Western Riverside County
Multiple Species Habitat Conservation Plan (MSHCP)
Biological Monitoring Program

Engelmann Oak *(Quercus engelmannii)*
Survey Report 2006

April 23, 2007

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NOTE TO READER:

This report is an account of survey activities undertaken by the Biological Monitoring Program for the Western Riverside County Multiple Species Habitat Conservation Plan (MSHCP). The MSHCP was permitted in June 2004. The Biological Monitoring Program monitors the distribution and status of the 146 covered species within the Conservation Area to provide information to Permittees, land managers, the public and the Wildlife Agencies (i.e., the California Department of Fish and Game and the U.S. Fish and Wildlife Service). Monitoring Program activities are guided by the MSHCP species objectives for each covered species, the information needs identified in MSHCP Section 5.3 or elsewhere in the document, and the information needs of the Permittees.

While we have made every effort to accurately represent our data and results, it should be recognized that our database is still under development. Any reader wishing to make further use of the information or data provided in this report should contact the Monitoring Program to ensure that they have access to the best available or most current data.

The primary preparer of this report was Lead Botanist, Jason Hlebakos. If there are any questions about the information provided in this report, please contact the Monitoring Program Administrator. If you have questions about the MSHCP, please contact the Executive Director of the Western Riverside County Regional Conservation Authority (RCA). For further information on the MSHCP and the RCA, go to www.wrc-rca.org

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INTRODUCTION

The Engelmann oak (*Quercus engelmannii)* has the smallest distribution of the oak species found in California. It occurs only in Riverside, Orange, San Diego and Los Angeles Counties. Its northernmost extent is just north of California State Highway 74 and extends southerly to scattered individuals just south of the Mexico-US border (Scott 1991). This species coincides with the coast live oak (*Q. agrifolia*) and is characteristic of southern oak woodlands. The Engelmann oak occurs only in the southern part of the southern oak woodland range, and dominates dry slopes and grassland habitats (Lathrop et al. 1991).

Successful regeneration is problematic for many oaks in California (Phillips et al. 1997). Many species are subject to factors that inhibit their ability to recruit germinated seedlings into adult age classes, thus raising concern over the future of the extant populations of the species. Some probable causes of this lack of regeneration include: 1) anthropogenic disturbances such as grazing or habitat destruction, 2) fire regime alterations, 3) introduced exotic species of plants and animals, and 4) predation on seedlings and saplings.

In western Riverside County, Engelmann oaks are confined predominantly to the Santa Rosa Plateau Ecological Reserve (SRP). There are additional populations at the Southwestern Riverside County Multi-Species Reserve and the Santa Margarita Ecological Reserve. In 2005 and continuing into 2006, the Monitoring Program began a recruitment study of the oaks within the boundaries of the SRP. The intention of the study was to test a protocol that could be used to assess recruitment rates of Engelmann oaks across the Conservation Area to determine if the MSHCP species objectives are being met. The goals of the study were as follows:

Survey Goals

A) Monitor recruitment in populations of *Q. engelmannii* at the Santa Rosa Plateau
B) Determine whether the rates of recruitment differ between vegetation classes
C) Determine the impact of fire regime on recruitment
D) Monitor the effect of non-native grasses and senescence on Engelmann oak recruitment

Species Objectives

The Western Riverside County MSHCP lists *Q. engelmannii* as a Group 2 species because of its specialized habitat requirements and limited distribution (Dudek & Associates 2003). The MSHCP specifies two separate species objectives for the oak that can be evaluated by the Monitoring Program. First (Objective 2), the Conservation Area must include at least 33 known occurrences of the species. Second (Objective 3), within the Plan Area, recruitment must be maintained at a minimum of 80% of the conserved populations. Recruitment, as specified, should be measured by presence/absence of seedlings and/or saplings across any consecutive 5 years.

