Guidelines for Managing California's Hardwood Rangelands



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Preface

California's hardwood rangelands cover estimated 11 million acres in the state. This area is characterized by an overstory canopy of at least ten percent cover of hardwood tree species, predominantly in the oak genus (*Quercus*), with an understory of annual grasses, forbs and occasional native perennial grasses. There are an additional 2.5 million acres of oak savannah, with less than a 10 percent oak canopy cover. Since European settlement of California, hardwood rangelands have been managed primarily for livestock production. These areas have taken on a new importance because of the recognition that they are one of the richest wildlife habitats in the state, with at least 313 terrestrial vertebrate species relying at least partly on hardwood rangelands for habitat. Other public values provided by these areas include water quantity and quality, erosion and sediment control, outdoor recreation, and aesthetics. Management decisions by landowners and managers are important, since over 80 percent of California's hardwood rangelands are in private ownership.

The purpose of this book is to help landowners and managers of hardwood rangeland properties develop management plans that maintain the profitability of their properties, while at the same time sustaining the ecological values provided by their land. There is no one best management system or one best set of guidelines. These guidelines will lead the reader through a close evaluation of their goals and objectives for their personal lives and their properties, and present a variety of management strategies to achieve these goals and objectives. This book is a revision of *The Preliminary Guidelines for Managing Hardwood Rangelands*, released in 1986 by the University of California. It incorporates nine additional years of research and experience developed by the University's Integrated Hardwood Range Management Program and other universities and agencies.

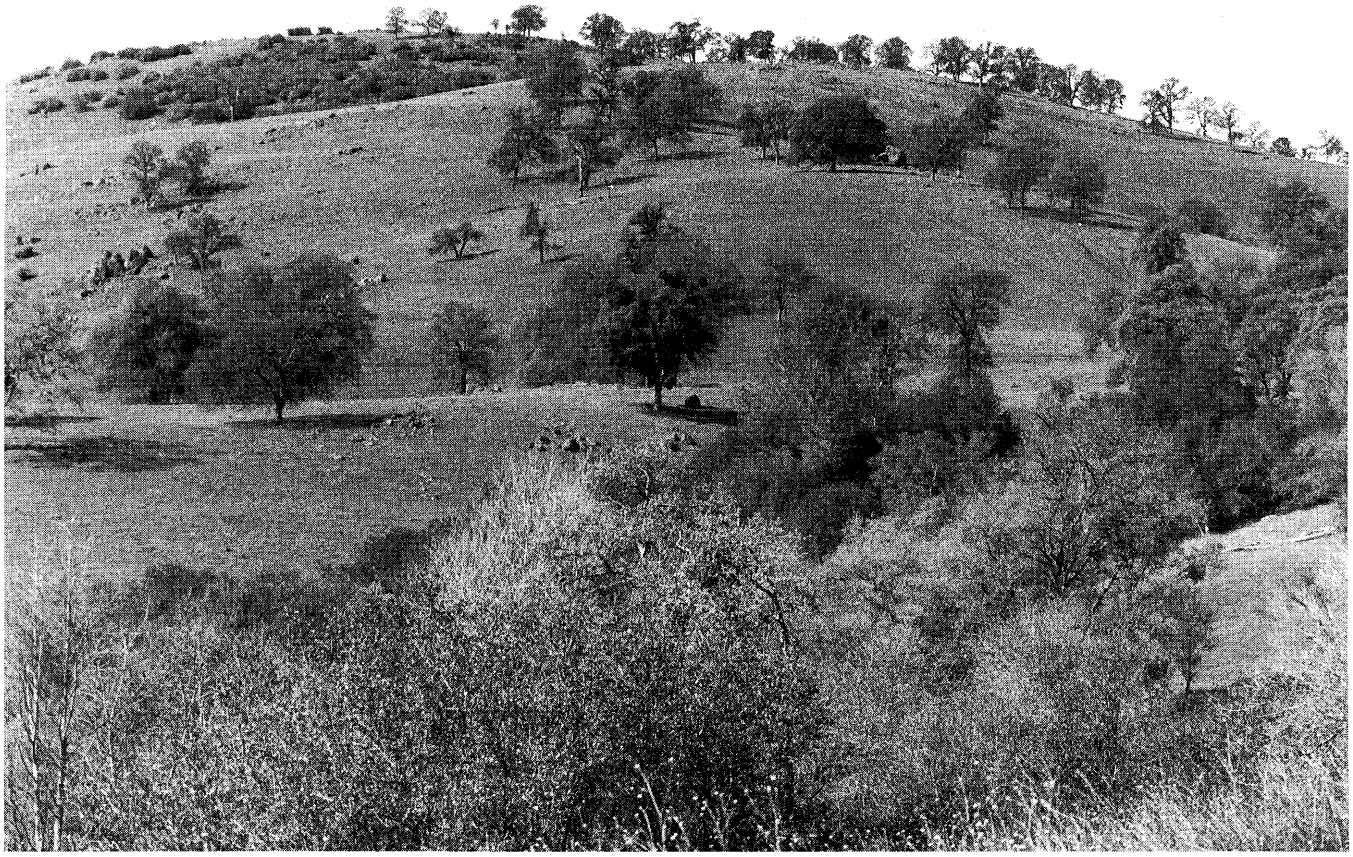
This book consists of three parts. Part I (The Hardwood Rangeland Resource) presents a framework upon which sustainable management is built. Setting conservation, economic, and quality of life goals, and assessing your resources are prerequisites for both economic success and success in maintenance of land values. Part I concludes with a chapter on oak woodland wildlife ecology and habitat relationships.

Part II (Hardwood Rangeland Management) presents four chapters on enterprises that can contribute to the economic and quality of life goals. First, the livestock enterprise on hardwood rangelands is examined, including relationships of oaks to forage production, grazing management, animal health issues, and predator management. Livestock grazing is still the major economic use of hardwood rangelands, with over two-thirds of the total acres grazed by domestic livestock. Fee hunting and other forms of outdoor recreation are discussed in this section, and how these enterprises allow owners to capture economic benefit. A chapter on open space values shows how owners can receive economic benefit from amenity values, which previously had been provided for free. A chapter is also presented on firewood utilization and other specialty wood products.

Part III (Sustaining Hardwood Rangelands) addresses management of hardwood rangelands to sustain their long-term economic and ecological values. Hardwood conservation is discussed at the regional and local level and at the individual tree and watershed level. Evaluations of the the relationships of fire and erosion to the long-term sustainability of hardwood rangelands conclude Part III.

With past wise stewardship of these lands by the owners and managers, hardwood rangelands continue to be a rich source of ecological value. As pressures for competing uses for these lands intensifies in California due to rapid urban population expansion into areas that were previously rural, it is important to ensure the economic well-being of the owners. The most cost-effective form of conservation of hardwood rangelands is maintaining sustainable economic enterprises. With rising public concerns about conservation of hardwood rangelands, there is an increased interest in the development of management practices and local guidelines for different areas of the state. This book is written for California's hardwood rangelands as a whole, and not for those in one particular region or county. It is hoped, however, that the general information, the processes described, and the references provided can help landowners, and resource management professionals develop site specific management recommendations and policies suited for local conditions.

A prudent approach to all decisions on hardwood rangelands is: preserve your options. Oak trees are long-lived because they are adapted to wide fluctuations in climatic conditions, periodic insect and disease outbreaks, and relatively benign but persistent human land uses. However, oak trees on hardwood rangelands are sensitive to drastic changes in land management, and once the trees are killed or removed, they are difficult to replace. *Preserving your options* helps to ensure that decisions you make today do not adversely affect your options in the future.



Chapter One
Setting Goals for Hardwood Rangeland Management

Primary authors: Richard Standiford , Univ. of California, Berkeley; and Melvin George, Univ. of California, Davis

This chapter will help you through the process of critically assessing your goals for a hardwood rangeland property. What are you trying to achieve with your hardwood rangeland property and how do you plan to use your time, effort, money, and management skills to accomplish this? A systematic evaluation of these questions helps determine your management goals. Management is simply an activity directed toward attainment of your goals. Therefore, the goals you set will provide direction to all your management efforts. Worksheet 1-1 will help you to develop the goals for your hardwood rangelands.

Types of Goals

All of us have goals that we work toward over many years - goals such as debt-free ownership of a farm or ranch, or "burning" the mortgage on the family home. Some goals require a lifetime to achieve. Others can be attained in a year, a few years, or a decade. Goals are typically written as action statements. " To complete ... " or "To earn ..." or other action statements are often used to introduce a goal. Shown below are three broad categories of goals – namely *conservation goals, economic and production goals, and quality of life goals* – which will greatly influence how you manage your hardwood rangelands.

Conservation Goals - What are your general goals for the long-term conservation of the resources on your property? In this book, we take the view that there are minimum levels of resource protection that individuals should attain through their management activities. However, many hardwood rangeland owners have conservation goals that exceed these minimum threshold values. They actively promote the concept of resource stewardship, whereby owners look at themselves as stewards of the broad array of market and non-market resources found on a property. Some of the general conservation goals for a property might include:

- *Sustain existing resources* - This would include sustaining the existing diversity of biological organisms on a property. It also seeks to maintain the ecological processes and habitat characteristics on hardwood rangelands at a variety of scales ranging from the individual tree to the watershed level.

- *Enhance or improve resources* - Owners may wish to improve the general condition of the natural resources on their hardwood rangeland property. This may involve planting oaks on areas where they once stood, or improving riparian habitat to enhance wildlife values and improve water quality.

- *Improve water quality and quantity* - Hardwood rangelands are under the auspices of various state and federal water quality programs. Landowners often wish to go beyond these minimum standards and reduce erosion from road networks or locate the source of gully erosion and adopt practices to reverse these processes. Landowners may also wish to enhance the water supply from their land for livestock and wildlife use.

- *Maintain aesthetic values* - In a recent survey of landowners asking why they were interested in the oaks on their property, one rancher replied, "Because the oaks make my property look like a ranch, and not a farm." Most owners are concerned with the consequences of their management activities on the appearance of their land. The beauty of hardwood rangelands helps maintain aesthetic and economic values of the property.

Economic and Production Goals - The setting of economic goals may involve sitting down and evaluating the economic needs of your family. How willing is the family to accept risk? What kind of cash flow is needed to provide for your family's basic needs? When do you need capital to purchase new equipment, or to send your children to college, or to take a vacation? Careful evaluation of each item listed below will help you to set these goals.

- *Risk* - How much risk are you willing to accept? How many years can an enterprise lose money? How much of a savings cushion is there? How heavily leveraged is the enterprise? Landowners may be willing to invest a certain percentage of their assets in more risky investments once their basic living expenses are ensured because of possible high rates of return. A general rule of thumb is that investments with high rates of return often have high risk.

- *Cash flow* - How often are returns required? Is this the sole income source for the family? Are there special upcoming expenses (i.e. college, new home, etc.)? How much reserve is needed for unanticipated expenses (medical needs, etc.)? Carefully evaluate your cash flow needs.

- *Profit* - What rate of return on invested capital is needed? How does this stack up with other investment opportunities available? Is it better to invest your money in a new enterprise on your hardwood rangeland property, or to take that money and put it into the bank or a mutual fund?

- *Estate planning* - How interested are your heirs in managing hardwood rangeland property? How do estate taxes figure into long-term sustainability? Hardwood rangeland owners need to carefully consider the value of their estate, and plan to find ways to reduce the impact of estate taxes on the continued ownership and production.

Quality of Life Goals - Each person is unique in the kind of lifestyle they desire for themselves and their family. What kind of person are you and how can your management activities help support the quality of life you desire for yourself or your family? How interested are you in working with other people? Are you comfortable with the idea of supervising labor or do you want your property to be a strictly family-run business? Do you enjoy working outdoors doing manual labor or do you prefer to spend your time on business and marketing activities?

- *Preservation of lifestyle* - Many ranchers own hardwood rangelands and desire to preserve a lifestyle that previous generations of ranchers have established. These individuals must carefully evaluate management alternatives and economic enterprises that may influence how they and heir children will live upon their rangelands.

- *Personal contact with others* - Some people enjoy owning hardwood rangeland because of the peace and solitude it offers. Others like working with people and providing a service to them. You need to carefully consider your aptitude and interest in working with people, as that will impact the kinds of management activities and enterprises that will be most appropriate for your situation.

- *Marketing skills* - Many hardwood rangeland enterprises require a great deal of effort to develop markets for the products or services provided. How willing are you to work on marketing? Do you have the skills or interest to develop new markets? There are lots of opportunities to expand the economic base of hardwood rangeland properties for individuals who have a keen interest in developing markets. However, if that is an area you are not comfortable with, you would be better to stick to enterprises that have well-developed markets.

- *Labor relations* - Do you intend to hire outside labor to carry out the enterprise, or is this to be only a family business? Is the necessary skilled labor available in your family, or do you need to hire help?

Assessing Your Goals

Worksheet 1-1 gives you some guidance in evaluating the goals for your hardwood rangeland property. Plan on sitting down with all members of your family who have an interest in your hardwood rangeland property, and systematically determining your goals. This process may take several meetings until everyone is comfortable with the ranch goals. You should first have each person complete this worksheet individually. Then, you can be-

gin the process of combining these goals into a working foundation for managing your hardwood rangeland resource.

Once you have gone through the process of systematically evaluating your goals, determine what types of enterprises are consistent with them. Table 1-1 shows a matrix of several conservation, economic and production, and quality of life goals. This shows what types of enterprises are worth considering in more detail as you go through the process of developing a management plan. For example, if your quality of life goals are such that you do not desire to have much contact with the public, then enterprises such as hunt clubs, recreational enterprises, and using your property as conservation land, are likely to be enterprises that will not be satisfying for you. The results of this assessment of your goals will help you decide which of the ideas and enterprises discussed in the following chapters are worth looking at more closely.

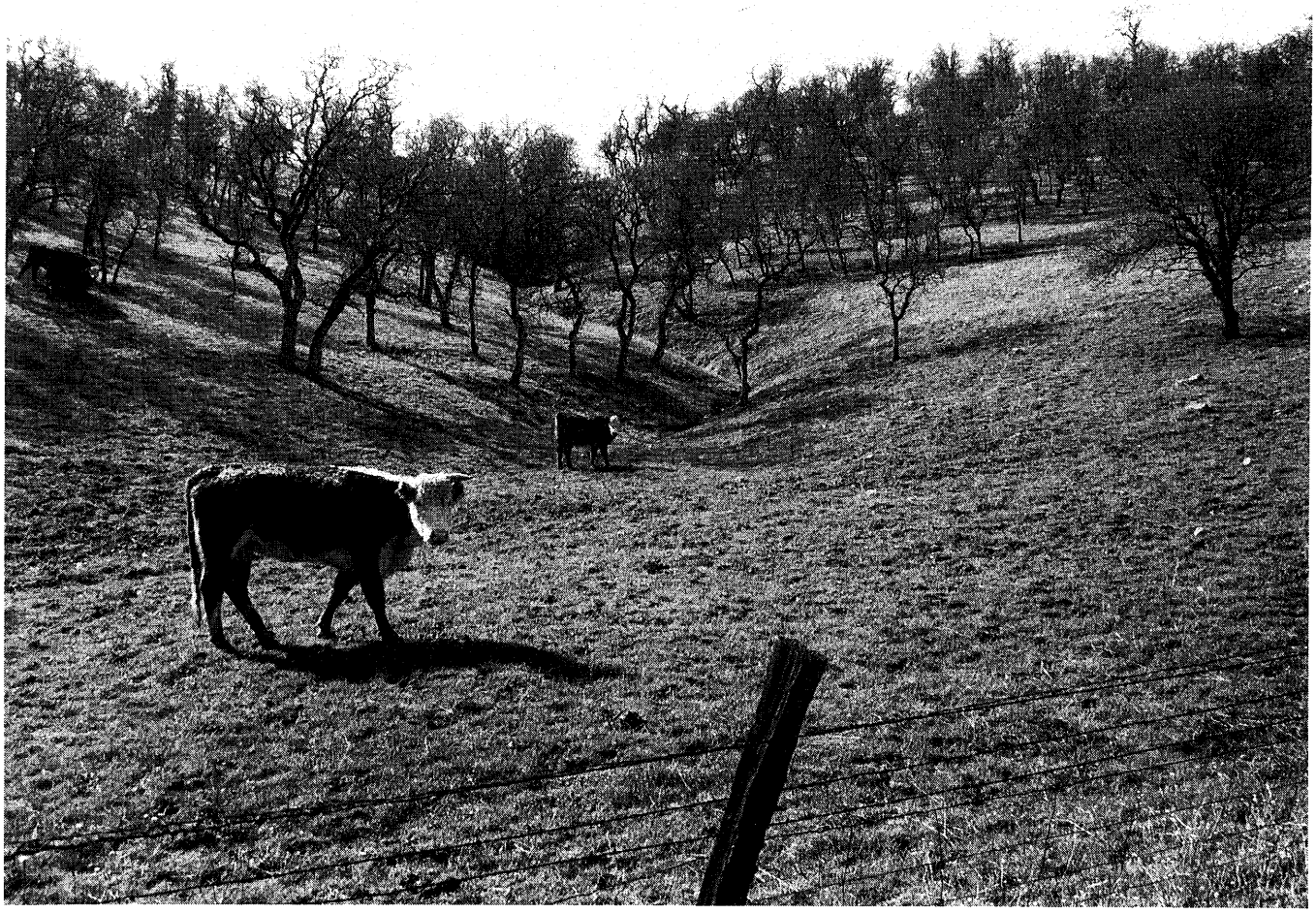


Table 1.1. Matrix of goals and management enterprises. Use results from Worksheet 1-1 to help evaluate possible resource management enterprises.

Enterprise	Conservation goals				Economic and production goals				Quality of life goals			
	Sustainable Manage-ment	Improve Resources	Water Quality	Aesthetics	Risk	Cash Flow	Estate planning	Profit	Preserva-tion of Lifestyle	Personal Contact	Marketing	Labor Relations
Livestock grazing **Chapter 5**	Simulate natural role of grazing in ecosystem	Grazing as a manage-ment tool	Protect riparian zones	Depends on aesthetic values desired	Moderate - periodic fluctuations in prices	Annual	Genetic stock, fencing, structures	Variable - usually low	High - traditional product	Low - does not require great contact with others	Low -Existing market structure	Variable - Depends on size
Hunt club **Chapter 6**	Can broaden economic base	Can help pay for restoration projects	Take care with roads and other improve-ments	Depends on aesthetic values desired	Low - usually involves long-term contracts	Annual	Client list, habitat improveme nt(water, lodge, etc.)	Moderate - high demand for recreational hunting	Variable - sometimes must deal with people having different values	High - requires contact with people	Moderate - will be start-up marketing; can contract	Variable - Depends on size; guides, hired hands
Recreation or tourism **Chapter 6**	Can broaden economic base	Can help pay for restoration projects	Take care with roads and other improve-ments	Depends on aesthetic values desired	High - uncertain markets in some areas	Annual	Client list, improve-ment	Moderate - depends on location, services	Variable - sometimes must deal with people having different values	High - requires contact with people	High - will require marketing skills	High - Usually involves outside labor
Conser-vation land **Chapter 7**	Can broaden economic base	Value enhanced through improve-ment	Can enhance through manage-ment	Depends on aesthetic values desired	High - markets beginning to develop in some areas	Variable - lump sum payments or annual rent	May affect title for land, future permissible enterprises	Variable - depends on location	Variable - depends on terms of conserva-tion easement	High - Will involve contact with variety of people	High - New concept, will require work to develop	Low - Once started, little hired labor needed
Wood products **Chapter 8**	Harvest only what can be grown; ensure regenera-tion present	Can use to thin and accomplish stand structure goals	Protect riparian zones	May be unsightly without tight supervision	Moderate - low short-term risk; long-term future uncertain	Variable - Dependent on product	Seedlings and saplings required for the future	Low - Depends on terrain, distance to market	High - depending on long-term wood-cutting effects	Low - little involved	Moderate - high - dependent on product	Moderate - high - dependent on product

Worksheet 1-1: Goals for Managing Hardwood Rangelands

Conservation Goals

Over the next five to ten years, what do you think will be the most important conservation goal?

What are the next most important conservation goals over the next five to ten years?

What are the most important conservation goals in the next year or two?

Shown below are several possible conservation goals for your property. Place a check mark by the ones that you feel are important to your situation. If you have other goals that don't appear, add them to the list.

- ❑ To maintain a mosaic of oak-woodland, shrub, and open grassland
- ❑ To stabilize the streambanks along _____ and increase stream shading
- ❑ To encourage a diversity of wildlife resources
- ❑ To reduce wildfire hazard
- ❑ To establish new oaks in _____ .
- ❑ To develop new water sources in _____ .

Other Goals:

- ❑
- ❑
- ❑
- ❑



Worksheet 1-1: Goals for Managing Hardwood Rangelands (cont.)

Economic and Production Goals

Over the next five to ten years, what do you think will be the most important economic goal? (record on these lines)

What are the next most important economic goals over the next five to ten years?

What are the most important economic goals in the next year or two?

Shown below are several possible economic goals for your property. Place a check mark by the ones that you feel are important to your situation. If you have other goals that don't appear, add them to the list.

- ❑ To pass on the ranch as an operating unit to be managed by the next generation
- ❑ To earn $ ____ annually from ranch enterprises
- ❑ To earn a ___ % return on invested capital
- ❑ To have $ ____ in savings to be used ____ years from now for ____
- ❑ To provide for adequate retirement income starting in _____

Other Goals:

- ❑
- ❑
- ❑
- ❑

Worksheet 1-1: Goals for Managing Hardwood Rangelands (cont.)

Quality of Life Goals

Over the next five to ten years, what one quality of life goal will be the most important? (record on these lines)

What are the next most important quality of life goals over the next five to ten years?

What are the most important quality of life goals in the next year or two?

Shown below are several possible quality of life goals for your property. Place a check mark by the ones that you feel are important to your situation. If you have other goals that don't appear, add them to the list.

- ❑ To preserve the existing quality of life associated with ranching.
- ❑ To maintain a level of living similar to friends/family living in towns
- ❑ To lead a quiet life away from urban influences
- ❑ To find new ways to develop new market products
- ❑ To interact frequently with people
- ❑ To maintain the beauty of my property
- ❑ To work outdoors and remain active
- ❑ To hire others to maintain the property

Other Goals:

- ❑
- ❑
- ❑
- ❑

Chapter Two

Oaks and Habitats of the Hardwood Rangeland

Primary authors: Barry Garrison, Calif. Dept. of Fish and Game; Greg Giusti, Univ. of California, Mendocino Co.; and Richard Standiford, Univ. of California, Berkeley

The main focus of these guidelines is on hardwood rangelands in California with at least a 10 percent canopy cover. These areas are also referred to commonly as oak woodlands. Both terms will be used interchangeable throughout these Guidelines. Eight major oak species occur on California hardwood rangelands. Blue oak, valley oak, Oregon white oak and Engelmann oak are all deciduous and members of the white oak group. Coast live oak, interior live oak, and canyon live oak are three important evergreen oaks. California black oak is a deciduous oak in the red oak group. Table 2-1 briefly describes the general characteristics of these important oak species. Figure 2-1 illustrates the typical leaf and acorn for each species, although these show great variation throughout the state.

Types of Oak Woodlands

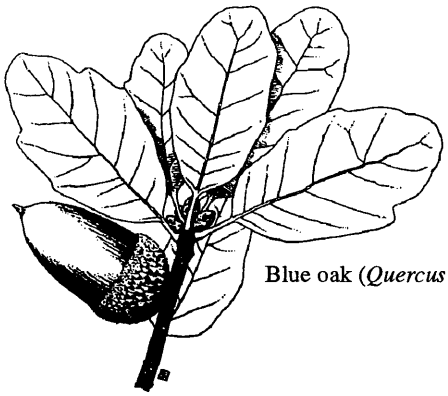
The distribution, density, and abundance of these oak species, together with other tree, brush, and herbaceous species, forms the basis for evaluating the potential of a hardwood rangeland site for providing economic and ecologic value and benefits. Although there are numerous ways to classify California's oak-dominated woodlands, the five vegetation types used in the California Wildlife Habitat Relationships System (CWHR) will be used in these guidelines. The CWHR types are based on the dominant tree species, and include Valley Oak Woodland, Blue Oak Woodland, Blue Oak-Foothill Pine Woodland, Coastal Oak Woodland, and Montane Hardwood Forest.



A list of some of the common names and associated Latin names for some of the tree and brush species used in the woodland type descriptions are provided at the end of this chapter.

A recent assessment of California by the California Department of Forestry and Fire Protection found approximately 11 million acres of the five types of hardwood rangeland habitats (Table 2-2). This assessment involved 54 of California's 58 counties, which were then placed into one of six geographic regions. Montane Hardwood and Blue Oak Woodland are the most abundant with 4.1 and 3.6 million acres, respectively. Valley Oak woodland was the least abundant, with only 76,450 acres identified. The North Coast and Southern California regions had the least amount of hardwood rangeland habitat types, with 834,800 and 520,000 acres respectively.

Fig. 2-1. Line drawing of acorns and leaves of California's eight major hardwood rangeland oak species.



