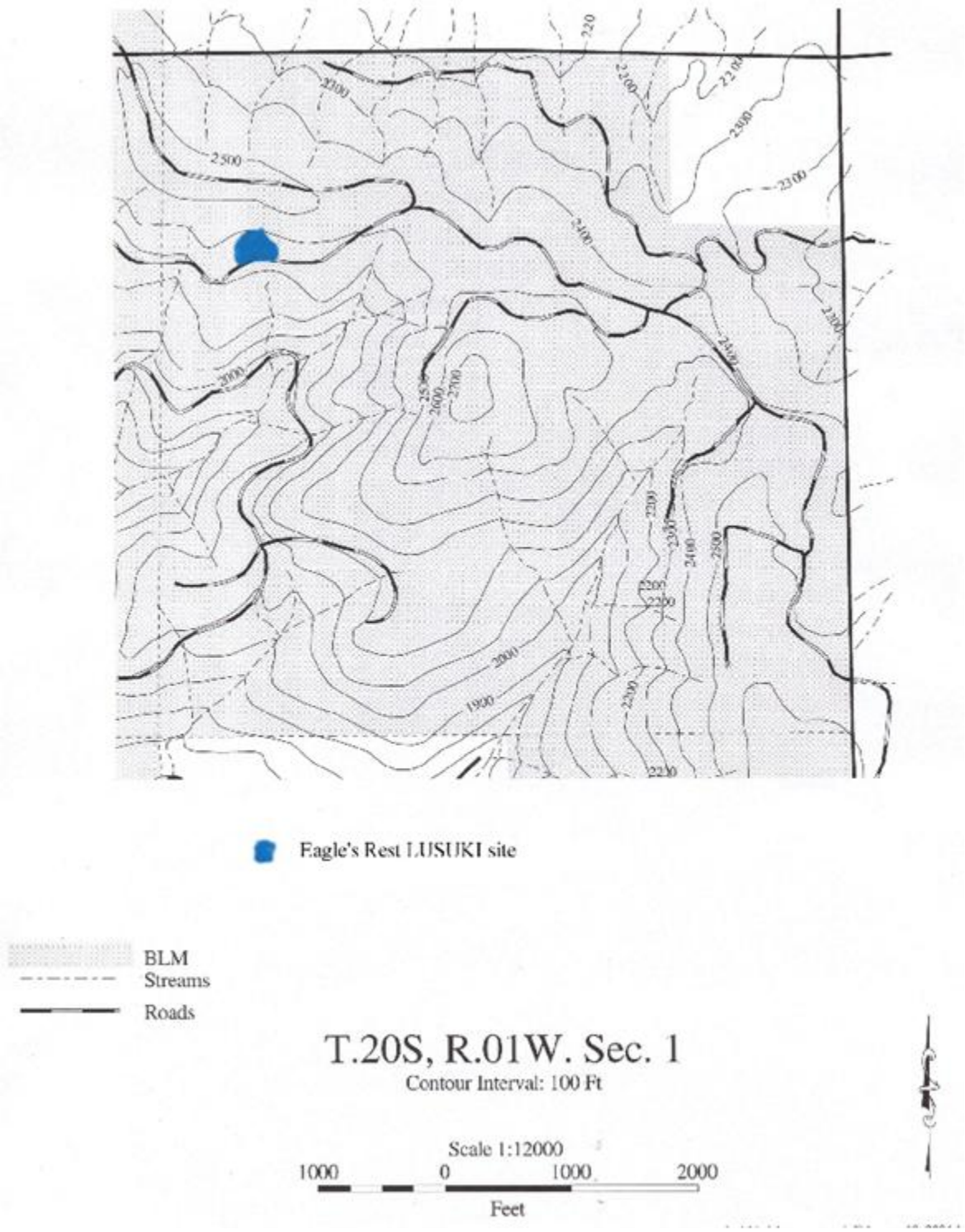

FIGURE 3. TOPOGRAPHIC MAP INDICATING THE LOCATION OF EAGLE'S REST.

Location of study site

Eagle's Rest is located in the northwest quarter of Township 20S, Range 1W, Section 1 (Figure 3). See Appendix A. Directions and gear list for directions to the site.

Plot layout

Five rectangular monitoring plots were established at Eagle's Rest in July 2003 to include virtually the entire population of *Lupinus oreganus* (Figure 4). The corners of the plots are marked with rebar or red-tipped conduit posts. Plot 1 is 20 x 15 m, plot 2 is 25 x 16 m, plot 3 is 23 x 5 m, plot 4 is 35 x 11 m, and plot 5 is 9 x 7 m. In 2005 and 2006, we replaced three and one (respectively) missing pieces of rebar that had marked plot corners generally located in the center of the meadow. The cause of the rebar loss was not determined (possibilities include tampering by the public, mistaken removal by maintenance crews, or insecure position in the loose and rocky soil).

Plot sampling

Within each plot, we determined the abundance of *L. oreganus* and counted the number of mature and aborted inflorescences and butterfly eggs. Eggs were not counted in 2010. Individual *L. oreganus* plants are often indistinguishable from one another due to the species' rhizomatous growth habit. From 2003 – 2006, we determined abundance of *L. oreganus* by counting leaves (Menke and Kaye 2003, and Gisler and Kaye 2004b). In 2004 – 2007, we determined abundance by making estimations of foliar cover; each patch of *L. oreganus* was visually manipulated into a rectangular shape, of which we recorded the length and width. We used both leaf and cover measurements in 2005 and 2006. Beginning in 2007, we only used cover to estimate abundance in accordance with the Draft Recovery Plan for the Prairie Species of Western Oregon and Southwestern Washington (USFWS 2008).