Our initial interpretation of these objectives suggests that at a minimum, presence of seedlings or saplings at 80% of the known 33 occurrences must be documented in each of 5 consecutive years. This initial interpretation implies that the species objective could be met by simply verifying the presence of a single individual seedling each year, regardless of whether there is continuity from 1 year to the next (i.e. the same seedling is present during consecutive years' surveys). One potential drawback of the initial interpretation is that mere presence of seedlings each year does not guarantee nor suggest successful recruitment into the oak stand. In order to rectify this shortcoming, we intensified our monitoring efforts to include the mapping of seedlings and saplings, with annual site visits to permanent monitoring points to verify their continued presence or absence. Our approach has been to broaden this interpretation in the interest of more closely monitoring trends in recruitment and regeneration into the oak stands. We suggest that the species objectives be assessed at the culmination of the 5 year monitoring interval. Oak stands with successful recruitment will be defined as those having continuity of recruitment over 5 years, or with seedling/sapling mortality at a level that allows for the survival of at least 1 seedling or sapling over the course of 5 years. Actual recruitment is limited to those juvenile individuals which eventually join the canopy layer of the surrounding trees.

METHODS

Protocol Development

To assess the success of recruitment within oak stands, our survey efforts focused on the edges of oak assemblages, as the edge is the region where most recruitment is known to occur (Lathrop and Osborne 1990). In order to capture the edge recruitment, we designed the sampling method to incorporate a belt transect that pivots in a random compass direction on the axis of a point randomly placed on the edge of the oak assemblage. We used permanent transects for this study. Belt transects, as opposed to line or point transects, were employed to increase the area surveyed along the edge of the oak stand.

Personnel and Training

All individuals contributing to this study demonstrated familiarity with *Q. engelmannii*, and studied the distinguishing characteristics of the co-occurring oak species (*Q. agrifolia* and *Q. berberidifolia*). All observers participated in field training at the SRP, and studied field collections of oak seedlings and adults that are stored in-house at the Biological Monitoring Program office and at the University of California Riverside Herbarium. Personnel conducting Engelmann oak surveys in 2006 included:

- Jason Hlebakos, Lead Botanist (Regional Conservation Authority)
- Kim Oldehoeft (Regional Conservation Authority)
- Rosina Gallego (Regional Conservation Authority)
- Debbie de la Torre (Regional Conservation Authority)
- Annie Bustamante (California Department of Fish and Game)
- Ricardo Escobar (California Department of Fish and Game)
- Angela Hyder (Regional Conservation Authority)

Study Site Selection

We chose the SRP as the site for our pilot study to test the initial protocol because it contains the largest contiguous stands of Engelmann oak in the Plan Area. We relied on the classification of Engelmann oak stands as defined by the updated GIS vegetation layer (CDFG et al. 2005) and used our own ground truthing efforts to refine these stands. Using GIS tools, a random grid was overlaid on the vegetation map and queried for the intersections with the edges of the oak assemblages. These points were then used to determine the sites of randomly placed sampling points. By querying the results, a total of 104 random sampling points were chosen (Figure 1). Survey points were distributed across the 7 oak associations that CDFG et al. 2005 defined in the vegetation map, providing us with the tools to compare recruitment between and amongst oak stands based upon affiliated vegetation types. This method can also be used to tailor future studies to address management-oriented questions that will better provide for the survival of extant oak stands in the Plan Area. Specifically, the data will allow us to assess the rates of recruitment relative to the surrounding vegetation type, which will be of particular interest given any changes in abundance of non-native grasses. The vegetation classes are included in Table 1, along with the relative proportion of area occupied by each.

Survey Methods

Surveys were conducted beginning 13 December 2005 and continued until 23 February 2006. Survey methods are outlined in the *2006 Western Riverside County MSHCP Engelmann Oak Protocol* (Appendix A). Observers navigated to predetermined random points along the oak edge using a GPS unit. In cases when the GIS-generated point did not correlate with an Engelmann Oak assemblage (due to mapping error), field personnel navigated by sight to the nearest Engelmann Oak stand. At each point, a random compass direction was chosen from a predetermined list of random numbers generated by the Microsoft Excel Random Number Generating Function. This point then became the center point of a 30 meter belt transect. The belt transect method generated an effective sampling area of $150m^2$.