Blue oak (*Quercus agrifolia*)



Oregon white oak (*Quercus garyana*)

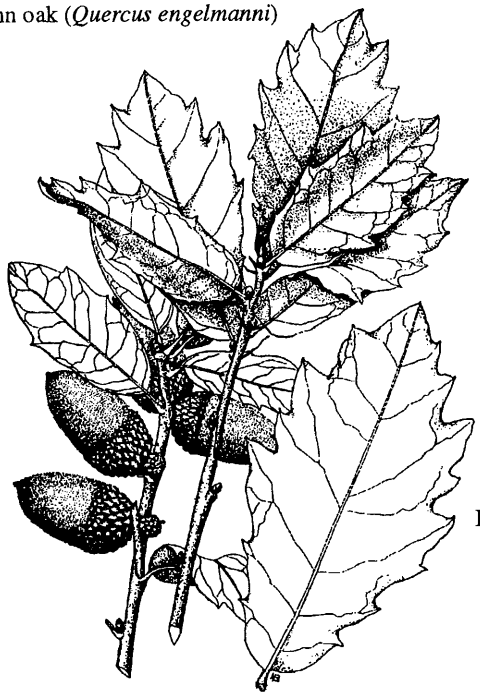


California black oak (*Quercus californica*)

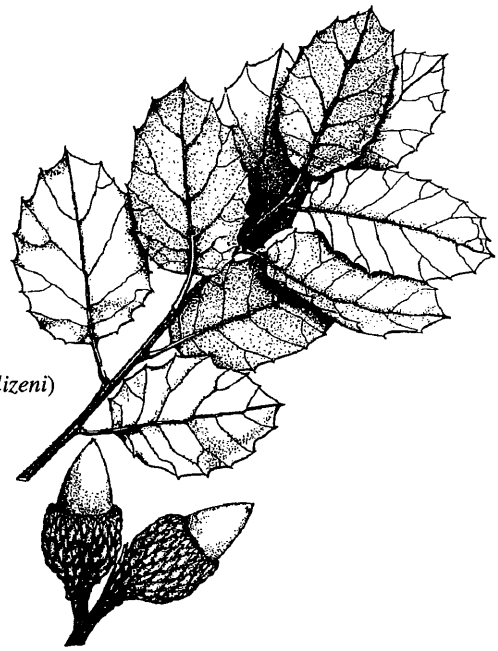
Canyon live oak (*Quercus chrysolepis*)

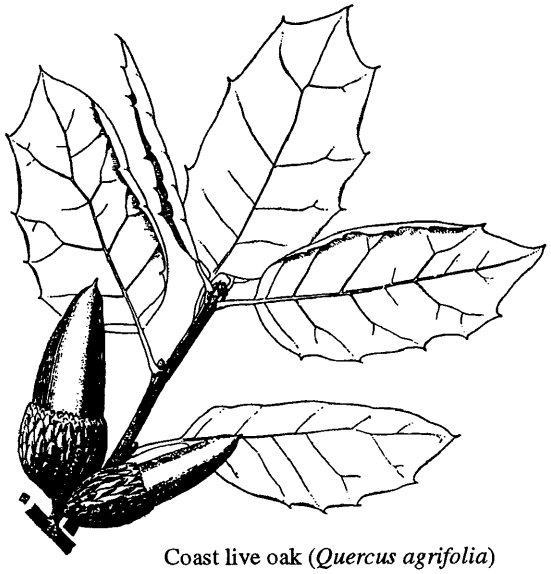


Engelmann oak (*Quercus engelmanni*)

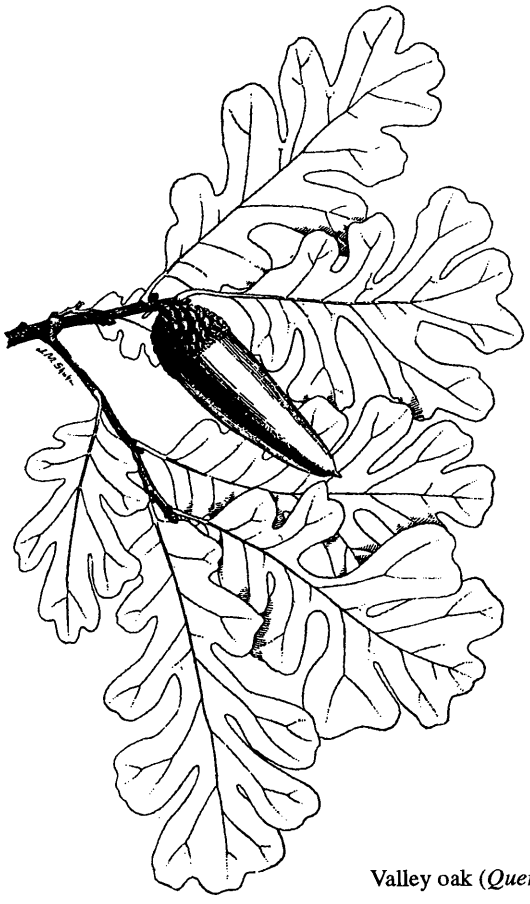


Interior live oak (*Quercus wislizeni*)





Coast live oak (*Quercus agrifolia*)



Valley oak (*Quercus lobata*)

Table 2-1. General characteristics of California's important hardwood rangeland oak species.

Characteristics	Blue Oak	Interior Live Oak	Coast Live Oak	Valley Oak
Scientific name	*Quercus douglasii* Hook. & Arn.	*Quercus wislizenii* A. DC.	*Quercus agrifolia* Nee	*Quercus lobata* Nee
Common names	blue, white, mountain, rock, iron, post, jack, Douglas	Interior live oak, highland live oak, Sierra live oak	Coast live oak, California live oak, encina	Valley, white, California white, mush, water, swamp, roble
Height	Usually 20-60 ft.; tallest over 90 ft.	Usually 30-75 ft.; shrub form 8-10 ft.	Usually 20-40 ft.; may reach 80 ft.	40-120 ft.
Mature Tree DBH (Diam. at Breast Ht.- 4.5 ft. above ground)	Less than 1 ft., up to 2 ft.; largest over 6 ft.	1-3 ft.	1-4 ft.	1-4 ft.; largest over 8 ft.
Longevity	Long-lived, 175-450 yrs.	150-200 yrs.	Long-lived, 125-250 yrs.	Long-lived, 200-250 yrs.
Sprouting	Variable sprouter; not vigorous on dry sites	Very vigorous sprouter	Very vigorous sprouter	Not a vigorous sprouter
Acorn	Matures first year; variable in shape; warty scales; Cup very shallow	Matures second year; very slender, pointed, 1 in. long; cup over half the nut	Matures first year; 3/4 to 2-3/4 in.; cup over 1/3 of nut and not warty	Matures first year, variable but large and tapered, cup over 1/3 of nut and warty
Foliage	Deciduous; blue-gray color; smooth or slightly to deeply lobed edges; 1-3 in. long and 1/2-2 in. wide	Evergreen with smooth to very spiny-toothed; dark green above and lighter below with waxy/shiny surface; 1-4 in.; flat	Evergreen; 1-3 in.; roundish; dark and shiny above with gray or rusty fuzz underneath; cupped or spoon-shaped	Deciduous; leaves leathery with shiny, dark green-yellow above and grayish below; deep irregular lobes; 2-4 in.
Shade Tolerance	Seedlings not tolerant	Somewhat shade tolerant	Shade tolerant throughout life	Seedlings somewhat tolerant, mature trees intolerant
Fire Tolerance	Tolerates grass fires; not hot brush fires	Not very tolerant, but sprouts well after fire	Very tolerant of hot fires due to thick bark	Not tolerant of fires
Elevation	500-2000 ft. in north; up to 5000 ft. in south	Below 2000 ft. in north and above 6200 ft. in south	Below 3000 ft. in north and up to 5000 ft. in south	500-800 ft. in north; up to 5600 ft. in south
Associates	Grades into open valley oak stands at low elevations; blends into denser live oak stands at higher elev.; foothill pine common	In pure stands or mixed with blue and/or coast live oak, and valley oaks in So. California	Forms pure stands; also grows with interior live oak and coast live oak	Blue and Oregon white oak; sometimes interior live oak
Sites	Hot, dry sites with rocky soils, 12-40 in. deep; can't compete with live oak on better sites	Wide range, from valleys to foothills; moister areas than blue oak	Common on valley floors or not-too-dry fertile slopes	Prefers fertile, well-drained bottomland soils, streambeds, and lower foothills
Notes	Confused with valley oaks when leaves are dusty	Confused with coast live oaks; distinguished by flat leaves	Confused with interior live oak but rounded and cupped leaves	Confused with Oregon white oak but acorns pointed with warty cups

Table 2-1. (cont.)

Characteristics	Engelmann Oak	California Black Oak	Oregon White Oak	Canyon Live Oak
Scientific name	*Quercus engelmannii* Greene	*Quercus kelloggii* Newb.	*Quercus garryana* Dougl.	*Quercus chrysolepis* Liebm.
Common names	Engelmann, mesa	Black, California black oak	Garry oak, white oak, Oregon oak	Canyon live oak, canyon oak, gold cup oak, live maul, maul oak, white live oak
Height	20-50 ft.	60-90 ft.	50-80 ft.	60-80 ft.
Mature Tree DBH (Diam. at Breast Ht.- 4.5 ft. above ground)	1-2 ft.	1-4 ft.	2-3 ft.; largest over 5 ft.	1-4 ft.; largest over 5 ft.
Longevity	100-200 yrs.	100-200 yrs., occasionally up to 500 yrs.	100-200 yrs.	Up to 300 yrs.
Sprouting	Variable sprouter	Excellent sprouter	Excellent sprouter	Variable sprouter
Acorn	Matures first year	Matures second year; 1-1/2 in. long; thin cup over half the nut	Matures first year; 1 in. long with shallow cup	1-1/2 in. long; thick, shallow cup,
Foliage	Considered deciduous but foliage may persist during winter; similar to blue-gray color of blue oak	Deciduous; 5 in. long; 5-7 lobed; spiny leaf tips; dark yellow-green above and pale yellow-green below	Deciduous; 4-6 in. long; evenly and deeply lobed with rounded leaf tips; lustrous dark-green and shiny above and pale green below	Evergreen; 3 in. long; persist 3 or 4 seasons on tree; usually not lobed; leathery
Shade Tolerance	Seedlings tolerant, mature trees intolerant	Intermediate tolerance as seedling and intolerant as tree matures	Intermediate tolerance as seedling and intolerant as tree matures	Tolerant of shad
Fire Tolerance	Very tolerant of hot fires	Very sensitive to cambium being killed in hot fires	Maintained in open stands by regular, low-intensity fires	Sensitive to hot fires
Elevation	Under 4000 ft.	200-6000 feet	500-3000 ft.	300-5000 feet
Associates	In pure stands and with coast live oak	Most common with tanoak, madrone, mixed conifer forest species;, also with coast live oak, interior live oak, and blue oak	Douglas-fir and mixed evergreen forests; Pacific madrone and tanoak	Found with mixed conifer, chaparral, and woodland species; tanoak, Douglas-fir, Pacific madrone, coast live oak
Sites	Warm, dry fans and foothills	More common on forest sites; found on moister hardwood rangelands; well-drained soils	Cool humid sites near coast to hot, dry sites inland	Most widely distributed oak on CA.; sheltered north slopes and steep canyons
Notes	Very limited range in southern California makes protection a high priority	Protected by Forest Practice Act on timberlands; commercial properties for finished lumber	Protected by Forest Practice Act on timberlands	Both a shrubby and tree form; very dense wood

Table 2-2. Acreages of California hardwood rangeland habitat types from the California Department of Forestry and Fire Protection database.

Habitat Type (CWHR)	Central Coast (acres)	San Joaquin Valley/ Eastside (acres)	Sac. Valley-North Interior (acres)	Central Sierra (acres)	North Coast (acres)	So. California (acres)	TOTAL (acres)
Blue oak woodland	1,096,990	1,078,080	945,170	365,920	75,900	34,000	3,596,060
Blue oak-foothill pine woodland	283,180	332,090	458,620	230,530	0	0	1,304,420
Valley oak woodland	54,600	16,870	1,760	0	2,230	1,000	76,450
Coastal oak woodlands	1,277,630	24,710	20,790	0	217,650	399,000	1,939,770
Montane Hardwood	632,880	775,450	1,087,910	1,019,910	539,020	86,000	4,141,170
TOTAL	3,345,270	2,227,200	2,514,240	1,616,360	834,800	520,000	11,057,870

Description of regions:
Central Coast: Alameda, Contra Costa, Lake, Marin, Monterey, San Benito, San Luis Obispo, San Mateo, Santa Barbara, Santa Clara, Santa Cruz, Solano, Sonoma, Ventura counties
San Joaquin Valley/Eastside: Fresno, Kern, Kings, Madera, Merced, San Joaquin, Stanislaus, Tulare counties
Sacramento Valley/North Interior: Butte, Colusa, Glenn, Lassen, Modoc, Plumas, Sacramento, Shasta, Sierra, Siskiyou, Solano, Sutter, Tehama, Trinity, Yolo, Yuba counties
Central Sierra: Amador, Calaveras, Eldorado, Mariposa, Nevada, Placer, Tuolumne counties
North Coast: Del Norte, Humboldt, Mendocino counties
So. California: Imperial, Los Angeles, Orange, Riverside, San Diego, San Bernardino counties

Valley Oak Woodland

Vegetation Composition and Structure: These widely scattered but sparsely occurring woodlands are dominated by valley oaks. Associated tree species in the Central Valley include California sycamore, California black walnut, California boxelder, Oregon ash, interior live oak, California buckeye, and blue oak. In the Coast Range, foothill pine and coast live oak occur in valley oak woodlands, while California black oak occurs with valley oaks at higher elevations. At low elevations close to water, valley oak is associated with Fremont cottonwood and tree willows. Valley oak woodlands vary from open savannahs to closed canopy forests. Dense stands occur along natural drainages in deep soils. Tree density tends to decrease as one moves from lowlands to uplands. The understory shrub layer can be dense along drainages and very sparse in uplands. Understory grasses and forbs are mostly introduced annuals. Mature valley oaks have well-developed crowns and reach maximum heights of 50 to 120 ft. The massive trunks (often up to 6 feet DBH) and branches of mature trees dominate valley oak woodlands.

Ecological Processes. In many areas, there is little valley oak recruitment to replace mature tree losses due to both natural and human causes. This is presumed to be related to moisture competition with grasses and forbs, wild and domestic animals feeding on acorns and seedlings, and flood control projects. Also, fire suppression has encouraged live oak and pine invasion in upland valley oak sites. Valley oaks tolerate flooding and young trees will sprout when damaged by fire. Valley oak woodlands should be able to maintain themselves with natural disturbances such as fire and flooding. However, suppression of fire and flooding has adversely affected sustainability of valley oak woodlands.

Locational Characteristics: Valley oaks are endemic to the state, meaning that they are found only in California. They occur in a patchy distribution throughout most major lowland valleys including the Sacramento-San Joaquin and those valleys occurring in the Coast Range and Transverse Range. Many valley oak woodlands occur as isolated stands in areas where surrounding habitats have been modified by agricultural, urban, and suburban activities. Annual grasslands, riparian forests, and other oak woodland types occur adjacent to valley oak woodlands. Conversion of valley oak woodlands to irrigated agricultural land uses has had the largest effect on the acreage decline of this type.

Physical Characteristics: Valley oak communities generally occur on deep, well-drained alluvial soils found in valleys and foothills below 2,400 feet. However, valley oaks can occur up to 5,600 feet as components of other vegetation types in the south Coast Range and Tehachapi Mountains.

Blue Oak Woodland

Vegetation Composition and Structure: Blue oak woodlands are highly variable with blue oak comprising 80-100 percent of the trees present. Foothill pine, California buckeye, valley oak, interior live oak, coast live oak, canyon live oak, and California black oak are common associates of blue oak. The overstory of blue oak woodlands range from sparsely scattered trees on poor sites to nearly closed canopies on good quality sites. Annual grasses form most of the understory in open woodlands. Characteristic shrub species in this community include poison-oak, California coffeeberry, and several species of ceanothus and manzanita.

Ecological Processes: Blue oaks are relatively slow-growing, long-lived trees. Most blue oak stands exist as groups of medium to large trees with few or no young oaks. This may or may not indicate there is a regeneration problem (see chapter 9). However, there is concern that in areas of poor regeneration, blue oak woodlands may be slowly changing into savannas and grasslands as trees die and are not replaced. Since young, vigorous blue oaks can stump sprout readily, while older, decadent trees cannot, younger stands are more likely to regrow after fires. Poor blue oak recruitment from acorns occurs for several reasons. Introduced annual grasses out-compete blue oak seedlings for soil moisture. In addition, acorns and seedlings are eaten or damaged by insects, domestic livestock, and wildlife. Blue oak is also somewhat intolerant of shady conditions, and is unable to survive under dense overstory canopies. Disturbances with small openings may be needed for seedlings to survive and grow sufficiently to promote a broader age class distribution. Furthermore, reduction in annual grass biomass through fire, limited grazing, or weeding may increase seedling growth and survival.

Locational Characteristics: Blue oak woodlands form a nearly continuous band along the Sierra Nevada-Cascade foothills of the Sacramento-San Joaquin Valley. They also occur along the western foothills of the Tehachapi Mountains and eastern foothills of the Coast Range. Typically, blue oak woodlands are found below 3,000 to 4,000 feet, but this elevational threshold drops to around 2,000 feet in the northern range, and rises to around 5,000 feet in the southern range. At lower elevations on gentle slopes, blue oak woodlands typically occur as large blocks with highly variable canopy cover. On steeper ground, blue oak woodlands occur in small patches interspersed with other habitats such as annual grasslands, chaparral, riparian forests, and other types of oak woodlands.

Physical Characteristics: Blue oak woodlands occur on a wide range of soils which are often shallow, rocky, infertile, but well-drained. Blue oak woodlands occur in dry, hilly terrain where the water table is usually unavailable to trees. Over the range of blue oaks, there is considerable climatic variation, with rainfall ranging from 10 to 60 inches annually.

Blue Oak-Foothill Pine Woodland

Vegetation Composition and Structure: Blue oak-foothill pine woodlands have a diverse mix of hardwoods, conifers, and shrubs, and widely variable overstories. Foothill pine (formerly known as digger pine) and blue oak typically form most of the overstory of this highly variable habitat type. Blue oak usually most abundant, although foothill pine is taller and dominates the overstory. Stands dominated by foothill pine have low blue oak density because of its shade intolerance. In the Sierra Nevada foothills, interior live oak and California buckeye are often associated with this type. Interior live oak becomes more abundant on steeper slopes, shallower soils, and at higher elevations. Coast live oak, valley oak, and California buckeye occur with this community in the

Coast Range. In the southern Coast Range and Tehachapi Mountains, California juniper also occurs. Shrub associates include several ceanothus and manzanita species, poison-oak and California redbud, and are usually clumped in areas of full sunlight.

Ecological Processes: Blue oak and foothill pine are relatively long-lived, but foothill pine tends to grow faster than blue oak. Historically, fires occurred every 5 to 25 years in this vegetation community. Regeneration is generally thought to be infrequent throughout California. Following fire, young, vigorous blue oaks sprout well, but older, more decadent trees do not. Therefore, younger stands are more likely to replace themselves after fires. Foothill pine is susceptible to severe damage to fire. This is due to the thin bark of young trees and high resin content in the sap. Furthermore, foothill pine does not reproduce by sprouting, so fire management as a tool should be carefully considered.

Locational Characteristics: Blue oak-foothill pine woodlands are found on steeper, dryer slopes with shallower soils than blue oak woodlands. At lower elevations on gentle slopes, these two communities intermix with grasslands. At higher elevations on steeper slopes, the communities are mixed with grasslands and shrublands. Riparian woodlands may bisect these mosaics along permanent and intermittent watercourses. Blue oak-foothill pine woodlands are found throughout the range of blue oak and form a nearly continuous band along the Sierra Nevada-Cascade foothills of the Sacramento-San Joaquin Valley, except for a gap in Tulare and southern Fresno counties. Elevation ranges from 500 feet in the north to 3000 feet in the south.

Physical Characteristics: This woodland type occurs on a variety of well-drained soils. Terrain is hilly and generally dry, and water is unavailable for much of the year.

Coastal Oak Woodland

Vegetation Composition and Structure: Coastal oak woodlands are highly variable because of their wide distribution along California's coast. Three oak species dominate the range of coastal oak woodlands: coast live oak throughout the central and southern range; Engelmann oak in a small area in southern California; and Oregon white oak in the moister, northern range of this community. Trees associated with Oregon white oak include California black oak, canyon live oak, Pacific madrone, and interior live oak. Species associated with coast live oak on moister sites are Pacific madrone, California bay, tanoak, and canyon live oak, while coast live oak occurs with valley oak, blue oak, and foothill pine on drier sites. In southern California, coast live oak is associated with interior live oak, valley oak, California black walnut and Coulter pine. Where Engelmann oak dominates, it may occur with coast live oak or in almost pure stands. Overstories range from open conditions to nearly closed canopies, resulting in a variable density of understory shrubs, grasses, and forbs. Annual grasses form most of the understory in open woodlands, but are almost non-existent in very dense woodlands. Coastal oak savannas typically occur adjacent to grassland habitats. Shrubs in closed canopy situations tolerate shade, and include toyon, poison-oak, California coffeeberry, and several species of ceanothus and manzanita.

Ecological Processes: Coast live oak, Oregon white oak, and Engelmann oak are relatively long-lived, slow-growing trees, requiring 60 to 80 years to mature to tree size under good conditions. Historically fires frequently occurred in these woodlands. Engelmann and coast live oaks are relatively resistant to low-intensity ground fires, while some mortality occurs to seedlings and saplings. Since coast live oak is fairly resistant to grazing pressure, it appears to be replacing the less resistant deciduous oaks in areas with intense grazing. Coast live oaks regeneration is generally good. However, adequate regeneration of Engelmann oak is not occurring for many of the same reasons affecting blue oaks. In Oregon white oak stands without frequent fires or other disturbances, Douglas-fir and other conifers may grow in the understory and eventually overtop the oaks.

Locational Characteristics: Coastal oak woodlands occur along California's coastal foothills and valleys. Elevations range from sea level to around 5,000 feet. On steep slopes, coastal live oak woodlands occur as relatively small woodland patches in mosaics with annual grasslands, shrublands, and riparian habitats. Blue oak woodlands and montane hardwoods are found with the more interior and higher elevation coastal oak woodlands.

Physical Characteristics: Soils and its underlying rock parent materials are extremely variable. Coastal oak woodlands typically occur on moderately to well-drained soils that are moderately deep and have low to me-

dium fertility. As with other hardwood-rangeland communities, considerable climatic extremes exist.

Montane Hardwood Forest

Vegetation Composition and Structure: Montane hardwood forests are perhaps the most variable of any California hardwood type. The dominant oak species vary by topography, soils, and elevation. Montane hardwood forests typically lack blue oaks and valley oaks. The characteristic oaks are canyon live oak, interior live oak, California black oak, and Oregon white oak. Many montane hardwood forests are located on fairly productive forest soils, and are not truly "hardwood rangelands", but commercial hardwood forests under the jurisdiction of the California Forest Practices Act (FPA). However, pure stands of black oak, tanoak, and madrone with no evidence of conifer associates are exempt fro the FPA at this time.

Canyon live oak often forms almost pure stands on steep canyon slopes and rocky ridge tops throughout the Coast Range, Klamath Mountains, Sierra Nevada, and Transverse and Peninsular Ranges. They have tremendously variable growth forms, ranging from shrubs with multiple trunks on rocky, steep slopes, to 60 to 70 foot tall trees on deeper soils in moister areas. Throughout the same range, California black oak tends to dominate on gentle topography at higher elevations. It grows to heights of 70 to 80 feet at maturity, with long, straight trunks in closed canopy situations. In open forests, California black oak has larger, spreading branches. Canyon live oak and California black oak are widely distributed and form the montane hardwood habitats throughout much of California's mountain areas. However, these two species are usually not associated with hardwood rangeland sites.

Interior live oak occurs with canyon live oak or alone on steep canyon slopes and rocky, steep slopes throughout the North Coast and Sierra Nevada. Its growth form varies much like canyon live oak. Both of these evergreen oaks have dense canopies. Oregon white oak dominates small amounts of montane hardwood types along the northern Coast Range and northern Sierra Nevada and Cascades. Oregon white oak grows to a height of 50 to 80 feet at maturity, with rounded crowns in open conditions and rather narrow crowns in closed conditions.

Associates of montane hardwood communities at higher elevation, good quality sites include ponderosa pine, Douglas-fir, Pacific madrone, Jeffrey pine, sugar pine, incense-cedar, and white fir. At lower elevations and poor soils with steep slopes, associates include foothill pine, knobcone pine, tanoak, and Pacific madrone. In southern California, many of the same species are found, as well as coulter pine and bigcone douglas-fir. Blue oak and valley oak can be associates at lower elevations. Understory shrub species include poison-oak, ceanothus, manzanita, mountain-mahogany, coffeeberry, wild currant, and mountain misery. Forbs and grasses are not as prevalent as on lower elevation hardwood rangeland types. Montane hardwood forests have a pronounced hardwood tree layer with poorly developed shrub and herbaceous layers.

Ecological Processes: Since oaks of montane hardwood communities are long-lived, the community is rather stable and persistent without stand replacing disturbances. Trees are initially established by acorns, and dispersal by animals plays a major role in planting and survival. Once established, the four dominant oaks - canyon live, interior live, California black, and Oregon white - can sprout vigorously from stumps, allowing rapid re-establishment after a fire. Frequent fires over relatively small areas result in a variety of age classes across the landscape. The large number of hardwood and conifer species allows this type to occupy many environments and locations. The general inaccessibility of these habitats have protected them from many of the human-induced disturbances such as intensive agricultural, residential and commercial development, grazing, and wood cutting.

Locational Characteristics: Montane hardwoods range throughout California from 300 feet near the coast to almost 9,000 ft in southern California. Surrounding habitats include conifer-dominated types, chaparral types, blue oak and valley oak woodlands, and exotic annual grasslands.

Physical Characteristics: A wide range of physical characteristics affect montane hardwood forests. Slopes range from gentle to steep. Soils are mostly rocky, coarse, and poorly developed. However, relatively large California black oak stands occur in mountain valleys on alluvial soils. Exposures tend to be south, west, and east, while conifers tend to dominate on northern exposures. Climates are typically Mediterranean but extremely variable given the wide distribution of this type. Average summer temperatures are moderate, while average winter temperatures range from near freezing to the mid-40's. Snow occurs in the winter at higher elevations, but does not remain as long as on adjacent conifer-dominated habitats.

