University of California
Oak Woodland Management

How to Grow California Oaks

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Introduction

Native oaks are a vital and important component of the vegetation of California. They grow in a wide variety of habitats and help provide a distinctive character to the landscape. Not only are they beautiful to look at, but they also provide food and shelter for many wildlife species, they stabilize soil, and they help counteract the "greenhouse effect" by taking up carbon dioxide and producing oxygen.

It is estimated that one or more species of oaks grow on over 20 percent of the state's 100 million acres of land. Unfortunately, there are also reports that some native oaks may not be regenerating very well in some locations. Poor natural regeneration raises concerns about the long term fate of these species. To assist Mother Nature in establishing new oak trees, efforts are underway to plant acorns and small seedlings. Such regeneration efforts will ensure that our magnificent oaks, which have graced California valleys and foothills for thousands of years, will be around for future generations to enjoy also.

The following guidelines provide successful techniques for growing oak trees. While there are many ways to get an oak tree started, the procedures described have proved successful for a variety of species and environments.

Acorns or Seedlings?

Oak trees can be started by either directly planting acorns or transplanting small seedlings. However, since relatively few native oak seedlings are produced in the state, it may be difficult to purchase them. Those that are produced are generally grown in containers ranging in size from a few cubic inches to 5 or 15 gallons. Seedlings grown in the smaller containers should be no more than one year old before transplanting since they quickly outgrow small pots. Even with large containers, it is important that seedlings be transplanted within a couple of years since oaks tend to produce massive root systems and can easily become "*pot-bound*."

Some bareroot oak seedlings are also available. For the past several years the California Department of Forestry Nursery at Magalia has been growing, and making available to the public, several species of oaks. The supply of both container and bareroot oak seedlings should increase in future years as techniques for rearing them are developed and perfected, and more people express an interest in planting native oaks.

The choice of whether to plant acorns or seedlings depends on a whole host of factors including availability of planting material and conditions at the planting site. Generally, acorns are easier to plant, but the survival of seedlings may be greater if they are planted correctly at the right time of the year. Another factor that may influence the choice is what kinds of animals are present at the planting site. If there are high populations of acorn-eating rodents (ground squirrels or deer mice), it may be easier to plant seedlings than trying to protect the acorns.

Maintain Local Seed Sources

Since most tree species have adapted to the specific environments where they grow, it is important to only plant a given oak species in areas where it naturally occurs or where it may have grown in the past. Even within a species, you must be careful to only plant acorns or seedlings that come from a parent tree growing in the same general environment. If you took an acorn from a blue oak tree growing on the coast and planted it in the foothills of the Sierra Nevada, for instance, it would probably grow poorly, or die, even though blue oaks grow in both locations. Since coastal trees are genetically adapted to more temperate, moister conditions, they would be subject to injury from the colder, drier conditions of the interior. If you collect acorns yourself, you can be sure where they come from, and know that they are also handled and stored properly. If you buy from a nursery, make sure you find out the location and elevation of the acorns collected, and insist on seed sources from as near your planting site as possible.

Collecting Acorns

Acorns can be collected either directly from the trees or from the ground beneath. However, the healthiest acorns are generally those picked from the trees. Those that fall to the ground often dry out and are damaged especially if they lie exposed for more than a few days during hot and dry weather. If you do collect acorns from the ground, leave behind those that are very small, cracked or feel light and hollow. Acorns collected directly from trees can be hand-picked or knocked to the ground using long poles or pieces of plastic pipe. It's easy to pick them up if tarps are placed under the trees first.

The best time to collect acorns is generally in the early fall, when they are just starting to turn from green to brown and some are falling to the ground. It's probably too early to collect them if they are all dark green and it is difficult to remove their caps (the cup covering the rounded end). Wait a couple of weeks and check them again.

Storing Acorns

Prior to storage, the caps on all acorns should be taken off. They should come off easily when twisted. Acorns collected directly from the trees should be put in plastic bags and immediately placed in a refrigerator. Refrigeration slows the metabolic activity and helps prevent them from heating up or drying out both of which can be

damaging. A recent study indicated that storing acorns in a refrigerator for a month or so before planting resulted in faster and more complete germination than planting acorns immediately.