Along the belt transect, all Engelmann oak seedlings and saplings were mapped and recorded by their position along the transect and distance from the center line. Seedlings were defined arbitrarily as those individuals with a basal diameter of < 1 cm and saplings were defined as those with a basal diameter of 1 to 10 cm. Adult oaks were defined as any individual with a basal diameter greater than 10cm and/or any individual that had joined the canopy of the surrounding oak stand. All oak individuals, regardless of size, were counted, their dbh (diameter at breast height) measured, and size class recorded (based on basal diameter). Additionally, an estimate of the level of senescence in the canopy trees was recorded in order to establish a covariate that would elucidate the level of drought stress present in the survey area.

Data Analysis

Raw data from this study are housed in a digital Microsoft Access database at the Biological Monitoring Program office in Riverside, CA.

We tabulated the number of seedlings and saplings per transect to provide a baseline for the ensuing years of this study. Although number of seedlings is important, we cannot assume that any were successfully recruiting. We developed maps of the seedlings within each of the transects. In subsequent years, all seedlings that match the location of the previous years' map will be considered to have positive survivorship. Should any such individual successfully join the canopy, recruitment will be considered successful. Five years of continuous survivorship for any individual will be counted as successful recruitment as defined by the species objectives. We also calculated the average number of seedlings within each vegetation class to determine if oaks in certain assemblages are responsible for greater levels of reproduction than others.

We also intended to analyze the presence of seedlings and saplings across the SRP against a backdrop of fire history. Maps of recent fire events have been kept by the personnel of the SRP. These maps are currently being updated. This analysis will be completed and incorporated into the subsequent years' analyses when these maps become available.

RESULTS

Survey efforts were divided amongst 7 different vegetation associations defined by the updated GIS vegetation layer (CDFG et al. 2005). The number of survey points within each class is included in Table 1 as well as the total number of transects that had seedlings and/or saplings present. The average number of juvenile oaks (seedlings and saplings combined) across all transects within each vegetation type, the average number of seedlings within only those points at which seedlings or saplings were found are tabulated in Table 2.

The percentage of random transects at which seedlings and/or saplings were found to be present, ranged from 0 to 100% for individual vegetation classes. Eliminating those that had a very small sample size (i.e., n<5), we found that at 22.2 to 37.5% of the points in each vegetation class seedlings or saplings were detected. Variance with vegetation classes was quite high (57.7 for Class 5) (Table 2). This indicates that there may be certain localized areas of increased productivity at any given time, which may be the result of localized masting events (years in which trees produce an unusually large number of acorns). For the entire sample of points across the SRP (n=104), 29.8% of the sample points showed evidence of regeneration as measured by the presence of seedlings and/or saplings.

On the transects where seedlings or saplings were detected, the average number of juvenile oaks within the transect ranged from 2.8 to 12.1 (Table 2). The highest average (12.1) was found in vegetation association 5 (*Quercus engelmannii-Quercus agrifolia/Toxicodendron diversilobum*/Grass). The next highest average was found in the *Q. engelmannii*/Annual Grass/Herb vegetation association (5.6 seedlings or saplings) followed by the *Q. engelmannii*/Chaparral association (5.0 seedlings or saplings).

We further tabulated the number of seedlings and saplings by vegetation type (Table 2). We found that the percentage of juveniles that have recruited into the sapling class ranges from 7.6% to 66.7%. The vegetation class with the greatest percentage of juveniles in the sapling class is *Q. engelmannii/Q. agrifolia/P. racemosa* while the class with the lowest percentage is *Q. engelmannii/Q. agrifolia/T. diversilobum*/Grass.

DISCUSSION

The analysis of data from the pilot study suggests that germination and recruitment of *Q. engelmannii* into the adult age class is low. Within each of the vegetation associations, seedlings or saplings were found in less than 40% of the randomly placed sampling areas. For the entire sampling frame of 104 points, seedlings or saplings were detected on only 29.8% of the transects. Until more data are collected, it will remain unclear whether this is a low, average, or high season in terms of germination or seedling presence. It is important to note that the species objective mentions 33 occurrences which are as yet undefined. These will be defined *post hoc* as we conclude our efforts to map the extant oak populations in the Plan Area. The distribution of sample points amongst these occurrences will then be used to assess the species objectives.

