Oak habitat mapping and monitoring in the southern Eugene Ridgeline

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Environmental Leadership Program
University of Oregon

A mapping and monitoring project in partnership with:
The City of Eugene Parks and Open Space Division

PREFACE

This report is the result of a cooperative mapping and monitoring project between the Environmental Leadership Program (ELP) at the University of Oregon (UO) and the City of Eugene Parks and Open Space Division (POS). The ELP is an interdisciplinary program that promotes learning through service to the community. The program links teams of undergraduate students with nonprofit organizations, government agencies and businesses to address local environmental issues. Definitions of select terms are provided in the Glossary, Appendix A.

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CITATION

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ABSTRACT

The prevention of fire regimes, in combination with increasing urbanization, has led to a drastic decline in woodland oak habitats over the past 150 years in the Pacific Northwest. Currently, less than 2% of pre-European settlement oak habitat remains in the Southern Willamette Valley. Oak habitats are home to a wide range of rare plants and animals. As a result, the City of Eugene made conserving oak habitats one of their top priorities. As members of the Ridgeline Oaks Team, we collected data within these native oak habitats to help the City of Eugene implement a future management plan and protocol. We compared the accuracy of previous habitat delineations to the data we collected in the field and found that the former habitat delineations were only 55% accurate. We collected baseline data as well as data on heritage trees, which are mature trees that are important for their ecological and historical value. We also modified the protocol to adapt to the conditions in the field and improve efficiency.

MISSION STATEMENT

The mission of the Ridgeline Oaks Team is to assist the City of Eugene's management of natural areas through the collection of ecological data in order to preserve remaining oak habitats.

CHAPTER 1: INTRODUCTION

1.1 History

The first Euro-American pioneers arriving in the Willamette Valley found themselves in an environment so scarce in trees that "early land surveyors had to build rock piles to mark section corners instead of using traditional witness trees" (Vesely et al., 2004). This environment was a result of active land management by the Kalapuya Indians who deliberately set periodic fires to the native grassland to maintain the oak savanna habitat that provided the bulk of their food supplies.

Upon colonization of the area, settlers ended the Kalapuya fire regime because it was viewed as a threat to their crops and wood supply (Vesely et al., 2004). One hundred and fifty years after the end of widespread burning, the majority of oak savanna and its associated prairies were degraded to a fraction of historic levels. The three main causes of this oak habitat decline are conifer encroachment, urbanization, and agricultural development.

Fire propagated by the Kalapuya historically killed off most of the young conifer saplings that were growing on the valley bottom. Once the fire regime ended conifers such as Douglas-firs, which grew taller and faster than oaks, over-topped, shaded and eventually killed off oak trees and their ecosystems. Oaks that were once dominant were out-competed by conifers. This factor, in combination with urbanization and agricultural development led to the decline of the oak habitats in the Willamette Valley, as demonstrated in Figure 1. The oak habitats that remain represent only 1.5% of the historic levels that would have been found in this area (Lane Council of Governments, 2008).

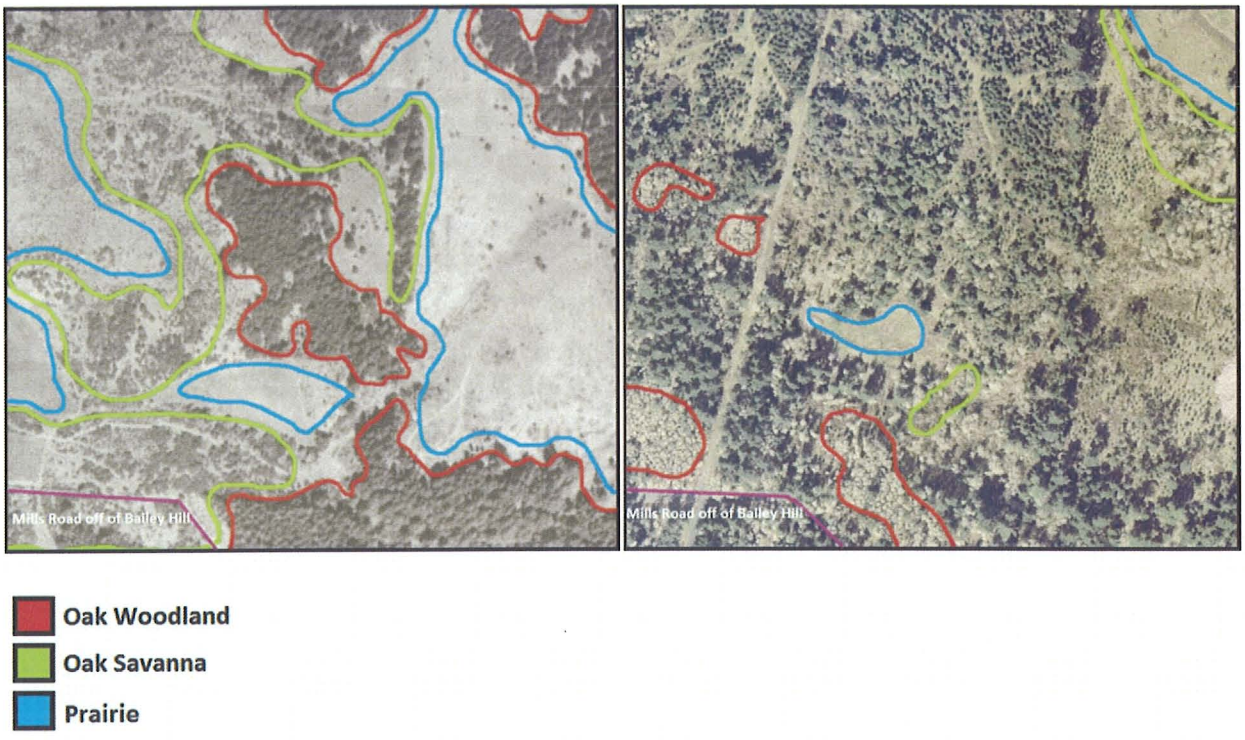

Figure 1. Oak habitat decline from 1936 (left) to 2009 (right) in southern Eugene

1.2 Importance of habitats

Figure 2. Oregon Wild Iris

Oak habitats in the southern Willamette Valley are home to more than 200 species of native wildlife (Vesely, 2004). The degradation and loss of this habitat has negatively impacted the unique species that resided in this ecosystem for thousands of years. In addition to providing ample shade during the summer, oak trees are a major contributor to the food chain in their surrounding ecosystem. They host a diverse insect community and provide important habitat for migratory birds. Oak trees in riparian zones also reduce water temperatures and improve stream quality for fish (Vesely, 2004). Birds and mammals use tree cavities as a home and for mating purposes. With the proliferation of conifer habitat, plants and animals that were suited to the open spaces were unable to flourish in shady conifer forests. Furthermore, because oak habitats are so unique, they provide exceptional recreational opportunity for people living in the Willamette Valley.

Table 1. Species associated with oak habitats (Vesely et al., 2004)

Taxonomic group	Oak woodland species	Oak savanna species
Amphibians	salamander, red-legged frog	long-toed salamander, Pacific tree frog
Reptiles	western skink, ring-necked snake, sharptail snake, rubber boa	western fence lizard, gopher snake, northwestern garter snake
Birds	white-breasted nuthatch, western wood-peewee, Merriam's wild turkey, northern pygmy-owl	American kestrel, western bluebird, savanna sparrow, western meadowlark
Mammals	vagrant shrew, western gray squirrel, coyote, blacktail deer	long-eared myotis, Botta's pocket gopher, brush rabbit

1.3 City of Eugene and land acquisition

The City of Eugene has engaged in property acquisition and management of oak habitats for over seventy years. After major fund-raising efforts, the City purchased the first piece of land containing oak habitats, Spencer Butte, in 1940. Other major acquisitions took place in 1970, 1995, 1998, and 2007. Currently, the City manages approximately 1,100 acres of land in the Ridgeline system in the hills of South Eugene. This is only a fraction of the existing oak habitats remaining in Eugene. Not only is the City interested in protecting these habitats, it aims to create recreational opportunities for community members, build on the Ridgeline Trail for hiking and wilderness opportunities, create a buffer between the City and the country, maintain clean water and air, create connective wildlife corridors, create educational resources for nearby schools, create possible business opportunities, and more (Lane Council of Governments, 2008). In 2008, the City created the *Ridgeline Area Open Space Vision and Action Plan*, which highlights existing conditions and lays out plans for future management and protection (Lane Council of Governments, 2008). The City of Eugene plans to maintain the beautiful and ecologically critical natural oak areas surrounding Eugene.

1.4 The Ridgeline Oaks Team Project

Figure 3. The Ridgeline Oak Team (from left to right: Kimmy Ertel, Alexi Russell, Alex Park, Matt Silva, Brittany Bigalke and Matt Liston)

In order to provide a hands-on environmental monitoring opportunity for university students and to supplement the POS' data collection needs, the University of Oregon's Environmental Leadership Program (ELP) created the Ridgeline Oaks Team. We worked in conjunction with POS to collect ecological data pertinent for oak habitat management strategies. We collected data on trees, ground vegetation, tree cover, wildlife, and other habitat indicators. This data is important to POS, allowing them to prioritize which areas need restoration, protection and management.

Goals

1) Collect ecological data in oak habitats in order to assist the City of Eugene in prioritizing management, protection, restoration and enhancement of these areas.
2) Determine the accuracy of current GIS-based habitat designations and modify them based on data collected in the field (ground-truthing)
3) Assist in the development of an effective monitoring protocol to be potentially used by both volunteers and City staff in the future.

Pilot Project

Our project protocol was created and designed specifically for mapping and monitoring in the Ridgeline. ELP Co-Director Peg Boulay and POS Restoration Ecologist Emily Steel designed the protocol. As part of our project, we tested the methods outlined by the protocol. Through this process, we adapted the protocol and made changes as needed in order for future use and implementation.

Heritage Trees

A major focus of this project was collecting data on heritage trees throughout the sites located in the Ridgeline system. Heritage trees are mature trees that were older than the surrounding forest. To be categorized as a heritage tree, a tree had to breach a certain trunk diameter measured at breast height (DBH). Heritage trees are important to oak ecosystems because they provide essential habitat for wildlife. Heritage trees also provide a historic example of what the southern Willamette Valley used to consist of. These large trees increase diversity of native insect populations, mosses and lichens, act as an important food source for wildlife, and maintain ecological processes (Vesely et al., 2004). Heritage trees that are found in the Ridgeline include Ponderosa Pines, Douglas-firs, California Black Oaks, Oregon White Oaks, Bigleaf Maples and Pacific Madrones. These large trees are the remaining pieces of Oregon's natural heritage. Because of their historical ecological value, the City of Eugene has made it a high priority to preserve heritage trees.

Ground-truthing

POS provided us with two Geographic Information Systems (GIS) layers: the South Ridgeline Habitat Study (SRHS) and the Ridgeline Oak-Prairie (ROP) habitat study. The SRHS layer was originally developed for regional-scale habitat categorization in 2000 for the southern Willamette Valley. In 2007, the layer was adapted by the City of Eugene to inventory and assess habitat. By converting a regional survey to a more focused, localized habitat assessment there was an inherent loss of accuracy; the larger habitat designations of the regional survey did not reflect more specific habitat delineations that the City was interested in. SRHS placed varying habitat into one designation. Conversely, ROP was designed to identify current and former oak and prairie habitats in order to focus conservation efforts. The ROP habitat study delineated more specific individual habitat types, which resulted in a more accurate layer. Using a Wild Iris stand as an example, Figures 4 and 5 provide an example of how the larger habitat designations of SRHS reduced accuracy of the layer, while ROP subdivided the larger polygon into smaller areas. Our goal was to make habitat designations based on data we collected on the ground and then compare our habitat designations with those of the two previous habitat studies.

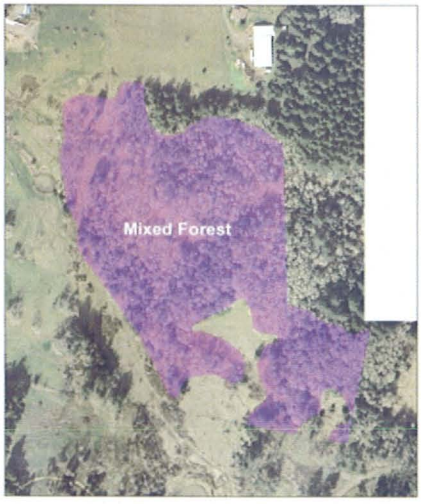

Figure 4. SRHS habitat delineation at Wild Iris Ridge

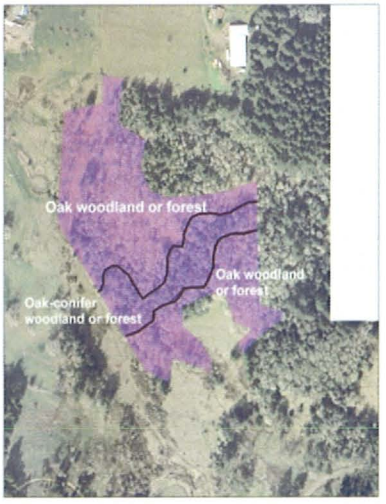

Figure 5. ROP habitat delineation at Wild Iris Ridge

CHAPTER 2: SITES

We collected data at three sites within the Ridgeline: Mariposa, Blanton Ridge and Wild Iris Ridge, as shown in Figure 6.