List of Common and Scientific Names for Plants Used in This Chapter

Bigcone Douglas-fir (*Pseudotsuga macrocarpa*)
Blue oak (*Quercus douglasii*)
Brome (*Bromus* spp.)
California bay (*Umbellularia californica*)
California black oak (*Quercus kelloggii*)
California black walnut (*Juglans hindsii*)
California boxelder (*Acer negundo*)
California buckeye (*Aesculus californica*)
California coffeeberry (*Rhamnus californica*),
California juniper (*Juniperus californica*)
California redbud (*Cercis occidentalis*)
California sycamore (*Platanus racemosa*)
Canyon live oak (*Quercus chrysolepis*)
Ceanothus (*Ceanothus* spp.)
Coast live oak (*Quercus agrifolia*)
Coulter pine (*Pinus coulteri*)
Douglas-fir (*Pseudotsuga menziesii*)
Engelmann oak (*Quercus engelmannii*)
Foothill pine (*Pinus sabiniana*)
Fremont cottonwood (*Populus fremontii*)
Incense-cedar (*Calocedrus decurrens*)
Interior live oak (*Quercus wislizenii*)
Jeffrey pine (*Pinus jeffreyi*)
Knobcone pine (*Pinus attenuata*)
Madrone (*Arbutus menziesii*)
Manzanita (*Arctostaphylos* spp.).
Mountain mahogany (*Cercocarpus betuloides*)
Mountain misery (*Chamaebatia foliolosa*)
Oregon ash (*Fraxinus latifolia*)
Oregon white oak (*Quercus garryana*)
Pacific madrone (*Arbutus menziesii*)
Poison-oak (*Toxicodendron diversilobum*),
Ponderosa pine (*Pinus ponderosa*)
Sugar pine (*Pinus lambertiana*)
Tanoak (*Lithocarupus densiflorus*)
Valley oak (*Quercus lobata*).
White fir (*Abies concolor*)
Wild currant (*Ribes spp.*)
Wild oats (*Avena* spp.)
Willow species (*Salix* spp.)

Chapter Three

Resource Assessment and General Hardwood Rangeland Values

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General Assessment of Property

Once you have completed an assessment of the goals for your hardwood rangeland property, it is necessary to assess the various resources to determine if it is possible to accomplish these goals, and where management activities should be directed. In this chapter, we will present two general worksheets. Worksheet 3-1 gives a framework for evaluating the overall hardwood rangeland property, while worksheet 3-2 will help you assemble basic information about your hardwood stands. Most of the information for 3-1 is easily available from a general reconnaissance of the property, as well as an evaluation of maps and aerial photos. The section on sources of assistance gives advice on ordering maps and photos if you do not already have these. You should plan on completing this entire resource assessment exercise because it can provide a foundation upon which sound land management actions may be built. This is a good activity for all family members or parties interested in a particular property to participate in together. The information gained in this exercise will ensure that everyone has a common base of knowledge about the existing resources on a property.



Stand Level Assessment

Once you have completed the general property assessment in Worksheet 3-1, take a look at the information in table 3-1 for some general resource enterprises that may work on your property. These possible enterprises can be compared with those which fit in with your goals developed from the worksheets in chapter 1, to decide on the management potential for your hardwood rangeland property. Then you will be able to direct your attention to detailed discussions in chapters 4 through 9 of this book on various hardwood rangeland enterprises. You may need to collect additional information for a detailed assessment of the individual enterprises. This should help guide your decision about which types of management activities will be best for your situation.

Seen at left is a large madrone tree located on a ranch in Sonoma County. In the background are black oak trees. Madrone trees frequently occur on montane hardwood rangelands.

Worksheet 3-1. Hardwood Rangeland Propety Assessment

General Property Information

Property name _____ Parcel size _____ acres Elevation _____ feet

Describe how property was acquired (date, method acquired, original purchase price/basis)

Current Property Value _____

Nature of ownership

❑ Sole ❑ Joint ❑ Partnership ❑ Other _____

Property location (describe general location of property; use local maps where possible)

Accessibility (describe road access to various parts of the property and locate on map/photo)

Adjacent land uses (describe all adjacent land uses)

❑ Ag./open space ❑ Suburban ❑ Rural Residential ❑ Urban ❑ Public land ❑ Protected Areas

Topography (show on map/photo)

Acres on slopes less than 30% ___ Acres on slopes greater than 30% ___

Distance to markets

Distance to urban areas/clientele base for hunt clubs and customers for firewood: ___ miles

Distance to livestock markets: ___ miles

Other markets: ___ miles

Legal/political/social constraints (list ordinances, deed restrictions, zoning, and neighbor concerns affecting property)

Water

Sources of water (describe all sources of water on property and locate on map/photo where appropriate)

❑ Ponds ❑ Water troughs ❑ Springs ❑ Intermittent streams ❑ Perennial streams

❑ Wells ❑ Irrigation ditch ❑ Municipal water source ❑ Other _____

Water quality concerns (describe and locate areas with specific water quality concerns)

General Vegetation Information

Acres by general vegetation cover types (locate vegetation types on map/photo)

Grassland _____ acres	Oak woodlands _____ acres	Shrubland _____ acres
Irrigated agric. _____ acres	Residential areas _____ acres	Wetlands/riparian zones _____ acres
Other forested type _____ acres	Other ( ) _____ acres	

Worksheet 3-1. Hardwood Rangeland Property Assessment (cont.)

Current Management/Economic Uses

Grazing/livestock (check current enterprises that apply, and general information below)

❑ Cow/calf ❑ Stocker ❑ Sheep; ewe/lamb ❑ Lease grazing to others

❑ Other livestock _____

Current livestock inventory: ____ head on ____ acres

Season of use (check all that apply): ❑ Fall ❑ Winter ❑ Spring ❑ Summer

Other sources of forage: ❑ Public land lease ❑ Private lease ❑ Another ranch ❑ Other _____

Tree harvest (describe current tree harvest and marketing programs)

Type of wood products sold: ❑ Firewood ❑ Sawtimber ❑ Biomass ❑ Other _____

Species of tree sold: ❑ Blue oak ❑ Live oak ❑ Foothill pine ❑ Other _____

Harvest _____ cords every ____ years on _____ acres

Hunt Club (describe any hunt club activities you have)

Game species hunted: ❑ Deer ❑ Turkey ❑ Other gamebirds ❑ Pigs ❑ Elk ❑ Other _____

Lease description (describe hunt club economic arrangement)

List other economic uses of hardwood rangeland property

Capital improvements (list of all capital improvements and show on map/photo)

Buildings	Fencing	Road systems	Other Improvements

Resource Constraints

Soils (list all soil series, general productivity, and constraints)

Erodible areas (list all eroded and erodible areas and locate on map/photo where possible)

Threatened and endangered plant and animal species

Table 3-1. Matrix of resource assessment and management enterprises (for assessment chapter)

Assessment Criteria	Livestock grazing	Hunt club/ recreation	Conservation land	Wood products	Specialty products
Parcel size	>25 acres	>500 ac (deer); >100 ac. (turkeys)	>100 ac.	>100 ac.	Depends on product
Cover type and pattern	Must have patches of open or low density woodlands for forage	Mixture of dense and open woodlands with large patches of dense connected woodlands	Must have some special cover type being lost near property or a highly desirable habitat	Must have stands with over 40 percent cover	Sufficient amount of vegetation type for product
Water	Need water	Need water	May enhance value	Not important	May be important
Access	Not important	Need road system for transport	Not essential unless public access desired	Need road system for hauling	Need access for transportation and management
Adjacent land use	Urban uses may present social conflicts	Urban uses may present social conflicts; Rely on neighbors for some habitat needs	Opportunities are best in areas close to urban/residential areas	Urban uses may present social conflicts	Urban uses may present conflicts or opportunities depending on product
Topography	Most areas <50 pct. slope	Need areas with <50 pct. slope for access	Slope class has little effect	Operate only in areas with <30 pct. slope	Most likely need areas <30 pct. slope
Distance to market	Unlimited with new video marketing sales	Need to be <120 miles	Generally near to urban areas or areas with some adverse impact	<100 miles	Should be <100 miles to market to minimize transportation
Capital improvements	Fences, water facilities	Not critical	Not critical	Depends on product	Depends on product
Legal constraints	Local ordinances, T&E species	T&E species, hunting regulations	Often restricts future land use; may be constraints on compatible enterprises	Local ordinances, T&E species, deed restrictions, Forest Practice Act	Need to check health codes, zoning restrictions, T&E species
Resource constraints	Need residual biomass	Species of interest should be present in sufficient numbers to support harvest (i.e. turkeys, deer, etc.)	Presence of critical habitat or threatened and endangered species may enhance value	Site must be capable of regeneration from seedlings or sprouting	Need to ensure that "product" management does not disrupt site ecological processes

Assessing Legal Concerns

Today's land management must often comply with numerous laws and regulations that are imposed at all levels - local, state, and federal. Federal laws and regulations are implemented by either the federal agency which has jurisdiction, or are delegated to a state agency. State laws and regulations for the most part are the responsibility of the jurisdictional agency, although responsibilities can be delegated to county or district agencies. Local ordinances are implemented by the county or district agency. An important part of an assessment is finding out which of these legal concerns apply to your situation, and what these require you to do. Some of the different types of laws and regulations you should be investigating are described, as well as where you might find more information.

Water: Water rights and water quality are both the responsibility of the California State Water Resources Board, who further delegate the water quality responsibilities to nine Regional Water Quality Control Boards. Federal laws such as the Federal Clean Water Act, Safe Drinking Act, and Coastal Zone Act are tailored for implementation in California by the Porter-Cologne Act. Water rights are involved when considering pond or spring development and diversions for water supplies. Water rights applications and information for land parcels are obtained at the county recorder's office. Stream water diversions require a "1603 permit" from the California Department of Fish and Game. Water quality considerations for hardwood rangelands most often involve nonpoint source pollution factors, including sedimentation, nutrients, and/or pathogens. Riparian vegetation management is frequently considered along with these other nonpoint source pollution factors.

Wetlands: Wetlands jurisdiction is confusing and landowners and managers should check to see what issues are of local concern and which agency is involved. Laws and regulations are under a state of revision. For most agricultural lands, the Natural Resources Conservation Service (NRCS) has the lead role for wetlands management. In some cases, the Army Corps of Engineers, the US Fish and Wildlife Service, or the California Department of Fish and Game may be the lead agency.

Air Quality: Any burning activities are under the jurisdiction of local Air Quality Management Districts (AQMD). Check with your local AQMD to determine an air quality restrictions that would apply to management of your hardwood rangelands.

Wildlife: The County Agricultural Commissioner handles issues related to controlled materials for predator control. The California Department of Fish and Game is responsible for issuing predation permits for some animals (deer, mountain lions, bear, etc.), and for setting regulations over hunting and fishing. Furthermore, the Department protects species listed as threatened, endangered, or protected by state law, and it has general jurisdiction and public trust responsibility for the state's fish and wildlife and their habitats.

Timber: Most tree species on hardwood rangelands are currently not considered "commercial species" and are not subject to the Forest Practice Rules administered by the State Board of Forestry. However, a number of counties and cities have ordinances that affect the harvest of oak trees on rangelands. Several other counties have voluntary oak tree harvesting guidelines and suggested best management practices. Check with local experts to see what local rules and guidelines apply to your area.

Endangered Species: Both federal and state laws list plants and animals that are threatened or endangered. The US Fish and Wildlife Service has jurisdiction over the federally listed species, while the California Department of Fish and Game has jurisdiction of those listed by the state (see Appendix A and B). Specific circumstances may prohibit certain management practices or changes in land use if they affect a listed plant or animal. Check locally with California Department of Fish and Game, U.S. Fish and Wildlife Service, or UC Farm Advisors for the situation in your area. This is discussed in more detail in chapter 4.

Archaeological Sites: There is increasing public concern about preserving historically and culturally significant

sites. The presence of such sites may impact proposed changes in land use or management. County planning, Community Colleges, State Colleges, and local museums are good sources of information on archaeological sites in your area.

Land Use: A number of land use related issues may influence certain management decisions. The California Land Conservation Act (Williamson Act) contracts with certain counties to provide tax relief for agreeing to not develop land for 10 years. County General Plans often have restrictions on parcel size, land use, and zoning. Easements for utilities, conservation, open space, and wildlife habitat are becoming more common. Other laws and ordinances to be aware of are those relating to the right to farm and fence, trespass laws, as well as private property rights laws.

Livestock: There are a number of laws relating to livestock including: animal identification (branding) law; laws relating to diseases such as TB and brucellosis; and laws concerned with the disposal of dead animals. Your local agricultural commissioner can provide information on each of these.

Professional Certification: The State Board of Forestry has the licensing authority over natural resource professionals to protect the natural resources of the state and to protect the public interest by ensuring competent professional work. Designations for Certified Rangeland Managers (CRM) and Registered Professional Foresters are maintained by the State Board of Forestry. Details on qualifications, duties, and a list of certified professionals are available.

Values for Hardwood Rangeland Stands

Worksheet 3-2 helps you to collect basic information on hardwood rangeland cover type, canopy cover, slope class, and associated habitat elements, and will allow you to look up some general ecological and managerial recommendations. Table 3-2 shows how the information on tree cover type and canopy density can be used to refer you to a specific description. For example, if your stand is a blue oak woodland with a 50 percent canopy cover, you would go to the description for site C, found on page 11 of this chapter.

Each of the 12 broad site descriptions gives general recommendations and assessments on four categories: oak cover/forestry; recreation; wildlife diversity; and grazing. These are based on some very broad statewide conclusions from practical experiences and research studies. These descriptions, assessments, and recommendations are intended to guide you through some general ideas on the potential uses for hardwood rangeland stands on your property. As you evaluate these recommendations, the rainfall zone, slope class, and presence of wildlife habitat elements such as snags, riparian zones, or downed woody debris, which you are assessing in worksheet 3-2, will allow you to refine these recommendations. These general recommendations must be followed up with site specific information for your local area. Chapters 4 through 9 will help you develop this site specific information for your property.

Table 3-2. Classification for hardwood rangeland sites based on tree cover type and canopy cover.

Tree Cover Type	Tree Canopy Cover			
	10 - 24%	25 - 39%	40 - 59%	60 - 100%
Blue oak woodland, blue oak-foothill pine woodland	A	B	C	D
Valley oak woodland	E	F	G	H
Coastal oak woodland, montane hardwood	I	J	K	L

Worksheet 3-2. Hardwood Rangeland Stand Assessment

Property name

Location of Stand (describe general location on property, use maps where possible)

Acres in Stand		Elevation		Soil Series
Aspect	❑ North	❑ South	❑ East ❑ West	
Av. Annual Rainfall	❑ <15"	❑ 15 - 25"	❑ 25 - 35"	❑ >35"
Slope Class	❑ Gentle (<30%)		❑ Steep (>30%)	
Erosion	❑ None	❑ Sheet/rill	❑ Gullies	
Ground cover	❑ <25%		❑ 25 - 50%	❑ 51 - 75% ❑ >75%

Tree Cover Type	❑ Blue oak woodland, Blue oak-foothill pine woodland ❑ Valley oak woodland ❑ Coastal oak woodland, montane hardwood		
Tree Canopy Cover	❑ Minimal (<10%) ❑ Moderate (40 - 59%)	❑ Sparse (10 - 24%) ❑ Dense (60 - 100%)	❑ Open (25 - 39%)
Average Tree Size	❑ Seedling (<1 in. DBH) ❑ Pole (6 - 11 in. DBH) ❑ Med./Large tree (>24 in. DBH)		❑ Sapling (1 - 6 in. DBH) ❑ Small tree (11 - 24 in. DBH) ❑ Multi-layered
Tree Mortality	❑ None	❑ Light (<5 % trees)	❑ Heavy (>5% trees)
Regeneration status (check all that apply)	❑ none evident ❑ Saplings (3 - 10' tall)	❑ Small seedlings (<1' tall)	❑ Large seedlings (1 - 3' tall)

Shrub canopy cover	❑ Minimal (<10%) ❑ Moderate (40 - 59%)	❑ Sparse (10 - 24%)	❑ Open (25 - 39%) ❑ Dense (60 - 100%)
Shrub age class (yrs. since fuel reduction)	❑ <5 years ❑ >25 years	❑ 5 - 15 years	❑ 15 - 25 years

Habitat elements (check all that apply)	❑ Brush piles ❑ Riparian zones	❑ Snags	❑ Dead and down logs
Water sources	❑ None ❑ Springs	❑ Perennial streams ❑ Water developments	❑ Intermittent streams ❑ Other _____

Threatened and endangered plants and animals present:

Site A: Blue oak woodland, blue oak foothill pine woodland; 10 – 24 percent canopy cover

Oak Cover/Forestry Assessment:
Oak volume ranges from 20 to 170 cubic feet per acre, and 10-year growth rate ranges from 2 to 40 cubic feet per acre. These are not good areas for commercial harvesting activities due to very low stocking and low growth rates. Many open blue oak savannahs lack oak regeneration, especially on low elevation and/or low rainfall zones. Managers should compare current levels of mortality to regeneration. In areas where mortality exceeds regeneration, it may be necessary to adopt management procedures to encourage regeneration.

Recreation Assessment:
These areas offer only limited opportunities for hunt clubs in their current condition because of low cover and acorn production. Medium populations of quail can be expected, which can be improved by providing additional water and cover with brush piles. It may be desirable to increase cover if feasible to improve habitat for deer and turkeys.

Wildlife Diversity Assessment:
These open blue oak savannah stands contain both grassland and woodland wildlife species. In general, the habitat is good for open grassland species such as western meadowlark, but marginal for woodland species such as Pacific-slope flycatchers. Habitat elements, such as riparian zones, snags, trees with cavities, and large woody debris, have an important effect on biodiversity by making habitats more complex. More complex habitats support greater numbers of wildlife. According to the California Wildlife Habitat Relationships system (CWHR) there are 21 amphibian species, 33 reptile species, 73 mammal species, and 137 bird species which are predicted to occur in these habitats if various elements occur. If there are no riparian zones or sources of water, no snags or cavity trees, and no large woody debris or brush piles on the site, the number of vertebrate wildlife species predicted to occur in these habitats falls to 10 amphibian species, 31 reptiles, 39 mammals, and 101 bird species. This points to the importance of maintaining diversity in the habitat elements present in the stand to provide for the highest possible diversity of wildlife species.

Grazing Assessment:
Average forage production capability is 3,000 pounds per acre with a range from 1,500 to 4,500 pounds. In low rainfall areas, the presence of scattered trees has been found to increase overall range forage production. However, thistles and other undesirable plants may occur under the tree canopy, although this is not common. Potential for range improvement through seeding, fertilization, and grazing management may increase productivity where production is currently at the lower end of the scale and available soil and soil moisture is not limiting.

Site B: Blue oak woodland, blue oak foothill pine woodland; 25 – 39 percent canopy cover

Oak Cover/Forestry Assessment:
Oak volume ranges from 170 to 425 cubic feet per acre and the 10-year growth is 25 to 70 cubic feet per acre. These areas are generally not good for commercial firewood harvesting. The existing stocking level is good for diverse resource values, and managers should not take canopy density much lower. Some light thinning may be possible in dense clusters, but avoid using equipment on areas with over 30 percent slope to minimize erosion. Perhaps 40 to 85 cubic feet could be harvested per acre in higher productivity sites every 20 years. Many areas like these have an absence of oak regeneration, especially on low elevation and/or rainfall areas. Managers should assess current levels of mortality and compare this to seedling and sapling regeneration. In areas where mortality exceeds regeneration, it may be necessary to adopt management procedures to encourage regeneration.

Recreation Assessment:
These areas have good overall habitat for mule and black-tailed deer, wild pigs and California quail. Habitat can be improved by enhancing acorn production, planting legumes, and maintaining these through proper livestock and deer management. Any reductions in oak cover will also decrease habitat value for many desired game spe-

cies. Areas with slopes greater than 30 percent will have lower values for hunt clubs because of the difficult access.

Wildlife Diversity Assessment:
These blue oak woodland stands support both grassland and woodland wildlife species. In general, the habitat is fairly good for a large number of wildlife species. The occurrence of more complex habitats, through the presence of habitat elements such riparian zones, snags, trees with cavities, and large woody debris, has an important effect on biodiversity. There are 21 amphibian species, 31 reptile species, 64 mammal species, and 128 bird species which are predicted to occur by CWHR on the most diverse habitats in these stands. If there are no riparian zones or sources of water, no snags or cavity trees, and no large woody debris or brush piles on the site, the number of vertebrate wildlife species predicted to occur on these habitats falls to 10 amphibian species, 29 reptiles, 30 mammals, and 95 bird species. This points to the importance of maintaining diversity in the habitat elements present in the stand to provide for the highest possible diversity of wildlife species.

Grazing Assessment:
Average forage production capability is 3,000 pounds per acre with a range from 1,500 to 4,500 pounds. In low rainfall areas, the presence of scattered trees has been found to increase overall range forage production. However, thistles and other undesirable plants may occur under the tree canopy, although this is not typical. Potential for range improvement through seeding, fertilization, and grazing management may increase productivity where production is currently at the lower end of the scale and available soil and soil moisture is not limiting.

Site C: Blue oak woodland, blue oak foothill pine woodland; 40 – 59 percent canopy cover

Oak Cover/Forestry Assessment:
Oak volumes range from 425 to 1200 cubic feet per acre. Ten year growth ranges from 50 to 130 cubic feet per acre. Firewood harvest potential exists, but avoid using equipment on slopes over 30 percent to minimize erosion.. Harvest levels should approximately equal growth to maintain existing oak cover for diverse resource values. Approximately 85 to 250 cubic feet per acre can be harvested every 20 years from these stands. Ensure adequate oak regeneration after harvest.

Recreation Assessment:
These areas are excellent for medium to large populations of mule and black-tailed deer, squirrel, wild pigs, wild turkeys, mourning dove, and band-tailed pigeons. On areas with less than 30 percent slope, the terrain is excellent for hunter access. Careful tree thinning can complement game habitat. Where controlled fire can be used, it can help stimulate palatable shrub browse. Seeding clover and other legumes and maintaining it through grazing will benefit deer, turkey and quail.

Wildlife Diversity Assessment:
These blue oak woodland stands support a large number of wildlife species. The higher tree density makes these areas less desirable for open grassland species such as western meadowlarks and western kingbirds, but very desirable for woodland species such as Pacific-slope flycatchers and wild pigs. The occurrence of more complex habitats, through the presence of habitat elements such riparian zones, snags, trees with cavities, and large woody debris, has an important effect on biodiversity. 19 amphibian species, 28 reptile species, 64 mammal species, and 128 bird species are predicted to occur by CWHR on the most diverse habitats in these stands. If there are no riparian zones or water sources, no snags or cavity trees, and no large woody debris or brush piles on the site, the number of vertebrate wildlife species predicted to occur on these habitats falls to 10 amphibian species, 26 reptiles, 30 mammals, and 95 bird species. This points to the importance of maintaining diversity in the habitat elements present in the stand to provide for the highest possible diversity of wildlife species.

Grazing Assessment:
Average forage production capability is 2,000 pounds per acre with a range from 1,000 to 2,800 pounds. In areas with less than 20 inches of annual rainfall and during drought years on higher average rainfall areas, range productivity and forage nutritional value is often enhanced by the presence of this level of oak cover. In higher rain-

fall areas, the shading effect of the canopy suppresses total production. Thistles and other undesirable plants may occur under the tree canopy, although this is not typical. Potential for range improvement on slopes less than 30 percent through seeding, fertilization, and grazing management may increase productivity by two- to three-fold where production is currently at the low end of the scale. Tree thinning will increase forage production under the removed canopy in the higher rainfall zones of the state (over 20 inches per year).

Site D: Blue oak woodland, blue oak-foothill pine woodland; 60 – 100 percent canopy cover

Oak Cover/Forestry Assessment:
Oak volume ranges from 1200 to 3800 cubic feet per acre. Estimated growth ranges from 170 to 510 cubic feet per acre over 10 year. Firewood harvest can be carried out to permanently reduce cover and improve habitat for selected wildlife species and range productivity. Areas with less than 30 percent slope are a good place to prioritize for harvesting on the ranch. 500 to 2500 cubic feet per acre can be harvested from these stands to permanently reduce stands to 40 to 60 percent canopy cover after 20 years. If stand openings are absent, you may wish to make some small openings through the firewood operation to encourage blue oak regeneration.

Recreation Assessment:
These areas provide excellent habitat for mule and black-tailed deer, squirrel, wild pig, wild turkey, mourning dove, and band-tailed pigeons. On areas with over 30 percent slope, hunter access is too difficult for commercial operations. Thinning stands back to 50 percent cover in a patchy pattern can enhance deer habitat. Turkeys do best with a dense canopy, and California quail do best with less tree canopy, but both species prefer dense shrub layers and ample water sources.

Wildlife Diversity Assessment:
These dense blue oak woodland stands support a large number of wildlife species, although the higher tree density makes these areas undesirable for open grassland species. A few species such as Cooper's hawks and orange-crowned warblers, actually prefer the dense conditions found in these stands. The occurrence of more complex habitats, through the presence of habitat elements such riparian zones, snags, trees with cavities, and large woody debris, has an important effect on biodiversity. There are 19 amphibian species, 25 reptile species, 62 mammal species, and 102 bird species which are predicted to occur by CWHR on the most diverse habitats in these stands. If there are no riparian zones or sources of water, no snags or cavity trees, and no large woody debris or brush piles on the site, the number of vertebrate wildlife species predicted to occur on these habitats falls to 10 amphibian species, 23 reptiles, 28 mammals, and 77 bird species. This points to the importance of maintaining diversity in the habitat elements present in the stand to provide for the highest possible diversity of wildlife species. Some thinning may help enhance overall biological diversity.