Acorns picked up off the ground should be soaked for a day before they are placed in cold storage. Those that float should be discarded. "Floaters" are generally acorns that have been damaged by insects or have dried out while they were on the ground. "Sinkers" should be saved. Remove the acorns from the water and place them on cloth or paper towels for a half hour to dry their surface. Then place the acorns in plastic bags in the refrigerator. Check them occasionally for molds. If molds do develop, take the acorns out and rinse them, and then put them back in the refrigerator. Leaving the plastic bag partially open at the end seems to reduce the tendency for molds to develop.

Another problem that can develop in cold storage is premature germination. Blue oak acorns are especially prone to this. The white tip emerging from the pointed end of the acorn is actually the start of the new root system. Once these roots have grown for a few weeks, they can start to go bad and turn dark brown or grey and mushy. Therefore, if you see the acorns starting to germinate in storage, it's best to plant them as soon as possible.

Acorn and Seedling Planting

Acorns can be planted from early November (after the first rains have soaked the soil) until early March. However, it's generally better to plant acorns early in the season since the earlier they are placed in the ground, the earlier they start to grow. Early planting also reduces the problems associated with premature germination during storage.

Plant the acorns one-half to one inch below the soil surface. Dig a hole using a hand trowel, hoe, or shovel. It's best to dig the hole several inches deeper than the acorn is actually planted, and then partially fill the hole back up with loose soil. This gives the new root a chance to get a good start in soft, easy to penetrate soil. If the acorns have germinated, try not to break the root tip, and position it in such a way that the root is pointing down. Even if the tip of the root has begun to turn brown, the acorns should still be okay as long as some of the root is white and fleshy. Place ungerminated acorns on their side in the hole and cover with soil.

Planting seedlings requires a little more care since there is greater risk of transplant shock and root injury. Seedlings should be planted between December and February, when the soil is wet but not frozen. When planting potted seedlings, try to keep the soil from falling off the roots when the seedling is removed from the container. Place the seedlings in the ground such that the top of the soil from the container is even with the ground line. It is especially important not to plant the seedlings so shallow that the potting mix sticks up in the air, since this can cause moisture to "wick-out" and the seedlings to dry up. If you are planting bareroot seedlings, be sure not to "J-root" them (planting in too shallow a hole so the root bends up). Also, tamp

the soil down in the planting hole so that air pockets are removed. If possible, water the transplants when they are planted. This settles the soil, ensures there is adequate moisture, and helps eliminate air pockets.

Recent studies have indicated that augering holes 1-2 feet below planting spots and backfilling with the broken-up soil can promote deep root development and stimulate vigorous growth. This is especially beneficial if you are planting in hard, compacted ground. Deep root development provides seedlings with greater access to moisture, thus reducing the ill effects of summer drought. Placing a fertilizer tablet a few inches below and to the side of the bottom of the root can also help ensure that the developing seedling will have plenty of nutrients for its initial growth.

The site where you choose to plant acorns or seedlings may also be critical for their success. Choose a sunny spot that has loose, well-drained soil and is fairly free of weeds. Also, avoid areas where there are lots of pocket gopher mounds or ground squirrel activity. If you do feel that the acorns may be threatened by rodents such as squirrels or mice, plant them a little deeper say, two inches below the surface. If they are planted deeper, it will be harder for these animals to dig them up. However, if they are planted too deep, they may rot or not be able to grow up to the soil surface.

Planting Layout

The number of acorns or seedlings to plant in a given area will depend on how many oaks you eventually want to grow there. Unfortunately, it is very difficult to predict how many trees will be produced from plantings, since a whole host of uncertain factors including weather, animals and competing vegetation can influence this. When laying out the planting area, consider spacing seedlings or acorns in a naturalistic manner, rather than in straight rows, using surrounding oak trees as a model. On open rangeland, it is recommended that trees be established in small clumps or clusters, with the goal of about 40 planting spots per acre. This comes out to an average of one cluster every 30-40 feet. Within each cluster, plant 3-4 seedlings. In restoration projects in riparian zones, a greater density is usually desirable, so have the clusters closer together say 15-20 feet apart.