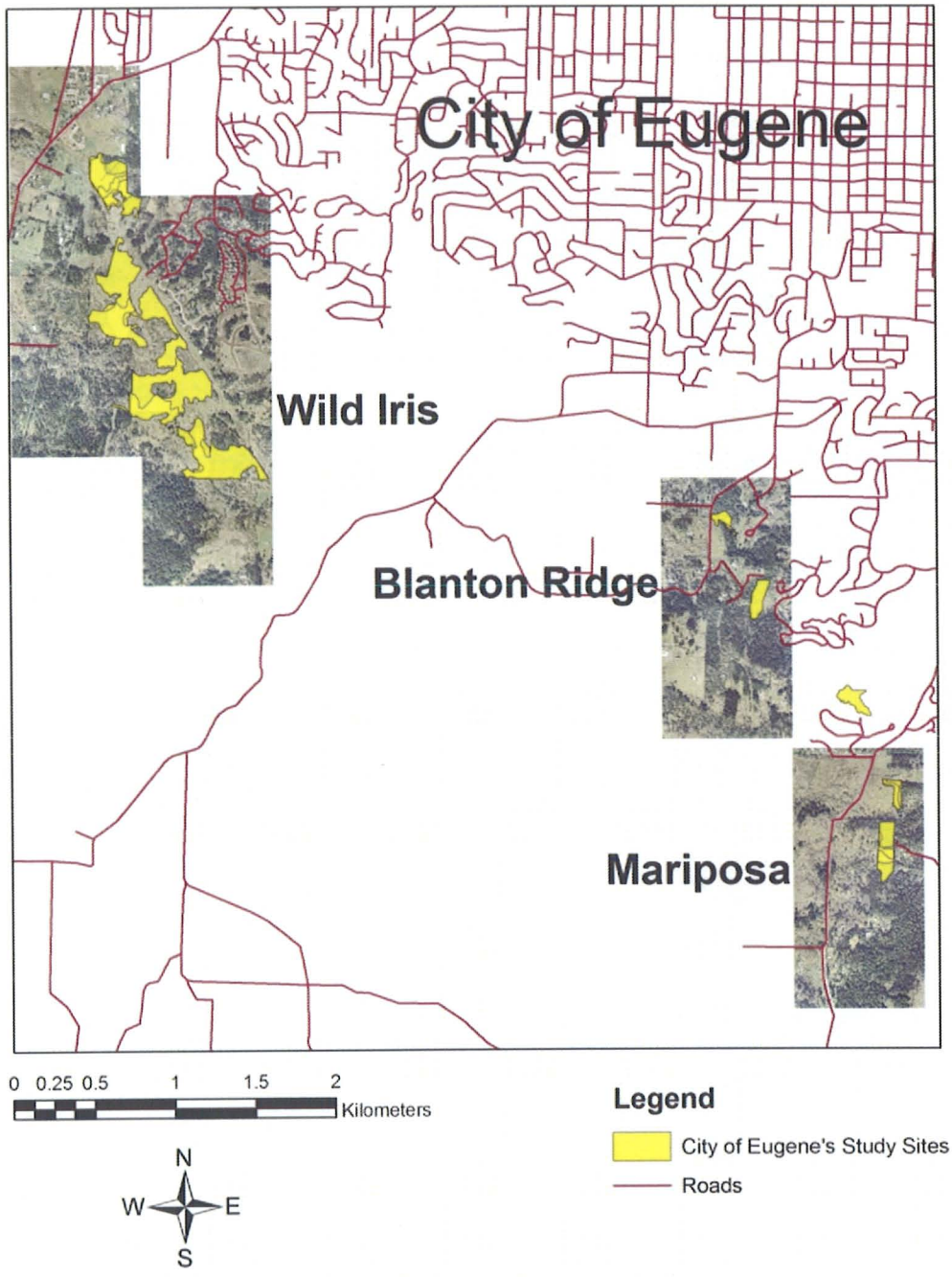

Figure 6. ELP study site locations

2.1 Mariposa

The Mariposa Woodland is located in South Eugene near Spencer's Butte. The site is a narrow half-mile long corridor totaling 29.5 acres. This section of the ridgeline is important to the City for two reasons: it contains a large segment of the Ridgeline Trail and it contains many key habitats such as oak-conifer woodland, savanna, and prairie. This land contains many large heritage trees, some which are more than five hundred years old. In addition, Mariposa has high quality ground vegetation that contains many native grasses and flowers. Shown in Figure 7 is a picture taken at one of the plots within Mariposa.

Figure 7. Mariposa photopoint

2.2 Blanton Ridge

Blanton Ridge contains many healthy oak habitats, which are a high priority for preservation by the City of Eugene. The extensive Blanton Trail, part of the larger Ridgeline Trail, leads to beautiful vistas overlooking Eugene, which provide for many recreational opportunities. This site is home to varied oak and conifer forests (see Figure 8) with native wildlife and diverse vegetation.

Figure 8. Blanton Ridge photopoint

2.3 Wild Iris Ridge

Wild Iris Ridge is a 228-acre site, located at the headwaters of Willow and Spencer Creeks. This land was not always under City ownership, but due to its high quality oak and conifer habitats, it was purchased in increments between 2003 and 2007. This site (see Figure 9) contains many unique plant communities and a wide variety native wildlife. Wild Iris Ridge is especially valuable due to its high range of diverse habitats and the potential for future land management, which will restore and enhance existing oak habitats.

Figure 9. Wild Iris Ridge photopoint

CHAPTER 3: METHODS

The protocol outlined the methods that we used to collect data in the Ridgeline. The sampling technique involved the selection of random plots within larger stands at each site. We collected data on three different scales: the plot, the quadrat and the heritage tree circle.

3.1 Selection of random plots within stands

Within each of the three sites we visited, we collected data from two to four stands. Stands were selected by POS based on previous habitat studies and ownership of land. Within each stand, POS randomly selected four to six plots (ten by ten meters) where we collected data. Plots were visually marked at the southwest corner with an orange stake as well as graphically by Universal Transverse Mercator (UTM) coordinates on an aerial map. We subsequently split up into groups of two or three and used the UTM coordinates to locate the plots.

3.2 Naming scheme

The plots were named according to the following scheme: site abbreviation and stand # – plot #. For example: Mariposa stand 001, plot 02 was written as MARI001-02. The abbreviations for Blanton Ridge and Wild Iris Ridge were BLR and WIR respectively.

3.3 Ten by ten meter plot

Once we located the plot marker, we set up the plot, took photo points and collected data on wildlife features, trees, shrubs, and percent canopy cover.

Setting up the plot

Using the stake as a starting point we paced the boundaries of the plot and marked each corner with a flag, being careful not to trample the plot.

Photopoints

At each plot we took photopoints at shoulder height in the cardinal directions and one photopoint of the plot. These pictures will be used in the future as a means for comparison.

Wildlife and general stand observations

Within the plot we noted bioturbation, downed logs larger than eight inches in diameter, woodpecker foraging activity, as well as other sign of wildlife and general stand observations.

Trees

We collected data on each tree within the plot. We recorded the tree species, and number of stems. At the first two sites, we measured the DBH of each tree using a diameter tape. However, as we became proficient at estimating tree DBH visually, we recorded only the DBH class. The DBH classes grouped similarly sized trees into a single group. The DBH class designations were: D1 (<2''), D2 (2-6''), D3 (6-12''), D4 (12-20'') and D5 (>20''). We also recorded the stratum of each tree, which described the relative height of the tree compared to the surrounding trees. The stratum designations were overstory (the tallest part of the tree is not in the shade of other trees in the plot, although it might be co-dominant so some branches may be shaded) and understory (the tallest part of the tree is in the shade of taller trees in the plot). We noted whether the tree was alive or dead and termed a snag. Finally, we made comments on the tree if there were any noteworthy characteristics.

Percent cover classes

To reduce observer bias, we used cover classes to categorize percent cover (0-5%, 5-25%, 25-50%, 50-75%, 75-95%, 95-100%). This method applied to any percent cover estimation that was conducted while monitoring. Whenever we could not reach a consensus as to whether a percent cover was above or below a range, we always rounded down to improve consistency of estimations.

Shrubs

We recorded the species, and percent abundance by species of all shrubs within the plot.

Canopy cover

Two types of canopy percent cover were determined in this study; total percent cover including all tree species, and percent cover of oak and conifer tree species. To determine total percent cover, one person took spherical densiometer readings standing at the center of the plot in each cardinal direction. These four readings were then averaged and multiplied by 1.04 according to standard spherical densiometer methodology. This averaged sum was then placed into a percent cover class. Percent cover by species was determined by visual estimation. We stood at the center of the plot, looked skyward, and came to a consensus on the percent cover of oak and conifer tree species. The percentages of each tree species were based on the percentage of the sky that the trees blocked out as viewed from the ground. When portions of the sky were still visible, the percentages did not add up to 100.

3.4 One by one meter quadrat

We placed a one by one meter quadrat made out of PVC pipes at the center of the plot as shown in Figure 10. Within this quadrat, we recorded the percent cover of several ground vegetation types: herbaceous, non-vascular, exposed rock and soil, leaf litter and duff, and woody debris.

Figure 10. One by one meter quadrat where we collected data on ground vegetation

3.5 Thirty meter-radius heritage tree circle

Heritage tree survey

We paced thirty meters in each cardinal direction from the center of the plot and placed a flag. This marked a thirty meter-radius circle where we searched for heritage trees. We temporarily marked all heritage trees within the circle with flags in order to prevent double recording. If no heritage tree were found within the thirty meter-radius, the radius was the expanded to fifty meters, as shown in Figure11. If still no heritage trees were found, the tree with the largest DBH was recorded.

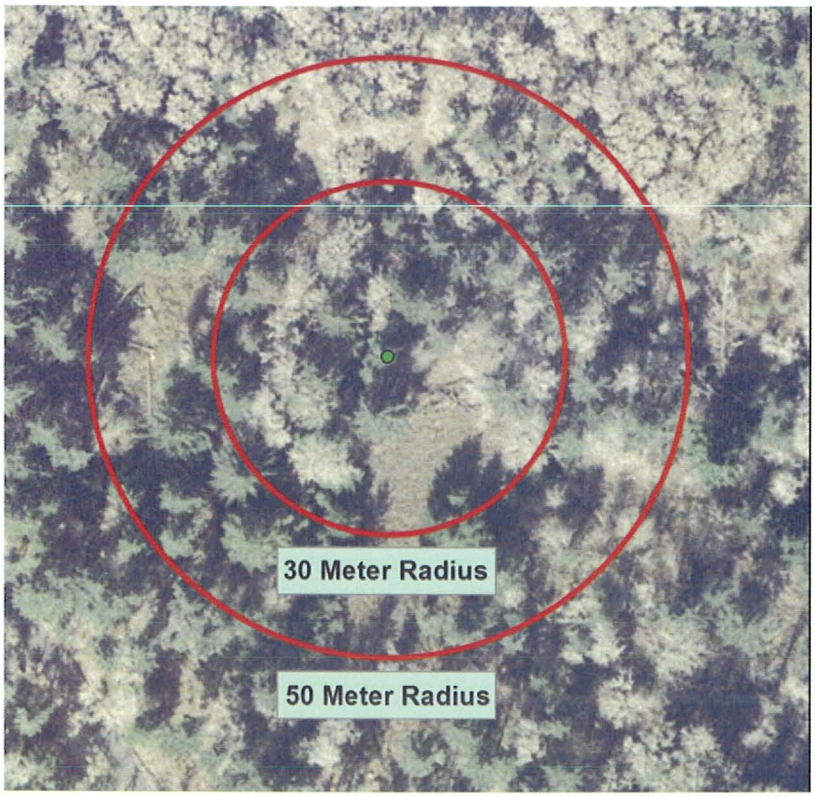

Figure 11. Heritage tree survey zones

Minimum DBH requirements

In order to qualify as heritage, a tree had to meet a minimum DBH requirement, which was unique for certain tree species. Table 2 below shows the minimum DBH requirements for each tree species.

Table 2. Minimum DBH requirement for heritage trees

Tree species	**Heritage tree DBH requirement**
Oregon white and California Black Oaks	16"
Douglas-fir	30"
All other tree species	20"

Heritage tree data (non-oaks)

For any heritage tree located, we recorded its species, DBH, health and competition. Health classifications ranged from 1 to 3, where 1 indicated healthy (all bark and major limbs present and alive, no visible rot, full crown of healthy leaves), 2 indicated moderately healthy (one or more of the following: missing bark, broken major limbs, visible rot) and 3 indicated unhealthy (signs of visible rot, sparse foliage, major branches that are broken or dead). Health only indicated the health of the tree and did not necessarily indicate the health of the surrounding habitat or wildlife.

Heritage tree data (oaks)

We collected additional data on oak trees such as number of contact trees (trees that touch or strongly influence the heritage oak tree's canopy), number of conifer contact trees, percent of crown contact, mistletoe load and tree shape (mushroom, columnar, or vase).

Figure 12. California Black Oak at Wild Iris Ridge

Documenting the location of heritage trees

We recorded the location of each heritage tree through two pacing methods. The first was termed the 'azimuth' pacing method, where we recorded the azimuth bearing from the southwest plot marker to the tree and paced the distance from the stake directly to the heritage tree. The second method was termed the 'x/y' pacing method, which was necessary for entering distances into GIS. This method required us to pace from the stake to the heritage tree on the x and y axes of the coordinate system (x-axis: East and West, y-axis: North and South).

3.6 Determining habitat types

We used the data that we collected at the individual plots to extrapolate to the larger stands and determined appropriate habitat types (Mixed Forest, Oak Woodland, etc.) for each stand. The habitat types we used were described in protocol, which is located in Appendix C.

More specifically, we used the percent canopy cover data to determine a habitat type for each plot and then determined an overarching habitat type for each stand. Table 3 illustrates how we used the data collected at each plot in Mariposa to determine an overall habitat type.

Table 3. Canopy cover data from Mariposa used to determine habitat types

Study stand	Mariposa stand 001			
Plot	1	2	3	4
%oak canopy cover*	25-50	25-50	0	0
%conifer canopy cover	5-25	0	0	50-75
% other canopy cover	0	0	50-75	5-25
Habitat type	Mixed Forest	Oak Woodland	Hardwood Woodland	Conifer Forest
Overall study area habitat type	Mixed Forest			
Confidence	Medium			
Notes	The Mariposa study area was varied, ranging from open meadows to swampy woodlands, but the overall classification that best-described the study area was Mixed Forest.			

*the percentages of each tree species are based on the percentage of the sky that the trees block out as viewed from the ground. When portions of the sky are still visible, the percentages will not add up to 100.

As shown above, we determined a level of confidence in our habitat designation. High confidence indicated that the plots were fairly similar, medium confidence indicated that there was some variation within the stand and low confidence indicated that the plots within the stand had conflicting information or completely opposite habitat types.

Then, we compared our habitat designations to those of the SRHS previous habitat study. Based on this comparison, we recommended whether to change the SHRS habitat designation polygon. 'Yes' indicated that our habitat designation did not match that of SRHS and that the polygon needed to be changed. 'No' indicated that our habitat designation was the same as that of SRHS and that the polygon did not need to be changed.

CHAPTER 4: RESULTS

The results of this monitoring project focused on habitat designation, heritage trees and associated data, and plot data. All results were derived from data collected in-field at the Ridgeline. Figures 17,18 and 19 show the stands, plots and heritage trees at each site we visited.