Grazing Assessment:
Average forage production capability is 900 pounds per acre with a range from 500 to 1,500 pounds. The dense tree cover suppresses forage production, leaving less available for livestock operations. Thinning stands on slopes less than 30 percent will increase forage production under the removed canopy for about 15 years by 50 to 100 percent especially on poor sites. After tree thinning, seeding, fertilization, and grazing management may increase forage production. Little improvement potential exists on steeper slopes.

Site E: Valley oak woodland; 10 – 24 percent canopy cover

Oak Cover/Forestry Assessment:
Oak volume ranges from 40 to 340 cubic feet per acre. Growth ranges from 17 to 80 cubic over 10 years. The canopy in these open valley oak savannahs needs to be maintained. These areas are poor candidates for any harvest activity. Managers should encourage the recruitment of young seedlings to sapling size through management activities.

Recreation Assessment:
These areas offer only limited opportunities for hunt clubs in their current condition because of low shrub cover

and acorn production. Medium populations of quail can be expected, which can be improved by providing additional water and cover with brush piles. It may be desirable to increase cover, if feasible, to improve habitat for deer and turkeys.

Wildlife Diversity Assessment:
These open valley oak savannah stands contain both grassland and woodland wildlife species. In general, the habitat is good for open grassland and open woodland species such as western meadowlark, and marginal for woodland species such as Pacific-slope flycatcher. The presence of more complex habitats, through the presence of habitat elements such riparian zones, snags, trees with cavities, and large woody debris, has an important effect on biodiversity. There are 19 amphibian species, 32 reptile species, 72 mammal species, and 132 bird species which are predicted to occur by CWHR on the most diverse habitats in these stands. If there are no riparian zones or sources of water, no snags or cavity trees, and no large woody debris or brush piles on the site, the number of vertebrate wildlife species predicted to occur on these habitats falls to 8 amphibian species, 30 reptiles, 38 mammals, and 99 bird species. This points to the importance of maintaining diversity in the habitat elements present in the stand to provide for the highest possible diversity of wildlife species.

Grazing Assessment:
Average forage production capability is 3,500 pounds per acre with a range from 2,000 to 5,000 pounds. In low rainfall areas, the presence of scattered trees has been found to increase overall range forage production. Thistles and other undesirable plants may occur under the tree canopy, although this is not typical. Potential for range improvement through seeding, fertilization, and grazing management may increase productivity where production is currently at the lower end of the scale and available soil and soil moisture is not limiting.

28 Site F: Valley oak woodland; 25 – 39 percent canopy cover

Oak Cover/Forestry Assessment:
Oak volume ranges from 340 to 1100 cubic feet per acre. Ten year growth ranges from 60 to 150 cubic feet per acre. Although these are not good areas for commercial harvesting, there is some potential for light thinning due to the relatively high productivity of valley oak stands. It may be desirable to utilize trees being lost to mortality if not needed to provide snags in the stand. Perhaps 40 to 170 cubic feet per acre could be harvested every 20 years on slopes less than 30 percent. The existing stocking level is good for diverse resource values, and managers should not take canopy density much lower. Attempts should be made to encourage recruitment of oak seedlings to sapling size through management practices. Rapid growth of seedlings is possible.

Recreation Assessment:
These areas have good overall habitat for mule and black-tailed deer, wild pigs and California quail. Habitat can be improved by enhancing acorn production, planting clover and other legumes, and maintaining these through proper livestock and deer management, and enhancing shrub cover. Any reductions in oak cover will also decrease habitat value for most commercial game species. Areas with slopes greater than 30 percent will have lower values for hunt clubs because of the difficult access.

Wildlife Diversity Assessment:
These valley oak woodland stands have both grassland and woodland wildlife species. In general, the habitat is fairly good for a large number of wildlife species. The occurrence of more complex habitats, through the presence of habitat elements such riparian zones, snags, trees with cavities, and large woody debris, has an important effect on biodiversity. There are 19 amphibian species, 30 reptile species, 71 mammal species, and 128 bird species which are predicted to occur by CWHR on the most diverse habitats in these stands. If there are no riparian zones or sources of water, no snags or cavity trees, and no large woody debris or brush piles on the site, the number of vertebrate wildlife species predicted to occur on these habitats falls to 8 amphibian species, 28 reptiles, 37 mammals, and 96 bird species. This points to the importance of maintaining diversity in the habitat elements present in the stand to provide for the highest possible diversity of wildlife species.

Grazing Assessment:
Average forage production capability is 3,000 pounds per acre with a range from 1,500 to 4,500 pounds. In low rainfall areas, the presence of scattered trees has been found to increase overall range forage production. However, thistles and other undesirable plants may occur under the tree canopy, although this is not typical. Potential for range improvement through seeding, fertilization, and grazing management may increase productivity where production is currently at the lower end of the scale and available soil and soil moisture is not limiting.

Site G: Valley oak woodland; 40 – 59 percent canopy cover

Oak Cover/Forestry Assessment:
Oak volume ranges from 1100 to 2900 cubic feet per acre. Ten year growth ranges from 120 to 420 cubic feet per acre. Some thinning on a sustainable basis is possible, especially in stands with large numbers of small trees to improve individual tree growth rate. There is some possibility to utilize harvested trees for solid wood products, such as white oak lumber or barrel staves. 170 to 680 cubic feet per acre could be harvested every 20 years on stands with less than 30 percent slope. It is important to ensure that adequate oak regeneration results after the harvest.

Recreation Assessment:
These areas are excellent for medium to large populations of mule and black-tailed deer, squirrel, wild pigs, wild turkeys, mourning dove, and band-tailed pigeons. On areas with less than 30 percent slope, the terrain is excellent for hunter access. Some careful tree thinning can complement game habitat. Where controlled fire can be used, it can help stimulate palatable shrub browse. Seeding clover and other legumes and maintaining these through grazing, as well as increasing shrub cover, will benefit deer, turkey and quail.

Wildlife Diversity Assessment:
These valley oak woodland stands support a large number of wildlife species. The tree density makes these areas less desirable for open grassland species such as western meadowlarks and western kingbirds, but very desirable for woodland species such as Pacific-slope flycatchers and orange-crowned warblers. The occurrence of more complex habitats, through the presence of habitat elements such riparian zones, snags, trees with cavities, and large woody debris, has an important effect on biodiversity. There are 17 amphibian species, 27 reptile species, 63 mammal species, and 123 bird species which are predicted to occur by CWHR on the most diverse habitats in these stands. If there are no riparian zones or sources of water, no snags or cavity trees, and no large woody debris or brush piles on the site, the number of vertebrate wildlife species predicted to occur on these habitats falls to 8 amphibian species, 25 reptiles, 29 mammals, and 93 bird species. This points to the importance of maintaining diversity in the habitat elements present in the stand to provide for the highest possible diversity of wildlife species.

Grazing Assessment:
Average forage production capability is 2,000 pounds per acre with a range from 1,000 to 2,800 pounds. On such sites, the shading effect of the canopy usually suppresses total production. Thistles and other undesirable plants may occur under the tree canopy, although this is not typical. Potential for range improvement on slopes less than 30 percent through seeding, fertilization, and grazing management may increase productivity by two- to three-fold where production is currently at the low end of the scale. Tree thinning will increase forage production under the removed canopy in the higher rainfall zones of the state (over 20 inches per year).

Site H: Valley oak woodland; 60 – 100 percent canopy cover

Oak Cover/Forestry Assessment:
Oak volume ranges from 2900 to 5100 cubic feet per acre. Estimated ten year growth rate ranges from 220 to 420 cubic feet per acre. Harvest could be carried out to increase individual tree diameter and crown growth rate on areas with less than 30 percent slope and high stem density and small diameter trees. This may help improve acorn production and create conditions favorable for seedling establishment. Seedlings are likely to be absent or very slow growing due to little sunlight reaching the ground. Harvest levels of 420 to 1700 cubic feet per acre can be

carried out every 20 years. There is some possibility to utilize harvested trees for solid wood products, such as white oak lumber or barrel staves. It is important to ensure that adequate oak regeneration results after the harvest.

Recreation Assessment:
These areas offer good opportunities for habitat for mule and black-tailed deer, western gray squirrel, wild pig, wild turkey, mourning dove, and band-tailed pigeons. On areas with over 30 percent slope, hunter access is too difficult for commercial operations. Thinning stands to 50 percent cover in a patchy pattern may enhance deer habitat if shrub cover is increased. Turkeys do best with a dense canopy, and California quail do best with somewhat less canopy.

Wildlife Diversity Assessment:
These dense valley oak woodland stands support a large number of wildlife species. The tree density makes these areas undesirable for open grassland species. A few species such as orange-crowned warblers and house wrens, actually prefer the dense conditions found in these stands. The occurrence of more complex habitats, through the presence of habitat elements such riparian zones, snags, trees with cavities, and large woody debris, has an important effect on biodiversity. There are 17 amphibian species, 24 reptile species, 61 mammal species, and 96 bird species which are predicted to occur by CWHR on the most diverse habitats in these stands. If there are no riparian zones or sources of water, no snags or cavity trees, and no large woody debris or brush piles on the site, the number of vertebrate wildlife species predicted to occur on these habitats falls to 8 amphibian species, 22 reptiles, 27 mammals, and 74 bird species. This points to the importance of maintaining diversity in the habitat elements present in the stand to provide for the highest possible diversity of wildlife species. Thinning may enhance biological diversity.

Grazing Assessment:
Average forage production capability is 1,200 pounds per acre with a range from 800 to 1,500 pounds. The dense tree cover suppresses forage production, leaving less available for livestock operations. Thinning stands on slopes less than 30 percent will increase forage production under the removed canopy for about 15 years by 50 to 100 percent at lower levels of current production. After tree thinning, improvement potential through seeding, fertilization, and grazing management may increase forage production. Little improvement potential exists on steeper slopes.

Site 1: Coastal oak woodland, montane hardwood; 10 – 24 percent canopy cover

Oak Cover/Forestry Assessment:
Oak volume ranges from 35 to 250 cubic feet per acre and growth ranges from 17 to 50 cubic feet every 10 years. These areas are not good locations for firewood harvests due to very open stocking. Regeneration concerns are not as pronounced in live oak stands due to rapid resprouting in most areas of the state.

Recreation Assessment:
These areas may offer only limited opportunities for hunt clubs in their current condition because of low tree cover. Medium populations of quail can be expected, which can be improved by providing additional water and cover with brush piles. It may be desirable to increase cover if feasible to improve habitat for mule and black-tailed deer and turkeys. The presence of sprouting live oaks allows greater latitude in quail management than deciduous oaks with similar cover.

Wildlife Diversity Assessment:
These open live oak savannah stands contain both grassland and woodland wildlife species. In general, the habitat is good for open grassland species such as western meadowlark and western kingbirds, and marginal for woodland species such as Pacific-slope flycatcher and western gray squirrels. The presence of more complex habitats, through the presence of habitat elements such riparian zones, snags, trees with cavities, and large woody debris, has an important effect on biodiversity. There are 18 amphibian species, 35 reptile species, 74 mammal species, and 135 bird species which are predicted to occur by CWHR on the most diverse habitats in these stands. If there are no riparian zones or sources of water, no snags or cavity trees, and no large woody debris or brush

piles on the site, the number of vertebrate wildlife species predicted to occur on these habitats falls to 7 amphibian species, 33 reptiles, 38 mammals, and 101 bird species. This points to the importance of maintaining diversity in the habitat elements present in the stand to provide for the highest possible diversity of wildlife species.

Grazing Assessment:
Average forage production capability is 2,700 pounds per acre with a range from 1,800 to 4,000 pounds. Oak canopy in these lightly stocked areas may enhance forage production in low rainfall areas or during drought years. These low canopy levels have only minimal impact on forage production in higher rainfall zones, although thistles and other undesirable plants may occasionally occur under the tree canopy. Potential for range improvement through seeding, fertilization, and grazing management may increase productivity where production is currently at the lower end of the scale and available soil and soil moisture is not limiting.

Site J: Coastal oak woodland, montane hardwood; 25 – 39 percent canopy cover

Oak Cover/Forestry Assessment:
Oak volume ranges from 250 to 850 cubic feet per acre, with a ten year growth of 50 to 100 cubic feet per acre. Rapid regrowth of stump sprouts and fairly high growth potential of live oaks would allow some commercial harvest to take place. Harvest levels of 85 to 250 cubic feet per acre every 20 years are possible on areas with less than 30 percent slope. It is important to ensure that regeneration from seedlings or stump sprouts is adequate to replace trees being harvested.

Recreation Assessment:
These areas provide good overall habitat for deer, wild pigs and California quail. Habitat can be improved by enhancing acorn production, planting clover and other legumes and maintaining these through proper livestock and deer management, and enhancing shrub cover. Some selective thinning of dense stands may improve habitat for some game species, although leaving some denser areas will maintain habitat values for species using denser cover. If brush is present, brush piles can considerably improve quail habitat. Areas with slopes greater than 30 percent will have lower values for hunt clubs because of the difficult access.

Wildlife Diversity Assessment:
These live oak woodland stands support both grassland and woodland wildlife species. In general, the habitat is fairly good for a large number of wildlife species. The occurrence of more complex habitats, through the presence of habitat elements such riparian zones, snags, trees with cavities, and large woody debris, has an important effect on biodiversity. There are 18 amphibian species, 34 reptile species, 74 mammal species, and 131 bird species which are predicted to occur by CWHR on the most diverse habitats in these stands. If there are no riparian zones or sources of water, no snags or cavity trees, and no large woody debris or brush piles on the site, the number of vertebrate wildlife species predicted to occur in these habitats falls to 7 amphibian species, 32 reptiles, 38 mammals, and 98 bird species. This points to the importance of maintaining diversity in the habitat elements present in the stand to provide for the highest possible diversity of wildlife species.

Grazing Assessment:
Average forage production capability is 2,500 pounds per acre with a range from 1,500 to 3,500 pounds. Tree cover will cause some suppression of winter and spring production except in areas of low rainfall. Thistles and other undesirable plants may sometimes occur under the tree canopy. Potential for range improvement on slopes less than 30 percent through seeding, fertilization, and grazing management may increase productivity by two- to three- fold where production is currently at the low end of the scale. Tree thinning may increase forage production under the removed canopy in the higher rainfall zones of the state (over 20 inches per year).

Site K: Coastal oak woodland, montane hardwood; 40 – 59 percent canopy cover

Oak Cover/Forestry Assessment:
Oak volume ranges from 850 to 2200 cubic feet per acre. Growth rates of 100 to 190 cubic feet per acre are expected every 10 years. These stands are excellent candidates for sustainable wood harvest operation if slopes are

less than 30 percent. There is some potential for utilization of trees for sawtimber in larger straight-stemmed trees. Harvest levels of 170 to 510 cubic feet per acre every 20 years are possible. It is important to ensure that regeneration from seedlings or stump sprouts are adequate to replace trees being harvested.

Recreation Assessment:
These areas are excellent for quail and moderately good for deer, wild pigs, wild turkeys, and band-tailed pigeons. On areas with less than 30 percent slope, the terrain is excellent for hunter access. Some careful tree thinning can complement game habitat, although some dense areas should be left for cover and breeding purposes. If brush is absent, brushpiles can improve quail habitat considerably. If possible, prescribed burning can stimulate shrub layer browse. Seeding clover and other legumes and maintaining it through grazing, and enhancing shrub cover will benefit deer, turkey and quail.

Wildlife Diversity Assessment:
These live oak woodland stands support a large number of wildlife species. The tree density makes these areas less desirable for open grassland species such as western meadowlarks and western kingbirds, but very desirable for woodland species such as Pacific-slope flycatchers and orange-crowned warblers. The occurrence of more complex habitats, through the presence of habitat elements such riparian zones, snags, trees with cavities, and large woody debris, has an important effect on biodiversity. There are 16 amphibian species, 30 reptile species, 66 mammal species, and 126 bird species which are predicted to occur by CWHR on the most diverse habitats in these stands. If there are no riparian zones or sources of water, no snags or cavity trees, and no large woody debris or brush piles on the site, the number of vertebrate wildlife species predicted to occur in these habitats falls to 7 amphibian species, 28 reptiles, 30 mammals, and 95 bird species. This points to the importance of maintaining diversity in the habitat elements present in the stand to provide for the highest possible diversity of wildlife species.

Grazing Assessment:

Average forage production is 2,000 pounds per acre, ranging from 1,000 pounds to 2,800 pounds. Forage production is usually suppressed by tree canopy except in low rainfall zones. Thinning may increase forage under some removed canopies by 100 to 200 percent. Brush understory may occur in some locations and is suitable for management burns. Potential for range improvement through seeding, fertilization, and grazing management may increase productivity where production is currently at the lower end of the scale and available soil and soil moisture is not limiting.

Site L: Coastal oak woodland, montane hardwood; 60 – 100 percent canopy cover

Oak Cover/Forestry Assessment:
Oak volume ranges from 2200 to 5100 cubic feet per acre. Growth ranges from 190 to 310 cubic feet every 10 years. These very dense stands could benefit from thinning to improve overall biological diversity, acorn production, and forage yields. Restrict harvest to areas with less than 30 percent slope. Harvest levels of 510 to 1700 cubic feet per acre can be carried out every 20 years. There is some potential to utilize larger diameter logs for sawtimber, especially if boles have few branches. It is important to ensure that regeneration from seedlings or stump sprouts are adequate to replace trees being harvested.

Recreation Assessment:
These areas offer good opportunities for habitat for deer, western gray squirrel, wild pig, wild turkey, mourning dove, and band-tailed pigeons. On areas with over 30 percent slope, hunter access is too difficult for commercial operations. Thinning stands back to 50 percent cover in a patchy pattern may enhance deer habitat if shrub and herbaceous cover are improved. Turkeys do best with a dense canopy, and California quail do best with somewhat less canopy, but both prefer moderately dense shrub layers.

Wildlife Diversity Assessment:
These dense live oak woodland stands support a large number of wildlife species. The tree density makes these areas undesirable for open grassland species. A few species such as orange-crowned warblers, actually prefer the dense conditions found in these stands. The occurrence of more complex habitats, through the presence of habitat

elements such riparian zones, snags, trees with cavities, and large woody debris, has an important effect on biodiversity. There are 16 amphibian species, 26 reptile species, 64 mammal species, and 99 bird species which are predicted to occur by CWHR on the most diverse habitats in these stands. If there are no riparian zones or sources of water, no snags or cavity trees, and no large woody debris or brush piles on the site, the number of vertebrate wildlife species predicted to occur in these habitats falls to 7 amphibian species, 24 reptiles, 28 mammals, and 76 bird species. This points to the importance of maintaining diversity in the habitat elements present in the stand to provide for the highest possible diversity of wildlife species. Some thinning may help enhance overall biological diversity.

Grazing Assessment:
Average forage production capability is 900 pounds per acre with a range from 500 to 1,500 pounds. The dense tree cover suppresses forage production, leaving less available for livestock operations. Thinning stands on slopes less than 30 percent will increase forage production under the removed canopy for about 15 years by 50 to 100 percent at lower levels of current production. After tree thinning, improvement potential through seeding, fertilization, and grazing management may also increase forage production. Little improvement potential exists on steeper slopes.

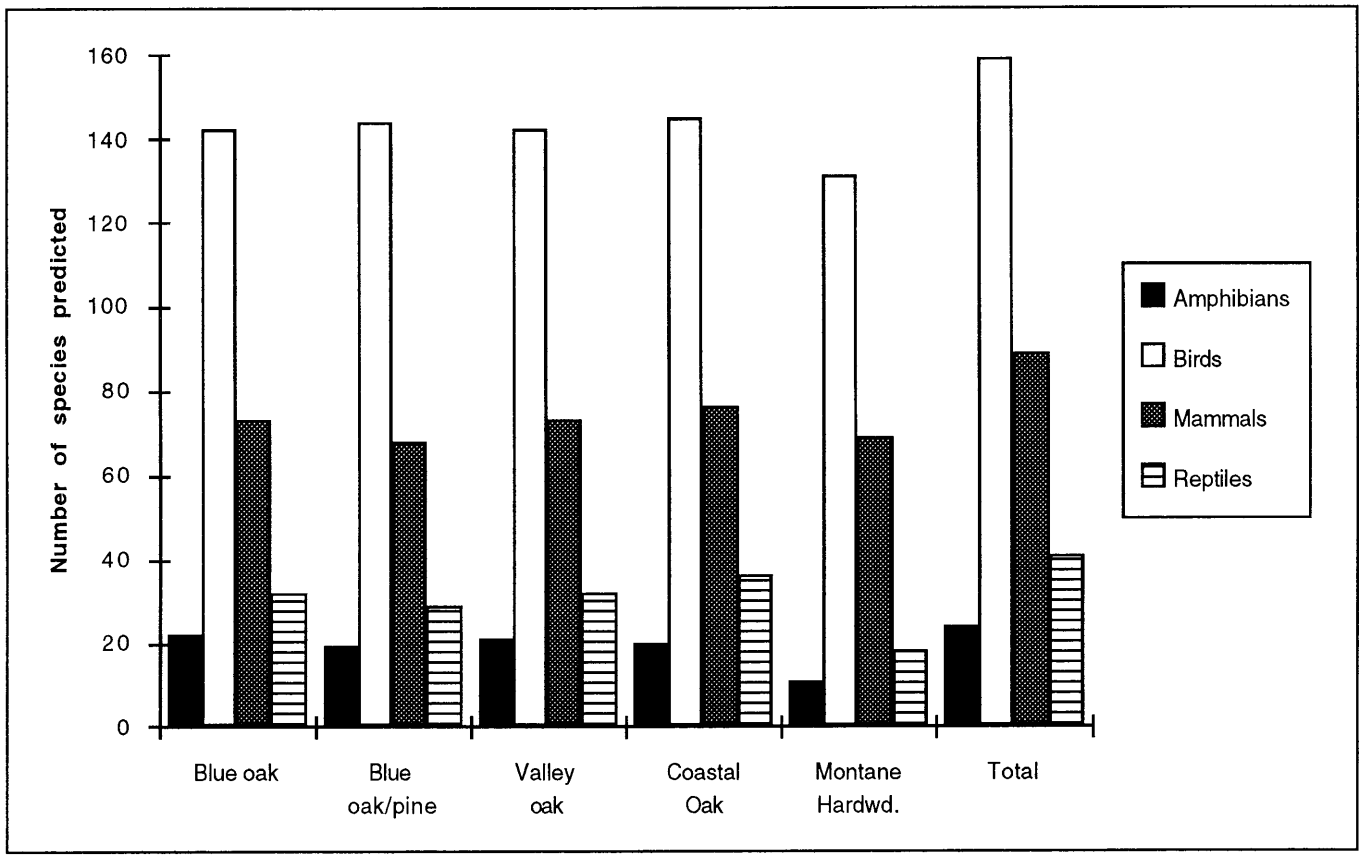
Chapter Four

Oak Woodland Wildlife Ecology, Native Plants, and Habitat Relationships

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The five habitat types occurring in California's hardwood rangelands (also known as oak woodlands) provide habitat for at least 313 species of birds, mammals, reptiles, and amphibians; more than 2000 plant species; and an estimated 5000 species of insects. Figure 4-1 graphically shows the diversity of vertebrate wildlife species predicted for each of the five major habitat types described in chapter 2. A complete list of all 313 species and their habitat associations is given in Appendix A. The management and long-term sustainability of California's hardwood rangeland habitats will best be served if ecological components and their inter-relationships are recognized and addressed by owners and managers. This chapter provides information on oak woodland ecology

Figure 4-1. Numbers of amphibians, birds, mammals, and reptiles predicted to occur in the five California hardwood rangeland habitats by Version 5.0 of the California Wildlife Habitat Relationships System (CWHR). This list only includes those species in the CWHR System that are predicted to use one or more tree size and canopy cover classes for breeding, feeding, and/or cover.



and wildlife-habitat relationships to serve as a guide for land management activities. The presence and sustainability of specific plant and animal species on hardwood rangeland properties needs to be evaluated with scientific information.

Wildlife Habitat Relationships

Habitats are the specific locations where the factors needed for wildlife survival and reproduction are provided. Successful long-term perpetuation of California's hardwood rangeland wildlife is best achieved by managing habitats because they are the foundation on which wildlife depend. California's five major hardwood rangeland vegetation types (see Chapter 2) and associated riparian types provide habitat for the largest number of vertebrate wildlife species in the state, when compared to habitats dominated by conifers, shrubs, grasses and wetlands. Hardwood rangeland habitats must be able to supply food, water, protection from weather and predators, and locations to reproduce in order to support viable wildlife populations.

In eastern Tehama County, deer use of the lower elevation blue oak and blue oak-foothill pine woodlands are an example of wildlife habitat relationships. These areas are important winter habitat with food and cover for deer that have migrated from higher elevation conifer and meadow habitats around Mount Lassen where they spend the spring and summer to produce fawns. Their autumn migrations take them through montane hardwood habitats where they feed on acorns and browse to gain weight for the strenuous rutting period where bucks (male deer) compete for breeding opportunities. Breeding takes place during the fall and early winter on the lower elevation oak woodlands. Does (female deer) feed on acorns and herbaceous vegetation of oak woodland wintering habitats to provide energy for fawning. These activities are critical and their populations would be dramatically reduced if hardwood habitats failed to provide these key breeding, food, and cover resources.

