Western Riverside County MSHCP
Biological Monitoring Program
Engelmann Oak Recruitment 2022 Survey Protocol

INTRODUCTION

Engelmann oak (*Quercus engelmannii*) has the smallest distribution of all oak species found in California and occurs from eastern Los Angeles County to northwestern Baja California (Scott 1991; Roberts 1995). Riverside County accounts for approximately 6% of the remaining Engelmann oak populations in California (Scott 1991). The largest occurrence of Engelmann oak in western Riverside County occurs at the Santa Rosa Plateau Ecological Reserve (SRP), and stretches along undeveloped areas in a narrow band west through the Tenaja Corridor to the eastern boundary of the San Mateo Canyon Wilderness Area in the Cleveland National Forest (CNF). Additional populations occur at the Santa Margarita Ecological Reserve (SMER), the Southwestern Riverside County Multi-Species Reserve (MSR), Bautista, Wilson Valley and a few remnant occurrences (ranging between 1 and 15 individuals) elsewhere within the Plan Area.

The MSHCP species-specific Conservation Objective 3 for Engelmann oak states that we are to "maintain recruitment at a minimum of 80 percent of the conserved populations as measured by the presence/absence of seedlings and/or saplings across any consecutive five years" (Dudek & Associates 2003). However, production of seedlings and saplings is often not a limiting factor in the regeneration of oak stands; rather, overgrazing, exotic grass presence, altered fire regimes, and resource competition hinder this process (Muick and Bartolome 1987; Lathrop and Osborne 1990, 1991). Therefore, we can more informatively track whether or not successful regeneration of Engelmann oak populations is occurring by quantifying change in abundance of individual age classes through time, as opposed to using a presence/absence metric that cannot capture replacement of senescing individuals or contraction/expansion of local populations.

We will survey randomly distributed plots within mapped Engelmann Oak vegetation at five study sites: the SRP and vicinity, MSR, SMER, Bautista, and Wilson Valley. Small remnant populations occurring at other locations will be surveyed separately in conjunction with Rare Plant Monitoring surveys. We will count individual oaks by age class at each of the randomly distributed plots. Age classes will be determined by measuring basal diameters of seedlings and saplings. Recruitment and replacement will be determined by following the growth of saplings and progression through age classes. We will analyze data collected for growth and replacement rates independently for each study site. Implementation of Objective 3 for this species will provide new data to guide management and monitoring efforts. Our specific goals and objectives are as follows:

Goals and Objectives

1. Quantify Engelmann oak abundance at study sites.
    a. Record abundance of Engelmann oaks within sample plots in three age classes: seedlings, saplings, and adult trees.
    b. Compare abundance across survey seasons.

2. Assess the health of the adult Engelmann oak population.
    a. Estimate percent leaf loss for individual adult trees within plots (where 0% indicates a fully foliated tree).
    b. Record adult trees that appear to be dead.
    c. Compare health across survey seasons.

3. Determine whether true recruitment is occurring and senescing individuals are being replaced.
    a. Record basal diameter and height category (tall or short, where tall is >1.37 m) of previously tagged saplings to determine growth rates.
    b. Tag and record basal diameter of new saplings.
    c. Record saplings that have grown into adult trees.
    d. Record saplings that have died or cannot be relocated.
    e. Determine rate of replacement (new adults to dead trees).

4. Improve accuracy of plot relocation in future survey seasons.
    a. Revise and create new plot maps as needed.

METHODS

Survey Design

For our sampling design (i.e., population sub-sampling) we will use circular plots randomly distributed within Engelmann oak habitat. To identify suitable plot locations, we used a Geographic Information System (GIS) vegetation map of Western Riverside County (CDFG et al. 2005) to delineate a survey area of Engelmann oak habitat within the SRP Ecological Reserve, the Tenaja Corridor, and a portion of the Cleveland National Forest. Based on the Sawyer and Keeler-Wolf (1995) definition of a vegetation association, we selected vegetation polygons where Engelmann oak is dominant or co-dominant with coast live oak (*Quercus agrifolia*), scrub oak (*Q. berberidifolia*), and/or western sycamore (*Platanus racemosa*). Using the "spsurvey" package (Kincaid 2017) of the R statistical program v. 3.4 (R Development Core Team 2017), we distributed points within this vegetation map following a Generalized Random Tesselation Stratified (GRTS) sampling design. GRTS designs create a spatially balanced distribution of samples that lead to more uniform coverage of patchy landscapes than a truly random sample (Theobald et al. 2007) and allow changes to the sample size without adversely affecting spatial balance. This design improves statistical effectiveness from our previous survey design (see Biological Monitoring Program 2009) by increasing randomness where large Engelmann oak populations occur, while allowing an increased sample size due to a decreased survey time per sampling unit.