4.1 Ground-truthing

When we compared our habitat designations to the South Ridgeline Habitat Study (SRHS), 5 out of 11 sites did not correlate with our habitat delineations for a 55% accuracy rate. Please see Table 10 for the complete habitat designation comparison. Due to time constraints, we were unable to do a detailed empirical comparison with the Ridgeline Oak-Prairie habitat study (ROP). However, we noticed that there was s significant amount of qualitative overlap between our habitat designations and those of ROP. For example, ROP designated Wild Iris Ridge stand 001 as Oak Woodland/Forest and our designation was Oak Woodland. Therefore, we believe that our data can be combined with ROP designations to create a more accurate GIS layer.

4.2 Heritage trees

Number and percentage

We found a total of 101 heritage trees at all study sites: 31 California Black Oak, 33 Oregon White Oak, 4 unidentified oak, 3 Bigleaf Maple, 6 Douglas-fir, 23 Ponderosa Pine, and 2 other, as shown in Table 4.

Table 4. Heritage tree count by site

Site	Species	Count	Percentage
Mariposa	Total	*32*	
	Deciduous		
	California Black Oak	7	22%
	Oregon White Oak	4	13%
	Unidentified oak	2	6%
	Conifers		
	Douglas-fir	3	9%
	Ponderosa Pine	16	50%
Blanton Ridge	Total	8	
	Deciduous		
	California Black Oak	1	13%
	Oregon White Oak	1	13%
	Conifers		
	Douglas-fir	1	13%
	Ponderosa Pine	5	63%
Wild Iris Ridge	Total	61	
	Deciduous		
	California Black Oak	23	38%
	Oregon White Oak	28	46%
	unidentified oak	2	3%
	Bigleaf Maple	3	3%
	Conifers		
	Douglas-fir	2	3%
	Ponderosa Pine	1	2%
	Other	2	3%

Heritage trees distribution

As shown in Table 5, Wild Iris Ridge had the highest ratio of heritage oak trees per plot, while Blanton Ridge had the lowest ratio. This data could be used to extrapolate the distribution of heritage trees at each site.

Table 5. Heritage trees per plot

Site	Total heritage tree to plot ratio	Oak heritage tree to plot ratio
Mariposa	~3:1	~1:1
Blanton Ridge	1:1	~0.2:1
Wild Iris	~2:1	~1.5:1

Heritage tree DBH

We encountered a large number of oak heritage trees that met the minimum heritage tree DBH. Furthermore, the maximum, minimum and average DBH of each priority heritage tree species are shown in Table 6.

Table 6. Heritage tree DBH statistics

Tree Species	Minimum DBH Requirement (inches)	Number found	Average DBH (inches)	Maximum DBH (inches)	Minimum DBH (inches)
Oregon White and California Black Oaks	16	68	21.3	53.4	16
Douglas-fir	30	6	35.2	39.6	30.6
Ponderosa Pine	20	22	33.8	41	30
Pacific Madrone	20	0	-	15	-
Bigleaf Maple	20	3	22.5	21.7	20.1
Other (cedar)	20	2	28.2	28.8	27.6

Heritage oak health

We found a total of 68 heritage oak trees located within the three study sites, as shown in Table 7. 56% of the heritage oaks in all stands were healthy, 41% of oaks were moderately healthy, and 3% were unhealthy.

Table 7. Heritage tree health by site

Site	Health	Count	Healthy	Moderate	Unhealthy
Mariposa	California Black Oak	7	4	3	0
	Oregon White Oak	4	2	2	0
	Unidentified oak	2	1	1	0
	Total	13	7	6	0
Blanton Ridge	California Black Oak	1	0	1	0
	Oregon White Oak	1	0	1	0
	Total	2	0	2	0
Wild Iris Ridge	California Black Oak	23	13	9	1
	Oregon White Oak	28	16	10	1
	Unidentified oak	2	2	0	0
	Total	53	32	19	2

CHAPTER 5: DISCUSSION AND RECOMMENDATIONS

As part of the pilot project, we tested the data collection procedures outlined in the protocol. We modified the protocol based on the conditions we encountered in the field. Below we discuss some of the problems we encountered and how we recommend solving them. We also discuss aspects of the project that are important for future implementation.

5.1 Ground-truthing limitations

The sampling technique chosen for verifying existing maps and habitat classifications within the Ridgeline was fairly successful. We effectively determined habitat types based on the data that we collected in the field and compared our habitat types with those of SRHS, and conducted sample comparisons with ROP. However, we encountered some problems during the ground-truthing process.

Variations within stands

The habitat types within many of the stands varied, making it difficult to assign overarching habitat types for the stands. For instance, within Mariposa stand 001 each plot was a different habitat type. Below are two pictures from opposite ends of Mariposa stand 001. Figure 13 was taken at plot 01, which was designated a Mixed Forest habitat type. Figure 14 was taken at plot 02, which was an Oak Woodland habitat type. These pictures portray the diversity of habitat types within some of the stands we encountered.

Figure 13. Mariposa stand 001, plot 01

Figure 14. Mariposa stand 001, plot 02

To account for habitat variations within stands, we determined a level of confidence in our habitat designation (high, medium or low) and we made note of any assessment difficulties or mapping issues that may be of interest to land managers. For instance, we designated Mariposa stand 001 as Mixed Forest, with a medium confidence, and noted that this stand was varied, ranging from open meadows to swampy woodlands, but could be classified overall as Mixed Forest. Many of these variations were visible on the detailed aerial maps provided to us. Therefore, we recommend splitting the larger SHRS stands into a few smaller pieces of land and redrawing habitat boundaries on a smaller scale to match the extent and distribution of the variations. Since the ROP habitat stands were already designated on smaller scales, it may be

more efficient to modify ROP boundaries to fit the habitat variations within stands. For example, the ROP study split Mariposa stand 001 into two sections, one as Mixed Woodland/Forest, and the other as Oak Woodland/Forest, which better represented the habitat variations within this stand.

Inaccuracy of canopy cover data

Initially, we exclusively used canopy cover data to determine habitat types. However, we found that this data was not inherently accurate. For instance, at Mariposa stand 001, plot 02, we realized that the canopy cover and the general stand notes conflicted: the spherical densiometer reading yielded a canopy cover percentage range of 75-95, which would make the plot a forest. However, the general plot notes described the plot as an 'open meadow.' This discrepancy occurred frequently as we were determining habitat types. We also noticed that spherical densiometer readings were typically higher than would be expected. In order to make an accurate habitat designation, we considered other plot characteristics such as photopoints, percent oak vs. conifer canopy cover and the trees in the plot.

Figure 15. California Black Oak crown as viewed from ground

We hypothesized that the cause of these discrepancies was variability between observers. Therefore, we conducted an observer-variability experiment, which is described in more detail in Appendix E. As a result of our experiment, we recommend continued use of the spherical densiometer for determining total canopy cover because it was the best method in terms of limiting observer variability. However, because the spherical densiometer is still not completely accurate, we recommend considering additional plot characteristics when determining habitat types, such as photopoints, percent oak vs. conifer canopy cover, and the species and number of trees in the plot. Although these other characteristics may be subjective (especially photopoints), they provide more facets of information in order to determine the most accurate habitat designation possible.

Habitat classifications based solely on tree cover

The habitat types that we used to designate the stands were based solely on tree cover. Vegetation and soil moisture did not factor into the habitat type designations. Occasionally we encountered stands that could be classified overall as one habitat type, but had varying ground vegetation. Therefore, we recommend creating subcategories within the habitat type descriptions, which include ground vegetation and soil moisture. We especially recommend creating two subcategories under the Mixed Forest category, which is where we most often encountered diverse ground vegetation and soil moisture characteristics, such as:

1) wet and swampy with a lot of ferns and moss
2) dry with a lot of leaf litter and duff

We believe that these subcategories will improve the accuracy of the habitat type data and better represent the conditions in the field.

5.2 Major protocol modifications

We found the protocol to be moderately effective in achieving the goals of the project, which were ground-truthing, collect baseline data, and finding heritage tress. We made several modifications to the protocol in order to improve clarity, consistency and to adapt it to the conditions in the field. Please see Appendix C for the revised protocol. Overall, this method will be feasible for Ridgeline-wide application after our suggested revisions are taken into account. Below we discuss three of the major protocol modifications in-depth.

Documenting the location of heritage trees

The protocol initially called for the use of GPS units to document the location of heritage trees. Unfortunately, the GPS units accessible to us were too inaccurate under canopy cover (errors of ten meters or more). Therefore, we determined the distance of the heritage tree from the southwest plot marker using the 'azimuth' pacing method described in the Methods section. However, we discovered that we were unable to record that data in the GIS program efficiently. Therefore, we adopted the 'x/y' pacing method. The disadvantage of 'x/y' pacing was that pacing in two directions increased the potential for error. An empirical comparison of these two methods in the lab showed that they were both very precise; there was not a significant difference between the location recorded by the 'azimuth' method and the 'x/y' method. However, we encountered problems with pacing as well. Occasionally there were obstacles to direct pacing (thicket of blackberry bushes, large trench, etc.) which necessitated us to estimate distances.

Our recommendations depend on who implements the protocol in the future. If volunteers are used, we do not recommend the use of GPS units because of inaccuracy under canopy cover, risk of damage to GPS units and necessary training associated with the devices. If City staff will be collecting data, then the use of GPS may be more efficient. Concerning pacing, we recommend the 'azimuth' method of pacing because it involves fewer steps, which reduces error and saves time. If needed, one can calculate the corresponding x/y distances from the azimuth distance and bearing using basic trigonometry.

Heritage tree survey

The protocol originally required a search for heritage trees within a thirty meter-radius circle form the center of the plot. This method was not very effective because we occasionally did not find any heritage trees in a thirty meter-radius circle. Since one of the City's top priorities was to find and document heritage trees, we modified the protocol so that we would find more heritage trees. If there are no heritage trees in the thirty meter-radius circle, we searched a fifty meter-radius circle. If there were still no heritage trees, we found and documented the largest DBH tree in the circle, because it they have the potential to grow into heritage trees in the future. Since heritage trees were few and far between, this method helped us to find them or the heritage trees of the future. Overall, this method was effective in meeting that goal with the time allotted.

Heritage tree DBH

The protocol originally specified that all trees greater than 20 inches DBH should be recorded as heritage trees, for ease of implementation. However, we found that by making some changes to this method, we could gather a more representative and accurate amount of data on trees within the study areas. First, we reduced the minimum DBH requirement for oak trees from 20 inches to 16 inches because we encountered very few oaks above 20 inches DBH. Moreover, oaks were the primary focus of our study and oaks grow relatively slow compared to conifers on the shallow soils. For instance, a small oak may be just as old or mature as a relatively large conifer. We also increased the minimum DBH requirement for Douglas-firs because we encountered an abundance of Douglas-firs above 20 inches DBH and because Douglas-firs grow faster than oaks. In keeping with this method, we recommend that the City of Eugene specify minimum DBH for each priority tree. Our tentative suggestions for species-specific minimum DBH requirements (inches) based on data in Table 6 are:

Oaks: 18
Douglas-firs: 30
Pacific Madrones: 14
Bigleaf Maples: 18
Ponderosa Pines: 30
Other tree species: 20

5.3 Evolution of the data forms

Throughout the pilot project, we made changes to the data forms to improve clarity and to match in-field conditions. We also created a canopy cover data form to record more detailed canopy cover data. On this data sheet we combined the spherical densiometer with visual estimation. We did this feeling it simplified data collection and data entry, rather than flipping back and forth between different data sheets.

The canopy cover data form allowed us to record spherical densiometer readings by rows, rather than the total count. This method proved to be a success in the field. We also added a section for notes on the form to both ensure proper documentation in the field as well as to improve data analysis. The revised data forms are available in Appendix B.

5.4 Time Requirements

As part of the pilot project, we recorded the time requirement for collecting data. This information is useful because it provides an idea of the time commitment required for future implementation by either volunteers or City staff.

Time requirement per form

There were three data forms filled out for each plot: the plot data form, the canopy cover data form and the heritage tree data form. It took 23 minutes on average to complete the plot data form. The canopy cover data form time requirements were included in the plot form time because they only took a few minutes. It took 21 minutes on average to complete the heritage tree data form. Overall, it took about 42 minutes to complete the data collection process at each plot. It took approximately 30 minutes per plot on average to enter data.

In general, it took more time on the plot data form depending on how many trees there were in the plot. However there was no clear correlation between plot data form time and number of trees because of our data-collection learning curve and because we stopped measuring DBH toward the end and only recorded DBH class which cut down on time significantly.

There was a direct correlation between time on the heritage tree data form and number of heritage trees, as shown in Figure 16 below. The time increased by about ten minutes with the every heritage tree after removing the first few plots. Filtering out those first few plots was necessary because they did not accurately represent the timing because we were still learning how to collect data. Furthermore, we made significant changes to the protocol after the first few plots, which altered the timing. After removing the first few plots, the following graph shows the direct correlation:

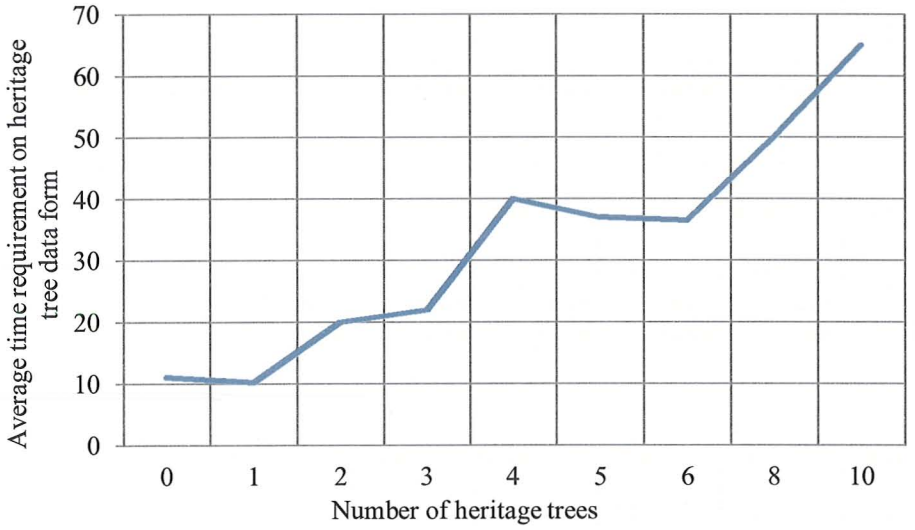

Figure 16. Number of heritage trees vs. average time requirement for heritage tree data form

Time requirement and number of group members

In the beginning of the project, we collected data in groups of three. Later, we started working in groups of two. It took groups of two about seven minutes longer than groups of three on average to complete a plot. Since this was not a significant difference, we recommend that either groups of two or three are adequate to collect data. Groups of two may save time overall if there are more than five data collectors because then they can split into three three groups instead two.