Previous monitoring had included looking for eggs of butterfly species. The size and location of the eggs on the underside of *L. oreganus* leaves was consistent with the behavior of Fender's blue butterfly. Surveys for Fender's conducted by Paul Severns did not find any adults at Eagle's Rest; thus we have a high degree of confidence that eggs at Eagle's Rest on the underside of lupine leaves are likely Columbia silvery blue (*Glaucopsyche lygdamus Columbia*) or Bousdauval's blue (*Plebejus icarioides*) (C. Mayrsohn *personal communication*). Thus, monitoring for eggs was discontinued in 2010.

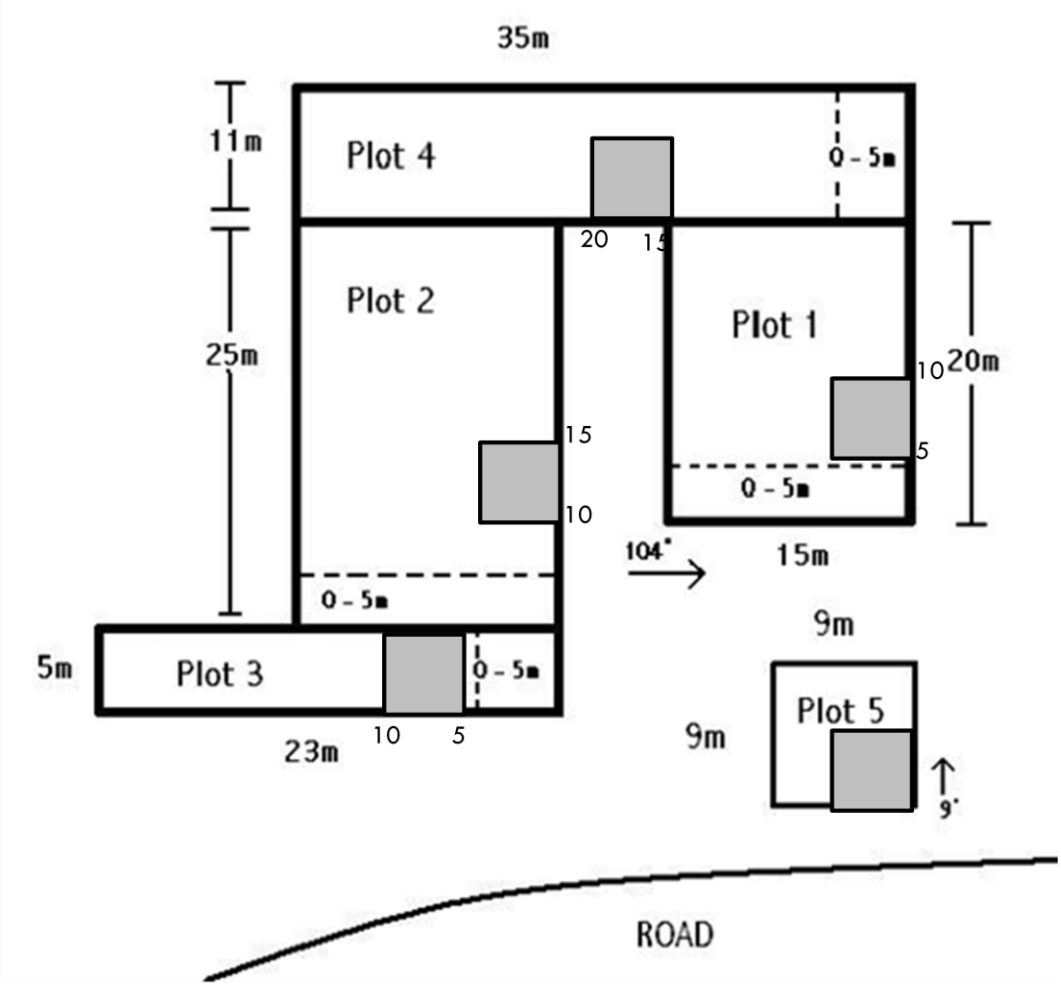

FIGURE 4. LAYOUT OF MONITORING PLOTS FOR *LUPINUS OREGANUS* AT EAGLE'S REST. DASHED LINES INDICATE ORIENTATION OF PLOT SECTIONS USED DURING SAMPLING. GREY SQUARES REPRESENT THE LOCATION OF THE 5M X 5M COMMUNITY PLOTS MONITORED IN 2012.

Baseline vegetation data

IAE collected baseline vegetation data within each of the five population monitoring plots in 2004 (Gisler et al. 2004a). Community composition was measured in 2012 in five 5m x 5m blocks (one per plot Figure 4).

Climate effects on *L. oreganus*

We used non-parametric multiplicative regression [NPMR; Hyperniche v. 2.0 (McCune and Mefford 2009)] to determine which climatic factors had the greatest impact on the number of inflorescences (mature and aborted), and the cover of *L. oreganus*. Climate data [monthly mean precipitation (in), monthly maximum precipitation (in), monthly average temperature (F), monthly minimum temperature (F), and monthly maximum temperature (F)] from 2003- 2012 were acquired from the Oregon Climate Service (Western Regional Climate Center 2008). Climate data were averaged into seasonal means (Winter= December-February, Spring = March-May, Summer= June-August, Fall=September-November) and were used as predictors for each model. NPMR uses a local multiplicative smoothing function with leave-one-out cross-validation to estimate the response variable. We used a Gaussian weighting function

with a local mean estimator in a forward stepwise regression of our response variable against the predictors, then expressed fit as a cross-validated R^2 (or xR^2). The xR^2 differs from the traditional R^2 because each data point is excluded from the basis for the estimate of the response at that point. Consequently, with a weak model, the residual sum of squares can exceed the total sum of squares and thus xR^2 becomes negative. Rather than fitting coefficients in a fixed equation, NPMR fits 'tolerances', the standard deviations used in the Gaussian smoothers. Predictors with narrow tolerances have greater effects on the model than do those with broad tolerances. Statistical significance of the whole model is evaluated using a randomization test, determining if the fit of the selected model is better than what would be expected by chance (McCune 2006).

