The Santa Barbara County Oak Restoration Program

1994 – 2005 Final Report

EXECUTIVE SUMMARY

INTRODUCTION

The Santa Barbara County Oak Restoration Program was funded as alternative mitigation for the loss of more than 2000 oaks during installation of the All American Pipeline (AAPL). As described in the original request for proposals, this program was intended to promote the regeneration of oak habitats within Santa Barbara County through fencing and cattle grazing management. Initiated in 1995 by investigators at the University of California at Santa Barbara, the Oak Restoration Program was designed as a program of research and restoration that would give practical guidance to resource managers and land owners concerned with management and restoration of local oak woodlands. This report provides a summary of the research findings and work completed within the initial 10-year contract period.

PROGRAM OBJECTIVES AND ACCOMPLISHMENTS

The Santa Barbara County Oak Restoration Program has been designed to achieve multiple objectives: to restore oak habitat, and to conduct a long-term ecological investigation that would improve our understanding of the role of cattle and other ecological factors in limiting or promoting establishment of oaks in large-scale, landscape-level environments. While establishing oaks in residential settings is generally straightforward and successful, efforts to replace oak habitats for landscape-level mitigation in Santa Barbara County and throughout the state have faced significant challenges, and have often resulted in failure. Thus, the goal of the Santa Barbara County Oak Restoration Program was not only to plant oaks, which had been attempted previously with mixed results, but to improve our understanding of the factors limiting establishment of oaks in large-scale rangeland settings.

This program represents a long-term commitment by the principal investigators, the University of California at Santa Barbara, and the UC's Natural Reserve System to: 1) restore several hundred acres of valley oak savanna and blue oak woodlands on Sedgwick Reserve, a 5896-acre ranch at the base of Figueroa Mountain; 2) conduct large-scale grazing and related experiments that will give practical guidance to resource managers and land owners in Santa Barbara County who are concerned with management and restoration of local oak woodlands; 3) disseminate findings in the form of presentations, onsite demonstration projects, and literature that is directed towards locals landowners and resource managers. Summarized below are the program's main accomplishments to date.

RESTORING OAK HABITAT

Although the emphasis of planting activities has been on conducting large-scale experiments, restoration of oak savanna and woodlands at the site is an integral component of the program. As a result of our planting experiments (1996 – 2002) there are currently 793 new oaks within five age classes: a total of 220 coast live oaks, *Quercus agrifolia*, and 573 valley oaks, *Q. lobata*, within the program area of 525 acres at Sedgwick Reserve in the Santa Ynez Valley. All plantings have been done in areas that are suitable for establishment of oaks, and that will be maintained as natural oak savanna and woodland habitats in the future.

HISTORICAL MAPPING OF OAKS AT SEDGWICK

Mapping the modern and historical distribution of oak woodlands at the Sedgwick Reserve was an important first step in designing the restoration experiment. We used archival air photos to measure changes in oaks between 1943 and 1989. Over the 46-year survey period there was a gradual but steady decline in oak population: 897 out of 5,343 canopy trees disappeared. Average stand densities declined from 5.5 to 4.4 trees per acre. No recruitment of new canopy oaks was observed in the 962 acre study area during the time period 1943-1989. Our historical analysis of oaks on the Sedgwick Reserve indicates that large areas of the reserve have supported higher oak densities in the recent past and would thus be good candidates for oak restoration. Oak woodlands on the reserve have experienced a range of land use histories providing an opportunity to study oak restoration methods in areas that have undergone complete tree removal, mechanical tillage under the tree canopies, and/or livestock grazing.

LARGE-SCALE PLANTING EXPERIMENTS

The primary effort of The Santa Barbara County Oak Restoration Program has been to conduct replicated large-scale planting experiments in four different years to determine the effects of cattle and other ecological factors on oak seedling establishment in oak savannas and woodlands. In 33 large experimental plots we planted acorns collected from valley oak and coast live oak on the site. Fifteen of these large plots are controls, open to cattle grazing, fifteen exclude cattle with the use of electric fence, and

three are ungrazed in large ungrazed pastures. Within the plots, experimental treatments included: 1) protection from small mammals such as gophers and ground squirrels, 2) protection from large animals such as cattle, deer, and pigs, and 3) no protection from mammalian grazers. In winters 1997, 1998, 2000, and 2001, we planted approximately 1000 acorns of each species. Acorns and seedlings did not receive supplemental water.

Coast live oak (L) and valley oak (R) saplings protected from both small and large mammals.