Habitat Scale Concepts

One way to understand the management complexities of hardwood rangelands is to look at the relationships among its component parts. Wildlife biologists typically evaluate woodland habitats on five levels, providing a convenient system for explaining woodland ecology. Although each level has its applications, it is critical for you to select the management level that is appropriate for your goals. From smallest to largest, these levels are:

1. *Individual*: The interactions of individual plants or animals with their surroundings is the most tangible level of woodland ecology. Survival and reproduction are results that you can observe from the interactions of individual plants or animals.
2. *Population*: The interactions among individuals of the same species and the interactions with their woodland environment form the population level of organization. A population is typically described by the shared characteristics of its individuals, including where they occur, the range of things they eat, when and how they produce young, and how they disperse or migrate. We use this composite picture to define the wildlife habitat relationships between a species and the areas where it occurs. Although this composite picture is somewhat abstract, population data allows biologists to predict the consequences of management activities in woodlands.
3. *Community*: The interactions among species that occur together in a community form the next step in the hierarchy. Species interactions define this level; some species prey on others, some compete with each other for resources, some share resources or recycle nutrients for one another, and some interact in hundreds of other ways. Examples include a deer browsing on oak seedlings, bees pollinating wildflowers, or jays planting acorns. Community interactions are often difficult to detect, and may occur over long time periods.
4. *Ecosystem*: The physical processes and structure that link living things to each other and their ecosystem is the next level of organization. Ecosystems are often defined by their resident or dominant species, such as the hardwood rangeland vegetation types discussed previously. This level of management is somewhat abstract, with boundaries that often blend into adjacent ecosystems.
5. *Landscape*: The geographic patterns of all the other levels creates the landscape level of organization. Some aspects of landscapes are quite tangible, such as the boundaries of a watershed. Others are abstract, such as the patterns of gene flow across the oaks in the coast ranges.

If you protect a 400-year-old oak in your backyard, then you are operating at the individual level of conservation. However, it is often impractical for landowners to manage their woodlands tree by tree. If your goal is to

maintain a specific density or age distribution of oak trees on your property, then you're working at the population level. If you control exotic plants to reduce their effect on oak seedling survival, then you're altering community level interactions among your understory plants. Altering fire frequency to re-establish oak understory would be an ecosystem level of action. Finally, fires burn many different patterns across a landscape, from small patches to catastrophic sweeps of multiple watersheds. Using prescribed burning to create a mosaic of burned and unburned habitats would be a landscape management action.

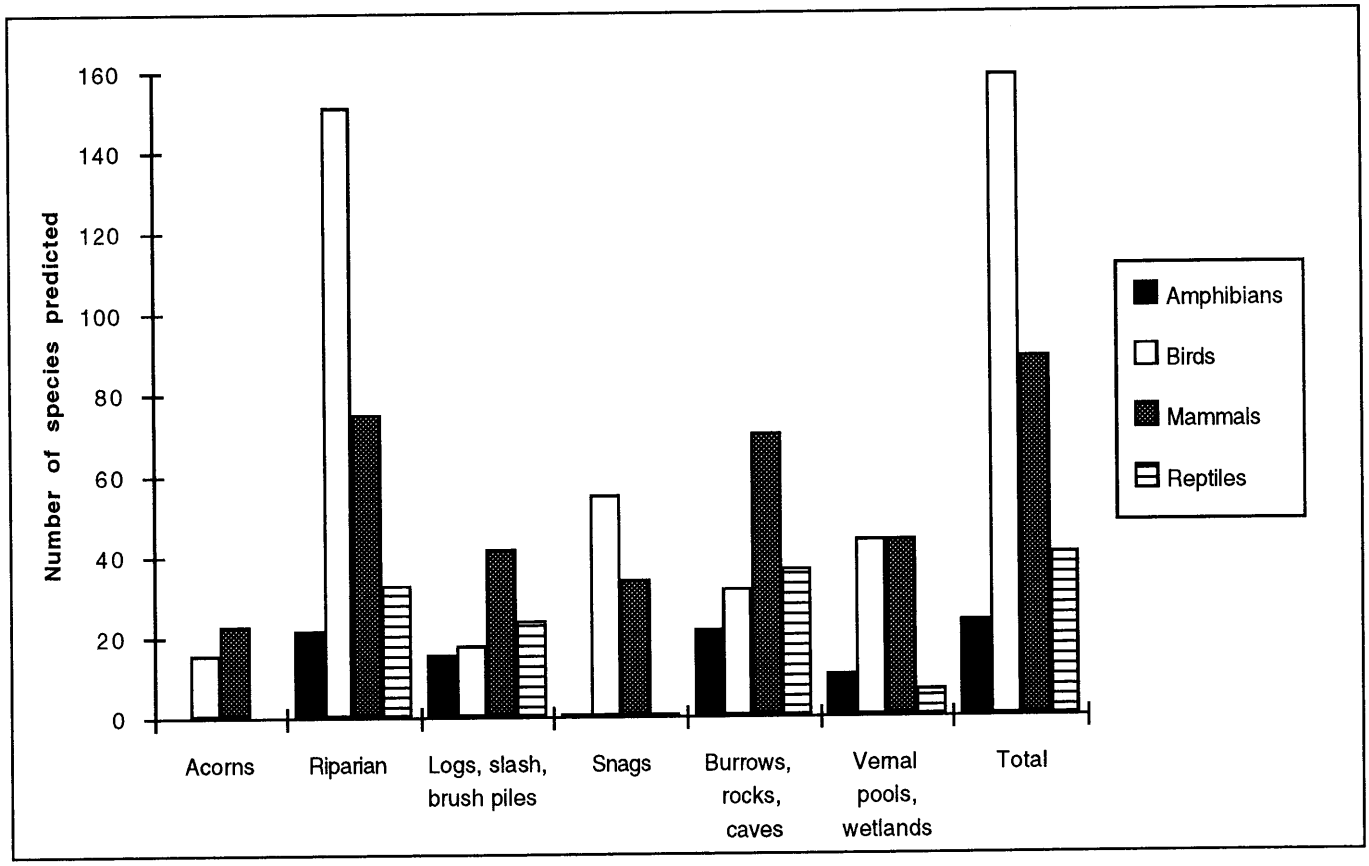
Habitat Structure

Favorable hardwood rangeland habitats supply food, water, and cover to sustain wildlife species. Each habitat element provides unique niches, favoring particular wildlife species. Conversely, the absence of a particular element in a habitat may limit species diversity.

Examples of elements of a hardwood rangeland habitat that are important to consider include riparian zones, vernal pools, wetlands, dead and downed logs and other woody debris, brush piles, snags, rock outcroppings, and cliffs. Figure 4-2 gives the relative number of wildlife species that are predicted to use various elements found on hardwood rangelands. The complete species list in Appendix A shows the specific species that are predicted to use these elements on hardwood rangeland habitats.

Riparian areas are those habitats influenced by the presence of adjacent seasonal or yearlong watercourses. They tend to have a higher biomass level of vegetation due to better water availability throughout the growing season. In general, they have higher tree crown cover, a more diverse assortment of vegetation species, and herbaceous material that stays green later into the summer. As shown, riparian habitat elements are used by almost 90 percent of all hardwood rangeland wildlife species, illustrating the importance of conserving this habitat element where present.

Figure 4-2. Number of amphibians, birds, mammals, and reptiles predicted to use several important habitat elements of California hardwood rangeland habitats by Version 5.0 of the California Wildlife Habitat Relationships System (CWHR). This list includes those species in the CWHR System that are predicted to use one or more of these elements for breeding, feeding, and/or cover.



Over one-third of all bird species on hardwood rangelands make use of snags, or standing dead trees in the stand. This suggests that management strategies to maintain an appropriate number of snags will result in greater wildlife species diversity.

Another important aspect of hardwood rangeland habitat structure is the spatial arrangement of the vegetative cover. The vertical and horizontal distribution of vegetation are both readily visible and easily measured.

Vertical Distribution

Vegetation often occurs in layers from grasses, to shrubs, to trees. This vertical layering affects the duration and intensity of light reaching the ground, which in turn, affects the insects, plants and subsequently those vertebrates dependent on them. Multi-layered habitats provide a diversity of elements offering more niches for wildlife. Most hardwood rangeland species, including California quail, western fence lizards, rufous-sided towhee and acorn woodpeckers, depend on multi-layered vegetation structure. Land managers should consider the consequences of activities that tend to simplify or eliminate vegetation layers.

Horizontal Distribution.

The distribution of different types of habitat or successional stages across a landscape creates diversity in all habitat elements needed for breeding, food and cover. Considering horizontal distribution is important for species that rely on large blocks of land, such as black-tailed deer, mountain lions, and red-tailed hawks.

Alteration of the horizontal distribution of habitats across large landscapes from fire, weather, residential development, rangeland conversion, or oak harvesting, can result in smaller, fragmented habitat patches. Small, isolated patches can eventually become *islands* of habitat that have a similar biological function to oceanic islands. The movement of populations of species isolated on these islands are restricted, so these populations are more susceptible to local extinction than populations which have free access to larger habitat patches. Less mobile species, such as many amphibians, have greater risks of local extinctions than those with greater mobility, such as bird species.

Maintenance of free interaction between reproducing adults is key to the survival of any wildlife species. Connecting patches of habitat through habitat *linkages* or *corridors* improves the interaction of breeding individuals between otherwise isolated populations. These linkages reduce predation and minimize impacts of harsh environmental conditions. Riparian areas often serve as linkages to hardwood rangeland habitats.

Resources Change Through Time

Important wildlife habitat attributes from oaks such as acorn-producing trees, snags, logs, and large and/or dead branches require considerable amounts of time to develop, even though they may persist for decades once they develop these characteristics. Land use practices that remove these attributes without allowing replacement will negatively alter the wildlife community. For example, it may take almost a century for most oaks to grow from acorn-produced seedlings to mature trees capable of producing abundant acorn crops. Oaks must be mature and several centuries old before they are large enough to have large diameter branches. Also, dead branches often result from heart rot which typically affects older, less healthy trees that are more susceptible to decay agents. An oak tree typically must live its entire life of several centuries before it dies and becomes a snag. Once developed, snags persist for many decades before they fall down and become logs. Logs will persist for many decades until they decay and become part of the soil. Furthermore, individual trees may produce more acorns, have more large branches, and make larger snags and logs than other trees. Therefore, trees with these desirable characteristics should be identified and retained so that wildlife communities will benefit. For example, observing acorn production of individual trees for two or three years over several weather cycles should allow most landowners to identify trees that produce large acorn crops relative to other trees on their lands (see chapter 9).

Habitat Use

The functional relationships among plants, animals and their physical environments are the foundation of ecosystems. Most wildlife species can use a variety of habitat types. The deer mouse is an example of a habitat generalist. It is thought to be the most widely distributed and abundant mammal in North America, and occurs in virtually every terrestrial vegetation type. Deer mice feed on a wide variety of plant and animal materials. They store food for use during periods of shortages, and build nests in almost any form of confined cover, such as rocks, leaves, or logs. The deer mouse can get its water from free water sources, dew, or from its food.

However, some wildlife species are so specialized that they occur in a relatively small number of habitats. The acorn woodpecker is an example of a habitat specialist. Although it has a widespread distribution, its habitat use

patterns are relatively restricted, coinciding with acorn-producing tree and shrub oaks in oak and oak-pine forests and woodlands.

Every wildlife community consists of both habitat generalists and specialists. Habitat generalists are more tolerant of a variety of land use practices than the habitat specialists. The challenge to any manager or landowner is to ensure that habitat needs are provided for all members of the wildlife community. This can be achieved by designing land use activities that ensure the continued presence of habitats and habitat elements needed by all members of the wildlife community.

For example, consider a large tract with a mosaic of oak woodlands, brush patches, riparian areas, savannas, pastures and grasslands. Cyclic, seasonal vegetation changes provide a diversity of food resources, including forbs, insects, fruits, and seeds, including acorns, that allow species with differing foraging strategies to co-exist. Birds that frequent oak woodlands throughout the year, both resident and migratory species, will partition these resources to minimize competition for them. If the necessary habitat elements are present, herbivores (plant eaters), insectivores (insect eaters), carnivores (meat eaters), omnivores (plant and meat eaters) and even highly specialized piscivores (fish eaters) can co-exist on this tract because of the way each group selects its food.

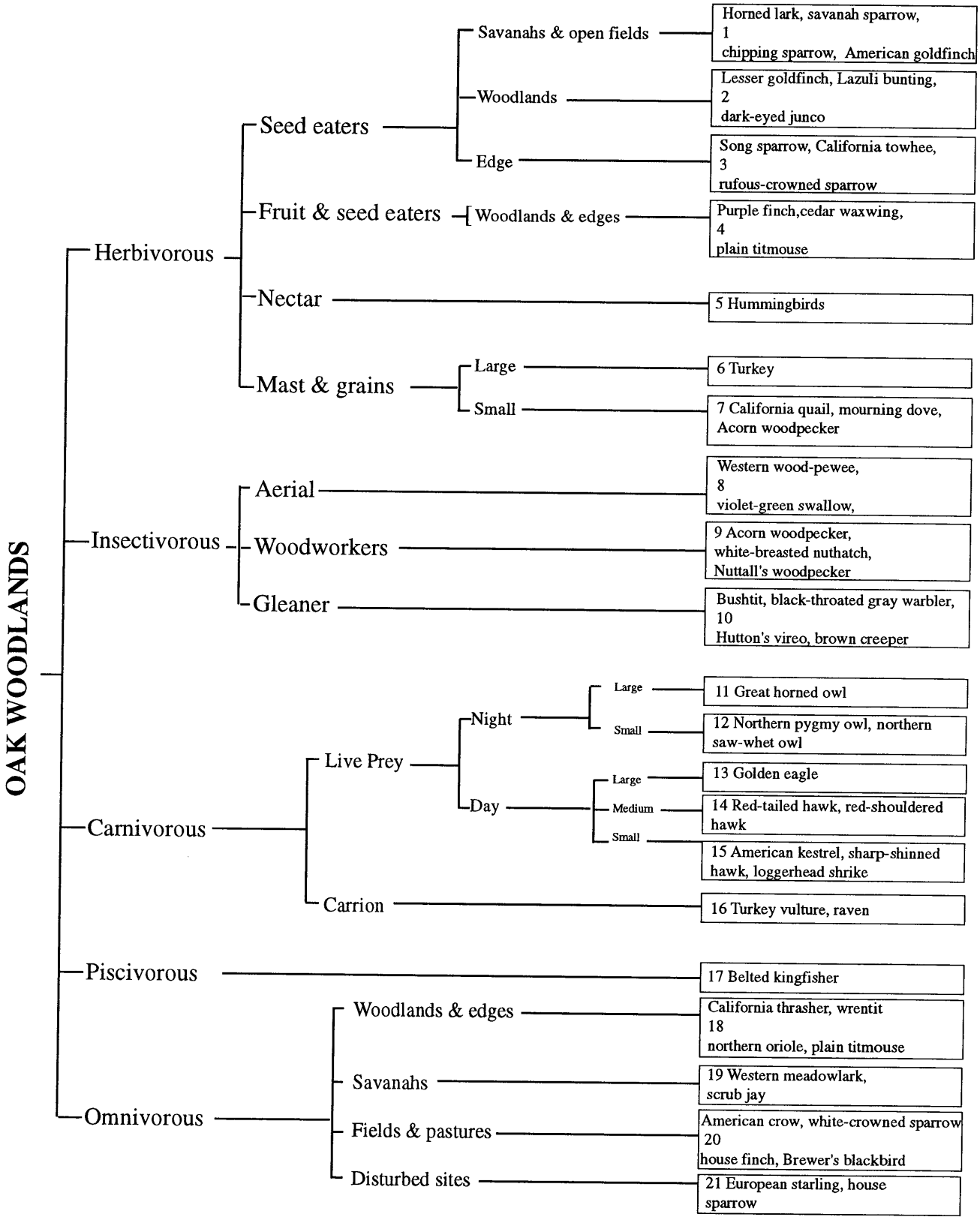
Species grouped according to a particular habit are referred to as a *guild*. (see Figure 4-3). For example, herbivorous species that eat seeds and are restricted to habitat edges are in a single guild. This includes song sparrows, California towhees, and rufous-crowned sparrows. If the necessary food and habitat elements are removed from an area, all species associated with this guild will also be removed. Similarly, insectivorous species that forage on wood would be negatively impacted if all standing and dead trees were removed from the site. Pileated woodpeckers, white-breasted nuthatches, and hairy woodpeckers are examples of species in this guild.

Wildlife use habitats at two broad levels usually defined as *macro* and *micro* levels. Management activities must consider both levels to sustain the biological integrity of hardwood rangeland habitats. The *macro*-level consists of all the habitats and their inter-relationships. *Macro*-level characteristics include habitat patch size and shape, edges with other habitats, and adjacent habitats. *Macro*-level features are used over a wide area during a time period that ranges from several weeks to several years.

Micro-level habitat characteristics are more focused on the individual features of the plants and the physical environment within an individual stand of trees. These features include species of plants, snags, rocks, water, acorns and other food items, tree size, and amount of vegetation cover. *Micro*-level elements are items an individual wildlife species uses throughout their daily and yearly cycles for breeding, feeding, and cover.



Fig. 4-3. An example of resource partitioning based on food habits of some land-dwelling birds that are commonly found in oak woodlands throughout California.



Wildlife respond to many different environmental characteristics when they select habitats to use. The three primary characteristics known to be important to many wildlife are: 1) habitat structure (e.g., size, height, amount of vegetation cover); 2) vegetation species composition; and 3) presence of *micro*-habitat elements.

Acorn woodpeckers are a good example illustrating the selection for the three broad habitat characteristics: structure, composition, and elements. They are found almost exclusively in open canopied, tree-sized habitats with substantial numbers of oaks, demonstrating selectivity in the structure and composition of their habitat. Their selection of habitats dominated by tree-sized oaks to provide live trees and snags large enough for granaries and nest cavities, demonstrates habitat selection on the basis of micro-habitat element characteristics. All three characteristics are inter-related to varying degrees, and the overall importance of a particular characteristic varies by season and geographic location.

Studies have also demonstrated the importance of habitat characteristics in California's hardwood habitats to other species. The importance of blue oak woodlands to wintering deer in Tehama County were discussed earlier in this chapter. Black bears showed greater use of habitats dominated by canyon live oak in the San Bernardino Mountains in spring, summer, and fall because these habitats provide cool environments, sufficient water, and low levels of human activity.

Wildlife habitat use changes over time and across landscapes. The migratory and wintering habitat use patterns of deer previously discussed is a good example. Black-tailed deer along the Coast Ranges are year-round residents and do not have pronounced migratory patterns. Yet, these resident deer use many habitats throughout the year, relying on oak-dominated habitats when acorns are available.

Golden eagles display fairly pronounced locational habitat use patterns. In hardwood rangelands, their nesting habitat includes area with large diameter, tall foothill pines with large branches, or tall cliffs with ledges for nests. Therefore, their nesting habitats are typically blue oak woodlands, blue oak-foothill pine woodlands, shrublands, or other habitats located in canyons or along cliffs. However, they feed in grasslands and open oak-dominated woodlands with sufficient populations of prey such as California ground squirrels, black-tailed hares, other medium-sized mammals, and ground-dwelling birds. These different nesting and feeding habitats must occur together over a large area in order to support a pair of nesting golden eagles.

Native Plants within Oak Woodlands

Oak woodlands are a diverse and dynamic ecosystem in California. In fact, for many people, oaks are a symbol of this State. Within oak woodlands, the several species of oak are the most striking plants present. But they represent only a small portion of the plant diversity which occurs in oak woodlands. As stated above, over 2,000 species of California native plants occur in oak woodlands. The scope of this book does not allow for detailed description of the many native plants of oak woodlands. For the more common plants associated with oak woodlands, refer to Appendix C. This section provides information on fundamental habitat relationships of plants that are considered to be sensitive to land use practices in oak woodlands. These species are a small, but special portion of those 2,000+ plant species that coexist with oaks.

Sensitive Plants

There are 130 known sensitive plant species that occur in oak woodlands. Sensitive is defined as plant species that are considered rare, threatened, or endangered within California, whether or not they are state or federally listed.Many of these plants are naturally rare because unique biological needs limit their distribution. Others may have been affected by human activities such that they have become rare, threatened, or endangered within California. Appendix B lists 130 sensitive plant species and their known oak habitat relationships. If a particular oak habitat exists on your property, you may have a particular sensitive plant species depending on the plants' distribution and special habitat relationships (see *Investigating the Occurrence of Sensitive Plants*)

Different Designations of Sensitive Plants

Appendix B designates sensitive species in three categories: federally listed, state listed, and California Native Plant Society (CNPS) categories 1B and 2. Eight oak woodland plant species are federally listed as threatened or endangered, while the State of California has listed 42 as rare, threatened, or endangered. The federal Endangered Species Act establishes protection for federally listed species. Plants state-listed as rare, threatened, or endangered are protected under the Native Plant Protection Act or the California Endangered Species Act. CNPS maintains an inventory that evaluates native plants on their rarity, endangerment, and distribution. This chapter lists only two of their five categories: 1B and 2. Category '1B' is defined as *rare or endangered in California and elsewhere*, while

category '2' is defined as *rare and endangered in California; more common elsewhere.* For a more thorough list of sensitive plant species and a detailed explanation of CNPS's inventory system, you may refer to the electronic or printed California Native Plant Society's INVENTORY of Rare and Endangered Vascular Plants of California (5th. Edition). You may also wish to attain a copy the California Department of Fish and Game's (CDFG) *Special Plants List.*

Investigating the Occurrence of Sensitive Plants

As stated above, the list of plants in Appendix B does not reveal whether a particular plant species does occur on your land. The table does inform you if a particular plant has been found in a particular oak habitat(s). Additionally, the table lists unique ecological characteristics of each plant species. This information is a starting point for you to determine the possibility of one or more rare plants being found on your land. In many cases, the type, periodicity, and intensity of the land use determines whether rare, native plants exist, just as is the case for wildlife.

When determining what plants occur on your land, surveying your land for all plants (*floristic* survey) allows you gain detailed knowledge about the occurrence, distribution, and abundance of all plants, whether they be oaks, common trees, shrubs, grasses, and herbs, or sensitive species. In some cases, plant survey information may already exist for your property. In addition, there are other sources of useful information. These sources would be the local university or college, the regional resource conservation district, individuals or firms involved in biological consulting, your regional CDFG Plant Ecologist or District Biologist, and CDFG's Natural Diversity Database (NDDB). NDDB maintains location information for sensitive plants, animals, and natural communities for all of California. Regional CDFG staff have access to NDDB information, and you may contact NDDB directly if you wish to investigate what is already known about sensitive plants in your area. However, if the NDDB does not include any known records of sensitive plants on your property, this is no guarantee that sensitive plants do or do not occur there. Only plant surveys can determine that.

Management of Lands for Sensitive Native Plants

In a nutshell, there is no recipe for maintaining an area's native flora. For certain species with certain needs, avoidance or minimum activity for a period of time may be crucial (i.e., removing cattle while plants are flowering and setting seed). On the other hand, management for native plants might involve a certain activity for a particular period of time (i.e., prescribed burning to allow seeds to sprout; maintaining grazing so to reduce exotic grasses which in turn allows native species to exist, etc.). Each sensitive plant has specific needs, and it is best to consult with your local botanists, field biologists, and other plant and vegetation experts when deciding on land management activities to meet your needs and the needs of the sensitive plants that may exist on your land.

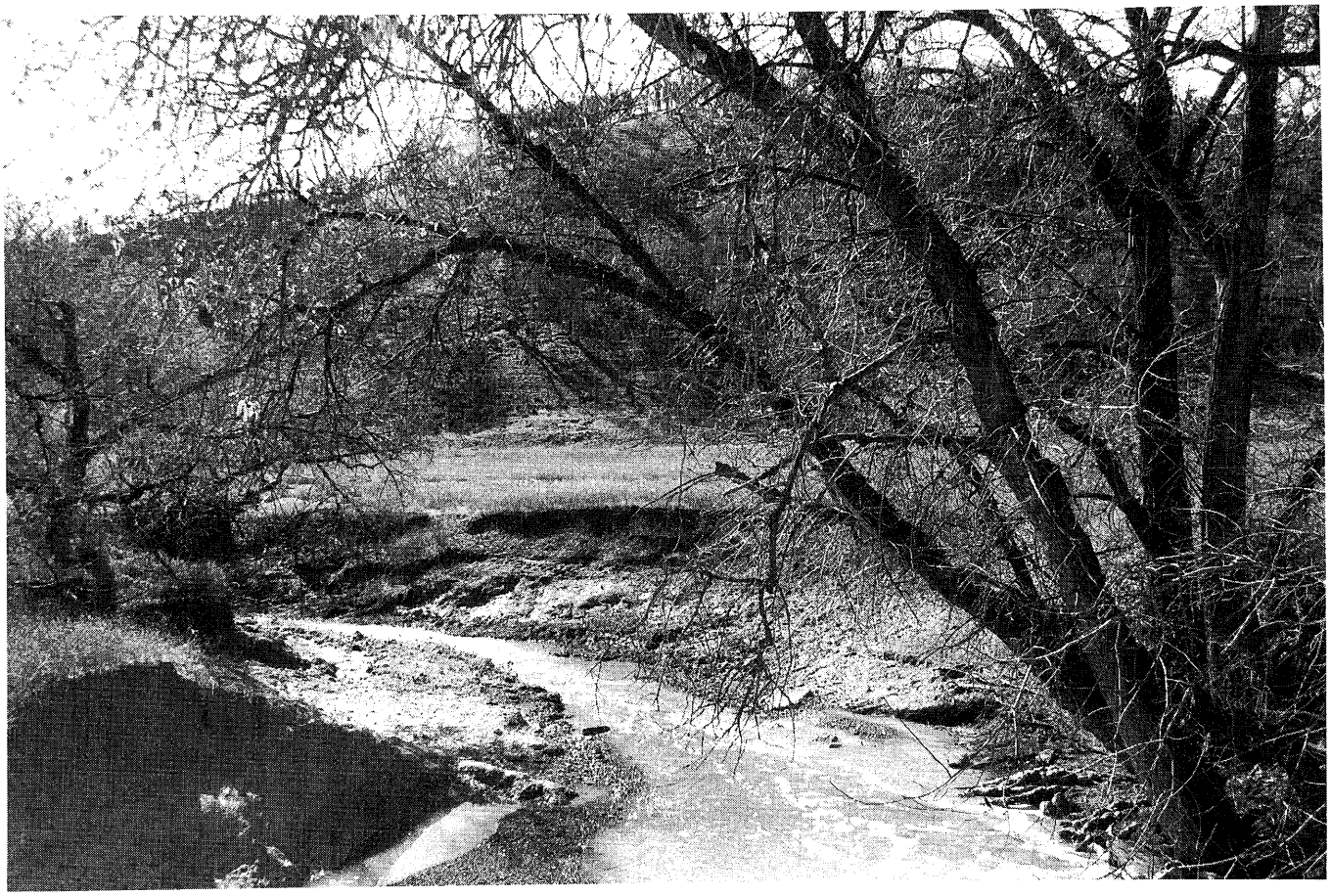
A Worksheet for Evaluating Woodland Habitat Impacts

There are many ways landowners can manage their oak woodlands for wildlife or to maintain native plants. One can choose to manage on the basis of vegetation composition, percent canopy cover, or even a single wildlife species such as deer. Yet, when assessing various management enterprises, land managers should consider a broad scale approach to management. This *system-wide* management approach considers both ecological and economic effects prior to implementing a management plan. This is really just a new way of saying *"don't put all of your eggs in one basket".*

When evaluating the impacts of various management actions, there are often unforeseen consequences. It is easy to recognize the consequences of harvesting individual oaks (e.g., they become firewood), but more difficult to recognize the potential consequences at the population (e.g. loss of acorn producers), community (loss of bird nesting locations), ecosystem (increased light to forage plants), and landscape (increased edge with grasslands or loss of habitat linkages) levels. Worksheet 4-1 is provided to help assess these broader effects by examining the resources present in the area proposed for management and the anticipated changes of the proposed enterprise to the woodland ecosystem. It is suggested that you work through this process for any enterprise you are considering, to allow you to assess the concepts presented in this chapter.