RESULTS AND DISCUSSION

Evaluation of cover as an estimate of leaf number

The number of leaves and cover were highly correlated across all sites where we monitor *L. oreganus* (Table 2). At Eagle's Rest in 2005, we estimated 606 *L. oreganus* leaves per square meter of cover ($R^2 > 0.94$). In 2006, we determined there to be 404 leaves per square meter of cover ($R^2 > 0.92$; Thorpe and Kaye, 2006). This relationship is similar to that determined for three partially shaded populations in Douglas County (China Ditch, Stout's Creek, and Dickerson Heights; Menke and Kaye, 2006) and partially shaded patches at Oak Basin in the Coburg Hills of Lane County (Thorpe, 2007). We calculated that there were on average 515 leaves per meter square of foliar cover at sites characterized by sun to partial shade.

Evaluation of cover and inflorescence counts

The cover of *L. oreganus* has steadily increased since monitoring began in 2003 (Figure 5, Table 2). The dramatic increase in cover between 2011 and 2012 could be an artifact of sampling bias, future monitoring will elucidate the long-term trends of the foliar cover of this lupine population. The number of mature racemes increased from 142 in 2006 to 682 in 2008, declined to 425 in 2010 (Table 1). In 2011and 2012 the number of racemes increased to the second highest and highest number since monitoring began; however this may be an overestimate of mature inflorescences as some had not developed sufficiently to determine if they would continue to mature or abort. The relative percentage of aborted to mature inflorescences remained steady from 2003-2009 at ~25%, (with the exception of 2004 when ~4% of inflorescences were aborted). In 2010-2012 less than ~4% of inflorescences were aborted, however monitoring occurred early enough that it was not possible to determine if some racemes would be aborted.

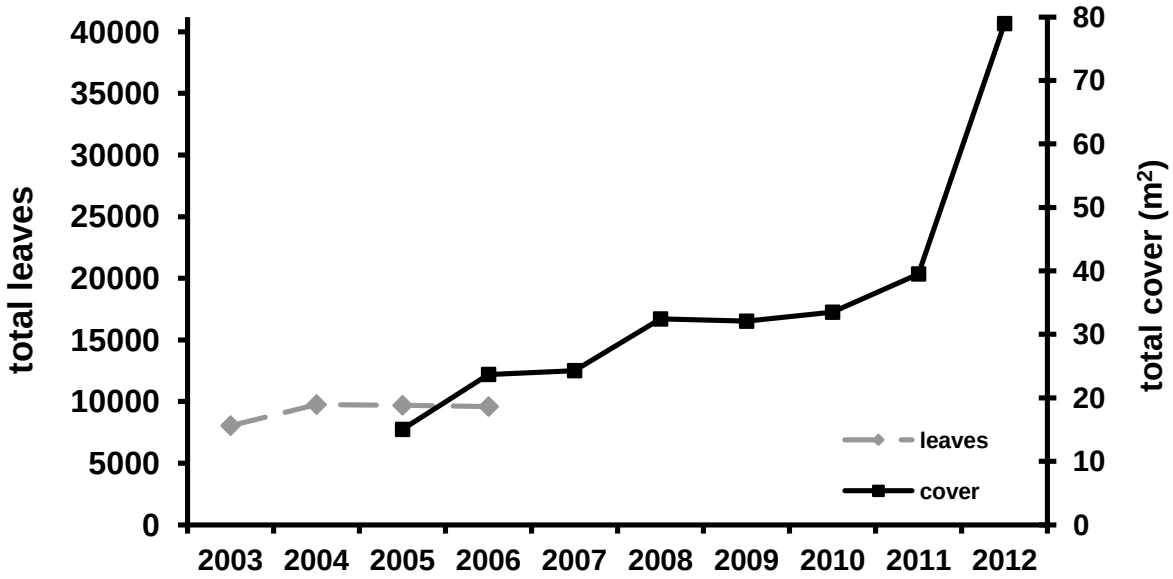

FIGURE 5. THE ABUNDANCE OF *L. OREGANUS* AT EAGLE'S REST, 2003-2012 TOTAL NUMBER OF LEAVES WAS COUNTED FROM 2003-2006 AND COVER WAS ESTIMATED FROM 2005-2012. THE SCALE BETWEEN THE TWO Y-AXES WAS DETERMINED USING THE RATIO BETWEEN LEAVES AND COVER AT ALL *L. OREGANUS* SITES CHARACTERIZED BY SUN TO PARTIAL SHADE: # LVS * 515 = COVER (M^2).

TABLE 1. RESPONSE VARIABLES USED IN CLIMATE MODELING OF *L. OREGANUS* AT EAGLE'S REST.

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Number of inflorescences	122	104	197	329	580	905	725	443	842*	995
Mature	51	100	136	142	399	682	546	425	-	993
Aborted	71	4	61	187	181	223	179	18	-	2
Total cover (m^2)	15.6	18.9	15.0	23.7	24.3	32.4	32.1	33.5	39.5	78.9

* Due to timing of monitoring in 2011 we were not able to determine which racemes would mature or aborted.