5.5 Baseline Data Collection

Overall, we collected a large amount of data, which we believe will help the City of Eugene prioritize management actions in the Ridgeline. Furthermore, the data that we collected will serve as a baseline against which to compare the effectiveness of future management actions. For instance, if the City of Eugene decides to do conifer thinning at one of the sites, someone can collect data after thinning and compare it to our data to determine whether the thinning achieved the desired results.

An important part of collecting baseline was how many plots we collected data at within each stand. We began by collecting data at only four plots, but started collecting data at six plots later in the project. From analyzing this data, we determined that four plots were adequate to collect a representative amount of data about the stand. In general, we got similar results and the accuracy did not improve when we added more plots. For example, Table 8 portrays that the data collected in the last two plots was consistent with the data collected in the first four plots, and did not necessarily increase accuracy, which is demonstrated primarily by the habitat types. This was the case with all other stands where we collected data at six plots. Therefore, we recommend that data be collected in only four plots because this is sufficient to collect accurate data about the stand and it saves time.

Table 8. Canopy cover data from stand Wild Iris Ridge 007 showing the difference between four and six plots

Plot #	Percent Canopy Cover	Percent Oak Cover	Percent Conifer Cover	Trees	Habitat Type
WIR 007-01	95-100	25-50	5-25	2 oak 3 conifer	Mixed Woodland
WIR 007-02	50-75	5-25	0	2 oak 1 conifer 1 other	Mixed Woodland
WIR 007-03	75-95	75-95	5-25	10 oak 1 conifer	Oak Woodland
WIR 007-04	95-100	75-95	25-50	7 oak 3 conifer 4 other	Mixed Woodland
WIR 007-05	75-95	75-95	0	0	Woodland
WIR 007-06	75-95	75-95	0	5 oak	Oak Woodland

5.6 Future implementation

We believe that both volunteers and City staff are good candidates for continuing to collect data in the Ridgeline using the updated protocol. Each group has advantages and disadvantages. Recruiting volunteers will serve to involve the public and educate them about oak conservation. Using volunteers is a cost-effective way to collect data. Still, the City of Eugene will have to recruit, train and coordinate the volunteers. On the other hand, City staff will likely be more consistent in terms of subjective measurements because they have more experience and training. More sophisticated equipment can be used by City staff because they have access to better equipments and there is less likelihood that the equipment will be damaged while in the field. Nonetheless, this would require City staff time or additional staff members.

If the City of Eugene decides to use volunteers, we suggest providing training prior to going out in the field. Such training should include brief introduction to identifying important plant and tree species, basic field safety and how to find the plots using map and compass. Accordingly, we have created a Ridgeline Field Guide for future use; please see Appendix D. We recommend that a City staff member oversee the volunteers on their first trip to the field to answer any questions. In addition, we suggest that the City of Eugene recruits volunteers who are willing to work towards the completion of a section the project. That is, the same group of volunteers would make a commitment to complete a certain amount of stands or work for a certain number of months. This will reduce the City of Eugene's time and effort in terms of recruitment, training and coordination. Some possibilities for recruiting volunteers who can commit to a timeline are unpaid internships for UO students (especially Environmental Studies and Sciences majors), future ELP teams, and local clubs or non-profit organizations. Moreover, utilizing the help of future ELP teams would ensure consistency in terms of training and type of volunteer. Finally, we recommend that the City of Eugene provide a brief introduction to future data collectors about poison oak, ticks and other field hazards.

CHAPTER 6: SUMMARY

Through habitat data collection and monitoring of oak stands we were able to successfully determine habitat types, collect relevant data on oak stands and revise the protocol for more efficient future use. We believe that this data will assist the City in determining priority restoration and management areas within the Ridgeline. Our implementation of the original protocol helped us to develop more efficient ways to collect the data. The updated protocol is user-friendly for both City staff and volunteers. Overall, we are confident that we accomplished the three goals outlined for the Ridgeline Oaks project. The results and conclusions of our monitoring efforts have the potential to assist in creating accurate Ridgeline habitat maps, protection of healthy oak stands, and restoration of oak savanna habitat in the Willamette Valley.

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ABBREVIATIONS AND ACRONYMS

POS – City of Eugene Parks and Open Space Division
ELP – Environmental Leadership Program
UO – University of Oregon
DBH – diameter breast height
GIS – Geographic Information Systems
UTM – Universal Transverse Mercator
SHRS – South Ridgeline Habitat Study
ROP – Ridgeline Oak-Prairie habitat study
GPS – Global Positioning System
MARI – Mariposa study site
BLR – Blanton Ridge study site
WIR – Wild Iris Ridge study site

ADDITIONAL FIGURES AND TABLES

Table 10. Habitat designation comparison

Site	ELP ID	SRHS ID	SRHS type	ELP type	Confidence	Change SRHS GIS polygon?
Mariposa	MARI001	11F	Mixed Forest	Mixed Forest	Medium	No
	MARI002	11H	Mixed Forest	Mixed Forest	High	No
	MARI003	11C	Mixed Forest	Mixed Forest	Medium	No
Blanton Ridge	BLR001	8C	Mixed Woodland	Mixed Woodland	High	Yes
	BRR002	8N	Hardwood Woodland	Oak Forest	Medium	No
Wild Iris Ridge (main)	WIR001	3T	Mixed Woodland	Oak Woodland	Medium	No
	WIR002	3Q	Hardwood Woodland	Hardwood Woodland	Medium	Yes
	WIR003	-	-	Mixed Forest	High	No
	WIR004	3C	Hardwood Forest	Oak Woodland	High	Yes
Wild Iris Ridge (Evans)	WIR006	2B	Mixed Forest	Hardwood Woodland	High	Yes
	WIR007	2B	Mixed Forest	Oak Woodland	High	Yes

* We did not have time to do stand WIR005 or any of the EREX stands.