Results indicate that several factors play a role in limiting or promoting seedling recruitment of oaks. First, rainfall levels in late winter and early spring significantly impact rates of establishment and survival. Abundant rainfall, as seen in the El Niño year 1998, was associated with highest seedling emergence and survivorship, and very low rainfall resulted in low seedling emergence, as seen in 1996 – 1997, and in increased seedling mortality as observed in 2002. Second, as observed in all four planting years, and at all planting sites, seed predation and herbivory by small mammals (most likely gophers and ground squirrels) significantly reduces oak seedling recruitment. Third, herbivory by insects such as grasshoppers may reduce seedling survivorship across all treatments in some years, as observed in 2000 - 2001. Fourth, acorn and seedling survivorship is not negatively impacted by winter/spring livestock grazing. In fact, survivorship of protected seedlings was slightly higher in areas grazed by cattle than in ungrazed areas. Contrary to our expectations, establishment and survival of coast live oak was lower than that of valley oak for all four planting trials. The results of these experiments also provide guidance for those planting oaks in similar conditions by indicating the range of survival and growth one might expect if acorns are planted using these treatments.

SUMMER DROUGHT PHYSIOLOGY OF OAK ADULTS & SEEDLINGS

We conducted preliminary physiological measurements in the fall of 1997 to assess water availability and drought stress in adult valley oak and coast live oak trees.

We hypothesized that the trees would be under great water stress due to the long interval since rainfall (January - November 1997), and that there might be differences between the two species. Contrary to our expectations, we found that mature trees of the two species had very similar water availabilities, and that the values indicated a relative lack of water-stress. This suggests that mature trees of both species may be using the same, deep water sources. We also found that natural seedlings (~ one or two years old) had significantly less water available to them, and there was considerable water stress for seedlings relative to the adult trees found in the same location. These measurements support our hypothesis that water stress was a dominant cause of mortality for seedlings establishing in 1996 - 1997. They also suggested that further study of plant water relations could provide information about factors limiting natural regeneration of oaks.

We began studies of the physiology of coast live oak and valley oak seedlings in 2002 to examine the effects of annual summer drought on seedling survival and transition to the sapling stage. During summers of 2002, 2003 and 2004, we measured water availability, rates of photosynthesis, and chlorophyll fluorescence characteristics of selected seedlings (planted in 1997-1998) and neighboring adults.

Measuring physiological characteristics of oak trees and seedlings.

There were similarities and important differences between the two species. The established (four- to six-yr-old) seedlings of both species showed no evidence of severe drought stress, even during a year (2002) of half average rainfall. However, valley oak seedlings had lower water availability and higher photosynthetic rates than coast live oak seedlings overall. We suspect that differences between the two species could be due to differences in root architectures, with coast live oaks developing extensive lateral roots plus deep, vertical roots, and valley oak developing primarily deep, vertical roots.

Supporting our previous findings, the adults of these two species did not differ in measurements of water availability, which were high, indicating these trees utilize a substantial source of perennially available ground water. In both species there were large differences between seedlings and adults of the same species, with seedlings having lower water availability and lower photosynthetic rates than those of nearby adults. However, it appears a few of these plants have attained access to a similar or the same

source of water available to the adults, and thus the population of seedlings in this study may be just on the verge of reaching substantial water sources, leading to consequent increases in growth rates. Observing the physiological characteristics of these oak seedlings over time will allow us to better understand what controls the seedling to sapling transition.

PATTERNS OF NATURAL OAK SEEDLING ESTABLISHMENT

In order to determine the spatial and temporal patterns of natural oak seedling establishment we surveyed a sub-sample of our experimental plots in savannas to locate naturally occurring oak seedlings in three different years. The numbers of natural seedlings varied considerably among years. For example in 1998, a year of high acorn production followed by a very wet winter (El Niño) resulted in relatively high natural establishment. However, most of these seedlings did not survive, as evidenced by the low numbers of seedlings present in 2004. Another finding is that natural recruitment of valley oak is the lowest of the three species recorded, even though the only species of mature oak trees within the plots was valley oak. We conducted more extensive and detailed surveys in one year. One finding was that there were very few valley oak seedlings produced per area of valley oak tree canopy present, compared to both coast live oak and blue oak. Although canopy cover in the plots average 12% overall and was predominately valley oak, most seedlings were blue oaks. We also found that the majority of natural seedlings were located in areas grazed by cattle. However, the relationship between grazing and natural seedling recruitment may vary among oak species; while there were more live oak seedlings found in ungrazed plots than in grazed plots, both valley oaks and blue oaks were more abundant in grazed plots. Another pattern we detected was that seedlings were strongly aggregated under or near adult trees. In nearly all plots, most seedlings were found under tree canopy rather than in the open grassland.