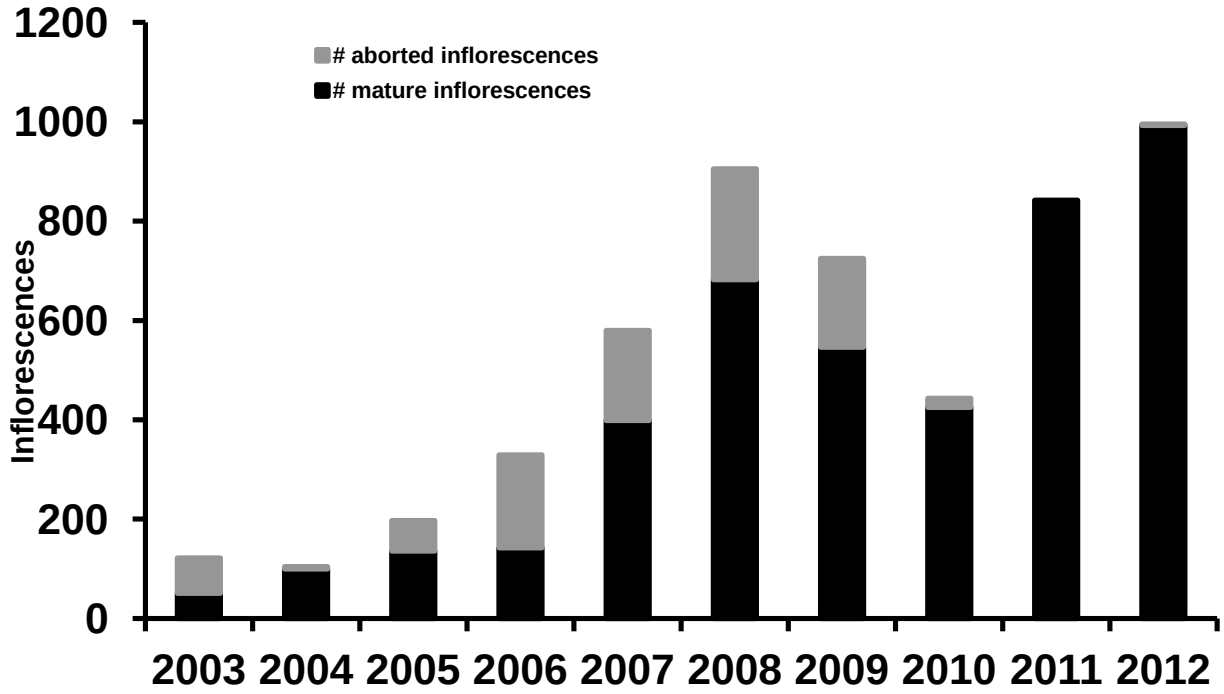

FIGURE 6. THE NUMBER OF ABORTED, MATURE, AND TOTAL *L. OREGANUS* RACEMES AT EAGLE'S REST, 2003-2012. *DUE TO THE MATURITY OF THE PLANTS, IN 2011 WE WERE UNABLE TO DETERMINE THE NUMBER OF ABORTED RACEMES.

Butterfly eggs

In spring 2010, Paul Severns determined that any butterfly eggs observed at the site were likely from either Columbia silvery blue (*Glaucopsyche lygdamus Columbia*) or Bousdauval's blue (*Plebejus icarioides*) (C. Mayrsohn, *personal communication*). The nearest extant population of Fender's blue butterfly can be found near Coburg, approximately 33 km away. The range for an adult Fender's blue butterfly is approximately 2km. Based on the absence of Fender's at this site and the distance to the nearest extant population, eggs are no longer counted at Eagle's Rest.

Vegetation Monitoring 2004 vs. 2012

In 2012 vegetation monitoring was performed in five 5m x 5m blocks (one per lupine monitoring plot). Baseline vegetation monitoring for the site occurred in 2004 and included the percent cover of species within each of the five lupine monitoring plots. The exact location of the plots monitored in 2004 was not noted thus community measurements in 2012 should not be considered direct comparisons. Plot locations in 2012 were selected for both ease of relocation and to be representative of the plot as a whole.

Vegetation data recorded in 2004 reflect the high quality of the native upland prairie habitat at Eagle's Rest. Of the 65 plant species present at the site, 51 (78%) are native species and only 14 are introduced (Appendix C). Overall, using summed means, native species exhibit 97.6% cover, whereas non-native species exhibit 34.2 % cover (note: total percent cover can exceed 100 percent due to the multi-layered, three-dimensional nature of vegetation growth). In 2012, 41 (81.3%) of the 60 plants observed were native with 81% native and 28% invasive. In 2012 the invasive forb *Leucanthemum vulgare* (ox-eye daisy) increased from an average cover of just 0.4% to 9.6% cover. In both 2012 and 2004, the dominant invasive species was *Cynosurus echinatus*. This grass, along with most of the remaining non-native species, are most abundant at the bottom of the Eagle's Rest site, near the paved road, within monitoring plots 3 and 5. Appendix C shows a complete list of native and non-native species present at the site, and their abundance within the 5 monitoring plots. Dominant native species (in both 2004 and 2012) include, *Danthonia californica, Eriophyllum lanatum, Bromus carinatus* and *Toxicodendron diversilobum* (Appendix C).

In addition to plant community information, the vegetation data collected in 2004 and 2012 demonstrate the efficacy of noxious weed control efforts implemented by BLM in 2003. Indeed, Scotch broom, which was once common throughout the site (Figure 3), is now completely absent from the vegetation sampling plots. Likewise, the infestation of Himalayan blackberry has been reduced such that it only occupies 4% in 2012 (2% in 2004) percent cover (within Plot 4). Although control efforts for these two species in 2003

were profoundly effective, BLM should maintain vigilance in their control efforts so these noxious weeds don't rebound within the site and eventually undermine the progress made in 2003.

Climate effects on *L. oreganus*

We modeled the response of total number of inflorescences (mature + aborted, 2003-2012), and cover (m^2) of *L. oreganus* from 2003-2012 using seasonal climatic predictors in NPMR. Models of mature and aborted inflorescences alone were not statistically significant but models for total inflorescences and total cover had fits that were better than expected by chance ($p < 0.10$). Response surfaces were not linear but did indicate trends regarding response variables (Figure 7, Figure 8). Total number of inflorescences was best explained by decreasing summer minimum temperature (tolerance = 1.5) and increasing fall precipitation (tolerance = 0.81; $xR^2 = 0.94$, Figure 7). Total cover was best explained by increasing winter minimum temperature (tolerance = 2.6) and increasing fall precipitation (tolerance = 0.81; $xR^2 = 0.64$, Figure 8). These results differ from models in 2011 where spring precipitation was an important predictor in explaining total cover of *L. oreganus* and number of mature inflorescences (Giles-Johnson et al. 2011). These differences could be due to the large increase in total cover observed in 2012.