This worksheet is designed to help assess the impact of the proposed hardwood rangeland enterprise on a particular habitat element. In column one of the worksheet, you should assess the particular habitat element in the area proposed for a particular enterprise. Column two is used to describe how significant that element in the enterprise area is in relationship to the broad region or landscape surrounding the enterprise area. Column three

is used to describe anticipated changes that are expected to occur as a result of the particular enterprise. Column four is used to list the anticipated regional impacts expected as a result of undertaking a specific enterprises. In order to undertake this exercise, you will need a map of your property and basic knowledge of its resources. It is best to have an aerial photograph of your land and the surrounding landscape, but you may use other estimates if a photograph is unavailable. The material you have developed from chapter 3 will help you get started. Instructions on the use of the worksheet and definitions of terms used will follow.



Worksheet 4-1: A checklist for evaluating woodland habitat elements and proposed enterprises.

Landscape Elements (fill out all that apply)	Description of Element in Proposed Area	Anticipated Changes From Proposed Activity	Expected Habitat Impacts
Total Area of Enterprise or Region			
Vegetation Types • oak woodlands • grasslands • shrublands • conifer forest • agriculture			
Patch Size and Linkage • description of woodland patch distribution • average patch size and range • Distance between patches • Linkage between patches			
Surrounding Land Use • Rural residential • Agricultural • Urban			

Ecosystem - Community Elements (fill out all that apply)	Description of Element in Proposed Enterprise Area	Anticipated Changes From Management Activity	Expected Regional Impacts
Vegetation Layers • herbaceous/grassland • only shrubs • canopy and herbaceous • canopy, shrubs, herbaceous • Mixture			
Tree Characteristics • snags • limbs/trunks size distribution • acorns			

Worksheet 4-1: A checklist for evaluating woodland habitat elements and proposed enterprises (cont.)

Ecosystem - Community Elements (cont.) (fill out all that apply)	Description of Element in Proposed Enterprise Area	Anticipated Changes From Management Activity	Expected Regional Impacts
Surface Water and Riparian Zones • Ponds • Rivers/Streams • Springs • Wetland Vegetation • Riparian Trees			
Dead Woody Material • stumps • logs • brushpiles			
Rock/substrates • cliffs • outcrops • boulders • caves			
Unique Habitats • rare soils • vernal pools • archaeological sites • others			
Fire • % Currently recovering • Years since last fire • Wildfire or controlled?			

Species Elements (fill out all that apply)	Description of Element in Proposed Enterprise Area	Anticipated Changes From Management Activity	Expected Regional Impacts
Endangered species.			
Habitat Specialists			

Instructions for the Worksheet:

General descriptions of the various categories included in the worksheet are shown below to help you fill out the worksheet for the situations you are interested in evaluating.

Description of element in proposed area (column one): This is the part of your property that will be altered by the enterprise you are considering (i.e., grazing, forest products, recreational development, conservation easements).

Anticipated changes column (column two): This helps compare how the habitat changes in the enterprise area will change general habitat conditions. This should help you create a context of the affect of your activities on the surrounding habitats and to understand the cumulative changes occurring in your region.

Potential change column (column three): List the impacts that are expected to occur as a result of the habitat changes described in columns one and two.

A description of the various habitat elements which may be affected by various enterprises is given below.

Landscape/Ecosystem Elements

Enterprise Acreage: The amount of woodland in your enterprise area defines the kinds of conservation decisions you must make. Large enterprise areas are more likely to alter landscape level habitat elements than smaller areas. The effect of small enterprises usually is incremental and cumulative, so it is best to create a long-term plan for your entire property as you develop each enterprise. You may want to compare notes with your neighbors to see what your region will ultimately look like before you design your enterprise.

Vegetation Types. Express the acreage or percent of the area in various vegetation types to help define the species diversity in your enterprise area.

Patch Size and Linkage — Woodland Distribution. Is the area composed of uniform woodland or divided into discrete patches? Will your enterprise increase or decrease this percentage of woodland in your enterprise area and what changes will occur as a result?

Patch Size and Linkage — Average Patch size. Describe the average and range of sizes (acres) of woodland patches in your enterprise area, as well as the average distance between patches.

Patch Size and Linkage — Habitat Linkages. The dispersal, migration, and movement of individuals are necessary to maintain populations and communities of woodland animals and plants. In the process of converting woodlands into other land uses, the ability of animals to move may be disrupted. Ultimately, natural linkages may be reduced to corridors, which become sensitive to disruption. Are your enterprise area and region still intact natural areas? What percent of the woodlands of each area are linked by multiple corridors, and what percent have only a single corridor? Are there woodlands with only one remaining corridor? Are some woodlands isolated without habitat linkages?

Surrounding Land Use: Calculating the percentage of rural, agricultural and urban areas will help to define the current level of habitat conversion. Urban areas should include houses, commercial buildings, and industrial sites; rural areas should include ranchettes, low density (>5 acre lots) housing, and parks; agricultural areas should include all cultivated crops, pastures, and golf courses. This information is available from your local planning agency.

Ecosystem/Community Elements

Vegetation Layers and Mixtures. Calculate the percent of your enterprise area covered with each vegetation layer and determine whether these layers occur together (integrated) or as discrete patches.

Tree Characteristics. Canopies provide a number of different habitat resources, ranging from insects on leaves to cavities for dens and nests. The size and age distributions of oaks in your woodlands provide key resources to the wildlife present. Snags are a special resource; their centers often rot away leaving cavities for many wildlife

species, and dead and dying branches provide additional cavity substrates. Acorns are important for many wildlife species.

Surface Water and Riparian Zones. Surface water sources increase woodland ecosystem diversity. Riparian areas (streams, creeks and rivers) are found throughout California in a number of oak woodland types. They provide essential habitat for large numbers of plant, vertebrate, and invertebrate species. Every stream influences its surrounding landscape, increasing plant productivity and species diversity in all habitats it flows through. Springs require special consideration because they may be the only water source for a large area, and many species may depend on them.

Dead Woody Material. As a tree ages over its lifetime, it drops branches and eventually collapses onto the ground. As the wood decomposes, it is used by many plants and animal species for nutrients and shelter. Shrubs also die over time, contributing brushpiles to the site.

Rock/substrates. Exposed rock creates a different type of substrate for plants and ground- dwelling species. Are cliffs or caves present in your enterprise area? Estimate the percent of your enterprise area covered with rock outcrops. Will your enterprise change any of these features?

Unique Habitats. Habitats such as vernal pools, limestone caves, serpentine outcrops, and springs result from unique combinations of soils, topography, and climate, and secondarily through biotic interactions. This uniqueness typically results in rarity.

Fire. Fire behavior has a profound affect on woodland habitats. Fires can create a mosaic pattern of vegetation, or may burn off entire regions. One way to calculate fire effects is to estimate the relative proportion of vegetation burned by the most recent fire on your land, and the years since the last fire. Finally you need to consider if fire suppression has left your enterprise area vulnerable to unnatural, catastrophic fires.

Species Elements

Many of the assessments for this section of the worksheet are quite involved, and require the assistance of professional resource managers. You can seek the assistance of California Department of Fish and Game, the Integrated Hardwood Range Management Program, or consulting resource managers to determine some of the information needed for these sections of the worksheet. The information in appendices A and B may help to get you started, as well as your general knowledge of the property.

Threatened and endangered species. You should determine if there are any plant or animal species that have been listed as threatened or endangered by the state or federal governments. Manipulation of habitats supporting these species typically require special permits from state and federal wildlife agencies. Some of these T&E species are naturally rare, while others have suffered widespread population declines. General locations and habitat information for these species are available from local Department of Fish and Game representatives. Appendix A and B give a listing of hardwood rangeland wildlife and plant species that have special status.

Habitat Specialists. List any wildlife species present that would be sensitive to habitat disruptions.

Response of Wildlife to Habitat Change

Once you have worked through this general assessment in the worksheet, the expected regional impacts of any changes in habitat should be evaluated. Consult with local resource management professionals to evaluate these possible impacts. Shown below are some general considerations to help you judge the various impacts.

Landscape Elements

Enterprise area: In general, decreasing woodland acreage creates a risk that the number of plant and animal species living there will decrease as well. Species present in your enterprise area are there in part because the woodland was large enough to support viable populations. Chance events such as droughts, catastrophic wildfires, or disease epidemics, can impact various species. The greatest risk is when small (<20 acre) regional woodlands are altered by large enterprises. Large mammals and raptors are especially sensitive, because these indi-

viduals require large tracts of woodland. Small, isolated woodlands may not be recolonized after a species is wiped out by chance events such as an epidemic. In contrast, if your enterprise area is 3 acres within a 10,000 acre woodland, then the change in your woodland is less likely to have a dramatic affect on species diversity.

Vegetation Types: Conversion from oak woodlands to shrubland or grasslands creates a change in the types of elements available for many species.

Patch Size and Linkage - Woodland Distribution: Fragmenting a large, contiguous woodland into smaller, isolated patches is likely to reduce the number of all woodland species. If your woodlands occur in isolated patches with low crown cover (i.e., 10% cover), where denser canopies previously existed, or in narrow, linear patterns, then they may already have a reduced number of woodland species and a greater number of species that prefer edges. Woodland species in general are more sensitive to landscape alterations than edge-oriented species.

Patch Size and Linkage - Average Patch size and Distance between Patches: Patch size often decides the species diversity and composition. It is difficult to maintain viable breeding populations of many species in small (<25 acre) patches. Decreasing patch size will test the ability of many species to overcome chance events such as epidemics (see above). Increasing the distance between patches strongly influences which species will be able to move among patches and how often they will do it. Making these inter-patch areas inhospitable, with houses or other forms of disturbance, further decreases the likelihood of wildlife movement or plant dispersal.

Patch Size and Linkage - Habitat Linkages: If the area will leave habitat linkages in an area that was previously contiguous woodlands, then these linkages will filter species dispersal, reducing the linkages that occurred before alteration. Corridors should be as wide as possible. Narrow corridors (<100 ft.) are generally less effective than wider corridors. However, if your woodland is already down to narrow corridors, then it is probably already experiencing these filtering effects. At this point, corridor removal may further reduce dispersal, especially if linkages to larger more intact woodlands are cut.

Ecosystem/Community Elements

Vegetation Layers and Mixtures. Removing the tree or shrub layers of a woodland will reduce its use by medium sized mammals, such as the ringtail cat, and 10 to 50 species of woodland birds. A few bird and mammal species use exotic-grass/woodland habitat mix, such as European starlings, western bluebirds, and California ground squirrels, and may increase if the shrub understory is lost. Relatively few woodland vertebrates will remain if both shrub and canopy layers are removed. Reducing shrub or canopy layers increases the amount of sunlight reaching the woodland floor, which heats and dries soils used by herbaceous plants and amphibians. Increased light may benefit growth of the herbaceous layer. Decreased canopy and shrub layers also causes more rapid heat loss from the herbaceous layer, changing plant species composition. Since only a few plant species dominate the shrub layer of most woodlands, it is easier to restore vegetation structure than it is to restore species diversity and composition.

Tree Characteristics - snags: Removing large snags adversely affects arboreal salamanders (primary habitat), acorn woodpeckers (acorn storage), other birds (nesting and roosting), and bats (roost and nursery roosts). Removing small (<6 in) snags is less likely to affect these species, but will reduce the source of dead wood on the ground (see below).

Tree Characteristics - limbs/trunks size distribution: If all large diameter trunks and branches are removed, you will adversely affect Nuttall's woodpeckers and other birds that excavate nest cavities, as well as large-bodied birds which nest on these branches, such as red-tailed hawks. The populations of birds and mammals that forage on tree trunks, such as the white-breasted nuthatch and western gray squirrels, also will be reduced. Larger stems tend to have the best developed cavities and cracks for salamanders, lizards, birds, bats, and rodents.

Tree Characteristics - Acorns: Acorns are key diet items for almost 50 species of birds and mammals, particularly many game species (see Appendix A). Removing trees that produce good acorn crops will adversely affect these wildlife species.

Surface Water and Riparian Zones: Surface water availability has a dramatic effect on plant and animal species. Riparian plants are adapted to various levels of soil moisture and flooding, and changes to either the flow or level of water can kill them. In contrast, most oaks on hardwood rangelands are adapted to drought and have difficulty maintaining root functions if soils become flooded. Surface water is the primary breeding habitat for many amphibians, and alterations of riparian characteristics can dramatically decrease amphibian populations. It can also create problems for birds and mammals, since water for drinking is necessary for many of these species. While these species may be flexible about the source, they often require cover vegetation and are unlikely to use exposed water areas. Birds nesting in riparian woodlands often cannot successfully nest in other habitats. Altering riparian vegetation can alter the volume and seasonal availability of insects for insect-eating bats and birds. Furthermore, standing or moving water is habitat for fish, which are food for several wildlife species such as ospreys, bald eagles, and belted kingfishers.

Dead Woody Material: Wood on the ground in the form of logs and branches is consumed by a number of invertebrates and fungi. It is one of the major sources of nutrients and energy underneath oak canopies. Many wildlife species prey on wood consuming invertebrates, including many salamanders, rodents and birds. Brushpiles provide habitats for ground and low shrub nesting birds, such as the California quail and white-crowned and golden-crowned sparrow, and removal of these reduces habitat value for these and other wildlife species.

Cliffs/Rock Outcrops: Habitats in exposed rock outcrops and cliffs are seldom altered by hardwood range enterprises, except for quarry and mining operations. However, wildlife use of these special habitats can be lessened if fragile soils and rock crevices are disrupted by heavy human-activity. Trails built to boulder piles, outcrops, and cliff tops can increase human activity and lessen their use by nesting birds, such as golden eagles, red-tailed hawks, white-throated swifts, and bats. Furthermore, quarry and mining operations will disrupt these species.

Unique Habitats: Hardwood rangelands often have rare soils, such as the serpentine or limestone formations. Plants adapted to these soils often can grow nowhere else, and can be lost if these areas are disturbed. Fortunately, the conditions that lead to these rare soils are fairly well understood and it should relatively easy to identify their locations and to conduct your enterprise without damaging these plants. Vernal pools create another unique habitat. These pools form during winter rains and can be damaged by disking or other manipulations of their soils. Preliminary results indicate some vernal pools are dependent upon disturbance, such as grazing, to maintain fairy shrimp populations. Enterprises that require substantial activity in meadows may damage the sensitive plants and federally listed-invertebrates that live in vernal pools.

Fire: Decreasing fire frequency increases woody biomass accumulation, and increases likelihood of a catastrophic fire in the future. A fire plan, with a design for a mosaic pattern of burns often reduces the likelihood that a fire will consume all the habitats in your enterprise area.

Example of Using Worksheet

Table 4-1 shows the use of this checklist for a firewood harvesting enterprise on a hardwood rangeland property. It is hoped that this will provide a general thought process for landowners and managers as they attempt to assess the impacts of various resource management enterprises on habitat values. As you investigate the enterprises described in Chapters 5 through 8, you should work through this checklist. If you are unsure about the expected habitat impacts, you should consult with a representative of the California Department of Fish and Game, your UC Farm Advisor, or a consulting biologist.

Worksheet 4-1: A checklist for evaluating woodland habitat elements and proposed enterprises.

Landscape Elements (fill out all that apply)	Description of Element in Proposed Area	Anticipated Changes From Proposed Activity	Expected Habitat Impacts
Total Area of Enterprise or Region	*150 acres*	*remove 20% of the total volume for firewood harvest*	*(see below)*
Vegetation Types • oak woodlands • grasslands • shrublands • conifer forest • agriculture	*80%* *10%* *10%*	*75%* *15%* *10%*	*Little effect is anticipated; Slight increase in grassland type is in small openings within a general woodland matrix*
Patch Size and Linkage • description of woodland patch distribution • average patch size and range • Distance between patches • Linkage between patches	*fairly contiguous block of woodland* *150 acres* *Interconnected* *Large block*	*Small openings created* *2 to 100 acres* *Interconnected* *Matrix of woodland maintained*	*Good retention of landscape features; little impact expected*
Surrounding Land Use • Rural residential • Agricultural • Urban	*Grazing land*	*No change*	*No impacts expected*

Ecosystem - Community Elements (fill out all that apply)	Description of Element in Proposed Area	Anticipated Changes From Proposed Activity	Expected Habitat Impacts
Vegetation Layers • herbaceous/grassland • only shrubs • canopy and herbaceous • canopy, shrubs, herbaceous • Mixture	*Small grassland area* *Small shrub area* *Most woodland area*	*Small grassland area* *Small shrub area* *Most woodland area* *Slight increase in shrub component with canopy reduction*	*Little impact expected*
Tree Characteristics • snags • limbs/trunks size distribution • acorns	*Scattered snags* *Some large limbs, trees 4 to 20" DBH* *Several good acorn trees identified*	*Some reduction in snags* *Similar distribution remaining* *Good acorn trees retained*	*Reduction in cavity nesting species*

Worksheet 4-1: A checklist for evaluating woodland habitat elements and proposed enterprises (cont.)

Ecosystem - Community Elements (cont.) (fill out all that apply)	Description of Element in Proposed Area	Anticipated Changes From Proposed Activity	Expected Habitat Impacts
Surface Water and Riparian Zones • Ponds • Rivers/Streams • Springs • Wetland Vegetation • Riparian Trees	*Only perennial water source a small spring; also an intermittent stream* *Willows in riparian area*	*Buffers will be maintained around spring and riparian areas*	*No changes anticipated; integrity of water supply and structural components of riparian zone maintained*
Dead Woody Material • stumps • logs • brushpiles	*Very low levels of dead woody debris in area*	*Increase in stumps* *Increase in logs* *Increase in brushpiles*	*Improved habitat for reptiles and amphibians; brushpiles improve songbird and game bird habitat*
Rock/substrates • cliffs • outcrops • boulders • caves	*None*	*None*	*No effect*
Unique Habitats • rare soils • vernal pools • archaeological sites • others	*Brush area has serpentine soils*	*Brush area will be avoided by equipment*	*No impact expected*
Fire • % Currently recovering • Years since last fire • Wildfire or controlled?	*None, all mature* *Over 30 years* *Controlled burns*	*Previous owners had regular prescribed burning program, but no fires over past 30 years; brush piles and woody debris may increase probability of wildfire*	*Higher wildfire probability after firewood harvest may lead lead to mortality of mature trees, and lead to type conversion of oak woodland to grassland; may want to consider prescribed burning*

Species Elements (fill out all that apply)	Description of Element in Proposed Area	Anticipated Changes From Proposed Activity	Expected Habitat Impacts
Endangered species.	*Some endangered plants suspected to be present in serpentine area*	*Serpentine area will be avoided; need to positively determine of endangered plants present and ensure survival in future management activities*	*No immediate effects expected*

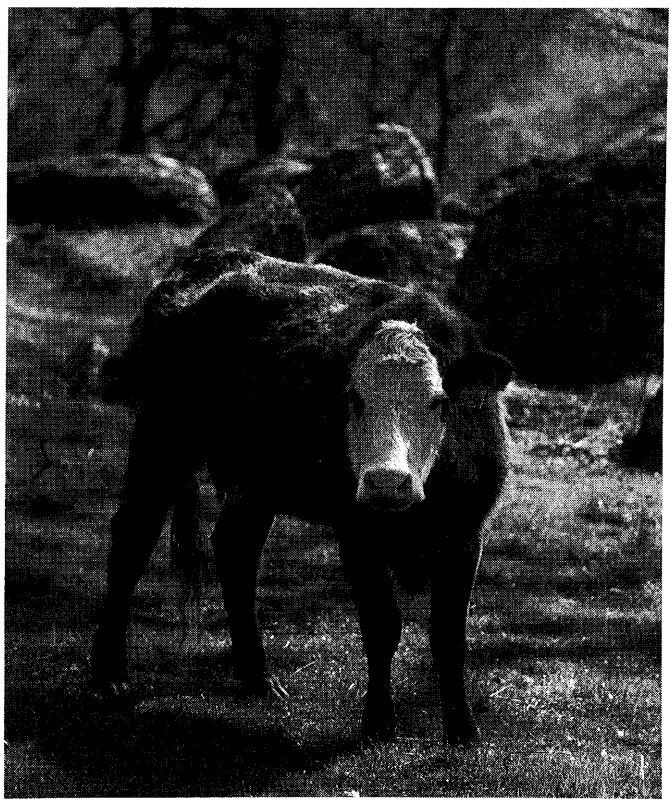
Chapter Five
Livestock and Grazing Management

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Livestock grazing is the dominant land use of California's hardwood rangelands. Livestock graze on approximately two-thirds of all hardwood rangelands in the state. These guidelines provide an overview of the livestock enterprise on hardwood rangelands. Livestock grazing is a complex topic that includes principles of agronomy, plant ecology, animal nutrition, and animal health. The main thrust of this chapter is on cattle production, the dominant livestock product on hardwood rangelands. For information on sheep and other livestock enterprises, as well as related information on the range livestock operation, refer to the reference section in the Appendix, or contact your local Cooperative Extension Farm Advisor

Annual Forage Productivity on Hardwood Rangelands

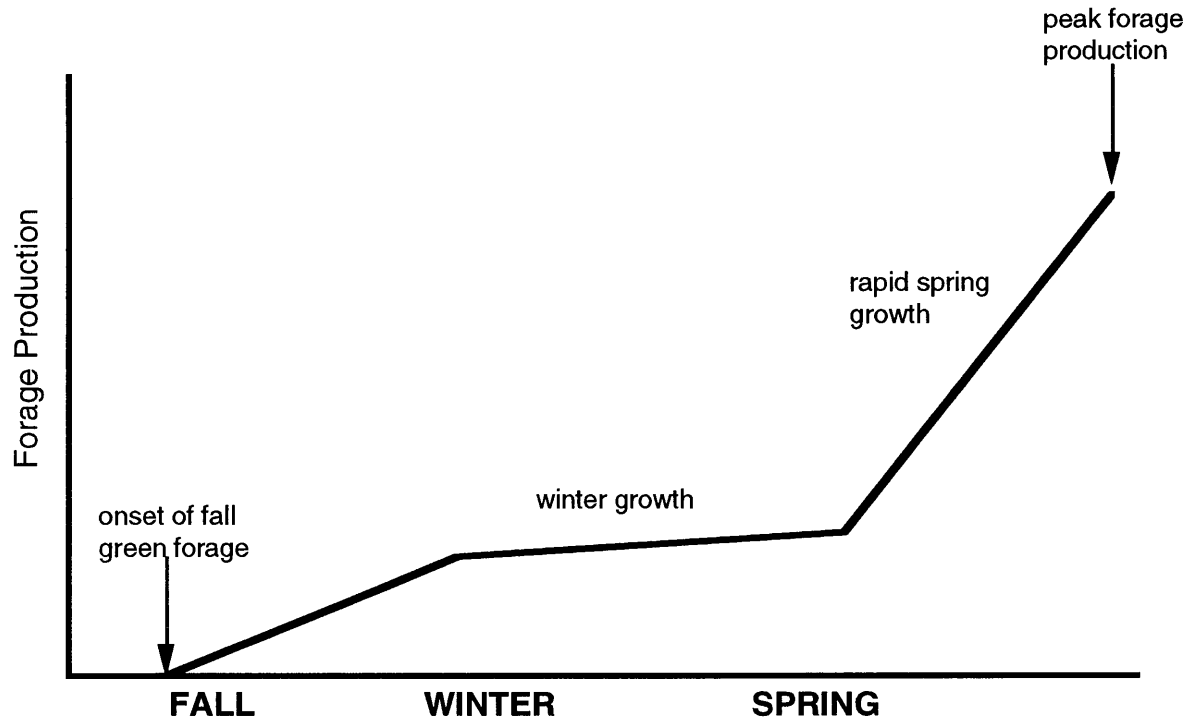
Development of a livestock grazing enterprise on hardwood rangelands depends on annual and seasonal forage production. There are four distinct forage growth phases in the annual grasslands found on hardwood rangelands. These are: 1) onset of fall green forage season; 2) winter growth; 3) rapid spring growth, and 4) peak forage production. Management decisions are guided by these patterns. Four factors have been shown to control seasonal forage productivity and species composition, namely: precipitation; temperature; soil characteristics; and plant residue on the site (residual dry matter or mulch).