Seedling Maintenance and Protection

Another critical factor affecting young oak seedlings is competing vegetation. Adjacent plants especially grasses can use up so much of the available soil moisture that little is left for the seedlings. It is therefore recommended that a 2-3 foot radius circle around the planting spots be cleared of other vegetation. This can be done by hand weeding, hoeing, scalping, or by spraying a contact herbicide. However, with any of these methods, be sure to check back in the spring and early summer to remove any additional weeds that may have come up. It is generally best to keep the weeds away for at least 2 years after planting.

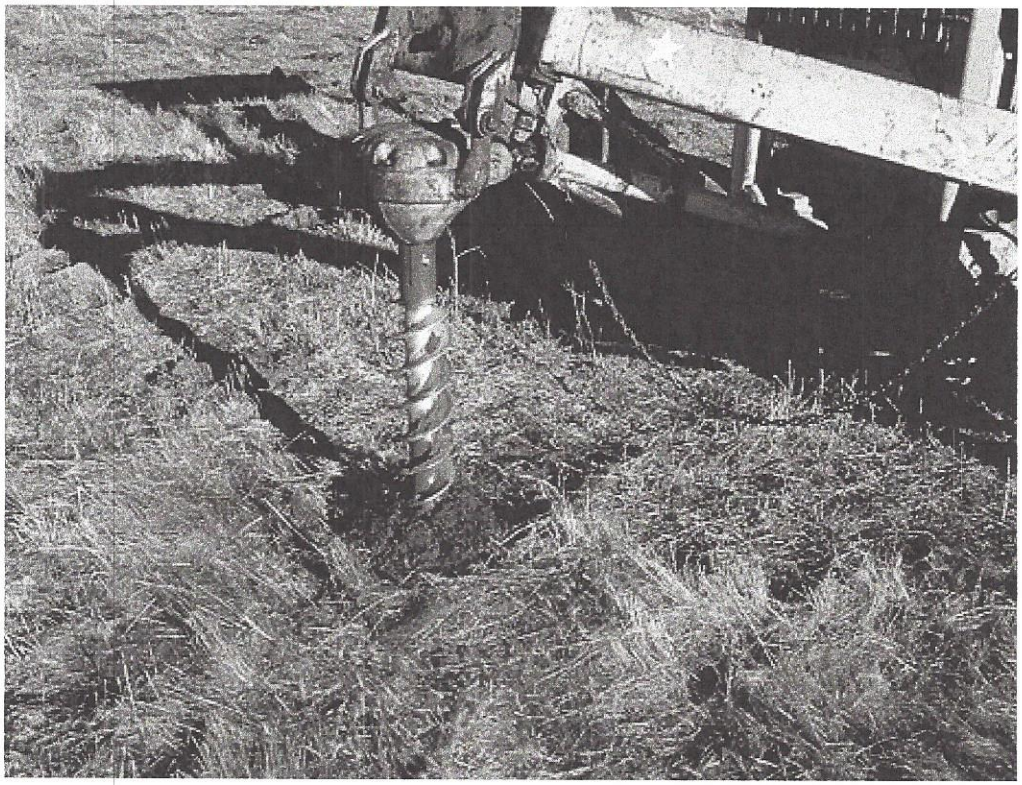


Figure 10. Tractor-mounted augers can be used to break through compacted soil.