ADDITIONAL EXPERIMENTS: RAPTOR POSTS AND WATERING

Since results of our large-scale planting experiments indicated that two factors, above-average rainfall, and protection from seed predation and herbivory by small mammals, are associated with high rates of oak seedling recruitment, we established two experiments to study potential means of influencing these factors in the field. We conducted a pilot study to investigate whether the addition of artificial raptor perches (large wood poles) would lead to a reduction in small mammal activity and thus to a decrease in oak seedling mortality. The results of this pilot study support our previous findings that small mammals significantly reduce emergence and establishment. However the addition of artificial perches to attract predators did not reduce small mammal activity. We also conducted a pilot study to investigate the effects of supplemental water on valley oak and coast live oak seedling establishment. We have

not yet detected any significant differences in establishment survival rates among watering treatments. However for coast live oak we found significant effects of treatment on seedling height; seedlings that received water were significantly taller than controls. In 2003 – 2004, rainfall was above average. Thus, our finding that watering treatments did not improve emergence may have been due to the fact that there was enough natural precipitation to ensure germination; even emergence in the unwatered treatment was very high. We suggest that supplemental watering could yield very different results in a year with below-average rainfall.

EFFECTS OF CATTLE GRAZING ON UNDERSTORY VEGETATION

To characterize the understory vegetation and to examine effects of cattle grazing on the herbaceous vegetation of oak savannas and woodlands we established permanent sampling quadrats within our large experimental plots in May 1996, and have recorded all plant species present and their percent cover almost every spring from 1996 to 2003.

Cattle graze at Sedgwick winter through spring, reducing abundance of non-native grasses.

Our main findings to date from this long-term vegetation monitoring are: 1) historical pattern of land use and physical terrain appear to be the dominant factors affecting species composition; 2) variation between years in community diversity and composition is related to rainfall patterns; 3) moderate cattle grazing (winter/spring) appears to have positive effects on diversity and proportion of native species in the community; and 4) *Bromus diandrus*, ripgut brome, increased with removal of cattle.

A PRESCRIPTION FOR ESTABLISHING OAKS

Based on results of our field experiments to date, we developed a prescription for establishing oaks in large landscape or rangeland settings in Santa Barbara County. These methods can be adapted as appropriate to various planting environments. We include recommendations on acorn collection, site selection, planting schedule and methods, and seedling protection. We also provide expected rates of growth and

survival, based on our findings. If seedlings are protected from both small and large mammals, but unwatered, seedling survival rates for valley oak may be as high as 37% to six-years-old, and for coast live oak as high as 30% to six-years. Growth of such seedlings may average ~10 cm per year, with a range of 0 to 18 cm per year.

PUBLIC OUTREACH

The outreach activities of the Santa Barbara Oak Restoration Program have been conducted since early in the project and on an ongoing basis to reach a diversity of people, including landowners, ranchers, school groups, policy-makers, restorationists, scientists, and other members of the community. Literally thousands of individuals have visited the experiments and restoration areas established for this program. Outreach has included site tours, public workshops, lectures, website development, and media coverage. Complementary research on oaks has been conducted at Sedgwick as a direct result of this program.

Students plant oaks and other native species in restoration plots at Sedgwick.

FUTURE WORK

We have demonstrated the relative importance of factors that limit the establishment and survival of oak seedlings, or the transition from acorn to seedling. The next unknown in the life-stage of an oak is: what limits the recruitment of saplings in rangelands, or what controls the transition from seedlings to saplings? We believe this transition may be the most important bottleneck in oak recruitment in this woodland system, and the Santa Barbara Oak Restoration Program is now in a unique position to be able to address this critical problem. We will be able to address questions essential to mitigation, restoration, and preservation of oaks in our county such as: is there a size or age at which seedlings or saplings have a very high likelihood of long-term survival?, and what are the growth and survival rates of young oaks at different life stages and under

different conditions? Thus, future work will emphasize the seedling to sapling transition, to determine the factors affecting growth and survival of seedlings planted in 1996-2001 as they transition to this larger size and age class. Other research could include: experiments on watering enhancement to determine the optimal amount and timing of supplemental watering; experiments to determine the relative benefits of various weed control treatments such as mulching or application of weed cloth; research on factors limiting the seedling to sapling transition in natural oak recruits, with the goal of developing a prescription for nurturing natural seedlings; a study of long-term demographic trends in valley oak using tree-ring analyses; additional oak plantings at appropriate restoration sites on Sedgwick Reserve in years that acorns are available, using methods described in our "prescription".

Sedgwick has been and will continue to be an ideal location to conduct this work, for several reasons. First, all three species of oak impacted by the AAPL project – blue oak, valley oak, and coast live oak – co-occur and are common there. Second, the reserve's large size and diversity of terrain, soil type, and land-use history have provided the opportunity to examine survival and growth of oak plantings in a range of environmental conditions. Third, consistent with the reserve's dedication to research and outreach, their staff and docents have contributed countless hours toward infrastructure maintenance and toward educating the community about oaks and this restoration program. Such outreach and continued support from the Sedgwick Reserve is valuable component of the Santa Barbara Oak Restoration Program. Finally, the reserve's use and management policies provide the stability required for the establishment and protection of a long-term planting experiment and restoration program that can be maintained far into the future.