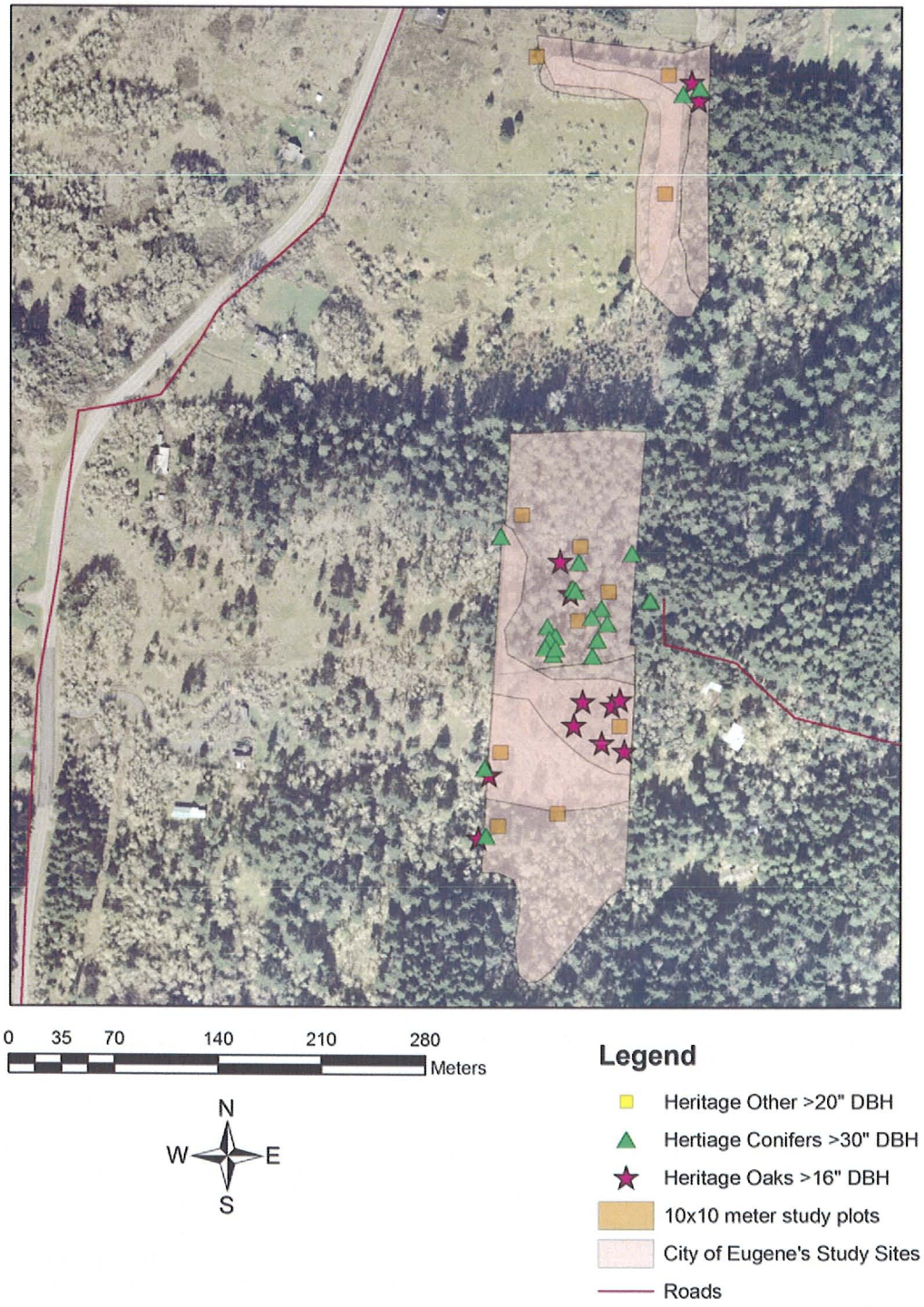


Figure 17. Mariposa study site overview

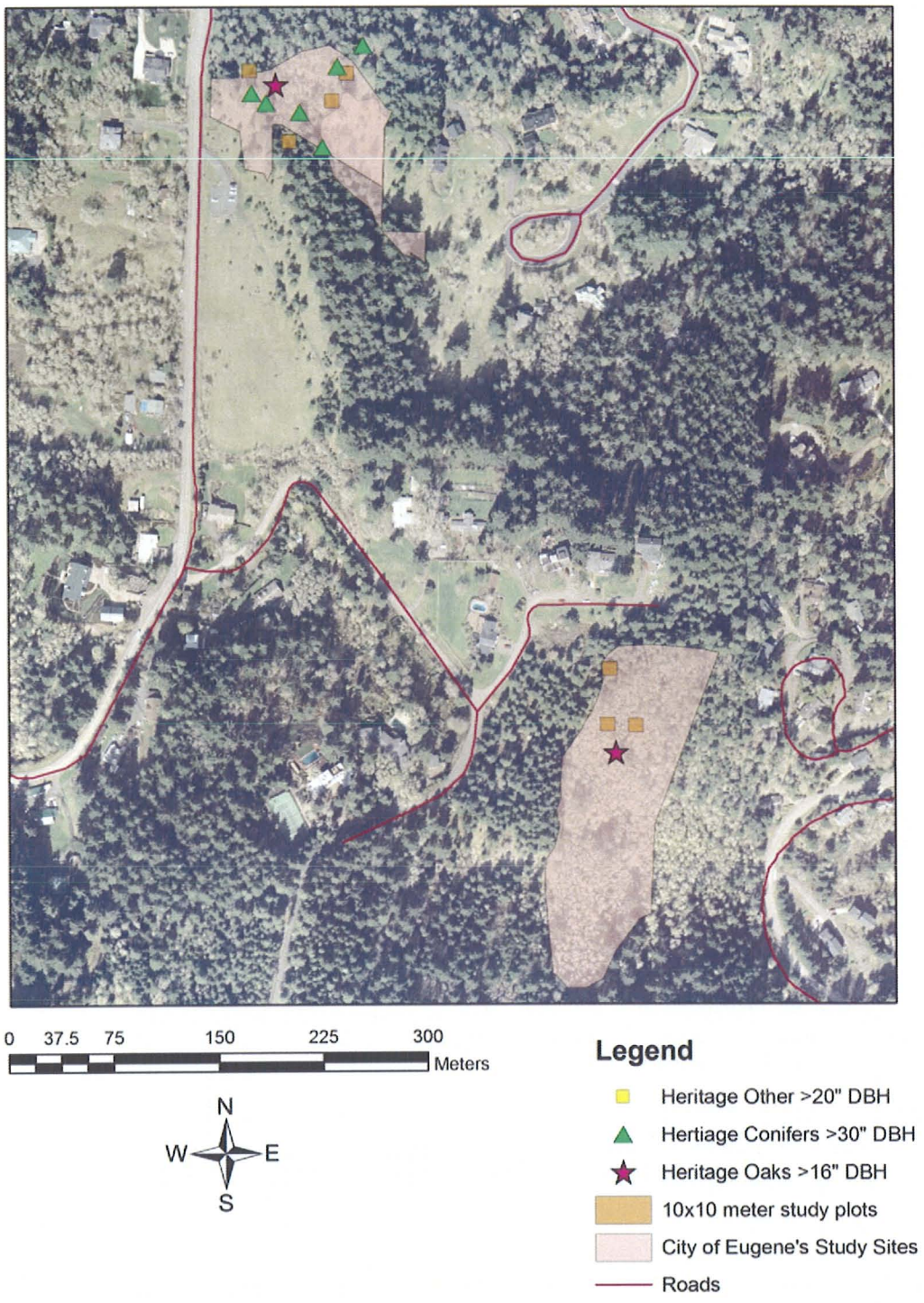


Figure 18. Blanton Ridge study site overview

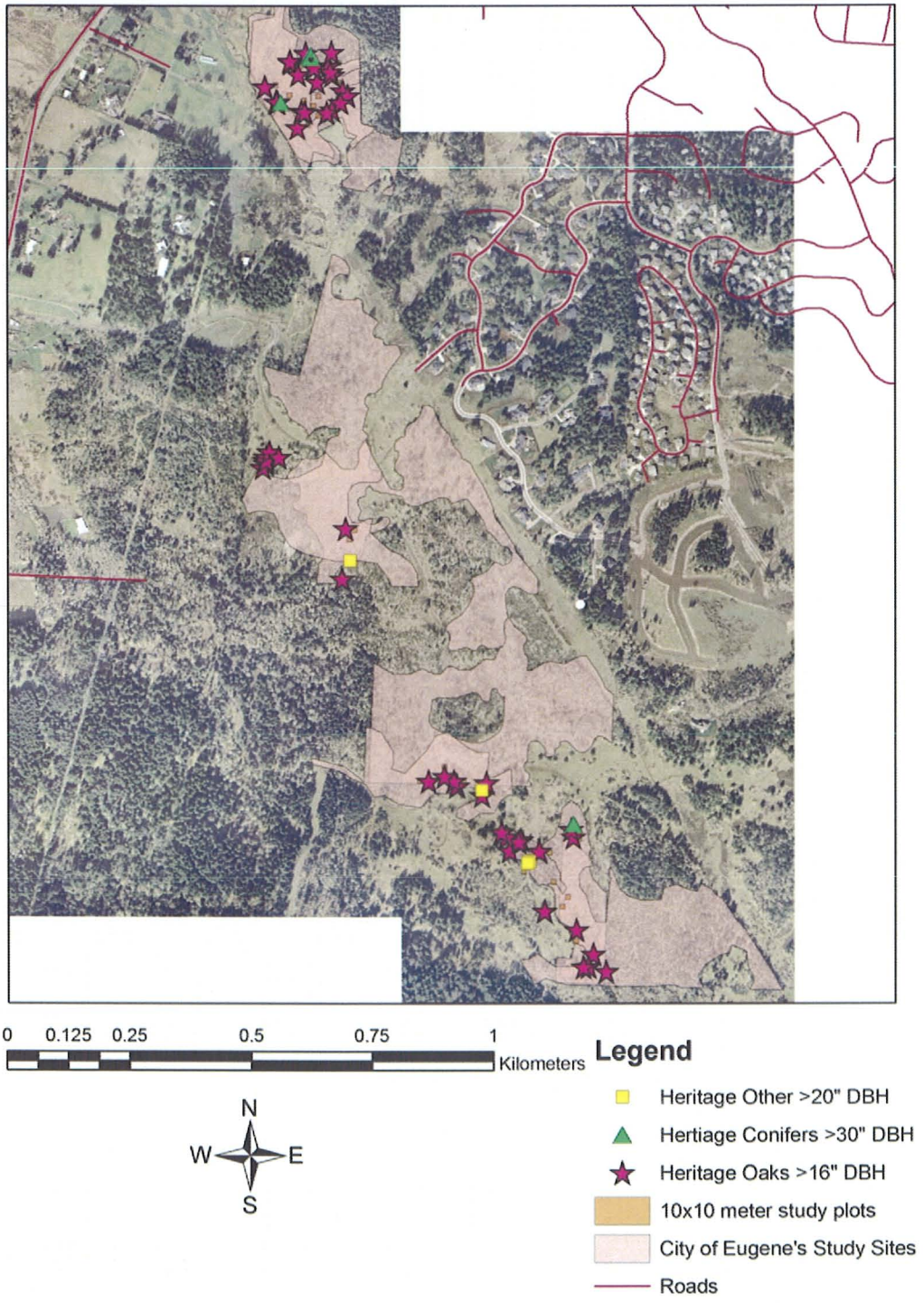


Figure 19. Wild Iris Ridge study site overview

APPENDIX A: GLOSSARY

Azimuth: The angle of horizontal deviation of a bearing from a standard direction.

Baseline data: Information collected in the field used to compare against data gathered in the future.

Bioturbation: The alteration and disturbance of a site by living organisms; the turning and mixing of sediments by organisms, such as moles, voles and other small rodents.

Cardinal directions: North, East, South and West.

Canopy cover: The percent of a fixed area covered by the crown of an individual plant species or delimited by the vertical projection of its outermost perimeter; small openings in the crown are included.

Crown: The upper part of a tree, which includes the branches and leaves.

Diameter at breast height (DBH): A measurement of a tree trunk made outside of the bark at breast height. Breast height is defined as 4.5 feet above the forest floor on the uphill side of the tree.

Diameter tape: consists of a cloth or metal tape that is mainly used to measure diameter at breast height (DBH) in inches.

Duff/ leaf litter: Organic matter in various stages of decomposition on the floor of the forest.

Encroachment: The propensity of conifer species to grow taller than oak trees which subsequently reduces the health of oak species through increased shading.

Ecological data: Data which helps describe and designate habitats.

Fire regime: The pattern, frequency and intensity of intentional fire-use to manage a specific area.

Ground-truthing: Comparing habitat designations made with in-field data against habitat delineations that are currently used.

Herbaceous cover: The total cover of all live, non-woody vascular plants.

Habitat classifications/ types/delineations: A group of plant communities sharing similar characteristics such as species composition and wildlife relationships.

Heritage tree: Pre-Euro-American settlement trees that are of ecological and historical value.

Kalapuya Indians: Native American ethnic group whose traditional homelands were located in present-day western Oregon spanning from the peak of the Cascade Mountains at the east to the Oregon Coast Range at the west, and from the Columbia River at the north to the Calapooya Mountains at the Umpqua River at the south.

Mistletoe load: Mistletoe is a parasitic plant that grows by using sugars manufactured by the tree. Mistletoe brooms are very obvious when the leaves are off the tree.

Non-vascular: Plants lacking roots, stems, or leaves, including not only all the algae, but also fungi.

Photopoints: A data collection method taking photographs of the four cardinal directions (starting with north and going clock-wise) and across the plot from the stake, which makes the south-west corner of the plot.

Pilot project: A pilot project is a test run of data collection procedures and is the first step in developing an effective management plan.

Plot: The four to six 10x10 meter areas found in a study stand.

Polygon: An irregular area used to designate an area of forest a specific habitat type.

Ridgeline Oak-Prairie (ROP): A regional-scale habitat categorization used by the City of Eugene used to inventory and assess habitat

Ridgeline Trail: A 14-mile long trail system running through southern Eugene, from Fern Ridge Reservoir in the west to Howard Buford Park & Mt. Pisgah in the east. Managed by Eugene Parks and Open Spaces.

Riparian zone: The interface between land and a river or stream.

Snag: A dead standing tree.

South Ridgeline Habitat Study (SRHS): A study by the city of 2,700 acres of the near the ridgeline of the South Hills to determine where important upland habitat areas exist.

Spherical densiometer: An apparatus containing either a concave or convex mirror etched a cross-shaped grid of 24 squares for measuring the percent canopy cover.

Study stand: The area of interest designated by the City of Eugene.

Stratum: A range of characteristics used to define vegetation such as "overstory" or "seedling".

Quadrat: The 1x1 meter area found in the center of each plot.

Universal Transverse Mercator (UTM) coordinate system: A grid-based method of locations on the surface of the Earth that is a practical application of a 2-dimensional Cartesian coordinate system. An example of these coordinates for the summit of Spencer's Butte is Zone: 10 Easting: 492323 Northing: 4869999.

APPENDIX B: REVISED DATA COLLECTION FORMS

Plot Form

A. GENERAL INFORMATION	
Date:	PLOT #:
Name(s) of surveyors (circle recorder):	

B. 10m x 10m PLOT: HABITAT AND VEGETATION DESCRIPTION			
Time start:		Time end:	
Bearing: (degrees) left axis from SW corner		Camera model:	
Take pictures (in order): stake, N, E, S, W, plot			
Herbaceous cover			
Cover classes: 0-5%, >5-25%, >25-50%, >50-75%, >75-95%, >95-100%		*(1m x 1m quadrat)*	
Herbaceous cover %:	Non-vascular cover %:	Plot representative? Y / N	
Non-veg cover:	Exposed rock/soil %:	Leaf litter/duff %:	Woody debris %:
Use other side for Trees & Shrubs ➔			

C. WILDLIFE HABITAT FEATURES AND SIGN		
Bioturbation (circle one)	**Current Year** High Medium Low None	**Past bioturbation?** Y / N
Logs > 8" DBH	**Length in plot (m)**	**Total length (m)**
	1.	
	2.	
	3.	
Stumps > 20" diameter at base (Y/N)		
Wildlife observations	(ex: woodpecker cavities, nests, foraging, scat, trails, tracks, etc.)	

D. GENERAL STAND OBSERVATIONS AND NOTES:
(ex: water sources, rocky features, overall vegetation, signs of current or historic disturbance (fire, flood, etc.), succession, threats (invasive species, garbage dumping, etc.), other)

TREES						
Tree #	Species	Stratum	DBH Class	# stems	Snag Y/N	Comments

***Stratum: O** (Tree in overstory), **U** (Tree in understory), **S** (Seedling) **Average DBH: D1** (<2") **D2** (2-6") **D3** (6-12") **D4** (12-20") **D5** (>20")*
***Number of stems:** refers to tree-clump or stump-sprout trees (multiple stems from a single base).Only record if >1.*

SHRUBS						
Species	% cover	Species	% cover	Species	% cover	Comments

% cover intervals: 0-5%, >5-25%, >25-50%, >50-75%, >75-95%, >95-100%.

Heritage Tree Form

A. GENERAL INFORMATION	
Date:	PLOT #:
Name(s) of surveyors (circle recorder):	

B. 30m CIRCLE: HERITAGE TREES	
Time start:	Time end:

For All Trees			
Health Class		**Competition**	
1	Healthy. All bark and major limbs present and alive, no visible rot, full crown of healthy leaves (careful in spring w/this).	**D**	Dominant. The majority of the canopy is above the canopy of immediately neighboring trees.
2	Healthy but has one or more of the following: missing bark, broken major limbs, visible rot	**C**	Co-dominant. The majority of the canopy is equal height to the canopy of immediately neighboring trees but is not being shaded.
3	Tree appears unhealthy. Much visible rot, sparse foliage, major branches broken or dead.	**I**	Intermediate. < 50% of the canopy ois below or being shaded by the canopy of neighboring trees.
		S	Suppressed. > 50% of the canopy is below or being shaded by the canopy of neighboring trees.

OAK TREES – Additional Information	
Contact Trees	Count the number of trees of any species that touch or strongly influence the canopy of the tree being surveyed.
Conifer contact trees	Of the contact trees, count how many are conifers
% Crown contact	Estimate what percent of the heritage tree crown circumference is making contact or merged with other trees of similar or larger size.
Mistletoe load	Mistletoe is a parasitic plant whose brooms are very obvious when the leaves are off the tree. They look like balls of fine branches. Record the number of brooms (bushels).
Crown width	Using a long measuring tape, record the longest and shortest crown widths.
Tree Shape	Shape of tree crown as viewed from the side. **C** – columnar **V** – inverted vase **M** – mushroom 

Pacing Calculation: Distance (m) = 10 x (number of steps you took) / (your pace)

HERITAGE TREES										
Heritage Tree # (e.g. HT01)	Species	DBH (in.)	Health	Comp-etition	Tree # in 10 x 10 plot	Azimuth bearing	Azimuth distance	X distance (E,W)	Y distance (N,S)	Notes

OAK TREES – Additional Information								
Heritage Tree #	TOTAL Contact Trees (#)	CONIFER Contact Trees (#)	% Crown Contact	Mistletoe Brooms (#)	Longest Crown Width (m)	Shortest Crown Width (m)	Tree Shape	Notes

Canopy Cover Form

Date: _____ Plot #: _____

Name(s) of surveyors (circle name of person filling in form):

_____

Is canopy cover representative of 10x10? Y / N
If no, explain: _____

Dot counts for rows on spherical densitometer:

N1_____	E1_____	S1_____	W1_____
N2_____	E2_____	S2_____	W2_____
N3_____	E3_____	S3_____	W3_____
N4_____	E4_____	S4_____	W4_____
N5_____	E5_____	S5_____	W5_____
N6_____	E6_____	S6_____	W6_____
Ntotal:_____	Etotal:_____	Stotal:_____	Wtotal:_____

Average from totals_____ x1.04_____ = _____

Canopy Cover classes: 0-5%, >5-25%, >25-50%, >50-75%, >75-95%, >95-100%

Visual Estimate

% Oak Cover: _____ % Conifer Cover: _____

Other Canopy Notes: _____

APPENDIX C: REVISED PROTOCOL

UO Environmental Leadership Program
Ridgeline Oak Habitat Mapping and Monitoring Protocol

1. CITY OF EUGENE'S (CITY) GOALS FOR THIS PROJECT

a. Ground-truth oak habitat mapping in the Ridgeline.
b. Collect baseline data for oak habitats in Ridgeline natural areas to inform and help prioritize management activities.
c. Develop and test a protocol and data sheet that can be used by city staff or volunteer monitors to complete data collection in oak habitats.

2. PROJECT SUMMARY

Plot location points will be selected randomly by City staff through Geographical Information System (GIS) analysis of delineated oak habitats. City staff will locate and mark the points in the field, and provide Universal Transverse Mercator (UTM) locations and maps with an aerial photo underlay showing each plot location. City staff will mark the center and the southwest (SW) corner for each plot. Environmental Leadership Students (ELP) students will receive field training, then locate each plot marker and lay out 10m x 10m plot on N-S and E-W axes based on the SW plot corner. Students then will record data on each plot and enter data into a spreadsheet. Students will cross-check data entry against field-recorded data and summarize findings in a report for the City. The report will include methods, recorded data, data summary and/or analysis, discussion, and conclusions or summary. The report will also include possible recommendations for improving the protocol for volunteer use, if appropriate.