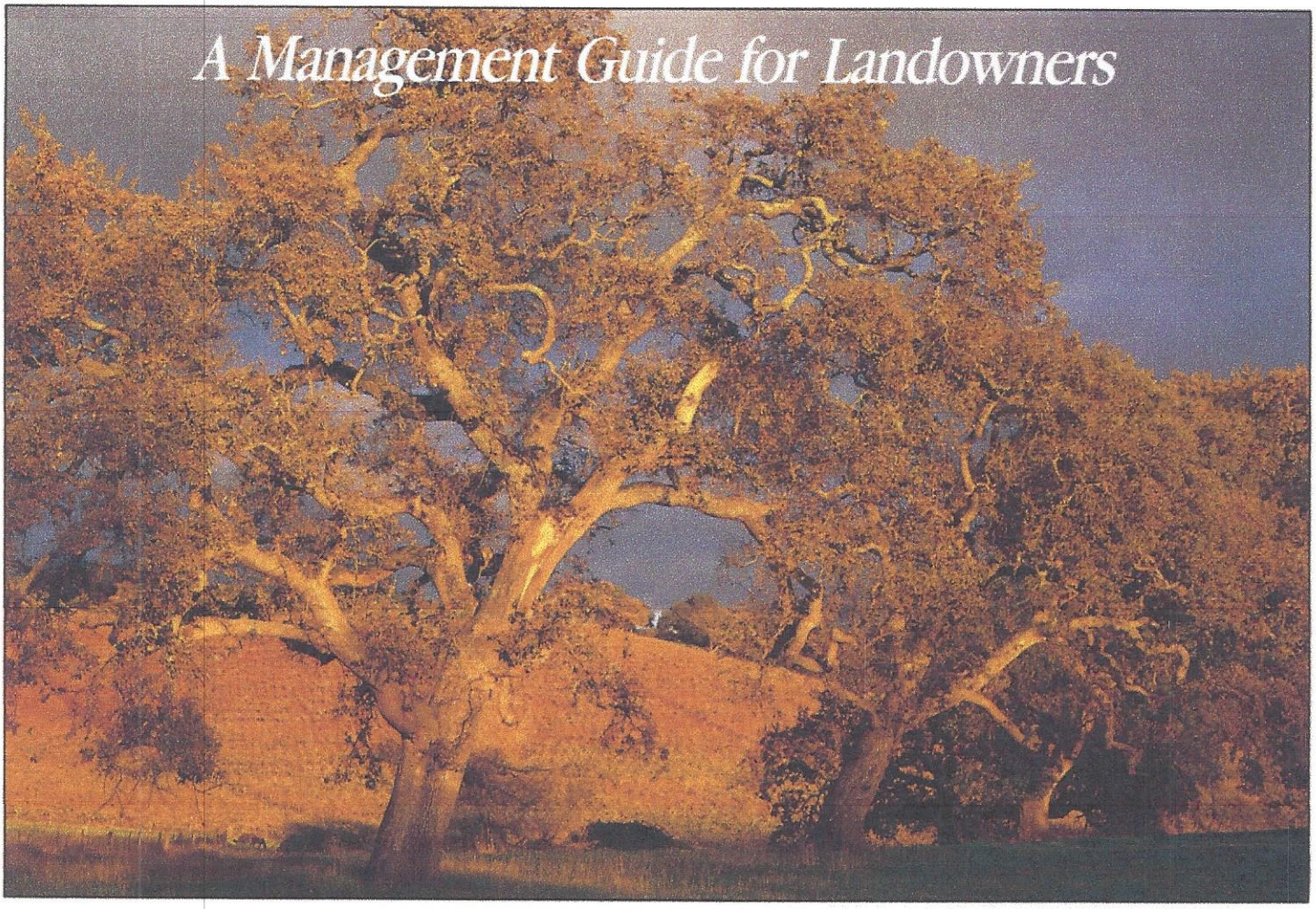
We could also detect little difference between the three augering depths tested. We attributed this to the fact that most of the compaction was in the upper foot of the soil, and as long as this area was broken up, the oak roots had little trouble growing deeper. We therefore recommend either augering compacted soils prior to planting or excavating holes with a shovel or post-hole digger, but only to the depth required to penetrate the bottom of the compacted layer. It is important to auger well in advance of planting either acorns or seedlings so that the soil can settle thoroughly with natural rainfall. Finally, in wet, heavy soils, augering can result in a slick, smooth surface on the inside of the hole created. This can make it difficult for the oak roots to penetrate, and even slow water percolation so that the holes act like a pot. If holes become glazed from augering, use a shovel or tiling spade to rough up the sides of the hole before planting.