These data suggest that climate affects growth and development of *L. oreganus* at Eagle's Rest. A wet fall was an important predictor for both number of inflorescences and total cover for *L. oreganus* at Eagle's Rest. Total number of inflorescences was predicted by a wet fall followed by a mild summer, and total cover was predicted by a wet fall followed by a mild winter. Wet and moderate conditions during development seem to play an important role in this species developing mature inflorescences. Our models only test for effects of climatic factors on the growth and development of *L. oreganus* at Eagle's Rest; additional environmental factors could also affect development and growth of this species. The ability to differentiate between mature and aborted inflorescences is dependent on the timing of sampling and phenology of the species.

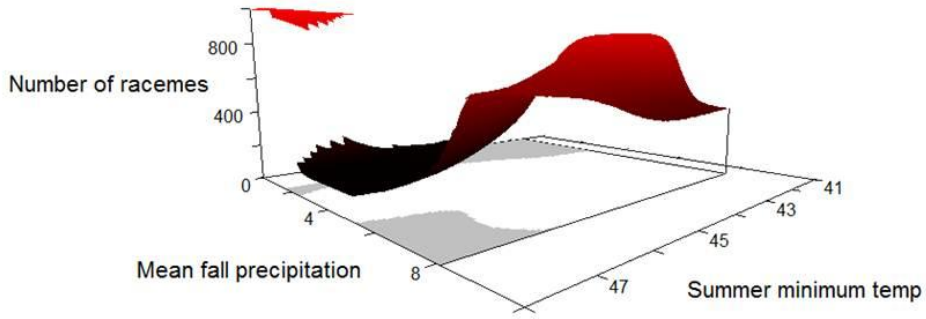

FIGURE 7. RESPONSE SURFACE OF A NPMR MODEL FOR THE NUMBER OF INFLORESCENCES OF *L. OREGANUS* FROM 2003-2012 AT EAGLE'S REST. AREAS IN GREY INDICATE A LACK OF DATA FOR THOSE PREDICTOR VALUES.

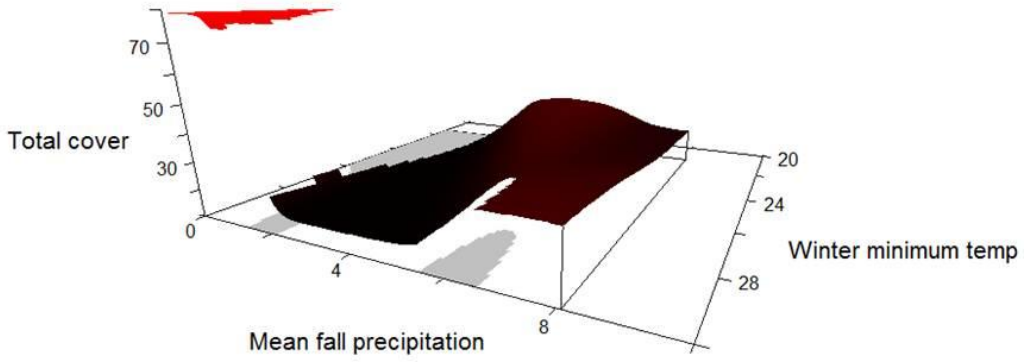

FIGURE 8. RESPONSE SURFACE OF AN NPMR MODEL FOR TOTAL COVER OF *L. OREGANUS* FROM 2003-2012 AT EAGLE'S REST. AREAS IN GREY INDICATE A LACK OF DATA FOR THOSE PREDICTOR VALUES.

ORV use of the site

Monitoring at Eagle's Rest in 2003 noted off-road vehicle use that damaged some *Lupinus oreganus* (85 leaves and 2 racemes; Kaye and Brandt 2004). The threat of continued ORV use led to the placement of boulders at the foot of the slope to discourage easy access to the site. No additional evidence of ORV traffic or damage to *L. oreganus* has been observed.

RECOMMENDATIONS

While the increase in total *Lupinus oreganus* cover between 2005 and 2012 suggests a stable population and even increasing lupine population, the relatively small size of this site and the population make it susceptible to damage (for example, the ORV damage in 2003). We suggest that population monitoring continue on a semi-annual basis in order to detect any population declines. Continued monitoring will also be valuable for gaining sufficient data to determine the role of climate in driving variability in reproduction. We also suggest that future monitoring efforts include surveying for Fender's blue butterfly.

Plant community surveys in 2003 and 2004 determined the quality of the prairie habitat to be relatively high. Observations in the past few years suggest that cover of some invasive species (including oxeye daisy [*Leucanthemum vulgare*] and exotic grasses) has increased. We recommend a plant community survey following the methods used in 2012 be performed in conjunction with lupine measurements to detect vegetation changes at the site. Particular attention should also be given for assessing if Himalayan blackberry (*Rubus armeniacus*) and Scotch broom (*Cytisus scoparius*), which were removed in 2003, have reinvaded. Additional assessment of the degree of invasion of *Leucanthemum vulgare* should be also be performed and criterion for action established.

TABLE 2. SITE, YEAR OF OBSERVATION, HABITAT TYPE, SCALE OF OBSERVATION, SAMPLE SIZE, REGRESSION COEFFICIENT (PROPORTION OF VARIANCE IN LEAF NUMBER EXPLAINED BY FOLIAR COVER, R^2), AND SLOPE OF THE RELATIONSHIP BETWEEN LEAF NUMBER AND COVER AT ELEVEN SITES OF *L. OREGANUS* FROM LANE AND DOUGLAS COUNTIES. "WEW" INDICATES LUPINE POPULATIONS IN THE WEST EUGENE WETLANDS.