3. EQUIPMENT

❑ Aerial photo with City marker locations mapped
❑ GIS habitat map of site
❑ Topographical map
❑ Field desk or clipboard
❑ Data sheets
❑ Pencils/pens
❑ Plastic sheet protectors and gallon plastic bag (to protect data sheets)
❑ Diameter tape (d-tape)
❑ 30m or 50m measuring tape
❑ Spherical densiometer
❑ GPS and extra batteries
❑ Compass
❑ Digital camera
❑ Flagging
❑ Hard Hats
❑ Two colors of flagging: one color to mark plot boundaries and 30m radius circle; other color to mark heritage trees
❑ Guide Books (to determine tree and shrub species)
❑ Sunscreen
❑ Technu

4. DETERMINE WHERE AND HOW YOU ARE GOING TO WORK

You will be ground-truthing and further characterizing habitat classifications in an existing GIS habitat layer. The layer already has habitat polygons delineated and numbered (Appendix II has information on how polygons were classified and a description of habitat types). Determine which polygons you will be sampling during your field visit. Because many polygons are large, we will be using randomly-selected sample plots to collect data and characterize the plant community. You will be provided a GPS waypoint for the southwest (SW) corner of the plot. The SW corner and plot center are marked with a wooden lathe stake and bright orange flagging on the stake. The plot number will be written on the stake. Use GPS, aerial photos and maps to find the plot marker. This protocol is written for a team of 3 students: 2 students will focus on the 10m x 10m plot and the 1m x 1m quadrat, and 1 student will focus on the 30m circle (to evaluate heritage trees).

5. PACING

Each person will need to determine how the number of paces per 10m for documenting the location of heritage trees. To determine your pace, stretch a measuring tape 30m on flat ground. Walk the length of the measuring tape and count how many steps you take. Do this 4 or five times and calculate the average number of steps you take and then divide by three. This is your unique 10m pace. To calculate the distance from pacing, use the following equation:

Distance (m) = 10 x (number of steps you took) / (your pace)

6. SET UP PLOT

You will be recording data in 10m x 10m plots, 1m x 1m quadrats, and 30m-radius circles. For the 10m x 10m and 1m x 1m plots, use the "Ridgeline Oak Assessment Plot Form." The plot should be laid out with North-South and East-West boundaries. If necessary because of site or stand constraints, you can use different bearings, but try to get as close as possible to N/S and E/W. Be sure to note any deviations from the N-S/E-W bearings. Within the 10m x 10m plot you will also record information in a 1m x 1m quadrat. See "B. 10m x 10m PLOT: HABITAT AND VEGETATION DESCRIPTION" for more details. For the 30m-radius circles, use the "Ridgeline Oak Assessment Heritage Tree Form." Before beginning the data collection at any given site, mark the location of the plots and their approximate 30m circles on the aerial map with the grid overlay.

The team may shift plot location if poison oak/blackberry is severe enough to pose a potential hazard. In this case, the team will use the stake as the NW corner (rather than the SW corner). They will record the plot marked by the SW corner as Plot# A (e.g., 4A) and note that data were not collected, but perhaps still take some photo documentation. They will record the plot marked by the NW corner as Plot# B (e.g., 4B) and collect data as per the protocol. If the poison oak/blackberry is also severe in the B plot, the entire plot will be abandoned and noted as such.

6. RECORD DATA

With the exception of diameter breast height (DBH), take all measurements in metric. Take DBH measurements in inches. Maintain consistency within a plot as far as who takes data readings. For example, only one person should take spherical densiometer readings within a plot and should not switch in the middle of the plot. Data collection responsibilities can switch between plots, but not during the middle of a plot. The same rule should apply to the person collecting DBH readings, and other data tasks. It is helpful that you have more than one observer make subjective observations, and that you discuss your observations and come to consensus.

1. RIDGELINE OAK ASSESSMENT PLOT FORM

A. GENERAL INFORMATION

Date: Date of the data collection.

Plot #: Number assigned in the office prior to field work. It consists of the polygon number followed by a dash and sequential number (e.g., MARI001-01 for plot #1 in Mariposa Woodland polygon #1). If the stake is mislabeled, record only the correct plot number on the data sheets.

Name(s) of surveyors: The full names of for everyone collecting data or otherwise assisting with sampling. The person recording the data on the form circles his or her name.

B. 10m x 10m PLOT: HABITAT AND VEGETATION DESCRIPTION

You will be recording cover data on trees (overstory and understory trees), shrubs, herbaceous/ground layer, and wildlife habitat features. For the tree and shrub layer, only consider living plants.

Time start and time end: Record the time you started and ended collecting data for this section. Your information will be used to determine how many people-hours each task requires.

Bearing, left axis at SW pt (note in degrees azimuth): Looking towards the plot, record the bearing of the axis to your left. If there are no stand constraints, the plot should be laid out with North-South and East-West boundaries. If necessary because of site or stand constraints, you can use different bearings, but try to get as close as possible to N/S and E/W.

Photograph #s: Begin by taking a picture of the stake, which has the plot number on it. If the stake is mislabeled, do NOT take a picture of the mislabeled stake, instead write the correct plot number on a piece of paper and take a picture. Then, standing at the SW corner, take four wide-angle photos in the main cardinal directions, always in order of N, E, S, W, clockwise beginning from the north. If for some reason photos cannot be taken in the four cardinal directions, or you determine that different angles would be more informative in the long term, document the selected compass bearings in the comments field. In addition, take one photo of the monitoring plot itself. For all photos, hold the camera at eye level (5 feet from the ground). Take photos with the camera zoomed all of the way out (wide-angle). Set the picture resolution to 3 megapixels or as close to 3 megapixels as your cameral will allow. Record the camera model and .jpg numbers. *(Note: you may need to record photo order and complete the .jpg number field after you download the photos).*

Trees (overstory and understory trees) (on back of form):

Overstory tree % cover (total cover, conifer, oak): From the plot center, use a spherical densiometer to estimate the total foliar cover of all live tree species. Estimate total cover, conifer and oak covers separately. The estimate of % canopy cover is taken independently for total cover, then oak, then conifer. Do a visual estimate of the oak and conifer cover as percents of the total cover. Do not record oak or conifer as a percent of a percent. Record within the following categories: 0%, >0-5%, >5-25%, >25-50%, >50-75%, >75-95%, >95-100%. Continue using spherical densiometer for record canopy cover even though it is difficult without leaf cover.

How to use a spherical densiometer: The spherical densiometer should be held 12-18 inches in front of your body and at elbow height, so that the operator's head is not visible in the mirror (and will not be counted as canopy cover!). Make sure the level bubble is level. In each square of the grid, assume that there are four dots, representing the center of quarter-

square subdivisions of each of the grids. In the following instructions, it is assumed that you are under a forest canopy where openings are less common than canopy. Systematically count the number of dots NOT occupied by canopy (where you can see sky at that dot). Multiply the total count by 1.04 to obtain the percent of overhead area not occupied by canopy, as there are only 96 dots to count. The difference between this and 100 is the canopy cover in percent. Make four readings per location – facing north, east, south, and west – and average them to provide an estimate of canopy cover from that point (Agee 2010). Make sure that only one person does spherical densiometer readings per plot. Someone else may take the readings at the next plot, but as long as it is only one person. Note whether the spherical densiometer readings are taken in a representative location in the plot. For instance, if you take sd readings right under a tree, but that is the only tree in the plot and the rest of the plot is a meadow, note that discrepancy.

Record information on every tree within the plot, including seedlings (if identifiable).

- **Tree#:** Assign each tree a unique number, starting with T01 at each plot. Start over with T01 when you visit a new plot. If a tree is on the line of the plot, follow these boundary rules: plants falling on the North and South boundaries will be counted; plants falling on the East and West boundaries will not be counted.
  If a tree is too small to be measured at dbh (e.g., dbh <1cm), then record the species as a shrub.
- **Species:** Record the species. Use the bark, branches, twigs, and buds, leaves, needles, and cones to help you identify the species. It helps to look on the ground for fallen leaves, needles or cones and to look at tall trees through binoculars. Use the species code sheet (Appendix I). It lists the priority tree and shrub species along with their Oregon Flora Project 6-letter species codes. If a species is not on the priority list, measure it but count it as "other." If you are uncertain about your identification, place a "cf." in front of the name (e.g., cf. QUEGAR).
- **Stratum:** Record the stratum: O for overstory (the tallest part of the tree is not in the shade of other trees in the plot, although it might be co-dominant so some branches may be shaded) or U for understory (the tallest part of the tree is in the shade of taller trees in the plot).
- **DBH Class:** Begin by estimating what the DBH class is for each tree. Then measure the exact DBHs of the trees (the measurements only need to be precise to the whole inch). With time, you will be able to accurately determine the DBH class without measuring every tree. (However, still measure the exact DBH of heritage trees, not the DBH class). Measure (or estimate) the DBH and record the DBH class. D1 (<2" DBH), D2 (2-6" DBH), D3 (6-12" DBH), D4 (12-20" DBH), D5 (> 20" DBH). If there are multiple stems originating from a single base, visually select an average diameter stem and use that for your DBH measurement. Diameters are taken 4.5 feet (1.3 m) up from the ground. If the tree forks below 4.5 ft. (1.3 m) or a branch or defect prevents measurement, measure the narrowest point below the fork or defect and record the height of the measurement. Note: If you do not have access to a forester's diameter tape, use a standard tape measure to obtain circumference or a stretch a string around the tree and measure it. Diameter is obtained by dividing the circumference by 3.14. If you are unable to take the DBH of a tree due to heavy poison oak vines, make an estimation and make a note of the situation. If you have a DBH stick, you can use that instead.
- **Number of stems:** This is assumed to be "1" unless otherwise noted. If there are multiple stems, count the number of stems visibly joined at the base of the sample tree. Also count multi-stems growing in a "ring" around a center point (within 1m of each

other). This represents basal resprouts that regenerated after a tree was cut down, which can happen in oaks and maple.

- **Snags:** Note weather the measured trees in the 10m x 10m plot are snags (dead trees)
- **Comments:** Record anything you notice about the tree including but not limited to are the leaves/branches only on one side of tree? Does the tree lean in any particular direction? Are there any gall pods? Is there fungus growing on the tree? Etc.

Shrubs:

For shrubs, you will not collect information for each shrub. Rather, collect information for each species. Use the code sheet (Appendix 1). It lists the priority tree and shrub species along with their Oregon Flora Project 6-letter species codes. As with the trees, use "cf." for uncertain identifications. Lump all other shrubs into a single "other" category. Young shrubs can be easy to miss so look carefully for them. For blackberry shrubs, try to distinguish between native and non-native blackberry, for management/restoration purposes. Note in the shrubs comments section if the RUBZZZ is native or non-native. Native blackberry is more prostrate, trailing/vine-like (less cane-like), has many small thorns (slender, curved, unflattened), a thinner stem that is often purplish at the base and 3 leaflets.

For each species, record the % cover class. You can think of this as the "bird's-eye view" looking from above. Think of each plot as a three dimensional column of space that goes up through the canopy when making cover estimates. Use the following cover intervals: 0-5%, >5-25%, >25-50%, >50-75%, >75-95%, >95-100%. You may end up with over 100% total shrub cover because species may overlap spatially, and you are recording cover for each species.

Herbaceous/ground layer (<1 m):

Place a $1m^2$ quadrat in the center of the 10m x 10m plot. Estimate the total aerial cover or "bird's-eye view" looking from above for each category. Use the following cover intervals: 0-5%, >5-25%, >25-50%, >50-75%, >75-95%, >95-100%. It's possible that your total may be over 100% because of overlap. If the cover seems to be on the line of a cover class (ex: if it looks to be exactly 25% and you cannot determine if it should be in the 5-25% or 25-50% class) then always round down.

% Herbaceous cover: The total cover of all live, non-woody vascular plants. Vascular plants are grasses, grass-like plants and plants such as wildflowers. Some plants will have flowers during your sample period, but many flower in late May and June.

% Non-vascular cover: The total cover of lichens, mosses and bryophytes.

% Non-vegetation cover: The total cover for each: exposed rock or soil, leaf litter/duff, woody debris.

Plot Representativeness: Is your quadrat representative of the entire 10m x 10m plot? Check the box next if the randomly selected quadrat you sample visually looks the same as the remainder of your 10m x 10m plot. An example would be: your random quadrat is mostly grass, and so is the rest of your plot. An example of a difference would be: your random quadrat happens to encompass a grassy patch, and the rest of your 10m x 10m plot has little to no herbaceous vegetation, but is characterized by bare dirt/rock.

C. 10m x 10m PLOT: WILDLIEF HABITAT FEATURES AND SIGN
Within the 10m x 10m plot, evaluate the following wildlife features. (*Note: wildlife habitat evaluations should also look at water sources, food plants and rocky features. These features either do not apply to the Ridgeline area or the information is collected elsewhere in the protocol).*

Bioturbation: Estimate the percent of the sample exhibiting soil disturbance by fossorial wildlife (any organism that lives underground; in this case, pocket gophers or moles). Do not include disturbance by ungulates (deer or elk). Circle one: High = greater than 10% ground surface area disturbed, Medium = 5-10% ground surface area disturbed, Low = 1-5% ground surface area disturbed, or none.

Past bioturbation: Are there signs of historic soil disturbance by fossorial wildlife? Circle Yes or No.

Logs greater than 20" (greater than 8" estimated average diameter: The minimum diameter of the downed logs must be met within plot (that is, if the log extends outside of the plot and is not big enough within the plot, do not record it). Only record the log if it is lying on the ground. If it has fallen and is leaning on another tree, count it as a snag instead of a downed log. Measure total length of log, even if it extends beyond plot. Also measure the length of log within plot. You do not need to record the DBH of the log.

Woodpecker cavities and/or foraging: Describe any circular holes that are likely woodpecker cavities. Also describe signs of foraging (e.g., large rectangular excavations in wood by Pileated Woodpeckers, horizontal lines of small holes by sapsuckers). If you cannot determine what type of holes are on a tree, note 'undetermined holes' and do not make a guess unless you are sure of the cause of the holes.

Wildlife observations: Describe any wildlife that you saw or heard, including sign such as scat or tracks. You don't need to identify scat or tracks to species (which can be difficult). However, try to guess if the scat/tracks are from a domestic animal or wildlife and, if wildlife, if made by a small animal (<2 lbs), medium-sized animal (2-20 lbs) or large animal (>20 lbs). Be sure to note if you observed any of these focal species: Pileated Woodpecker, Western Bluebird, White-breasted Nuthatch, Acorn Woodpecker, or Western Gray Squirrel. For assistance in identification, refer to the reference photos provided to you.

Large Stumps: Record large stumps greater than 20" diameter at base.

D. GENERAL STAND OBSERVATIONS:
Briefly describe the stand's overall vegetation, any signs of current or historic disturbance (e.g., fire, landslide, flood, animal burrowing), succession, threats (e.g., invasive species, off-highway vehicles, garbage dumping, vandalism, erosion, "user trails") and other site environmental and vegetation factors of interest. Describe any rocky areas, especially if there are large, loosely-piled rocks that provide crevices for wildlife hiding cover, or if the rocky area is in the sun so could provide basking habitat for reptiles.