Selecting Microsites for Planting

Many areas targeted for oak regeneration contain a range of possible planting locations, or microsites, for individual seedlings. Even over short geographical distances, conditions at these planting sites can vary greatly. Some may be adjacent to rocks, logs, or stumps that provide natural protection and reduce direct solar radiation. Others may be close to gullies, swales, or even springs where soil moisture is greater. Still others may be far from obvious animal populations, as evidenced by gopher mounds or ground squirrel tunnels that can pose a threat to seedlings planted nearby. Finally, there is some evidence that certain shrubs may act as nurse plants for blue and valley oaks and promote establishment of seedlings planted near them (Callaway 1992). Because resources for plant restoration projects are generally limited, and it is too expensive to plant everywhere, it makes sense to choose microsites where seedlings will have the best chance to survive and grow. These may be difficult to determine, but insight can often be gained by looking at nearby areas where oaks are present and observing patterns where trees have become established naturally. In oak woodlands, south-facing, exposed ridges are generally less likely to have oaks than are north-facing slopes or drainages because soil conditions are much drier on southern aspects. And in grazed areas, oaks that have survived can often be found in locations that present some natural barrier to livestock and deer, such as rock outcrops. Mimicking such patterns in artificial regeneration efforts and choosing sites that afford some natural protection or better environmental conditions can often enhance success rates.

LIVING AMONG THE OAKS

A Management Guide for Landowners



LARRY ULRICH

What is more characteristic of the California landscape than the oak? Round-crowned oaks dapple the rolling hills, solitary monarchs shade our rural roads, and valley giants stretch skyward in banners of leaves and lichen. Both past and present-day travelers have stopped in awe of our native oaks, and countless photographs and memories are framed by their spreading, weather-worn branches. The oak is particularly emblematic of the inland regions of California, where scattered oaks, rolling pasture, and distant cattle are the common elements of an infinitely variable landscape.

In this region—often called the hardwood range by land managers—the vistas of oaks, pasture, and cattle bestow a tranquility that sometimes belies the fourth element—people. Like the earliest Californians, humans today come to the oaks for food, shelter, and beauty. As we appreciate the beauty of oak landscapes, we fatten our flocks on their bounty, and seek homesites in their shadows. But intensifying land use in the hardwood range has brought soil erosion, reduced forage production, poor

All Californians can assist in the protection and enhancement of native oak resources, but none are in a better position to do so than landowners in the hardwood range. These individuals shape the future by their decisions, which cumulatively direct the management and land use of more than seven million acres of California's oaks and pasture.

This brochure is designed for you—the landowner. It brings together a variety of current information about living and making a living among the oaks. The University of California Cooperative Extension hopes that you will find this information useful as you manage your land and make decisions that shape the future of your oaks.

OAKS GIVE US:
- **Shade & Shelter**
- **Increased Property Values**
- **Beautiful Carefree**

Needs and Conflicts

In designing and building homes, workspaces, storage areas, gardens, orchards, and places for animals, your decisions are shaped by your over-all objectives for your land. Managing land as a residential site, for animal production, for wild or park-like qualities, all may require different actions. As you choose management objectives for your land and evaluate its suitability, also consider the oaks on those sites and whether your objectives are compatible with the basic needs of the trees. Careful planning and design can often provide benefits for both people and oaks.

Past development among the oaks has revealed specific areas of conflict. Various construction practices seriously injure oaks or inadvertently kill them, increasing fire hazards and creating liability and management problems. Gardening practices such as amending the soil, planting lawns, or irrigating under established oaks will kill them. Domestic animals and wildlife, as well as insect and fungus pests, also take their toll. In combination these

MANAGING AND ENHANCING

Historically, livestock grazing and wildlife production have been the dominant land use throughout the hardwood range. We can thank the livestock industry for the open, pastoral character of much of California's countryside. But it is also in portions of this region that regeneration for several oak species has been poor, especially during the last 80 years. Cattle are the oft-named culprits, and although it is true that cattle do take their toll on the oaks by consuming acorns, seedlings, and saplings, oaks often do not regenerate even when the cattle are taken off the land. Obviously, the oak regeneration problem is more complex.