Site	year	Habitat	size of sample unit	n	R^2	slope (leaves/m^2)
Lane County						
Fir Butte (WEW)	2004	full sun	200 m^2	36	0.97	986
	2005			36	0.91	767
Oxbow (WEW)	2004	full sun	1 m^2	225	0.93	925
	2005			197	0.87	844
Isabelle (WEW)	2005	full sun	≤2 m^2	154	0.88	907
Turtle Swale (WEW)	2005	full sun	1 m^2	116	0.87	790
Eagles Rest	2005	sun to partial shade	15 - 75 m^2	20	0.97	606
	2006			17	0.94	404
Oak Basin	2007	sun	variable	18	0.89	659
	2007	partial shade		27	0.64	497
Douglas County						
China Ditch	2005	sun to partial shade	10 to 45 m^2	48	0.623	569
	2006			48	0.74	606
Stout's Creek	2005	sun to partial shade	variable	68	0.623	444
	2006			82	0.81	429
Dickerson Heights	2005	sun to partial shade	10 m^2	28	0.71	424
	2006			34	0.88	521
Loose Laces	2005	partial shade	1 to 40 m^2	76	0.73	415
	2006			37	0.91	357
Letitia Creek	2005	partial shade	100 m^2	22	0.75	380
Callahan Meadows	2005	partial shade	2 m^2	24	0.75	291
	2006			42	0.92	357

LITERATURE CITED

Giles-Johnson, Denise E.L., E.C. Gray, A.S. Thorpe, and T.N. Kaye. 2011. Population monitoring for *Lupinus oreganus* (Kincaid's lupine) at Eagle's Rest. Prepared by the Institute for Applied Ecology for the USDI Bureau of Land Management, Eugene District. Corvallis, Oregon. iii + 11.

Gisler, S., Kaye, T.N., and A. Brandt. 2004a. Population monitoring for Kincaid's lupine (*Lupinus sulphureus* ssp. *kincaidii*) at Eagle's Rest. Prepared by the Institute for Applied Ecology for the USDI Bureau of Land Management, Eugene District. Corvallis, OR. iii + 15.

Gisler, S., and T.N. Kaye. 2004b. Population monitoring for *Lupinus sulphureus* ssp. *kincaidii* at the Fir Butte and Oxbow West Sites, West Eugene. Prepared by the Institute for Applied Ecology for the USDI Bureau of Land Management, Eugene District. Corvallis, OR. iv + 28.

Kaye, T.N. 1999. Obligate insect pollination of a rare plant, *Lupinus sulphureus* ssp. *kincaidii*. Northwest Science 73:50-52.

Kaye, T.N. and A. Brandt. 2004. Population monitoring for *Lupinus sulphureus* ssp. *kincaidii* at Eagle's Rest, 2003 Progress Report. Prepared by the Institute for Applied Ecology for the USDI Bureau of Land Management, Eugene District. Corvallis, OR. iii + 11.

McCune, B. 2006. Non-parametric habitat models with automatic interactions. *Journal of Vegetation Science* 17: 819-830.

McCune, B., and Mefford, M. J. 2009. HyperNiche. Nonparametric Multiplicative Habitat Modeling. Version 2.0. MjM Software, Gleneden Beach, Oregon, U.S.A.

Menke, C.A. and T.N. Kaye. 2003. Population monitoring and survey for *Lupinus sulphureus* ssp. *kincaidii* on the BLM Roseburg District. Prepared by the Institute for Applied Ecology for the USDI Bureau of Land Management, Roseburg District. Corvallis, OR. vii + 84.

Menke, C.A. and T.N. Kaye. 2006. Population monitoring for *Lupinus sulphureus* ssp. *kincaidii* on the BLM Roseburg District. Prepared by the Institute for Applied Ecology for the USDI Bureau of Land Management, Roseburg District. Corvallis, OR. vi + 48.

Thorpe, A.S. and T.N. Kaye. 2006. Population monitoring for *Lupinus sulphureus* ssp. *kincaidii* at Eagle's Rest, 2006 Progress Report. Prepared by the Institute for Applied Ecology for the USDI Bureau of Land Management, Eugene District. Corvallis, OR. iv + 11.

Thorpe, A.S. 2007. *Lupinus sulphureus* ssp. *kincaidii* (Kincaid's lupine) and *Icaricia icarioides fenderi* (Fender's blue butterfly) at Oak Basin. 2007 Progress Report. Prepared by the Institute for Applied Ecology for the USDA Bureau of Land Management, Eugene District. Corvallis, OR. 32 pp.

Western Regional Climate Center. 2008. Trout Creek Oregon (RAWS), Monthly Climate Summary: 2003-2011. Available at: http://www.wrcc.dri.edu/cgi-bin/wraws/orF.html. Accessed February 11, 2012.

APPENDIX A. DIRECTIONS AND GEAR LIST

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Directions to Eagle's Rest:
From Corvallis, take I-5 South to Hwy 58. Drive 10.9 miles east on Hwy 58 going through Pleasant Hill. At Dexter Reservoir, turn right onto Lost Creek Road, proceed for 3.7 miles, then turn left onto Eagle's Rest Road (19-1-33.1). Continue 3.8 miles up Eagle's Rest Road to the field site, parking at a pullout just beyond the open meadow. To avoid creating an obvious trail from the main road, enter the site on foot along the forest edge rather than straight up through the meadow. Refer to Figures 2 and 3 and the following map.

Gear List:
Last Year's Report
Last Year's Datasheets
Blank datasheets, some write-in-the-rain
Community data from 2004 and 2012
Community datasheets
ID books
Clipboards/pencils
Maps/gazetteer
3 Tapes, at least one 100m
5 Candy canes
Rulers- one per person
Flagging
4-5 rebars, mallet and pin flags to replace lost/bent rebars
Compass
Health and Safety box
Extra water

Eagle's Rest:
Park at the star and follow the trail through the woods. (Do not walk directly into the meadow from the road! We want to keep people out!)