Weather Influences

Figure 5-1 shows a generalized forage growth curve for California's hardwood rangelands. The new fall growing season begins when rains start the germination of seed stored in the soil. Young annual plants then grow rapidly if temperatures are warm, but more slowly if it is cool. Little growth occurs when winter temperatures are low. Rapid spring growth commences with warming conditions in late winter or early spring, and continues until soil moisture is exhausted. Peak standing crop occurs at the point where soil moisture limits growth or when plants are mature.

Figure 5-1. Typical pattern of seasonal forage growth on California's hardwood rangelands.



The new fall growing season has been shown to occur following the first fall rains that exceed 1 inch during a 1-week period. This may occur at any time from September 15 until January 1. Early false breaks may occur in summer or early fall, in which case emerged plants may not survive until the true break. Filaree, which has a long taproot, is one of the few annual plants that may survive a false break.

Depending on fall rains and temperatures, forage species composition is usually established by December 1. In dry years, filaree usually dominates, while grass dominates in high rainfall years. Early rains coupled with evenly spaced, adequate rainfall generally produce clover years.

The period of low winter forage growth occurs as fall ends and is the result of cooling temperatures, shorter days, and lower light levels. The winter growth period is short when the season breaks late. This occurs when there is almost no new growth apparent in the fall. However, forage production is greater in mild winters.

Rapid spring growth begins as temperatures warm in the spring and days lengthen. Normally this period occurs between February 15 and March 15 when average weekly temperatures exceed 45 degrees F. The length of rapid spring growth varies from a month in dry southern regions to more than three months in wetter coastal regions.

Maximum forage production occurs at the end of rapid spring growth (peak standing crop). This date can vary from April 1 in the southern San Joaquin Valley to May 25 on the north coast. Late arrival of peak standing crop requires adequate rains in April or early May. The date of peak standing crop on the same site varies widely among years and according to species composition. In years of filaree dominance, peak standing crop will be earlier than in years of grass dominance.

Moisture from summer thunderstorms, although not important for plant growth, leaches nutrients from dry standing forage, and may speed decomposition. Standing residual dry matter frequently shatters into ground litter.

Site Influences

Available moisture depends on rainfall, soil depth, soil texture, aspect, and topography. Most annual plants depend primarily on moisture in the top foot of soil, although filaree and summer annual forbs use water at greater depths.

Heavier clay soils, commonly found on swale areas, hold moisture and conserve it for plant use between widely spaced rains, resulting in a longer rapid-growth period. Upland slopes are drier due to high runoff and lighter-textured soils. South-facing slopes dry faster than north-facing slopes, resulting in different forage production levels.

Hardwood rangeland soil fertility varies tremendously. Nitrogen is the most limiting nutrient, but phosphorus and sulfur can also be limiting. Fertilization with these limiting elements can substantially improve forage productivity. Soil pH varies considerably and influences legume species composition. Acidic soils tend to occur in high rainfall areas of hardwood rangelands, whereas alkaline soils tend to occur in drier areas.

Residue and Grazing Influences

Management of residue, the dry forage component remaining at the end of the dry season, governs forage productivity and composition. Residue, acting as a mulch, influences plant germination and soil organic matter. UC Leaflet 21327, "Guidelines for Residue Management on Annual Range", helps managers determine minimum residue standards. These vary from 200 pounds of dry matter per acre in the southern California to 1250 pounds per acre on steep north coast slopes.

Low fall residue levels encourage higher proportions of silver hairgrass, little qualcinggrass, nitgrass, broadleaf filaree, burclover, redstem filaree, and clover. High fall residue levels encourage dominance by slender wildoats, soft chess, wild oats, and ripgut brome.

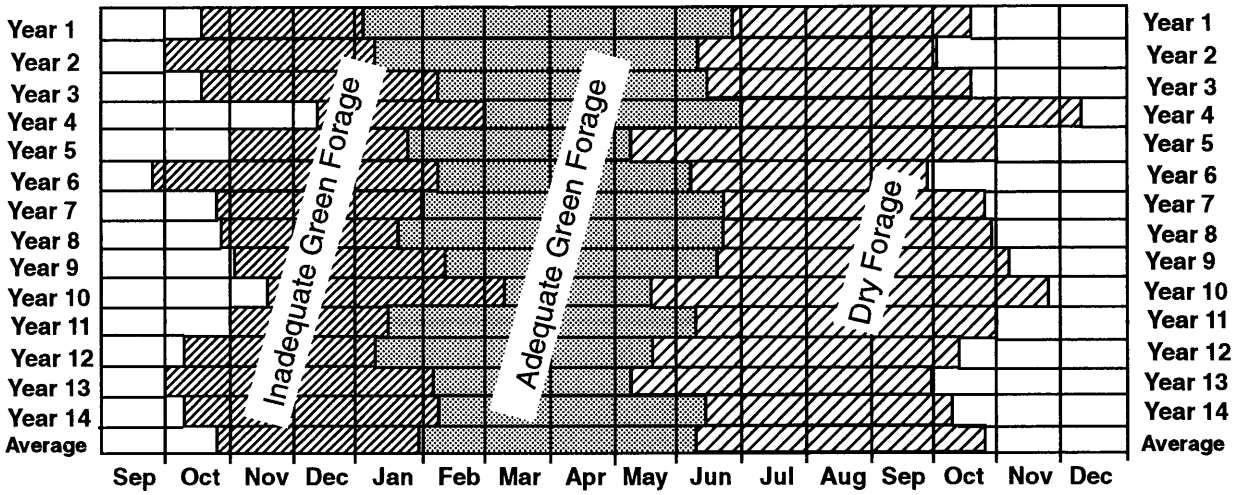
Shading understory forbs with high residue levels result in grass dominance, particularly in an ungrazed situation. Grazing increases forb and legume dominance by opening the canopy. On a moderately-utilized range, livestock do not graze heavily enough to make complete use of available forage, resulting in a patchwork of grasses and forbs.

Seasonal Forage Influences on Animal Performance

Seasonal forage productivity affects livestock weight gains. Cattle that graze in the fall following seed germination may lose weight. This period is called the inadequate green forage season. The onset and length of this period depends on weather conditions. During a dry or cold fall and winter, green forage production will be poor and supplemental feeding may be necessary to maintain cattle performance. A warm fall with adequate precipitation will result in greater forage production and animal performance will improve. Dry residual forage from the previous growing season is commonly available in the fall to provide energy to livestock, but is low in protein and other vital nutrients. The inadequate green forage contains adequate energy, protein, phosphorus, and vitamin A on a dry matter basis. However, livestock are unable to consume enough forage to meet their nutritional needs due to either the high water content of the forage, or simply a lack of available forage.

Animal performance improves during the rapid spring growth period in late winter or early spring. This period is called the adequate green forage season. Forage is usually nutritionally adequate for livestock growth, maintenance and gestation. Peak standing crop occurs when soil moisture limits growth or when plants are mature. Rapid spring growth is followed by the summer dry season, when the forage is a fair energy source but is low in protein, phosphorus, carotene and other important nutrients. Since livestock performance on hardwood rangelands during this summer dry season may be poor, managers commonly provide supplements, transport livestock to high elevation meadows, or use irrigated pasture. Figure 5-2 graphically shows the annual variation that occurs in the timing of these seasons.

Figure 5-2. Example of variation in length of time of the inadequate green season, adequate green season, and dry season at the San Joaquin Experimental Range over a 14-year period.

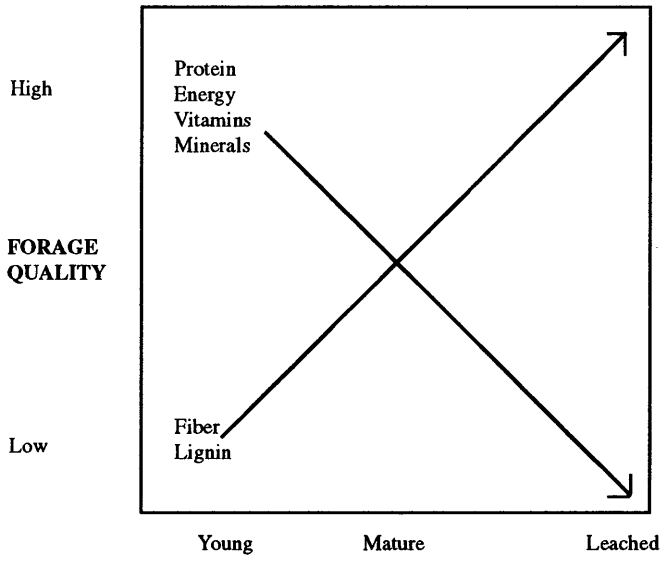


Seasonal Forage Quality

Matching the nutrient demands of livestock and the nutrients supplied by range forage comprises a real balancing act for a considerable portion of each year. Range forage quality varies with species, season, location or elevation, and improvement practices. Hardwood rangeland forage is optimal for livestock growth and production for only a short period of the year, although with management, livestock can graze for extended periods on hardwood rangelands. Early in the season, forage may be of high nutrient content, but nutrients are soluble and may not be efficiently utilized by the livestock's rumen microflora, essential for digestion. Late in the season, high fiber content limits nutrient ingestion and use.

Measures of forage quality such as protein, energy, vitamins, and minerals follow a declining trend as the season progresses (Figure 5-3). Conversely, measures of low quality such as fiber and lignin increase as forage plants mature.

Figure 5-3. General relationship of forage quality to the stage of plant growth.



Stage of Plant Growth

The four nutritional factors of most concern to hardwood rangeland livestock managers are protein, energy, carotene (the precursor of vitamin A), and phosphorus. Forage may also be deficient in copper. High molybdenum aggravates copper deficiency. Potassium and zinc may be deficient in mature weathered forage. Other minerals such as selenium may be found in deficient or toxic levels in localized areas of the state.

Nutrient content changes as plants develop. Stages of plant development (vegetative, flowering, mature, dry, etc) can be visually identified and are good indicators of forage quality. Generally, anything that retards the rate of plant development, such as moisture, slight stress, or grazing, will foster higher nutrient status. Anything that advances the rate of development, for example, extra water or nitrogen, allows greater structural development and reduces nutrient quality (but increases yield). Complete information on seasonal forage relationships are available from UC Cooperative Extension Farm Advisors.

Forage Alternatives for Hardwood Rangeland

Because of this seasonal variability in forage productivity and quality on hardwood rangelands, complementary forages and feed sources must be provided. A hardwood rangeland ranch plan that thoroughly assesses potential forage sources and grazing management can identify the most cost effective means of meeting animal performance objectives (see references at end of this chapter). The following seasonal forage and grazing management practices can provide solutions to limitations in forage production, quality, and utilization that affect animal production per acre.

Season 1 (onset of green season, fall) — The timing and amount of forage productivity is highly variable and may require feed from other sources to provide adequate dry matter or protein. Protein supplements are commonly used. The management options described below can be used individually or in combination with each other to produce complementary forage sources, depending on cost effectiveness.

1-1. Supplemental irrigation of annual ryegrass, winter cereals, or subterranean clover for early fall green feed.
1-2. Development of summer dormant perennials such as perlagrass, hardinggrass, Berber or Palestine orchardgrass for early fall green feed.
1-3. Stay on summer pasture until annual range can be used. However, cold weather may restrict this option.
1-4. Fall or winter grazing of alfalfa fields.
1-5. Provide protein and energy supplements and graze unused dry residue from previous season.
1-6. Feed hay.

Season 2 (winter season) — Following fall growth, cold winter weather stagnates forage productivity. Although protein supplementation may be unnecessary, inadequate dry matter intake may require feeding of hay. Complementary forages to improve winter feed are shown below:

2-1. Nitrogen fertilization of annual range can increase winter feed.
2-2. Properly managed annual legumes increase winter forage productivity.
2-3. Items 1-1, 1-2, 1-4, and 1-5 above can also provide feed during this season.

Season 3 (rapid spring growth, adequate green season) — Forage production on hardwood rangelands during the spring season is usually not limiting. The time of warming temperatures and the amount and timing of spring rains largely determine the length of this season.

3-1. Items 1-2, 2-1, and 2-2 above can increase feed during this period.
3-2. The development of cool season irrigated pasture can provide high quality feed during this period.
3-3. Production of winter cereals or ryegrass can provide extra feed or hay during this season.

Season 4 (dry season, inadequate dry) — The dry season starts as soon as soil moisture is depleted following the end of the rainy season. The dry feed is low in protein. The following complementary forages or strategies can provide summer grazing.

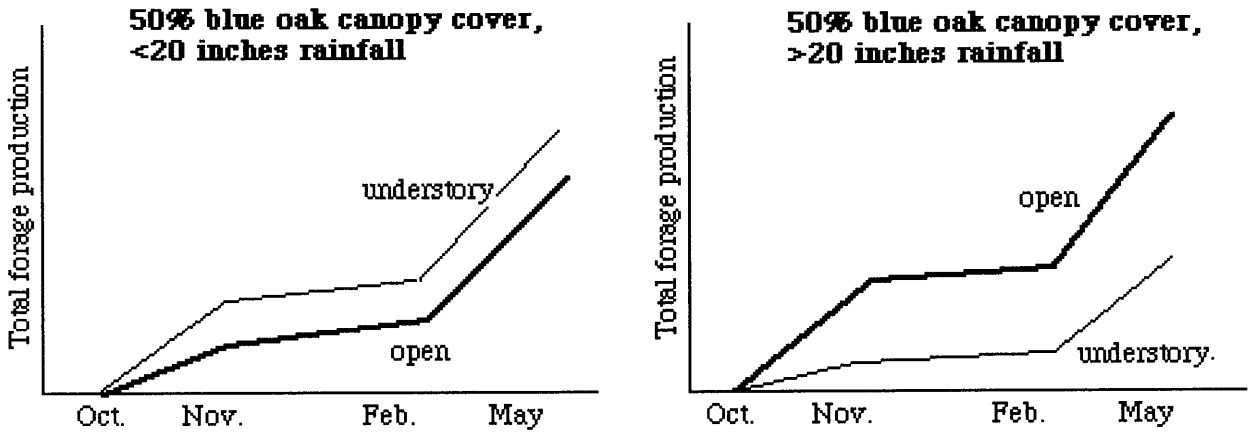
4-1. Item 3-2 above. Rotation of livestock from dry range to irrigated pasture can be a cost effective method of providing adequate protein and dry matter in summer.
4-2. Transport livestock to high elevation range and mountain meadows where feasible. Grazing management of these forage sources should follow established guidelines for perennial range and pastures.
4-3. Sudangrass for pasture or hay production.
4-4. Annual legumes such as rose clover, lana vetch, and annual medics can raise the quality of dry feed for all or part of the summer season.
4-5. Crop residue such as winter cereal stubble can provide dry matter. Shattered grain may improve the quality of this feed source.

Oaks and Forage Production

The oak canopy has an effect on forage production, composition, and quality that varies around the state depending on precipitation, soil, elevation, oak species, and amount of oak canopy cover. Oaks compete with the forage understory for both sunlight and moisture, and alter the nutrient status of the site because of the deep-rooting of oaks and nutrient cycling from litter fall.

Oak removal was historically recommended as a means of increasing forage production on hardwood rangelands. For the deciduous blue oak, most studies have demonstrated increased forage production following tree removal on areas previously containing over 25% canopy cover and receiving over 20 inches of rain. Conversely, where there is less than 20 inches of rain, areas with low blue oak canopy (less than 25 percent cover) consistently had higher forage yields than adjacent open areas. In areas with blue oak canopy between 25 to 60 percent, the canopy effect on forage production varied (Table 5-1). Figure 5-4 shows how moderate blue oak canopy (50%) affects seasonal forage production in different rainfall areas of the state.

Figure 5-4. The effect of 50 percent blue oak canopy cover on seasonal forage production compared with open annual grasslands in two rainfall zones.



In evergreen live oak stands, with leaves that shade forage growth during the winter and early spring months, the few studies which have been carried out show a larger competitive effect of oaks on forage production (Table 5-1). In general, live oak stands with over 25 percent canopy cover will have lower forage growth than cleared areas. One study in the Southern Sierra Nevada foothills, however, showed that in drought years, live oak shading helped conserve soil moisture, resulting in higher forage production than on open sites.

Table 5-1. The effect of oak canopy on hardwood rangeland forage production (note: a "+" indicates forage production is enhanced by oak canopy, a "–" indicates forage production is inhibited by oak canopy, and a "– / +" indicates that the effect is variable in different locations in the state).

Species Group	Canopy Cover	Winter Forage Production	Spring Forage Production
Live oaks	Scattered (<10% cover)	– / +	– / +
	Sparse (10 - 25% cover)	– / +	– / +
	Moderate (25 - 60% cover)	–	–
	Dense (over 60% cover)	–	–
Deciduous oaks	Scattered (<10% cover)	+	+
	Sparse (10 - 25% cover)	+	+
	Moderate (25 - 60% cover)	– / +	– / +
	Dense (over 60% cover)	–	–

The increase in forage production beneath blue oak canopies, or in areas previously beneath blue oak canopies, is attributed, in part, to increased soil fertility due to leaf fall and decomposition. Enhanced soil fertility also improved forage quality beneath blue oaks or where blue oaks were removed. However, since the nutrient input from leaf litter ceases after tree removal, forage production increases will be temporary, until soil fertility gradually declines to similar levels as adjacent open areas. Long term studies have found it may take 15 years for this nutrient effect from oak cover to dissipate after tree removal.

Oak canopies also have an effect on forage species composition. Studies have found that understories of both blue and live oak stands favor later successional herbaceous species such as wild oats, soft chess and ripgut brome. Clovers, annual fescues, filaree, soft chess, and foxtail fescue account for more of the total herbage biomass in open areas than under oak canopy.

In general, managers of livestock enterprises on hardwood rangelands should consider the following general guidelines when managing their oaks:

- There is little or no value in removing blue oaks in areas with less than 20 inches of annual precipitation;
- On areas with over 20 inches of rainfall, thinning oaks where the canopy exceeds 50 percent will have the greatest effect on forage production;
- In areas thinned for forage enhancement, residual tree canopies of 25 to 35 percent are able to maintain soil fertility, retain some components of wildlife habitat, and minimize erosion processes; and
- Tree removal activities should always be planned considering all values of the trees, including wildlife habitat, soil stability, etc. in addition to the possible forage production benefits.

Grazing Management in Hardwood Rangelands

On hardwood rangelands, forage species production and composition, livestock diet preferences, stocking rate and distribution, kind and class of stock, season of use, and range improvement practices influence animal performance and the profitability of the livestock enterprise. The relationship of each of these factors enter into the development of a grazing management strategy for hardwood rangelands.

Livestock Diet Selection and Grazing Behavior

In general, cattle tend to prefer diets that are higher in protein and lower in fiber than that contained in the available forage. Protein in the diet can become limiting before energy content, especially for young stock and lactating cows. This is one of the main reasons why performance of these classes of cattle declines sharply when the forage matures.

Studies at the Sierra Foothill Research and Extension Center, near Marysville, show that organic matter intake and digestibility was greatest in April and early May. Protein consumed was greatest in March. Each of these indicators of forage quality reached their peak during the period of rapid spring growth, and were at a minimum during the summer or fall dry season.

Unpalatable plants do not necessarily have poor nutritive value, but are of low value because they generally are not selected. It is possible to minimize the effects of selective grazing by forcing uniform use during particular seasons, but the animals may not perform quite as well. Where grazing is not forced, livestock will select the most palatable plants first.

Cattle grazing can be divided into three activities: grazing, ruminating and idling. Typically grazing starts at sunrise or a little before, and lasts for two hours. Then, there is a brief period of idling, followed by ruminating and then a longer period of idling. The total time spent on this first cycle is typically about four hours. Four or five shorter cycles (grazing-ruminating-idling) follow through the remainder of the daylight hours, with at least one grazing cycle after sunset.

Time spent grazing is about 8 hours per day, but there are variations in daily duration of grazing due to breed and forage conditions. Hunger will not drive an animal to graze beyond 10 hours per day. Under poor forage conditions, time actually spent grazing may change little, but time spent looking for food can increase from a normal of around 3 hours up to 5 hours. Time spent ruminating is heavily influenced by the fiber content of the forage.

The mechanical task of harvesting the daily requirement of forage is formidable. Under optimum pasture conditions (3 - 5 inches of green forage), the animal must take about 80 bites per minute to harvest 200 pounds of green material in an 8 hour day. Where the number of bites falls to 40 per minute, the intake will be about 44 to 55 pounds of green material per day, which is scarcely enough for maintenance. During the dry season, high fiber content slows rumination, which suppresses intake.

Stocking Rate

Stocking rate is the number of specific kinds and classes of animals grazing a unit of land for a specified period of time. It is usually expressed as animal unit months (AUM) per acre or the reciprocal, acres per AUM. An animal unit is usually defined as one mature (1000 lb) cow. An animal unit month is the amount of feed or forage required by one animal unit for one month to maintain its weight.

Deciding stocking rate is the most important grazing management decision, influencing the health or condition of vegetation, livestock and wildlife. Improper stocking rates result in wasted forage or overstocked range that sooner or later reduces economic return. Incorrect stocking rate may cause other range or livestock management practices to be ineffective, and management goals will not be reached.

Carrying (grazing) capacity is defined as the total number of animals which may be sustained on a given area year after year without damage to vegetation or related resources. Although actual stocking rates vary considerably between years due to annual forage fluctuations, grazing capacity is generally considered to be the average number of animals an area will sustain over time. Ranches are usually bought and sold on the basis of grazing capacity.

There are many ways to estimate stocking rate and carrying capacity. Modern USDA Natural Resource Conservation Service (NRCS) Soil Surveys report forage production and/or stocking rate for poor, average and favorable years. Stocking guides have also been developed based on slope, canopy cover, distance to water and other factors.

Animal performance is influenced by stocking rate. Research at the San Joaquin Experimental Range sug-

gested that moderate grazing gave the most efficient cattle production, while maintaining satisfactory herbage production. Close grazing reduced range forage production in subsequent years as well as efficiency of cattle production. The effects of gazing intensity were apparent in winter forage growth and in mature herbage yield. Grazing intensity effects on spring plant vigor were not apparent. Differences in grazing during the current season partially obscured the effects of past grazing use. However, differences in forage yield and composition were still apparent in the spring.

Livestock Distribution

Slope, distance to water, forage production, forage composition, forage nutritional value, and pests are important factors affecting livestock distribution on hardwood rangelands. Studies at the San Joaquin Experimental Range have shown that livestock spend much more time grazing the highest producing swale sites than the less productive slopes, although this varies by period of forage growth and maturity. From the time the cows are placed in the pasture until the start of rapid forage growth in late March, average cow distribution on swales remains constant and about equal to distribution on slopes. During April and May, when forage is growing rapidly on swales and has matured on other land classes, swales receive heavier livestock use than rocky, brushy slopes. As forage matures and dries in June, cow distribution in swales decreases sharply and increases markedly on slopes. Even though forage on swales has been closely grazed, the cows may continue to spend considerable time regrazing these areas. As the forage matures and dries, cows spend less time grazing south slopes and more time on north slopes. When rains start the new forage growth in winter, use of north slopes decreases, and use of south slopes increases.

Grazing Practices

While most ranches on hardwood rangelands are subdivided into a few to several pastures, intensive control of grazing is seldom practiced. Seasonal or year-long continuous grazing of different hardwood rangeland pastures is traditional. Hardwood rangeland grazing management currently emphasizes maintenance of adequate residue and efficient utilization of forage to encourage desired forage species and adequate soil protection.

Although annual plants do not survive from year to year, their management influences productivity the following year. Light to moderate grazing intensities, leaving moderate amounts of dry forage residue in the fall, tends to result in more desired forage species the following growing season and increased forage levels in January. Research has shown that excessive grazing, with very low amounts of dry residue, tended to produce less desirable forage species with lower total production the following year. Leaving too much residue also results in less total forage production the following year than moderate residue levels.

Specialized grazing management systems adapted to hardwood rangelands have not been widely used nor have they been the subject of extensive research. Some evidence from the literature supports year-long grazing rather than a three pasture deferred rotation, where a different pasture was used during each third of the grazing season. In the 1980s, a small number of ranchers began to subdivide their pastures and rotationally graze. Several changes in ranch productivity have been observed in controlled grazing case studies. Increased stocking rate has resulted in increased total animal productivity, reduced hay feeding during fall and winter, less dependence on hay feeding during drought, reduced weed populations, and reduced predator losses. Additional information on these specialized grazing systems is available from the local office of your Cooperative Extension Farm Advisor, or the Natural Resource Conservation Service.

Nutrient Requirements of Beef Cows

One of the main factors in planning a cow herd supplementation program is the cow's nutritional requirements. Table 5-2 gives the estimated requirements for a 1000 pound beef cow for five periods of production. The nutrients which should be considered as potentially deficient on hardwood rangelands are energy, protein, phosphorus, magnesium, sodium chloride, certain trace minerals and vitamin A. Table 5-3 below shows some general symptoms for deficiencies of the various nutritional elements.

Table 5-2. Nutrient requirements for a 1000 lb. beef cow

Nutrients	Stage of Production				
	Period 1	Period 2	Period 3	Period 4	Period 5
	Calving (45 days)	Breeding (45 days)	Early Gestation (90 days)	Mid Gestation (90 days)	Late Gestation (90 days)
Dry Matter (lbs/day)	20.6	21	19.5	18.1	19.6
Protein (lbs/day)	2.5	2.6	2	1.3	1.6
Energy - Total digestible nutrients (lbs/day)	13.8	14	11.5	8.8	10.5
Calcium (g/day)	36	38	25	15	23
Phosphorus (g/day)	25	27	20	15	18
Vitamin A (1000s IU/day)	37	38	36	25	31

Energy: Energy is the most important nutritional factor to consider for beef cows for several reasons. It is the nutritional factor most commonly lacking due to the shortage of forage. Were it not for energy requirements, a beef cow's nutrients could be met by 2 to 4 pounds of total feed per day. Insufficient energy intake may occur when cattle are forced to graze deficient dry forage in the fall or inadequate green season.