It has been suggested that grazing for the last hundred years has caused a combination

DAVID CAVAGNARO

of ecological reactions that are inhibiting natural oak regeneration. Such factors as changes in the species composition of the grassland, greater ground squirrel populations, insect and soil fauna changes, and alterations in populations of acorn and seedling eaters may all complicate oak regeneration. Whatever the causes, careful management is needed—of both land and oaks—if these trees are to continue their traditional and ecological role on the hardwood range.

In managing land, animals, plants, and other property resources, there are many things landowners can do to encourage healthy, vigorous oak populations. Some basic management considerations are discussed in the following section. But, in making management decisions that affect oaks, your greatest guidance will probably come from your own observations. Oaks and ecological settings vary tremendously from place to place, as does the relevance of management concepts. So before making decisions, study what actually takes place on your land. Experiment if you want to—you may discover techniques that could also be useful to other landowners.

Grazing Animals and Oaks

Minimizing direct impact on existing by girdling if they chew around the tree, through the bark, and into living wood. These types of problems are of particular concern in paddocks or pastures where animals are concentrated.

Measures such as reducing numbers of stock, alternating pastures in use, installing exclosures, screens, or other protective devices to keep animals away from sensitive or damaged areas, can alleviate problems. If damage is severe, you may want to consult an arborist for remedial treatments.

Pasture management. In managing your pastures, always remember the general prohibition against summer watering of oaks. If your pastures are improved by summer irrigation, adjust irrigation devices to apply water outside of the root zone only . Adjusting watering schedules to infrequent but long periods of irrigation will also reduce stress on oaks. Always try to keep the base of the tree dry (see "Oaks in the Home Garden"). Observe the location of watering devices and other water sources to make sure that the area beneath an oak's canopy does not become wet from leaky water lines, valves, holding tanks, or from animals splashing in troughs.

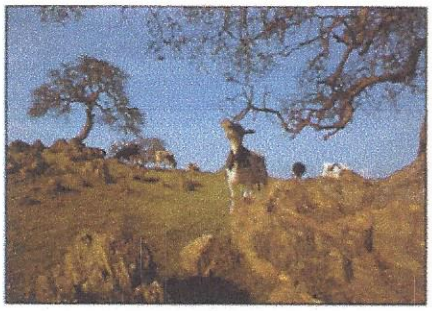
Experiments to Encourage Natural Oak Regeneration

This is currently an area of considerable experimentation and few results—in part because it takes a long time to obtain results from trees that live many years. But if you have the interest and flexibility in your management needs, you might experiment to encourage greater natural oak regeneration on your land. Do not count on high success rates, however, since other, unknown factors may be limiting the oaks.

Promising sites. Areas particularly favorable to natural regeneration include north-facing slopes, regions with an annual precipitation greater than ten inches, deep soils, alluvial sites, swales, or other places with subsurface water. The absence of large numbers of seedling, sapling, or acorn eaters, like ground squirrels, deer, or feral pigs will also improve seedling survival.

Because seedling mortality is usually high, regeneration possibilities are best in areas that can remain free from grazing animals for a number of years, and where several mature trees provide acorns. Small groves or clusters of trees could provide such sites. Sites offering some natural protection, such as rocky or shrubby areas that naturally exclude or impede the movements of deer or livestock seedlings or large enough to accommodate entire groves. They are designed to exclude specific animals . For example, some of the smaller exclosures can keep out birds and ground-burrowing animals. You can design appropriate exclosures yourself, look at examples on this page, or refer to the references in this brochure for ideas.

2) Experiment with seasons of grazing, as well as duration and numbers of animals in areas where seedlings or saplings are present. These may be in areas where you have employed exclosures or in areas where regeneration is occurring naturally. Cattle may avoid oak leaves when other forage is abundant. Oak seedlings and saplings can also resprout after being grazed.



DAVID CAVAGNARO

Helping Nature—Propagation and Planting

Propagation and planting are rewarding ways to speed up nature's processes, beautify your home site, or even enhance the woodland on more remote parts of your property. Your investment for propagation activities can vary according to the time and money you want to spend. Both simple and elaborate efforts have proved successful. Site factors such as soil moisture, predators, weather, and luck are important in propagation success, and these are often hard to evaluate.