The average number of juveniles per transect ranged from 0 to 4.14 (Table 2). Small sample sizes for some vegetation associations may have been the cause for numbers at the lower end of this spectrum. There was only one sample taken from the vegetation type that yielded zero results (*Q. engelmannii/T. diversilobum*/Grass). Accessibility for some vegetation associations is an issue due to density of vegetation or steepness of terrain, and sample size for these vegetation classes will clearly need to be increased in order to draw valid conclusions. The next lowest germination rates were found in the *Q. engelmannii/Q. agrifolia/P. racemosa* vegetation type. These are areas of riparian habitat. This low rate is best explained by the germination characteristics of the Engelmann oak, which is adapted for establishment in open and exposed dry habitats (Snow 1991). Interestingly, this vegetation type was second highest in terms of the percentage of juveniles that had recruited to the sapling stage. The greatest germination rates were found in the *Q. engelmannii/Q. agrifolia/T. diversilobum*/Grass vegetation type. Until more data are generated, it will remain unclear the extent to which this vegetation class may favor greater productivity in terms of germination or recruitment.

The preliminary data show that 7.6 % to 66.7 % (average across all vegetation types with sample sizes large enough to demonstrate recruitment: 32.6 %) of all juveniles were in fact saplings (Table 2). This indicates that recruitment is occurring at least in the initial stages (from seedling to sapling).

Other oak species in California typically have fairly low germination rates (Phillips et al. 1997; Standiford et al. 1991; Swiecki 1997). Our study indicates that average recruitment rates for Engelmann oaks may be similarly low. The MSHCP species objective states that there should be recruitment at 80% of conserved occurrances. Many factors can influence recruitment success rates on an annual basis, such as fire or drought events. It will take several years of data to see if there is sufficient germination to eventually meet this requirement. Additionally, recruitment as defined in this study entails a continuity of seedlings over a 5 year period of time. That number of years will be requisite to make any robust conclusions.

Recommendations for Future Studies

Subsequent surveys will be based on the same transects surveyed in this study and will again count the seedlings, saplings, and adult recruits. The study is designed to revisit sites every year for 5 consecutive years in order to follow the success of individual recruits over the long term. These data serve as the baseline for our Engelmann oak study. We will continue to revisit all 104 points on an annual basis to assess the future productivity of the points. In order to establish better coverage of the SRP, and to lower the within-class variance for some vegetation classes, we will increase the sampling intensity in 2006/2007. It is recommended that the number of sample points be doubled. Additional sites within the Plan Area will also be added to the study.

We have plans to revise the study in order to better quantify recruitment at a cross-section of the oak edge, while still maintaining randomness. We also plan to include more covariates, which our field observations suggest may help explain differences in germination and recruitment rates across sites. We will include estimates of grass cover and rock cover along the belt transect. We also plan to experiment with various methods to mark transects in order to facilitate annual site revisits. It is very important that transects be relocated precisely on each revisit so that individual seedlings which have been mapped can be relocated with certainty.

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Table 1. Vegetation classes containing Engelmann Oak populations, percent area occupied by each on the SRP, number of survey points selected in each vegetation class, number of transects containing juvenile oaks and percentage of the transects surveyed containing juvenile oaks.