APPENDIX B. EXAMPLE DATA SHEET

APPENDIX B. LUPINE MONITORING DATASHEET.

Lupinus oreganus monitoring at Eagle's Rest

Name:_____
Date:_____

Plot	subplot	Leaves	Inflorescences		Eggs	cover	notes
			Mature	Aborted			
1	0-5m						plot measured uphill
1	5-10m						
1	10-15m						
1	15-20m						
2	0-5m						plot measured uphill
2	5-10m						
2	10-15m						
2	15-20m						
2	20-25m						
2	Outside						

Plot	subplot	Leaves	Inflorescences		Eggs	cover	notes
			Mature	Aborted			
3	0-5m						
3	5-10m						
3	10-15m						
3	15-20m						
3	20-23m						
3	Outside						Below plot at 10 m?
4	0-5m						plot measured right to left
4	5-10m						
4	10-15m						
4	15-20m						
4	20-25m						
4	25-30m						
4	30-35m						
5	whole plot						

APPENDIX C. COMMUNITY DATA

APPENDIX C. COMMUNITY DATA COLLECTED IN 2004 AND 2012.

In 2004 the cover of litter, moss and rock was not recorded. Because the precise location of the monitoring plots in 2004 is not known, the 2012 community data should not be considered directly comparable. Invasive species are listed in bold.

Species	Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		2004 average	2012 average
	2004	2012	2004	2012	2004	2012	2004	2012	2004	2012		
Litter	-	30	-	40	-	95	-	80	-	50	-	59
Moss	-	60	-	45	-	0.1	-	10	-	40	-	31.02
Rock	-	0.2	-	0.2	-	0	-	2	-	2	-	0.88
Bare Ground	3	2	4	1	2	0.1	1	1	8	1	-	1.02
Achillea millefolium	1	0.1	0.1	0.1	0.1	2	0.1	0.1	0.7	3	0.4	1.06
Aira caryophyllea	4	0.1	1	0	1	0.2	0	0.1	20	0.1	5.2	0.1
Arabis sp.	0	0	0.1	0	1	0	0	0	0	0	0.22	0
Aster radulinus	0	0	0	0.1	0	0	0.5	0.1	0	0	0.1	0.04
Berberis aquifolium	0	0	0	0	0	0	0.1	0	0	0	0.02	0
Brodiaea congesta	0.1	0	0.1	0	0.1	0	0	0	0.1	0	0.08	0
Bromus carinatus	50	10	70	15	3	3	2	25	15	20	28	14.6
Bromus hordeaceus	0	0	0	0	0	0	0	0	0	1	0	0.2
Calochortus tolmei	0.1	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.12	0.14

Species	Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		2004 average	2012 average
	2004	2012	2004	2012	2004	2012	2004	2012	2004	2012		
Castilleja hispidula	0.1	0	0.1	0	0.1	0.2	0	0.2	0.1	0.1	0.08	0.1
Centaurium erythrea	0	0.1	0	0	0	0	0	0.3	0	0	0	0.08
Cerastium arvense	0	0	0	0	0	0	0	0	0.1	0	0.02	0
Cirsium callilepis	0.5	0	0.1	4	0	0.5	0.1	0	0	0	0.14	0.9
Clarkia sp.	0.1	0	1	0	2	0	0	0.1	1.5	0.5	0.92	0.12
Clinopodium douglasii	0	0	0	10	0	0	0	5	0	0	0	3
Collomia heterophylla	0	0	0.1	0	0	0	0.1	0	0	0	0.04	0
Cryptantha intermedia	8	0	3	0	1	0	0.1	0	4	0	3.22	0
Cuscuta sp.	0.1	0	0	0	0	0	0	0	0	0	0.02	0
Cynoglossum sp.	0	0	0	1	0	0	0	0.2	0	0	0	0.24
Cynosurus echinatus	3	2	3	0.2	80	50	0	3	50	16	27.2	14.24
Danthonia californica	1	2	8	20	2	4	0.5	6	2	4	2.7	7.2
Daucus carota	0.1	0	0.1	0	0.1	0.2	0	0.2	0.2	1	0.1	0.28
Daucus pusillus	0	0	0	0	2	0	0	0	2	0	0.8	0
Dianthus armeria	0.1	0	0.1	0.1	0	0.1	0	0.1	0	0	0.04	0.06
Dichelostemma congesta	0	0	0	0.1	0	0.1	0	0.1	0	0.1	0	0.08
Elymus glaucus	3	0.1	2	10	0.1	0.1	0.5	1	0.1	0.5	1.14	2.34
Epilobium sp.	0	0.1	0	0	0	0	0	0	0	0	0	0.02

Species	Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		2004 average	2012 average
	2004	2012	2004	2012	2004	2012	2004	2012	2004	2012		
Eriophyllum lanatum	30	45	12	2	8	12	3	4	10	14	12.6	15.4
Erodium cicutarium	0	0	0	0	0	0	0	0	0.1	0	0.02	0
Euphorbia sp.	0	0	0.1	0.1	0	0	0	0	0	0	0.02	0.02
Festuca arundinacea	0	0	0	0	0	0	0	0	0	8	0	1.6
Festuca californica	0	0	0	0	0	0	80	0	0	0	16	0
Festuca roemerii	4	2	1	0	5	4	0	0	8	16	3.6	4.4
Fragaria vesca	1	0	7	12	0	0	2	8	0	0	2	4
Galium parisiense	0	0	0.1	0	0	0	0.1	0	4	0	0.84	0
Gilia capitata	0.1	0	0	0	0	0	0	0	0	0	0.02	0
Holodiscus discolor	0	0	0	0	0	0	0	0.1	0	0	0	0.02
Hypericum perforatum	0.1	0.1	0.1	0	0.1	0.1	0.1	0.1	1	0	0.28	0.06
Hypochaeris radicata	0	0	0	0	0	0	0	0.1	0	0	0	0.02
Iris tenax	0	0	0	0	0	0	0.1	0.2	0	0	0.02	0.04
Koeleria macrantha	2	0	2	0	0.5	0.1	0	0	2	1	1.3	0.22
Lathyrus nevadensis	0	0	0.1	0	0	0	0.1	0	0	0	0.04	0
Leucanthemum vulgare	1	40	1	4	0	0	0	4	0.1	0.1	0.42	9.62
Linum bienne	0	0.1	0	0	0	0.1	0	0	0	0	0	0.04
Linum perenne	0.1	0	0	0	0.1	0	0	0	0.1	0	0.06	0