E. INTERPRETATION OF STAND (TO BE DONE IN THE OFFICE)
In this section, you will use your field data and "ground-truthing" to evaluate the polygons within the City's GIS layer.

GIS habitat classification: Fill in the existing habitat type classification (as provided to you).

Field-assessed habitat classification: Based on your field assessment, fill in your classification of the habitat type within the plot. See Appendix II for a description of habitat classifications.

Confidence in identification. Circle one – high, medium, or low – to indicate how confident you are in the field-assessed habitat classification. Low confidence can occur from such things as a poor view of the stand, an unusual mix of species that does not meet the criteria of any described habitat type, or a low confidence in your ability to identify species that are significant members of the stand. If your confidence is Low or Medium, explain why.

Do you recommend a change in the GIS polygon classification? Circle No if your habitat classification agrees with the GIS classification. Circle Yes if your habitat classification differs from the existing habitat classification and you think the GIS classification should be changed. If yes, explain why under "Justification."

Other assessment or mapping information: Discuss any assessment or mapping issues that may be of interest to land managers.

2. RIDGELINE OAK ASSESSMENT HERITAGE TREE FORM

A. GENERAL INFORMATION

Date: Date of the data collection.

Plot #: Number assigned in the office prior to field work. It consists of the polygon number followed by a dash and sequential number (e.g., MARI001-01 for plot #1 in Mariposa Woodland polygon #1).

Name(s) of surveyors: The full names of for everyone collecting data or otherwise assisting with sampling. The person recording the data on the form circles his or her name.

B. 30m CIRCLE: HERITAGE TREES ("Heritage trees are oak trees >16" DBH, conifer trees that are >30" DBH, and any other trees >20" DBH Time start and Time end: Record the time you started and ended collecting data. This will be used to determine how many people-hours each task requires.

GPS datum: The standard GPS datum for this project is NAD 83. If you discover that your unit is recording using a different datum, record it here.

Pace approximately 30m from the plot marker in 4 cardinal directions and place a temporary flag. Use the flags to help you delineate an approximate circle with a 30m radius. Within that circle, record information for all live trees >20" DBH (all trees, not just oaks) and snags (dead tree) >12" DBH, except for Doug Firs, which will only be recorded if they are greater than 30" DBH. ; the minimum dbh for Oregon white oak trees and California black oak trees is 16". For each tree, assign a tree number. If the 30m-radius circles around two plot markers overlap, record information only once and note overlap on data sheets. Do not record the same tree twice for two different 30m-radius circles. . For example: if the 30m circles of plot 1 and plot 2 overlap, and the heritage trees in the overlapping area were recorded in the plot 1 30m circle first, note on the plot 2 form that there were blank number of heritage trees that were in overlapping circles and that they are recorded on the plot 1 form as HT 01 and HT 02. During an overlap situation, communicate with the team who is doing the nearby plot to let them know which heritage trees are in the overlapping portion of the 30m circles. Or, if the same team will be collecting data on both plots, make a note of which trees are in the overlapping area. If necessary, mark the heritage trees in the overlapping area with a unique-colored flag to designate which trees have been recorded. Then, when data for the second plot are collected, it will be clear which heritage trees were already recorded. It will be the responsibility of the team recording the second plot to pick up the heritage tree flags when they are finished.

Your 30m-radius circle will encompass your 10m x 10m plot. If there is a heritage tree within your 10m x 10m plot, record the tree on both data sheets. Clearly indicate which tree on the data sheets and make a note in the comments field on both data sheets. The tree will have two different ID numbers, which is okay – put the heritage tree number on the 10m x 10m plot data sheet and vice versa. Also record the tree number from the other data sheet for a cross-reference.

If there are no heritage trees in the 30m-radius circle, search a 50m circle. If there are still no heritage trees, find and document the largest DBH tree in the circle.

For each Heritage Tree, record species, DBH, health, competition, and UTMs:

- **DBH:** Using a forester's diameter tape (d-tape), measure the DBH. Diameters are taken 4.5 feet (1.3 m) up from the ground. If the tree forks below 4.5 ft. (1.3 m) or a branch or defect prevents measurement, measure the narrowest point below the fork or defect and record the height of the measurement. Note: If you do not have access to a forester's diameter tape, use a standard tape measure to obtain circumference or a stretch a string around the tree and measure it. Diameter is obtained by dividing the circumference by 3.14.
- **Health**: Health Class 1 is the healthiest with no visible health problems. Health Class 2 trees are probably also healthy but there may be some question. Health Class 3 trees look unhealthy. Use the following codes: **1)** healthy, all bark and major limbs present and alive, no visible rot, full crown of healthy leaves (be sure to account for season when assessing canopy health); **2)** healthy but has one or more of: missing bark, broken major limbs, visible rot; **3)** tree appears unhealthy-- much visible rot, sparse foliage, major branches broken or dead. If a tree has conks (perennial fungal fruiting bodies), classify the tree as Health = 2 or 3 (depending on the presence of other health indicators noted in the protocol) and note the presence of conks in the comments section.
- **Competition**: D – Dominant (the majority of the canopy is above the canopy of immediately neighboring trees), C – Co-dominant (the majority of the canopy is equal height to the canopy of immediately neighboring trees but is not being shaded), I – Intermediate (<50% of the canopy is below or being shaded by the canopy of neighboring trees), S – Suppressed (>50% of the canopy is below or being shaded by the canopy of neighboring trees).
- **Tree # in 10 x 10 plot** – If the Heritage Tree falls within a 10m x 10m plot, record the tree number from your plot form.

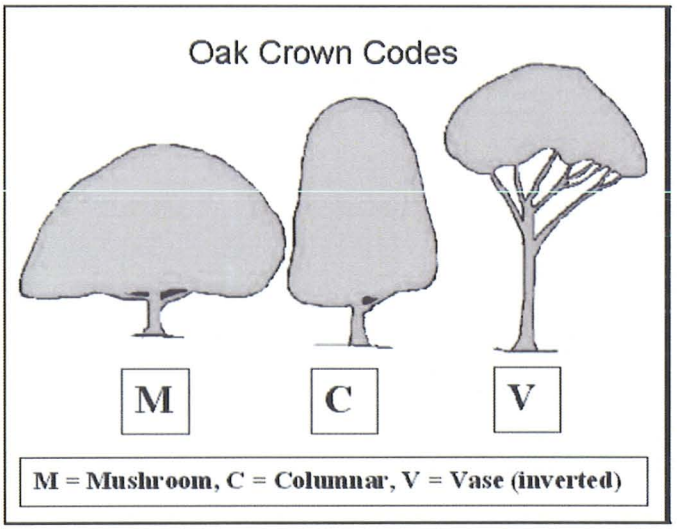
If possible, note location of heritage trees on aerial photo.
Do not record GPS locations for heritage trees. Instead, record location of heritage trees by pacing directly from the SW stake to the tree, recording the distance and the azimuth bearing. Calculate the distance while in the field using the equation:

Distance (m) = 10 x (number of steps you took) / (your pace)

If necessary, one can calculate the corresponding x/y distances from the azimuth distance and bearing using basic trigonometry.

For oak trees, record this additional information for each tree:

- **Total contact trees (#)**: Count the number of trees of any species that touch or strongly influence the canopy of the tree being surveyed.
- **Conifer contact trees (#)**: Of the contact trees, count how many are conifers.
- **Percent of crown contact**: Estimate what percent of the crown circumference is making contact or merged with other trees of similar or larger size.
- **Mistletoe load:** Mistletoe is a parasitic plant that grows by using sugars manufactured by the tree. Mistletoe brooms are very obvious when the leaves are off the tree. They look like balls of fine branches. Record the number of brooms .**Crown width.** Using a long measuring tape, record the longest and shortest crown radius, not width, (in other words, record from the trunk to the canopy edge).
- **Tree Shape**: This is the shape of the tree crown as viewed **from the** side. Record: C - columnar, V - inverted vase, M - mushroom (see drawings on data form and diagram below, Galloway et al. 2006):



SOURCES AND ACKNOWLEDGEMENTS

This protocol was developed based on ideas from:

1. Agee, J. Vegetation/Terrain Field Equipment Procedures, Ecosystem Sciences Division, College of Forest Resources, University of Washington. http://www.cfr.washington.edu/Classes.esc.221/Classes.ESC.221.BAK/skills/VegTerrain%20Field%20Procedures.doc.htm, Accessed February 4, 2010.
2. California Native Plant Society/California Department of Fish and Game's Protocol for Combined Vegetation Rapid Assessment and Releve Sampling Field Form, September 10, 2009. http://www.cnps.org/cnps/vegetation/pdf/protocol-combined.pdf
3. Galloway, A. W. E., M. T. Tudor, and W. M. Vander Haegen. 2006. The reliability of citizen science: a case study of Oregon white oak stand surveys. Wildlife Society Bulletin. 34:1425-1429.
4. U. S. Forest Service. Quercus garryana Acorn Production study. http://www.fs.fed.us/pnw/olympia/silv/oak-studies/acorn_survey/
5. Peer review from Bruce Newhouse, Salix Associates.
6. Elzinga et al. (2001).

Appendix 1
Priority Tree and Shrub Species with Codes

Trees

	Code	Scientific Name
Hardwoods		
California black oak	QUEKEL	*Quercus kelloggii*
Oregon white oak	QUEGAR	*Quercus garryana*
big-leaf maple	ACEMAC	*Acer macrophyllum*
Pacific madrone	ARBMEN	*Arbutus menziesii*
cherry sp.	PRUZZZ	*Prunus* sp.
Conifers		
Douglas-fir	PSEMEN	*Pseudotsuga menziesii*
ponderosa pine	PINPON	*Pinus ponderosa*

Lump all other tree species under "Other" category (e.g., grand fir, incense cedar, cascara, etc.).

Shrubs

	Code	Scientific Name
osoberry	OEMCER	*Oemlaria cerasiformis*
Scotch broom	CYTSCO	*Cytisus scoparius*
Armenian or European blackberry	RUBZZZ	*Rubus* sp.
poison oak	TOXDIV	*Toxicodendron diversilobum*
red elderberry	SAMRAC	*Sambucus racemosa*
baldhip or Nootka rose	ROSZZZ	*Rosa* sp.
Pacific serviceberry	AMEALN	*Amelanchier alnifolia*

Lump all other shrub species under "Other" category (e.g., vine maple, Pacific ninebark, Oregon grape, common snowberry, black twinberry, mock orange, etc.).

APPENDIX II

Ridgeline GIS Layers – Background and Ground-truthing

LONG-TERM GOAL: Refine existing landscape-scale vegetation cover maps in the Ridgeline to site-scale accuracy for forested cover types. Add oak-dominated stands as a cover type.

ELP GOAL: Check accuracy of maps for ELP study stands. Confirm, edit, or create polygons and update attributes using field observations. Test feasibility of this method for Ridgeline-wide application.

BACKGROUND:

- The City of Eugene currently has two different landscape-level GIS layers showing major vegetation types in the Ridgeline.
- Each project had specific objectives, which are reflected in the final maps. There are currently two sets of cover types, and delineated polygons often do not coincide.
- The vegetation mapping is derived from aerial photo interpretation, and in some cases, from field visits. Each layer also has unmapped areas due to methodology or to acquisition of property after the layer was completed. Field verification (or assignment) of vegetation cover types is needed.
- The City's Ridgeline Team reviewed each layer and determined that a hybrid of the two layers was most desired for long-term management and planning.
- The South Ridgeline Habitat Study ("SRHS") layer will be the foundation, and will be augmented with data from Ridgeline Oak-Prairie ("ROP") mapping.

SOUTH RIDGELINE HABITAT STUDY (SRHS) Layer:

The SRHS approach generated a vegetation cover map as follows (SRHS Final Report, Salix Associates, 2007):

Cover Type Classification (p.13):
"...the consulting team successfully adapted and utilized a cover type (also called "habitat type") classification system defined in Adamus, et al. (2000). This system contains brief summaries of the general type of vegetation that is in the tallest layer, which is the most visible layer to see both in the field and on aerial photographs. The system classifies vegetation by the density (or

"percent cover") of the tree layer into four categories, listed here in descending order of tree density: forest, woodland, savanna and prairie (or grassland).

The system was adapted to address locatl conditions in Eugene. As it was initially designed, the system was intended for use incategorizing cover types using regional-scale aerial or satellite photography, whereas for the ...Eugene project, it was adapted for on-the-ground use supplemented with local scale aerial photography."

The cover types used in the SRHS are as follows:

COVER TYPES

The EPA/Adamus Resource Assessment (ARA) used for satellite interpretation served as a basis, but required modification for field use – so there is not a 1 to 1 correspondence. Details of natural vegetation and development cover type categories as adapted for our on-the-ground application follows. (All covers are actual, not relative.) An "R" suffix added after a number indicates a "riparian/wetland" element.

Cover Type	Code	Description
FOREST (>70% tree cover)	1-6	Conifer forest
	7	Mixed conifer/hardwood forest (each > 30% cover of tree layer)
	8	Hardwood forest
WOODLAND (31-70% tree cover)	9	Conifer woodland (conifer cover >60% of tree layer)
	10	Mixed conifer/hardwood woodland – (each not > 30% cover)
	11	Hardwood woodland (hardwood cover >60%)
SAVANNA (5-30% tree cover)	12	Other savanna (not oak)
	13	Oak savanna - trees scattered (white and/or black)
SHRUBLAND (shrub cover >30-100%)	14	Shrub – upland (tree cover to 70%)
	15	Shrub – wetland
AGRICULTURE	17	Orchard
PRAIRIE/GRASSLAND/ROCK (shrub cover <30%, tree cover <5%)	20	Grass short - lawn, heavily grazed pasture
	21	Grass natural - native and introduced, but not cultivated, mowed or grazed
	22	Grass tall - cultivated grass and grass-like vegetation including ryegrass, orchard grass, fescue, wheat, hayfields, and lightly grazed pasture
	24	Rock – large outcrops, balds; open rocky areas
WETLANDS	26	Seasonal wetlands
	27	Permanent wetlands
RESIDENTIAL HABITAT	33	Low density residential (≤ 4 dwelling units/acre) w/habitat

Adamus, P.R., J.P. Baker, D. White, M. Santelmann, and P. Haggerty. 2000. Terrestrial Vertebrate Species of the Willamette River Basin: Species-Haibtat Relationships Matrix. Internal Report. U.S. Environmental Protection Agency, Corvallis, OR. http//www.fsl.orst.edu/pnwerc/wrb/access.html (select "Related Data").