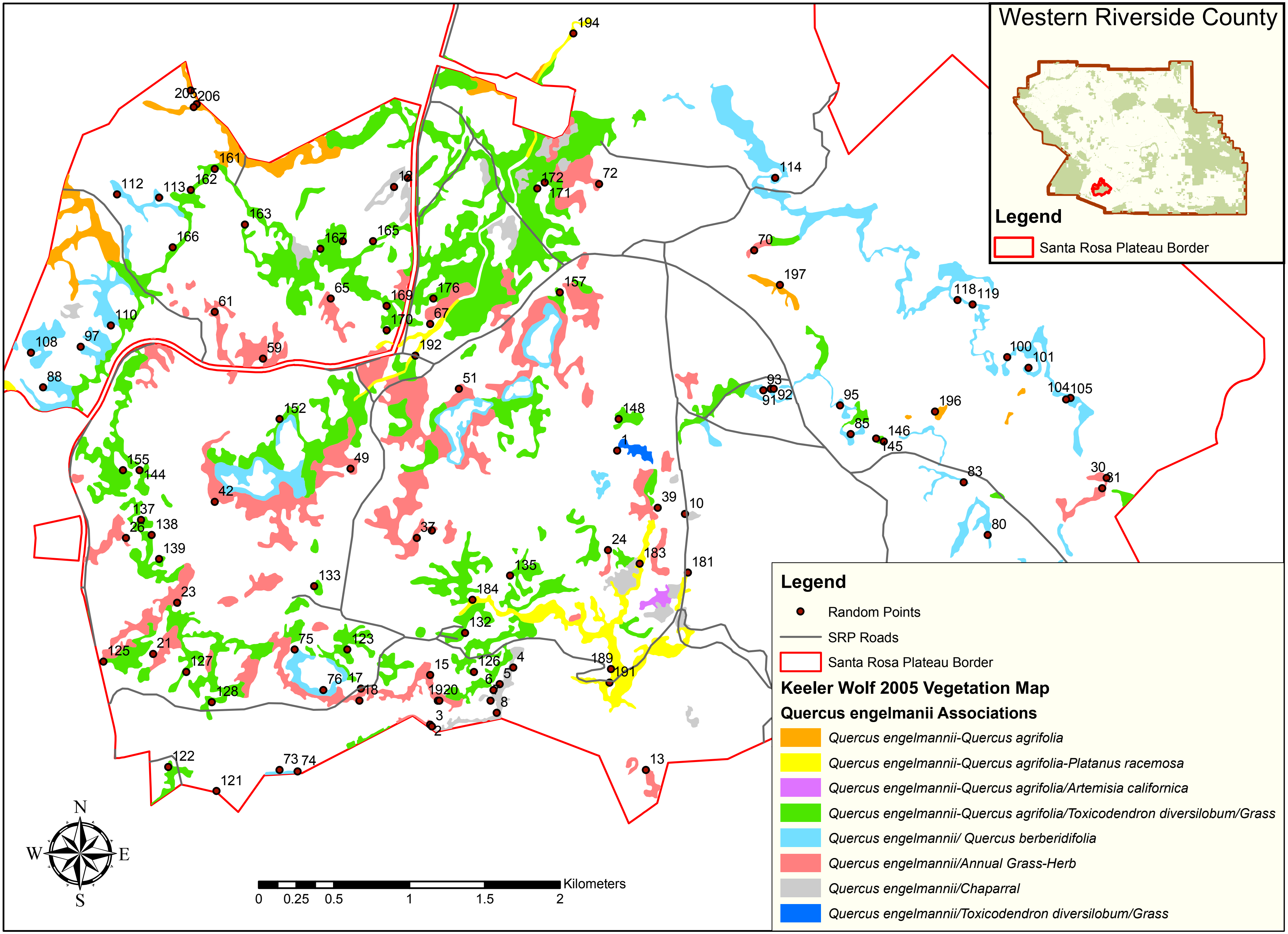
Vegetation Type	Percent area	Number of Transects	Number of Transects with juvenile oaks	Percentage of transects with juvenile oaks
Q. engelmannii/T. diversilobum /Grass	0.6	1	0	0.0%
Q. engelmannii /Chaparral	4.2	9	2	22.2%
Q. engelmannii/ Annual Grass/Herb	24.4	40	9	22.5%
Q. engelmannii/Q. berberidifolia	15.1	16	6	37.5%
Q. engelmannii/Q. agrifolia/T. diversilobum /Grass	46.2	35	12	34.3%
Q. engelmannii/Q. agrifolia/P. racemosa	5.1	2	1	50.0%
Q. engelmannii/Q. agrifolia	4.4	1	1	100.0%
Total	**100**	**104**	**31**	

Table 2. Number of juvenile oaks (seedlings or saplings) by vegetation type, including variance within each type, and juveniles broken down by seedling versus sapling and percentage of individuals that have recruited into the sapling stage.