Species	Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		2004 average	2012 average
	2004	2012	2004	2012	2004	2012	2004	2012	2004	2012		
Lomatium utriculatum	0.1	0	0	0	0.1	0	0	0	0.5	0	0.14	0
Lonicera sp.	0	0	0	0	0	0	0	0.1	0	0	0	0.02
Lotus corniculatus	0	0	0	0	0	0	0.1	0	0	0	0.02	0
Lotus micranthus	0.1	0	0	0	0.1	0	0	0	1	0	0.24	0
Lotus micranthus Benth.	0	0.2	0	0.1	0	0	0	0.1	0	0.1	0	0.1
Lupinus oreganus	7	9	0.5	0.1	2	1	16	6	1	1	5.3	3.42
Luzula comosa	0.1	0	0	2	0	0.1	0	0.1	0	0	0.02	0.44
Madia glomerata Hook.	0	0	0	0	0	0	0	0.2	0	0.1	0	0.06
Madia gracilis	0.1	0	0	0	0.1	0	0	0	5	0	1.04	0
Madia sp.	0	0	0	0	0	0	0	0.2	0	0	0	0.04
Microseris sp.	0	0.1	0	0.1	0	0	0	0.1	0	0	0	0.06
Osmorhiza chilensis	0	0	0	0.1	0	0	0.1	0	0	0	0.02	0.02
Phleum pratense	0	0	0	1	0	0	0	0	0	0	0	0.2
Phlox subulata	0	0	0	0	0	0	3	0	0	0	0.6	0
Plagiobothrys sp.	0	0.1	0	0.1	0	0	0	0.1	0	0	0	0.06
Plectritis congesta	0	0	0	0	0	0	0	0	0	0	0	0
Polystichum sp.	0	0	0	0	0	0	0	1	0	0	0	0.2
Prunella vulgaris	0	0.2	0	0	0	0	0	25	0	0	0	5.04

Species	Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		2004 average	2012 average
	2004	2012	2004	2012	2004	2012	2004	2012	2004	2012		
Ranunculus occidentalis	0.1	1	2	0	1	4	0	0.2	2	0.5	1.02	1.14
Rosa gymnocarpa	0	0	0	0	0	0	0.5	0	0	0	0.1	0
Rubus armeniacus	0	0	0	0	0	0	2	4	0	0	0.4	0.8
Rubus ursinus	0	0	0	0	0	0	1	0	0	0	0.2	0
Rupertia physodes	0.1	0	0	0	0	0	5	8	0	0	1.02	1.6
Sanicula bipinnatifida	0.1	0.2	0.1	0	0.1	6	0	0.3	0	1	0.06	1.5
Sanicula crassicaulis	**0**	0.1	0.1	3	0.1	0	0.1	0.1	0.4	0	0.14	0.64
Satureja douglasii	0.5	0	2	0	0	0	4	0	0	0	1.3	0
Senecio jacobaea	0.1	0	0.1	2	0	0	0	0	0	0	0.04	0.4
Silene antirrhina	0	0	0	0	0	0	0	0	0.1	0	0.02	0
Silene sp.	0	0	0.1	0	0.1	0	0	0	0	0	0.04	0
Sisyrinchium bellum	0	0	0.1	0.1	0	0	0	0	0	0	0.02	0.02
Sonchus asper	0	0	0	0	0	0	0	0.1	0	0	0	0.02
Symphoricarpos albus	0	0	0	0	0	0	0.1	0	0	0	0.02	0
Synthyris reniformis	0	0.1	0	4	0	0	1	0.1	0	0	0.2	0.84
Taraxacum officinale	0	0	0	0	0	0	0	0.2	0	0	0	0.04
Toxicodendron diversilobum	0.5	10	0	12	5	12	12	4	3	3	4.1	8.2
Trifolium microcephalum	0	0	0	0	0	0	0	0	0.2	0	0.04	0

Species	Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		2004 average	2012 average
	2004	2012	2004	2012	2004	2012	2004	2012	2004	2012		
Triodanis perfoliata	**0**	0	0.1	0	1	0	0	0	0.3	0	0.28	0
Veronica americana	0	0	0	0	0	0.1	0	0.1	0	0	0	0.04
Vicia americana	0.1	0	0.1	0	0.1	0.1	0.1	0.1	0.1	0	0.1	0.04
Vicia sativa	0	0.1	0	0.1	0.1	0.2	0	0.1	0	0.5	0.02	0.2
Whipplea modesta	0	0	0	1	0	0	0	1	0	0	0	0.4
Wyethia angustifolia	16	0	16	16	0	0	5	1.5	0	0	7.4	3.5
Zigadenus venenosus	0.1	0	0	0	0	0	0	1	0	0	0.02	0.2
Species Totals	**134.5**	**123.1**	**133.5**	**120.5**	**116.1**	**100.3**	**139.5**	**111.8**	**134.9**	**91.7**	**131.7**	**109.48**
										Count Native	51	41
										Count Invasive	14	19
										Total # of Species	65	60