Seed and seedling sources. Regardless of whether you are planting acorns you collect or seedlings raised elsewhere (by native plant nurseries, youth groups, or service clubs, for example), an effort should be made to use local seeds for all wildland planting. Scientists believe that local ecotypes, or strains of species, have evolved in response to local conditions and are therefore best adapted for survival.

Collecting acorns. Most acorns ripen from late October to early November, with seeds on the lower branches ripening first. Use tools, such as long-handled loppers, or sticks to knock them down. Fully mature acorns will dislodge easier than green ones,

Fire in California's Oak Woodlands

Compiled by Douglas D. McCreary, Natural Resources Specialist
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History of Fire

Fires Today in California

Everyone who lives in California is aware that fires regularly occur in our state and can have devastating consequences. This past year (2003) we were again reminded by the fall fire siege in Southern California that despite of our long-standing efforts to suppress and control fires, we are still at the mercy of the Mother Nature and during extreme fire weather, there is little we can do to prevent, or even contain, fires that do start. This White Paper was prepared in the aftermath of these tremendously destructive fires to provide information to landowners, resource managers, and policy makers about fire in oak woodlands. It is meant to provide a broad overview and address several limited, but important, subject areas including historical fire patterns, prescribed fire, the effects of fire on oaks and ecological processes in oak woodlands, what can be done to help prevent future fires, and what landowners can do following fire to help the land and associated resources recover. It is our hope that this paper will provide concise information about this critical subject to help a variety of people understand fire in oak woodlands and assist them in developing strategies to minimize its negative effects.

Natural Fire Frequency

Native California oaks evolved in a Mediterranean climate where natural fires burned regularly. Pavlik et al. (1991) characterize Mediterranean climates in general as fire-prone, with major fire intervals between 30-50 years in savanna, woodland, and chaparral plant communities, with major fires in forests occurring every 40-100 years. Fire is an essential element of oak ecosystems, but since the early part of the 20th century, fires have been aggressively suppressed in California, resulting in fewer escaped fires.

Research indicates that prior to European settlement in the mid-1800s, fires occurred in the northern Sierra foothill woodlands approximately every 25 years (McClaran 1986). During the decades following the Gold Rush, fires were even more frequent. Fire history research by Stephens (1997) found that in a mixed oak-pine forest (75%-25%) in El Dorado County, mean fire intervals in three study plots were approximately 8 years between 1850 and 1952 (range was from 2-18 years). The intentional use of fire by early range managers probably contributed to an increase in fire frequency.

In central and southern California coastal shrublands, fires frequencies prior to the arrival of Europeans were higher than would have occurred naturally, presumably because Native Americans regularly used fire to convert shrublands to grasslands (see below), and in the 1800s, European settlers continued this practice. There were also infrequent high intensity fires during extreme fire weather (Moritz 1997).

Native American Use of Fire

Prior to the arrival of Europeans, Native Americans used fire as a management tool (Blackburn and Anderson 1993). Woodland understories were regularly burned for a variety of reasons, including facilitating access, stimulating the growth of materials used for weaving baskets, improving habitat for game animals, making it easier to collect acorns, and killing insects that damaged acorn crops (McCarthy 1993). Frequent low-intensity woodland burning probably resulted in the creation and maintenance of cohorts of large oak trees. Repeated burning would likely have killed brush and small trees and there would have been efforts to protect large trees since they are generally the best acorn producers. Shrublands were also likely regularly burned by Native Americans in California's coastal ranges to reduce shrub cover and convert areas to grasslands (Keeley 2002). In the lower elevation valleys, repeated burning would have promoted more open savannah-like stands with widely spaced valley oaks, and a mosaic of fine-grained vegetation patches, with relatively little shrub cover. This is certainly what the earliest explorers reported seeing in the central valley of California in the early part of the 19th century (Pavlik 1991).