Vegetation Type	Total No. Juveniles	Average No. Juveniles Per Transect	Average* No. Juveniles Per Occupied Transect	Variance** from Single Factor ANOVA	Number of seedlings	Number of saplings	% of juveniles that Recruited to Sapling Stage
Q. engelmannii/T. diversilobum /Grass	0	0.0	0.0	N/A	0	0	N/A
Q. engelmannii /Chaparral	12	1.1	5.0	8.861	10	2	16.7%
Q. engelmannii/ Annual Grass/Herb	62	1.3	5.6	8.859	43	19	30.6%
Q. engelmannii/Q. berberidifolia	29	1.1	2.8	2.996	17	12	41.4%
Q. engelmannii/Q. agrifolia/T. diversilobum /Grass	211	4.1	12.1	57.655	195	16	7.6%
Q. engelmannii/Q. agrifolia/P. racemosa	3	0.5	1.0	0.500	1	2	66.7%

* Average number of seedlings for only those transects that had oak seedlings/saplings
** Variance in number of juveniles per transect within each vegetation class

Figure 1: Total of 104 Engelmann Oak sampling points distributed along the edge of the oak assemblages on the Santa Rosa Plateau Ecological Reserve



Appendix A:
Engelmann Oak Monitoring Protocol

<u>Engelmann Oaks:</u>

The most extensive populations of Engelmann Oak (*Quercus engelmannii*) in Western Riverside County occur on the Santa Rosa Plateau Ecological Reserve. This area will be the primary focus of our sampling efforts. Engelmann's occur in pure stands, or within populations of coast live oak (*Quercus agrifolia*). Populations of Engelmann tend to cluster in flat valleys, on foothill slopes, or above stream channels. A shrubby oak, *Quercus berberidifolia,* is also found on the plateau, but can be easily distinguished based upon habit. There is some level of hybridization amongst these. The areas of hybridization tend to be the areas of intermediate geography. For the purposes of this study, those oaks that appear to be Engelmann based upon leaf morphology and habit will be considered *Q. engelmannii.* Hybrids are widespread and often cryptic; deciphering them is beyond the scope of this study.

The Engelmann oak is a sprawling tree, ranging from 20 to 50 feet (6-15 meters) in height. At maturity, trees have a dbh (diameter at breast height) of 1-2 feet (0.3 – 0.6 m). The leaf of the Engelmann is distinctively long, elliptical, and green/gray in color.

The scrub oak, *Q. berberidifolia* is a shrub or low growing tree. Leaves are defined as being evergreen, simple, oblong to elliptical, 1/2 to 1 1/2 inches long, base often heart-shaped, leathery and stiff, spiny teeth, shiny green above and smooth or finely fuzzy beneath. Leaf characteristics are easily distinguishable from *Q. engelmannii*, though there may be some confusion with the coast live oak. Hybridization readily occurs amongst these species, with the most common areas of hybridization being the areas of intermediate geography and distribution.

Quercus agrifolia (coast live oak) is the other oak common to the plateau. It is distinguishable from the Engelmann based upon its dark green oval leaves with prickly edges. The leaves of the coast live oak also tend to be distinctively cupped downward around the edges (see illustration below).

The initial phase of the Engelmann oak monitoring program is the demarcation of the several monitoring units. Although the MSHCP calls for a certain number of "occurrences," we find that the population does not easily lend itself to such a division. Instead, we have taken the Keeler-Wolf vegetation classifications and stratified our sampling amongst the several classifications. The classifications are listed in the table below, and illustrated in the attached map.

<u>Engelmann vegetation associations:</u>

Quercus engelmannii/Toxicodendron diversilobum/Grass
Quercus engelmannii/Chaparral
Quercus engelmannii/Annual Grass-Herb

Quercus engelmannii/ Quercus berberidifolia
Quercus engelmannii-Quercus agrifolia/Toxicodendron diversilobum/Grass
Quercus engelmannii-Quercus agrifolia-Platanus racemosa
Quercus engelmannii-Quercus agrifolia

Oak Ecology:

A vast majority of all oak recruitment will occur within a short distance of the outer edge of the canopy of any oak cluster. Generally, seedlings tend to be more abundant in the shade, though within the limit of the canopy edge, seedling survival tends to increase as shade decreases. Furthermore seedlings tend to show an affinity for the canopy edge or dripline. For this reason, we have focused our monitoring efforts on the canopy edge. All monitoring points are chosen on the edge, and sampling design incorporates a stratification to account for variation in relative recruitment between vegetation types.