Because of the large geographic separation of the populations at SMER, MSR, Bautista, and Wilson Valley we distributed survey plots at these locations independently of the larger population at SRP, Tenaja, and Cleveland National Forest. We used the same vegetation map (CDFG et al. 2005) to delineate the survey area at SMER, however, this vegetation map does not identify Engelmann oak vegetation associations at MSR, Bautista, and Wilson Valley. For MSR, we used location information from survey work conducted in 2004 (*Zachary Principe, The Nature Conservancy, unpublished data*) to

delineate two distinct areas occurring within the mapped Coast Live Oak association where individual adult Engelmann oak trees have been observed. For Bautista and Wilson Valley we used personal Engelmann oak tree observations to delineate our survey area. We then distributed points throughout the resulting polygons using the GRTS sampling design described above.

We clipped all survey areas so that no points were distributed within 15 m of the conservation area boundary or paved roads. Each of the random points was buffered 15 meters to create circular survey plots with an area of 707 m^2. Overlapping plots were excluded. When the protocol for Engelmann oak sampling was first developed (2010-2011 survey season) we identified 1000 sample plots for the SRP study site alone; however, after completing over 700 of these plots we determined that a sample size of 400 plots was sufficient to obtain stable means of oak abundances (see Biological Monitoring Program 2010 and 2011 for a complete description of the methods used). The sample sizes for SMER, MSR, Bautista and Wilson Valley are 25 plots, 10 plots, 8 plots, and 3 plots, respectively. Following initial plot establishment, we created maps of each plot to increase the accuracy of plot relocation, thus reducing data error due to slight differences in plot relocation over time. Surveys will be conducted between the months of October to January, or until all plots have been sampled.

Field Methods

We will re-survey plots using the same methodology as initial surveys in 2011-2012. Surveyors will be paired for each plot survey to aid in data collection and enable increased accuracy of visual estimates for some data. Surveyors will use the distance and bearings to the landmarks provided on plot maps to aid in relocating the plot center points (Figure 1).

Once a plot's center point has been relocated, the circular plot boundaries will be delineated by extending four 15-m long ropes from the center of the plot in the four cardinal directions. A fifth, unsecured 15-m long rope will be used to confirm whether any oaks near the edge of the plot boundary are in the plot. Surveyors will record all Engelmann oak and hybrid individuals (seedlings, saplings, and adults) within the plot (Figure 1).

All saplings on plots will be tracked across survey seasons. We believe that tracking the intermediate sapling stage of oak growth will provide us with the most reliable indicator of successful recruitment from seedling to adulthood. Based on Muick and Bartolome (1987), we define seedlings as individuals with a basal diameter of <1 cm, saplings as individuals with a basal diameter of 1–10 cm, and adults as individuals with a basal diameter ≥10 cm (see also Lathrop and Osborne 1991; Principe 2002). We use size as a surrogate for age because mortality risks and reproductive behavior are often size-dependent (Tyler et al. 2006) and because size can be more accurately recorded than other methods of capturing age. Saplings initially recorded during the 2011-2012 season will be relocated and measured. Large seedlings will be measured and tagged if they are determined to have grown into saplings.

Figure 1. Locating circular plots, trees and landmarks.

To understand the potential impacts on juvenile oak survival, surveyors will also record the type or types of substrate (e.g., rock, leaf litter, thatch) that dominate the area within a 1 meter radius of individual saplings; health categories (e.g. good, resprout, stressed, disease, dormant/dead); canopy cover; and presence of fire. Canopy cover is noted if the sapling occurs 50% or greater under the canopy of any larger tree, regardless of species. Fire is recorded at this time if it occurs within 1 meter of the sapling, but may also be recorded in the survey notes if it occurs elsewhere on the plot. Surveyors will record height categories (e.g., short or tall, where tall is ≥1.37 m) of saplings. Short saplings are more likely to survive to adulthood than seedlings due to having a woody stem and well-developed root system. Tall saplings, with leader stems that reach above the deer-browse line, gain height and girth more rapidly than short saplings, thus progressing more rapidly to the adult stage (Griffin and Muick 1990).

In previous survey seasons, surveyors recorded hybrids between adult Engelmann oak and scrub oak as one of two types based on morphological characteristics: either more closely related to Engelmann oak (H1), or more closely related to scrub oak (H2). Predominance of characteristics was considered, such as leaf shape and color, appearance of the bark, and acorns. Because we have observed that leaf type can be highly variable in hybrids, even on a single individual, we chose to simplify the classification of questionable individuals based on habit: a hybrid oak with a tall, single trunk will be classified as H1, and a hybrid oak with multiple trunks and a smaller, shrub-like habit will be classified H2. For seedlings and saplings, surveyors will not differentiate between hybrid types; instead, they will determine if an individual appears to be a pure Engelmann (Pure) or a hybrid (Hybrid).

To assess the overall condition of the Engelmann oak woodland within the survey area, surveyors will estimate the crown density of all adult trees. Density is used to assess