Salix Associates. 2007. South Ridgeline Habitat Study final report. Unpublished report to the City of Eugene. http://www.eugene-or.gov/portal/server.pt/gateway/PTARGS_0_2_285493_0_0_18/SRHS_Report_2007-08-30_FINAL.pdf

Ridgeline Oak-Prairie (ROP)Habitat Mapping GIS Layer:

The purpose of this project was to identify current and former oak and prairie habitats to focus conservation efforts. This mapping project was implemented by Ed Alverson of The Nature Conservancy between 2006 and 2008, with support from others. The GIS layer was developed in the office from aerial photo interpretation; it has not yet been ground-truthed.

Ed used 1952 air photos, 1:12,000, supplemented by reference to 1936 and 1940 air photos in areas where the 1952 photos were ambiguous. A stereo viewer was used to draw by hand the boundaries of the areas that would be mapped further and those which would not (e.g., current and former conifer forest), using a Xerox copy of 1952 air photo and visual examination of topography and forest appearance. Then, areas supporting prairie, savanna, or oak/deciduous woodland ca. 1952, were interpreted and mapped by hand as individual map units on ortho-rectified 2004 air photos, at a scale of 1:8000. The 2004 air photos were taken in early spring, so it was possible to distinguish hardwoods from conifers on the 2004 air photo layer. These were supplemented with 2005 and 2006 NAIP aerials, taken in the summer, with full leaf-out.

Symbol	2004 Habitat Type	Historic (1952)	Current Vegetation	Tree Canopy	Notes
Existing Prairie/Savanna/Oak cover types:					
PU	Upland prairie or pasture	prairie/savanna/ oak	• Open grassland habitat on non-hydric soils.	<5%.	
PW	Wet prairie or pasture on mapped hydric soils	prairie/savanna/ oak	• Open grassland habitat on hydric soils.	<5%.	
S	Savanna	prairie/savanna/ oak	• Dominant tree spp.: *Quercus garryana* and *Quercus kelloggii*; *Pseudotsuga menziesii* or *Pinus ponderosa* may also occur. • Mostly upland but can be hydric.	5% - 25%	
WO	Oak woodland or forest		• Oaks (QUGA and QEKE) are the predominant tree cover • Relative % cover of conifers ≤25%.	> 25%.	• Woodland (25-60% canopy cover) was not distinguished from forest (>60% cover).
WOF	Oak-conifer woodland or forest	prairie/savanna/ oak	• Oaks (QUGA and QEKE) mixed with conifers • Relative % cover of conifers is generally 25% - 75%.	> 25%.	• Generally represents stands w/an oak component where conifer invasion can be addressed. • Woodland not distinguished from forest .
WA	Ash or ash-oak woodland	prairie/savanna/ oak	• Hydric soils where Oregon ash (*Fraxinus latifolia*) is a predominant canopy species. • Oaks (mainly QUGA) may also be present.	> 25%.	• Woodland was not distinguished from forest.

TO GROUND-TRUTH Ridgeline Vegetation Cover Types:

- In the field, confirm vegetation type and boundaries on existing maps, or edit or delineate them as needed. If boundaries need to be edited, hand draw changes on the aerial photos provided, or GPS the boundaries. GPS will likely provide the most accurate boundaries in woodland or forest settings, but there are cases where the boundary is obvious and GPS is unnecessary, such as when the woodland/forest is bordered by grassland or prairie. Alternately, GPS accuracy may be reduced under dense canopy, and thus hand-mapping may be more accurate. Use best judgment to obtain the greatest accuracy in the most time-efficient manner.
- If you GPS the boundaries, save the file with the same name as the plot you are sampling.
- Start with the SHRS polygon cover type that is given on your map.
- As appropriate, classify and map areas where Oregon White Oak or California Black Oak are the dominant canopy species, using the ROP mapping as a guide to indicate to you when these might be the dominant cover types. (Note – not all oak stands are mapped in ROP.)
- Use the modified SRHS definitions for determining final vegetation type (see table below).
- Example: A polygon is classified as "Hardwood Woodland." Vegetation sampling confirms that canopy cover is within the 31-70% range, and also that the dominant species is Oregon White Oak. Change the vegetation type to "Oak Woodland."
- Minimum mapping unit = 2 acres (~5 ha), except where oak dominated = 1 acre (~2.5 ha).

Use the following vegetation cover type categories (from SRHS study, modified to add oak cover):

Cover Type	Description
Mixed Forest	More than 70% of the mapped area covered by trees, as viewed from above. Generally, <60% of this tree layer covered by trees with needles (such as Douglas Fir), and <60% covered with hardwood trees (which have leaves, such as Bigleaf Maple or Oregon White Oak).
Hardwood Forest	More than 70% of the area covered by trees, as viewed from above. Generally 60% or more of this tree layer covered by trees with leaves (rather than needles), such as bigleaf maple and Oregon White Oak. 40% or less covered by conifers (trees with needles, such as Douglas Fir and Grand Fir).
Oak Forest	More than 70% of the area covered by trees, as viewed from above. Generally ≥60% covered by trees with leaves, and ≥20% total canopy cover of oak species.
Mixed Woodland	31-70% of the area covered by trees, as viewed from above. <60% of this tree layer covered by trees with leaves (rather than needles) such as Oregon White Oak, California Black Oak or Pacific Madrone, and < 60% covered with trees with needles (rather than leaves), such as Douglas Fir.
Hardwood Woodland	31-70% of the area covered by trees, as viewed from above. ≥60% of this tree layer covered by trees with leaves (rather than needles) such as Oregon White Oak, California Black Oak or Pacific Madrone.
Oak Woodland	31-70% of the area covered by trees, as viewed from above. ≥60% of this tree layer covered by trees with leaves, and ≥20% total canopy cover of oak species.
Other Savanna	5- 30%of the area covered by trees, as viewed from above. "Other savannas" have Douglas fir and/or ponderosa pine as dominant tree species, sometimes in combination with Oregon White Oak and/or California Black Oak.
Oak Savanna	5-30% of the area covered by trees, as viewed from above. Oak savannas have Oregon White Oak as the only dominant tree (or possibly California black oak).

APPENDIX D: RIDGELINE FIELD GUIDE

Trees:

Oregon White Oak

Scientific Name: *Quercus garryana*

Code: QUEGAR

Description: Oregon white oak, this oak is a heavy limbed oak which grows up to 25 meters tall with light grey thickly furrowed and ridged bark. The leaves are round-lobed which are thin and get to be 12 cm in length and the acorns are 2-3 cm long. They are normally found in deep well drained soils and bluffs.

California Black Oak

Scientific: *Quercus kelloggi*

Code: QUEKEL

Description: California black oak is an oak that shares many of the same characteristics of Oregon white oak, however its leaves have sharper angles and pointed tips with bristles.

Big-leaf Maple

Scientific Name: *Acer maacrophyllum*

Code: ACEMAC

Description: Big-leaf maple, can grow up to 35 meters tall and normally contain multiple stems with five lobed leaves that range from 15-30 cm across. When flowering clusters of greenish yellow flowers 2-3 mm across droop in a cylindrical pattern. Maples are normally found in dry low areas that are commonly disturbed by fires, logging or human clearing.

Cherry

Scientific Name: *Prunus* sp

Code: PRUZZZ

Description: Cherry trees are a deciduous tree which have a medium textured grey bark and can grow from 4 to 6 feet tall. It features leaves which are somewhat oval shaped which meet at a sharp point. The edges are serrated and can range anywhere from 2 to 5 inches. It flowers in early spring with many white flowers and in the summer small reddish black fruits can be seen.

Douglas-fir

Scientific Name: *Pseudotsuga menziesii*

Code: PSEMEN

Description: Douglas Fir, is a conifer which when fully grown ranges from 70 to 90 meters tall. It has rough, thick brown bark with flat, pointed light green needles. It is found in a variety of habitats from dry low elevations to moist mountain areas.

Ponderosa pine

Scientific Name: *Pinus ponderosa*

Code: PINPON

Description: Ponderosa pine, is a conifer which when fully grown ranges from 20 to 30 meters tall with a soft looking crown and thick "puzzle piece like bark"(see pic below). The needles range from 10-20 cm long and occur in bunches of three. It is an inland pine species which is normally found in dry open sites of the Cascades and the Puget Sound.

Pacific madrone

Scientific Name: *Arbutus menziesi*

Code: ARBMEN

Description: Pacific madrone, is a heavy limbed tree which when fully mature grows up to 30 meters tall. When its bark is young it is smooth and tan but it turns reddish-brown and peels as it ages. The leaves are dark shiny ovals which reach 15 cm long. At times it has orange red berries and white urn shaped flowers. Pacific madrone is normally found on dry, sunny, rocky sites at low middle elevations.

Shrubs:

Poison Oak

Scientific Name: *Toxicodendron diversilobu*

Code: TOXDIV

Description: Poison oak is a shrub which can grow up to 3 meters tall and contains 3-5 irregularly lobed leaflets which turn bright scarlet in autumn. It is found in dru sunny slopes at low elevations. Watch for this shrub because to oils contained in the leaves may cause skin irritation.

Scotch broom

Scientific Name: *Cytisus scoparius*) INVASIVE

Code: CYTSCO

Description: Scotch broom, grows around 3 meters tall with strong 5 angled branches that have small leaves containing 3 leaflets. The flowers are small pea shaped and bright yellow usually 2 cm long. It also contains black flattened pods around 2 cm long. Scotch broom is normally found at low, open areas.

Baldhip or Nootka Rose

Scientific Name: *Rosa* sp.

Code: ROSZZZ

Description: Nootka Rose, is a tall perennial shrub which grows anywhere from 1-3 meters when fully mature. It has light green paired leaflets which have toothed edges and sharp spines on the bottom. The flowers are 5-8 cm wide and occur in clusters of 1 to 3. The flowers range in color bur stay in the area of pink and red normally. The stems are also very spiny.

Native (Armenian or European) blackberry

Scientific Name: *Rubus* sp.

Code: RUBZZZ NATIVE

Description: Leaves clustered in threes and undersides are green stems are vine-like and trailing many small thorns (slender, curved, unflattened) stem is thin, round and often purplish at the base. In late spring and early summer this weed will flower with clusters of white or pale pink petals which grown from 2-3 cm in diameter and it will eventually contain a black or dark purple berry.

Non-native Blackberry

Scientific Name: *Rubus* sp.

Code: RUBZZZ INVASIVE

Description: Leaves are clustered in fives and undersides are white stems are thick and cane-like larger stems are distinctly five angles large thorns (curved like hooks with broad base). In late spring and early summer this weed will flower with clusters of white or pale pink petals which grown from 2-3 cm in diameter and it will eventually contain a black or dark purple berry.

Osoberry

Scientific Name: *Oemlaria cerasiform*

Code: OEMCER

Description: Osoberry, also known as Indian Plumb is one of the first plants to flower in the spring with small greenish-white flowers. This shrub grows up to 5 meters tall and it has purple bark with leaves that are long and lance shaped that are 5-12 cm long. The fruit is a peach colored and it ripens to a deep bluish black color, and it is normally found in open areas.

Red Elderberry

Scientific Name: *Sambucus racemosa*

Code: SAMRAC

Description: Red Elderberry is a plant which is normally found in Riparian areas, woodlands, or moist areas and it grows from 2 to 6 meters tall. The leaves are composed of 5 to 7 leaflets which can grow up to 16 cm long and are lance-shaped with serrated edges. This shrub's flowers are pink when closed, and become white, cream, or yellow when they open. Each flower is small and has five petals with distinctive yellow anthers. The fruit is bright red or purple and contains 2-5 seeds.

Pacific serviceberry

Scientific Name: Amelanchier alnifolia

Code: AMEALN

Description: Pacific Serviceberry has grey bark and slender branches and ranges between 3-12 meters when fully grown. Normally found in larger thickets with leaves that are large, long ovals with razor edges. In spring clusters of white flowers appear before it leaves out and during the summer dark purple to black berries form on the shrubs.

Wildlife Features:

Bioturbation:

The alteration and disturbance of a site by living organisms; the turning and mixing of sediments by organisms, as rodents (such as mole hills). If the disturbance has been seeded or looks clumped (as washed by rain) it is past bioturbation.

APPENDIX E: CANOPY COVER OBSERVER VARIABILITY EXPERIMENT

Based on discrepancies between the percent canopy cover data and general plot notes and photopoints, we conducted an experiment to determine the most consistent method for estimating percent canopy cover. We marked a spot on the ground where each person visually estimated total canopy cover by looking up into the sky, took spherical densiometer readings and visually estimated total canopy cover using a tool which we created called the 'Cheerios box' tool. In order to improve data collection for visual estimation we designed the 'Cheerios box' tool. This device was built from cardboard, tape, and a clear plastic transparency. The box was roughly a six inch cube which was open on two ends. One end was covered with the plastic transparency that had been quartered by an ink marker. This tool was then used to create a frame (like the PVC frame used to evaluate ground cover) that both confines a portion of the canopy to be assessed and placed this sample against a grid (to improve percent cover quantification). Each person took readings out of ear-shot from the rest of the group in order to avoid biasing the results. Our results are shown in the Table 9 below.

Table 9. Percent canopy cover observer estimates using three methods

Observer	Visual estimate	Spherical densiometer	'Cheerios box' tool
Alexi	50-75	50-75	50-75
Matt L	50-75	75-95	75-95
Alex	75-95	75-95	75-95
Brittany	95-100	75-95	95-100
Matt S	50-75	75-95	50-75
Kimmy	50-75	75-95	50-75

From this experiment, we determined that the spherical densiometer readings were the most consistent method of determining total canopy cover; five out of six observers had the same result. Visual estimation was the most inconsistent method; percent canopy cover classes ranged from 50-75 to 95-100. The 'Cheerios box' tool had nearly the same results as visual estimation. Although this tool increases speed of estimation, it only improved precision in 1 of 6 users. Although the 'Cheerios box' tool was not effective at reducing observer variability, we believe that it still has potential. We recommend enhancing the gird on the viewing screen (that is keeping the original quarters with bold lines and then further quartering the original four sections, in lighter lines), allowing for practice prior to use and having more than one observer use it and then coming to a consensus.