Engelmann Oak Recruitment Protocol:

1. Locate the point on the edge of the oak assemblage. Given the error associated with GPS locations, the point should be established on what the surveyor judges to be the edge of the canopy closest to the location the GPS reads for the point. The edge will be that boundary where the main body of the canopy ends; the outer edge of the leaf area of the outer oaks in the assemblage. Maps have been generated for each assemblage to eliminate error. Record on the data sheet the original GPS point, which is predetermined, and the final GPS point taken in the field. Record both values regardless of if they differ from one another.
2. A stake should be put in the ground to mark this as a permanent monitoring plot. (Once the mapping is complete, we will have a list of those sites that are to remain permanent and those that are to be temporary).
3. Use a compass to find the direction of the randomly generated compass bearing. From the center point, the transect should extend 15m in either direction. This will be 15m into the oak assemblage, and 15m out. A 50m tape will be used. A stake should be used to mark both endpoints.
4. From the center point, use a compass to measure the slope and aspect. Record these values on the data sheet.
5. The surveyor will walk the transect, preferably with a short measuring device. A search image should be developed to survey a belt 2.5m on either side of the transect. Within this belt, every oak should be recorded.
6. The end of the transect that is outside of the oak assemblage will be defined as the beginning, with this end beginning at zero and the end that protrudes into the oak assemblage ending with 30m.
7. For every oak encountered, write on the first data sheet, first column, the distance along the transect that it was encountered.
8. Measure the basal diameter using a dbh tape. Basal diameter should be taken at the highest point of emergence for those trees emerging on uneven ground. Record this number in the fifth column.

9. Measure the diameter at breast height (dbh), if the oak is tall enough to warrant this. Breast height is defined as 4.5 feet (1.37m) above the forest floor on the uphill side of the tree. This measurement is measured off of the highest ground level at the base of the tree for those on uneven surfaces. Record this number in the 6th column.

10. Write Y or N in the "joined canopy" column. A positive response is justified if any of the individual's branches/leaves are at or above the level of the lowest average canopy level for that area within the assemblage; negative, if the leaves are beneath the canopy level.

11. Based upon the measurements taken, individuals should be placed into an appropriate category. These are as follows

Seedling: basal diameter < 1cm
Sapling: Basal diameter 1 – 10 cm
Adult: 10 cm dbh and/or having joined the canopy

12. For trees with multiple trunks: The dbh should be the sum of the dbh's of the many trunks. These should be entered as individual measurements in the dbh column, separated by commas. In the "notes" column, make note that there are multiple stems.

13. The notes column should also be used to include any relevant information about the individual trees (fire scarring, mortality, etc)

14. The notes section at the bottom of the page should be used to include all relevant information (ecological, disturbance, et cetera) about the oak assemblage.

15. Finally, there should be an estimate given to the relative amount of deciduousness within the stand. This will reflect the health of the stand and its reaction to environmental stress. In the area encompassed by the belt transect, the overlaying canopy's deciduousness should be estimated and recorded on the bottom of the datasheet. This estimate should be a percentage that reflects the area that has lost, or is losing its leaves.

16. Data sheet number two should be simultaneously filled in as the surveyor works down the transect. There should be two copies for each transect, one diagramming the transect from zero to 15m, and the other from 15m to 30m. Every oak that is encountered and included on the data sheet should be diagrammed on the appropriate data sheet. This will facilitate ease of monitoring in subsequent years. Nor further information is necessary on this data sheet.

17. If there are two crew members per transect, the individuals can begin at opposite ends of the transects, meeting in the middle. Aside from the appropriate use of data sheets 2 and 3, each individual will need one copy of data sheet 1. These should be referenced to one another, with both surveyors' names included on each data sheet.