Fire Suppression in the 20th Century

There has been a policy of active fire suppression in California during much of the 20th century which has altered

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larger diameter trees that have thicker bark (Plumb and Gomez 1983). This is because bark is a good insulating material and the thicker it is, the better it is at preventing heat damage underneath. However, if the fire has been hot enough to actually burn into the bark and reduce its thickness, the cambium is usually killed. One can often determine the severity of damage by cutting into and under the bark to observe the cambium. Healthy cambium is white and moist, while dead cambium is usually brown and partially dried out.

Sprouting by Oaks

Even if an oak has been girdled and the aboveground portion of the tree has been killed, most will sprout from their base the following year. Sprout-origin trees initially produce many new shoots. These sprout clumps thin out over time, although even mature trees that started as sprouts usually have multiple trunks. In general, live oaks are more vigorous sprouters than deciduous oaks, and smaller diameter trees are more likely to sprout than large diameter ones, although all California oak species will sprout. Oaks in moister areas also generally sprout better than those growing on dry sites. Many of the oak trees in California today originated as sprouts following fire and can be recognized because they usually have several main trunks. Sprout-origin trees generally grow faster than young seedlings starting from acorns. This is because they have a massive root system compared to a newly germinated acorn. As such, they have access to greater amounts of water and nutrients to support top growth.

Oak Regeneration

Some believe that fire suppression in the last century may be contributing to some of the oak regeneration problems in California today. According to this theory, frequent fires in the past may have created conditions more favorable to oak regeneration. These include eliminating competition, creating a more favorable seedbed for acorns to germinate, and reducing the habitat of wildlife species that eat acorns or seedlings. Since oaks sprout and many other plants don't, fires could give sprouting oaks a "head start" and enhance their chances of survival. Also, fuel buildup as a result of fire suppression may have created conditions unfavorable for recruitment (Mensing 1992). However, most people believe that poor oak regeneration is primarily caused by factors other than fire suppression.

Planting Oaks in Areas Where Oak Trees Have Been Killed

Even though most oaks will sprout following fire, in lower rainfall areas this is less likely. And although there is little data on the subject, sprouting may also be inhibited in areas where the fire burned extremely hot — especially where a portion of the root system was consumed. In such instances it may be desirable to plant young oaks to replace trees that were killed.

Practices to artificially regenerate oaks in California are well established (McCreary 2001). It is important to utilize plant material that is well adapted to the site (i.e., locally collected acorns), to plant acorns or seedlings at the right time of year (i.e., in the late fall or early winter when soils are moist), to make sure that the young plants are protected from damaging animals, and to control competing vegetation in the immediate vicinity of the seedlings for at least two years. Chances for success will also be enhanced by choosing favorable microsites for planting. These sites may be difficult to identify, but often one can gain some insight by looking at nearby areas where oaks are present and observing patterns where the trees have established naturally. Usually south-facing exposed ridges are much less likely to have oaks growing on them than are north-facing slopes or drainages, because soil conditions are much drier on southern aspects. And in grazed areas, oaks that have survived can often be found in locations that present some natural barrier to livestock and/or deer, such as rock outcrops or steep slopes. Mimicking these natural patterns in artificial regeneration efforts, and choosing planting sites that afford some natural protection or better environmental conditions, can often enhance success rates.

Effects on Erosion and Water Quality

In addition to the enormous costs of large wildland fires from suppression and the loss of property and possibly life, fires can also have serious negative consequences on a variety of ecosystem functions. Of significant concern is the potential for erosion after a fire, as denuded landscapes are buffeted by early winter storms. Sediment from burned slopes can clog streams and reduce water quality. And, as the recent events in Waterman Canyon in San Bernardino County (the tragic mud slides on Christmas Day 2003 that claimed 14 lives) demonstrated, there are also serious safety concerns associated with unstable soils and mud and debris flows following fire. To mitigate the likelihood of soil movement, it has been common practice since the 1940s to seed annual rye grass (*Lolium multiflorum*) onto exposed slopes and cat trails. This has been done to quickly establish a plant whose roots will theoretically help anchor the soil. The seed of annual rye has historically been used because it germinates rapidly, is relatively inexpensive, and is easy to broadcast.

However, seeding annual rye has become a controversial practice that is generally not supported by the eco-

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