Protein: Protein is most likely to be deficient in the summer and fall when dry forage is plentiful but green forage is not adequate. Supplemental protein for wintering cows is usually the largest annual cost in maintaining a cow. Supplements such as cottonseed or safflower oil meal, and alfalfa hay are primary sources. Urea is a non-protein compound which ruminants may convert to protein with varying degrees of efficiency. Use of liquid supplements and blocks has increased drastically in recent years. Presently, urea has a low to moderate value for cattle on dry range when it replaces protein in a natural protein supplement. Proper management procedures are important when urea is fed to prevent ammonia toxicity and to enhance urea utilization. Special concern needs to be given to dry livestock ranges on years with heavy acorn crops. Feeding urea may result in loss of cattle due to uremic poisoning.

Calcium: Calcium deficiency is not a serious problem in most livestock diets. Calcium is seldom deficient in California forage.

Phosphorus: Phosphorus may be borderline to definitely deficient in diets during summer, fall and winter periods. Feeding with high protein and liquid supplements usually supplies adequate phosphorus to supplement native forage.

Salt: Salt should always be accessible for livestock to use as needed in loose pack or block form. Placing salt away from water is a common practice for improving livestock distribution and improving range utilization.

Magnesium: Under California conditions, grass tetany or hypomagnesemic tetany, often occurs. It is a major problem, especially in lactating cows grazing lush, rapidly growing pastures fertilized with high levels of nitrogen during cool foggy seasons. Grass tetany can be prevented by providing supplemental magnesium.

Trace Minerals: Deficiencies of trace minerals such as copper, iodine and selenium exist in many areas of California. It may be desirable to provide a trace mineralized salt mix as a precautionary measure if there is any reason

to suspect a deficiency. Selenium deficiencies are concentrated in northern (especially northeastern) California. In these selenium deficient areas, it can be administered as an injection or as a pellet placed in the reticulum. Selenium provided in supplement blocks has generally not proved effective.

Vitamin A: Vitamin A deficiencies may occur in beef cow herds. A cow stores up several months supply in her liver during the adequate green feed period, but this supply can be rapidly depleted in a lactating cow. Vitamin A deficiencies may also occur in fall calves during dry years or in young cows. Supplemental vitamin A may be needed.

Potassium: Generally, forages contain more potassium than required by beef cows. However, potassium concentration decreases with advancing maturity of forage and can be reduced further by leaching. Potassium deficiency results in decreased feed intake, decreased milk yield, reduced weight gain and muscular weakness.

Table 5-3. Symptoms of nutritional deficiencies of livestock on hardwood rangelands

Energy Deficiency	Protein Deficiency	Calcium Deficiency	Phosphorus Deficiency	Salt Deficiency	Selenium Deficiency	Vitamin A Deficiency
Retarded growth and loss of body weight	Reduced appetite	Poor Growth	Decreased appetite	Licking and chewing various objects	White muscle disease	Watery eyes
Delayed sexual maturity and poor conception	Reduced growth rate in fetus and calf	Depletion of calcium	Chewing wood, bones and hair	Loss of appetite	Retained placentas	Night blindness
Shortened lactation period and decline in milk yield	Loss of weight	Swollen, tender joints	Low blood phosphorus	Unthrifty appearance	Reduced gains	Scouring
Lowered resistance to disease and parasites	Inadequate intake of other nutrients	Arched back	Stiff joints and lameness	Rough haircoat	Unthriftiness	Respiratory infection
Increased mortality by toxic plants	Delayed or irregular heat	Stiffness	Decreased milk production	Decreased milk production	Diarrhea	Poor conception
	Poor conception rate	Deformed legs	Failure to show heat	Reduced gains		Abortion-shortened gestation period
	Reduced milk production	Fractures	Poor conception rates	Lack of coordination		Birth of dead, weak or blind calves
				Weakness		Retained placentas
				Death		Uncoordinated calves

Range Supplementation of Beef Cows

Supplementation means making up the difference in quality between what range forage provides and what cattle need. It does not mean substituting purchased feed for range forage. A supplement program is designed to enhance utilization of the total diet, and requires knowledge about which nutrients are deficient, the degree of deficiency, and the cost of alternative supplemental feeds.

Frequency of Supplementation: Cattle do not require daily supplementation. Research has shown that it makes no difference whether the supplement is fed at a given rate each day, tri-weekly, or bi-weekly. However, the animals should receive the same amount of supplementation on a weekly basis, regardless of feeding interval. Even if the cows are not fed daily, they should be observed as often as necessary, especially during the pre- and post-calving season.

Forms of Supplements: Dry roughages, alfalfa, grass, or grain hay can be used but should be analyzed to determine nutritive value. Quality hays properly supplemented often result in a satisfactory supplemental feeding program.

Dry supplements may be furnished as meals, blocks or cubes. Blocks and cubes have the advantage that they may be fed on the ground whereas meals require the use of a feeder. Intake of meals can be successfully controlled by the use of salt. Hardness of the food supplement has also been used successfully to limit intake.

Molasses or other feed by-products, such as corn steep liquor or ammoniated whey, are the principle ingredients of liquid supplements. Liquid supplements are easily handled and dispensed by liquid feed companies.

Animal Health Issues on Hardwood Rangelands

A variety of animal health issues affects the livestock enterprise on California's hardwood rangelands. You should contact your local veterinarian or CE Livestock Farm Advisor to evaluate specific concerns you might have about livestock health. Shown below are several important health concerns that are specific to livestock enterprises on hardwood rangelands.

Acorn Calves

The acorn calf syndrome is characterized by deformed calves born to cows that received inadequate nutrition during pregnancy. The condition is not directly caused by eating too many acorns, but is more commonly seen in cattle feeding on hardwood rangelands than in other grazing areas of the state.

Acorn calves suffer various types of deformities. Most commonly, the long leg bones (humerus and femur) are short and bent at the joints. The calves may be "knuckled over" at the joints and appear bow-legged. They may be weak and uncoordinated, making it difficult for them to stand alone and nurse. The head may be short with an undershot jaw, giving a "bull-dog" appearance, or an abnormally long, narrow, pointed jaw.

Acorn calves are often born alive, but are likely to die soon under natural range conditions. If assisted in nursing, many calves will survive. However, this is economically impractical. Most surviving acorn calves will not grow efficiently, and tend to be chronic bloaters, resulting in early death or extreme inefficiency in the feedlot.

Researchers have concluded that this syndrome is not inherited, and is also not directly caused by consumption of acorns. However, high levels of acorn consumption may be an indirect factor in the syndrome, affecting utilization or metabolism of other feeds.

The most likely cause of the abnormalities seen in acorn calves is inadequate nutrition to the mother cow during the third to sixth month of gestation. The exact nutrient deficiencies causing the syndrome are not known, but it is probably the result of reduced availability of a combination of nutrients which may include protein and vitamins A, B-complex and D. Protein is certainly implicated because acorns are low in digestible protein, and protein supplementation of cattle consuming substantial amounts of acorns has been shown to improve their efficiency considerably.

Cow herds can be affected dramatically. Some herds reported up to a 20% incidence of acorn calves during a recent drought year. Once the problem shows up in the herd, little can be done since the nutritional deficiencies that were the cause occurred three to six months earlier during pregnancy.

This syndrome can be prevented by following basic herd nutrition practices as discussed above. Acorn calves usually appear in herds confined for long periods on dry annual range with low forage availability and lack of green feed. First-calf heifers are especially susceptible, probably because of their increased nutrient requirements. If animals cannot be rotated to pastures with better feed conditions, then supplemental feeding of pregnant cows and heifers can be used to prevent acorn calf disease.

Oak Products as Livestock Forage

Oak trees can provide a valuable source of forage to livestock in the form of both leaves and acorns (mast), especially during summer and early fall when the annual forage is dry and sometimes in short supply. A study in

Mendocino County showed that up to 55 percent of the total mid-summer diet of individual cattle was acorns and oak leaves. Oak products made up 28% of sheep diets during the same period.

Acorns contain high levels of energy, but are low in digestible protein, vitamin A, phosphorus, and calcium. These nutrients (except calcium) are also low in annual range forage during the dry season. However, acorns are undependable as forage because production varies annually. Supplemental feed, especially protein supplements, improves animal performance under such conditions.

Oak Poisoning

Although oak products can be a valuable supplement to herbaceous forage, health problems will result if cattle are forced to eat too much of these products because of lack of other feed sources. This is because of the poor balance of nutrients in acorns and the high levels of tannins in acorns and oak leaves. Acorn calf syndrome is a possible health problem, and oak poisoning can have disastrous effects under certain conditions.

Oak poisoning in cattle is caused by consumption of unusually high levels of oak products. This results in high concentration of tannins in the blood, which is toxic to the kidneys and liver. In 1986, several thousand cattle died in two Northern California counties following a severe late spring snow storm. Range feed was particularly short that spring, and the snow knocked millions of new oak buds off the trees and covered most of the ground feed that was present. Hungry cattle consumed the fresh buds, resulting in toxic levels of tannins in the blood. Similar effects have been reported in various parts of the country when oak leaves are prematurely shed after wind or hail, and forage is limiting.

Poisoning from oak buds or other products, while disastrous when it happens, occurs rarely. Managers can protect against it by providing supplemental feed immediately if natural forage is short and a storm results in unusual amounts of oak buds or leaves on the ground. Managers might also want to provide short-term supplemental feed allowing hungry cattle to feed on an inadequate forage supply.

Anaplasmosis

Anaplasmosis is an infectious disease which can cause severe anemia in cattle, sometimes resulting in death or, in pregnant cows, abortion. It is not unique to hardwood rangelands, but it is quite common in such locations because of the high concentration of ticks and other vectors on these lands, and because deer and other wild animals typically found in these areas serve as reservoirs for the disease.

Anaplasmosis is caused by a rickettsial organism called *Anaplasma marginale*. (Rickettsiae are intermediate in size and biology between viruses and bacteria.) Anaplasmosis occurs when *A. marginale* infects a susceptible animal and causes severe anemia due to the destruction of red blood cells, resulting in illness or death in the animal.

Cattle of all ages are susceptible to infection by *A. marginale*. However, the age of the infected animal determines the severity of any clinical disease. When cattle less than one year of age are infected, they will not show any signs of disease. They will become carriers of the organism and develop an immunity which will be protective against the clinical disease. Cattle infected between 12 and 24 months of age have an increasing risk of becoming ill. All infected cattle over two years of age become ill, and approximately 50% will die if not treated. Once infected, the cattle tend to be carriers of *A. marginale* for many years. These animals can serve as a source of infection for other cattle.

The disease agent is spread by ticks and biting flies which carry infected blood from a carrier animal to a susceptible animal. Ticks are unique biological vectors in that they carry *A. marginale* in their tissues and can infect cattle when feeding at subsequent molts or stages of their life cycles. The disease is also spread by humans through the use of dehorning and ear tagging tools, castration instruments, needles, and implanting devices that are not sterilized frequently.

The disease results in severe anemia, manifested as lack of appetite, muscle weakness, and depression. The blood appears thin and watery, and the mucous membranes are pale. The latter is most easily noticed in the lips and around the eyes. On exertion, animals often show signs of respiratory distress. Cows may abort in late pregnancy, and the disease may cause temporary infertility in bulls. A definite diagnosis can be made by a veterinarian from a blood sample from cattle suspected of having the disease. Several different control strategies have been proposed, and your veterinarian can suggest the most appropriate one for you.

The effect of anaplasmosis on a herd, and thus the appropriate protection program for that herd, is dependent on its geographic location within California. In areas such as the Central Valley, there is very little tick activity and cattle do not become infected. Groups of cattle in such areas are not carriers of the organism, do not develop the

disease, but are quite susceptible to infection. If adult cattle such as these are taken to a locale where *A. marginale* is common, they can become infected and can experience heavy losses due to anaplasmosis. These cattle should be protected with a vaccine well before the time they are taken into high risk areas (check with your veterinarian).

In areas with high rates of infection with *A. marginale*, such as portions of the Coast range, almost all cattle are infected early in life. They do not develop any signs of disease, and are carriers of the organism for life. Cattle losses do not commonly occur in these herds unless outside, susceptible cattle are brought in. This occurs commonly with purchased bulls or replacement cows and, therefore, these introduced cattle should be vaccinated well before being shipped into the area. Resident cattle in these locations do not require routine vaccination.

In other locations, including some foothill areas where there is some tick activity and a moderate level of exposure, a significant number of cattle will reach two years of age before they become infected. These susceptible cattle, with herd mates who are infected carriers, can become infected and will develop the anemic condition that can result in illness or death. In herds such as this, it is common to vaccinate all animals since it is impractical to determine which are susceptible and which are carriers. In these herds, older animals are vaccinated with the killed vaccine and young animals are vaccinated with a modified live vaccine.

Since this disease is complicated by many factors, including significant differences among some small local areas within larger regions, it is important to discuss any prevention programs with your veterinarian.

Foothill Abortion

Foothill abortion results in major calf crop reductions in cow herds grazing on hardwood rangelands. The disease, also known as epizootic bovine abortion (EBA), occurs when susceptible cows are exposed by a tick bite, resulting in abortion of the fetus three to four months later, or the birth of a weak calf.

The exact organism responsible for this disease has not been isolated, and thus a preventative vaccine has not yet been developed. UC veterinarians have determined that the soft-shelled pajaroello tick is the carrier of the EBA-causing organism. This tick is common in hardwood rangeland habitats, living in the soil in dry areas around trees, brush, and rock outcroppings. It is less common in more open pastures, although the tick may remain for many years in areas previously cleared of brush. The tick is not found in wet locations.

The pajaroello tick feeds on the blood of cattle, deer, and humans. Since it feeds briefly, and then drops off, they are seldom seen on cattle. The tick is most active on hardwood rangelands during warm, dry weather, and feeds from May to October.

If a pregnant cow is infected through a tick bite, her developing fetus shows the disease effects. Only fetuses under six months gestation are susceptible. Affected fetuses are aborted in late term or born as weak, premature or near-or full-term calves. These calves usually die under range conditions. It is not uncommon for a 40 to 50 percent abortion rate in first-calf heifers. Abortions may occur in groups ("abortion storms"), in which many cows or heifers abort during a short time period. These events may be brought on by some kind of stress, such as extremely cold weather, driving or trucking over a long distance, or inadequate nutrition. Non-pregnant cows exposed through tick feeding become immune to the disease for an unknown period. Periodic re-exposure may be necessary for continued immunity.

Calves that have been aborted due to EBA will exhibit the following symptoms: abortion after 6 to 9 months of pregnancy; large, fluid-filled belly; enlarged lymph nodes; and small hemorrhages in the white part of the eye. Calves born premature because of EBA are weak and smaller than usual.

No vaccine or cure is available, but management recommendations have been developed to reduce disease incidence. These are designed to develop a natural immunity in the cow or heifer by encouraging tick feeding prior to pregnancy or after six months of gestation, or by keeping pregnant cows out of tick-infested pastures before their sixth month of pregnancy. The recommendations are:

1. Locate tick infested pastures. This can be accomplished by checking ranch records to see where cattle were three to four months prior to EBA-caused abortion. Also, sampling procedures have been developed using dry ice to attract ticks.

2. Purposely place sexually mature heifers in known tick areas prior to breeding. The weather should be at least 70 degrees or warmer for at least a few hours during the day at the time of exposure.

3. Place cows or heifers in known tick areas after their sixth month of pregnancy to gain or maintain an active immunity.

4. Keep pregnant cows out of tick infested pastures before their sixth month of pregnancy. Open valley pastures, treeless hay meadows, and irrigated pastures should be safe.

5. Keep cows or heifers that have aborted since these may be especially valuable because of their immunity.

6. Buy replacement cattle from EBA-affected ranches.

Predator Management on Hardwood Rangelands

Hardwood rangelands provide excellent habitat for a variety of wildlife species, including predators such as coyotes, mountain lions, bears, and other carnivores. These predators may attack, kill, and feed on livestock. It is important to note, however, that predators also rely on a host of other wildlife species as sources of food as well.

Preventing and controlling such conflicts between humans, livestock, and predators requires a degree of understanding of the biology and behavior of the predator species, as well as a concerted effort on the part of the land owners or livestock manager. Although landowners can take certain actions to prevent or reduce predation, the services and expertise of a predator control specialist are often required to solve problems.

Predator Biology and Damage Characteristics

Accurate determination of the predator responsible for damage to livestock is an essential first step in preventing further damage. In many cases, close investigation of the evidence of predation in the field helps to identify the species responsible. Detailed descriptions are found in the books listed in the reference section. Predators do have some positive value, by reducing rodents which consume oak regeneration, such as ground squirrels or pocket gophers.

Coyotes: The coyote, a small to medium-sized canid, is responsible for a majority of the predation to sheep, goats, and occasionally to calves. They are found in a wide variety of habitats, and can live in close proximity to humans. Coyotes form mated pairs, breed from January to March, and give birth to pups from mid-March through May, depending on locality. Pups remain with their parents until fall, and then disperse to find mates and establish their own territories. Some are not territorial, but wander nomadically over fairly large areas.

Although the percentage of coyotes that attack and kill livestock is not known, they can inflict serious losses. Small prey such as poultry, young lambs, kids, and pigs are killed with a single bite to the head, neck, or back, and may be carried away without a trace. Multiple sheep and goats may be killed in a single episode, although coyotes only feed upon one, usually consuming muscle or internal organs. Calves are often attacked at the flank, hindquarter, or legs, although newborn calves may be attacked at the throat. Cows attacked while giving birth have severe injuries to the genital organs and hindquarters.

Domestic Dogs: Free-roaming dogs are a serious cause of predation on hardwood rangelands near human dwellings, where dogs are often permitted to roam unsupervised. Many dogs, even well-trained family pets, have a natural inclination to chase livestock. It is not unusual for domestic dogs to join with other dogs in attacking and seriously injuring livestock. The California Department of Food and Agriculture permits livestock owners to receive monetary compensation from the owners of the dogs responsible.

Dogs do not usually feed on livestock they have killed. The carcasses show multiple attack sites on the body and appear mutilated. A dog attack is typically "messy" as compared with a coyote attack. True feral dogs kill for food, and more closely resemble coyote attacks. When a group of dogs attack livestock, they may do so during daylight, they may bark, and be less wary of humans.

Mountain Lions: The incidence of mountain lion attacks on livestock has risen dramatically in recent years, most likely due to increasing lion populations. Lions are seen on hardwood rangelands where they were not present a decade or two ago. Because of their size and capabilities, lions will attack, kill, and feed on various types of livestock, including adult sheep, goats, and cattle.

Mountain lions kill with a single bite, typically to the back of the neck or head, often breaking the necks of the livestock. Larger prey such as cattle or horses may be attacked by lions leaping on their shoulders and biting the neck. Claw marks on the neck, back, and shoulders are evidence of lion attacks. Lions will drag the carcasses to a more secluded location for feeding, and may attempt to cover the carcass by scratching up soil or vegetation.

Although multiple prey may be killed by lions in a single episode, they usually feed on only one carcass. They consume considerably more of an individual carcass than coyotes.

Bears: Because of their omnivorous food habits, bears are commonly found in hardwood rangelands, where they may kill livestock, as well as feeding heavily on acorns and other plant products. They can kill adult cattle and horses, but seem to prefer sheep, goats, calves, and pigs. They may kill multiple livestock when they encounter them on their bedgrounds at night. Bears kill with a bite to the neck and shoulders and may break the neck or back with blows from their paws. Claw marks are often seen on the neck, back, and shoulders of prey. Bears may drag their prey to a secluded location and feed extensively until the whole carcass is consumed, except the hide. Bear droppings and bedding sites are commonly found near the location of the feeding.

Foxes and Bobcats: Because of their small size, these animals usually feed only on lambs and kids and rarely become serious predators. Fox attacks resemble those of coyotes, although tooth punctures are smaller and more closely spaced. It may require multiple bites to subdue their prey. Bobcats usually attack lambs or kids with a bite towards the top of the head. Tooth size and spacing, and claw marks on the carcass, help identify the bobcat. Bobcats may attempt to cover their prey following feeding.

Predator Damage Prevention and Control

Livestock Management: Predation can be reduced by using pastures that have less history of predator problems. Some predators avoid areas of high human activity, so keeping young lambs and kids near to barns, houses or other areas of high human use can be effective. Herding livestock also reduces predation due to human presence.Since coyote predation is often highest during times when the pups are born and being fed, changing lambing, kidding, and calving seasons can help reduce predation. Confining livestock during birthing can also reduce predation. Carrion should be removed from pastures to reduce predator problems.

Exclusion: Various fence designs can protect livestock from predators. Standard woven-wire fencing can exclude coyotes and dogs, or direct their movements in more predictable ways. High tensile, electric fences are also useful. It is more difficult to exclude mountain lions and bears with conventional fence designs, and costs of predator-proof fencing may be prohibitive.

Frightening: Lights, sounds, and other stimuli have been attempted to keep predators from entering pastures with livestock. They have short lived effectiveness, as predators eventually adapt to this stimuli. A strobe-siren device recently developed by USDA shows promise. Chemical repellants for the most part have not been effective. Guard dogs have been used to frighten off predators with mixed success.

Lethal Control: Removal of the predator is often necessary. The landowner may be able to control domestic dogs or coyotes, but larger predators such as bears or mountain lions require a depredation permit issued by the California Department of Fish and Game. Bear, lion, and often coyote control activities are conducted by trained animal damage control specialists, available through cooperatively-funded programs in most counties in California. Check with your local County Agricultural Commissioner or the Department of Fish and Game to see what is available in your area. Specific information on traps and other control methods is also available.

Ranch Management Planning Tools

Developing ranch plans for livestock on hardwood rangelands is a complex and involved process. This chapter has illustrated some of the forage production, grazing, and livestock management considerations that are applicable to operations on hardwood rangelands. It is necessary to conduct detailed planning and analysis, which is beyond the scope of this book. The UC Cooperative Extension Range Program can provide several tools that can help in range planning. These tools are used in Ranch Planning, Grazing Management, and Range Nutrition short courses offered throughout the state with the local Farm Advisors. Some of the specific tools that are presented in these educational materials are discussed below. A complete list of materials available and the address for ordering these are given in the references section.

Calendar of Operations

A calendar of operations chronologically describes the activities in a livestock enterprise. On hardwood rangelands, the calendar starts by listing the timing of activities during the livestock reproductive year. Adding in herd health activities, nutrition, marketing, pasture management, and other production activities will complete the calendar. A completed calendar should include all activities that result in expenditures and income. The calendar can be used for planning and review. It is particularly useful for identifying potential time or labor conflicts when considering new enterprises.

Stock Flows

A stock flow is simply a calendar of livestock inventory, usually by month. Typically, the number of each kind and class of animal is listed at the beginning of each month. This listing can be used to estimate feed demand and to predict numbers of animals to be marketed.

Feed Flow

A feed flow is a calendar of forage and feed availability. It should show feed sources for each month of the year. It will also show when and how much hay or other supplements will be fed during the year. A pasture worksheet is often used to develop feed flows. Comparing feed flows and stock flows allows the manager to estimate periods of forage shortfalls.

Grazing Plans

A grazing plan can be useful if the ranch has many pastures or other forage sources. It is particularly useful for planning rotational grazing. A chart is used to plan what herd will be in what pasture on what day. The chart is also used to record actual grazing locations so that deviations from the plan can be monitored and adjustments made as needed.

Chapter Six

Developing Recreational Sources of Income from Oak Woodlands

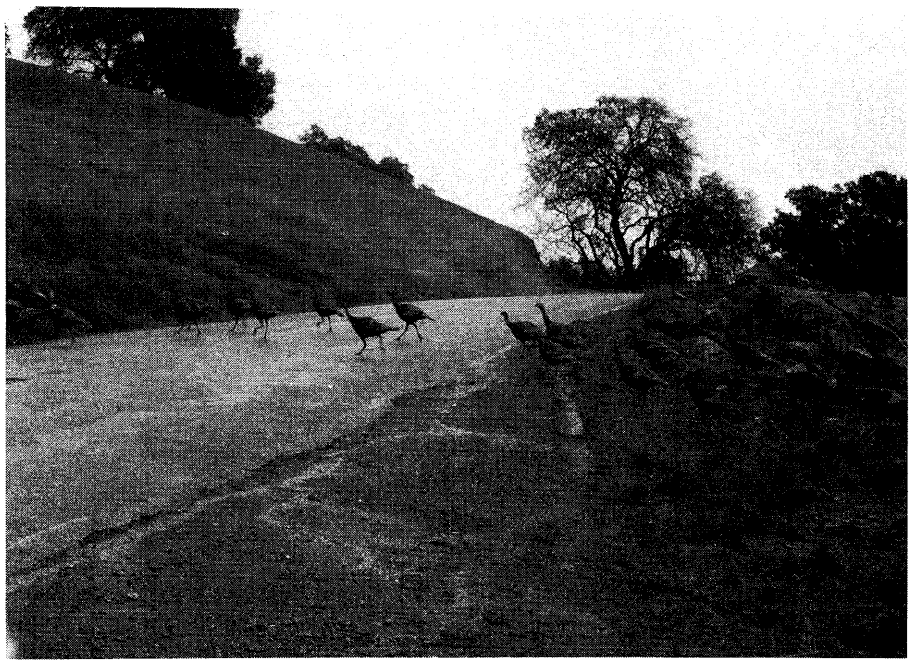
Primary authors are: Gregory Giusti, Univ. of California, Mendocino Co.; Barry Garrison, Calif. Dept. of Fish and Game; and E. Lee Fitzhugh, Univ. of California, Davis

Do you consider yourself a rancher, livestock producer, landowner, resource manager or all of the above? By not limiting your view of yourself, and considering all options, potential income from your lands can be greatly increased. People who envision themselves as managers of a wide array of resources have the ability to recognize a wide array of marketing potentials.

California's oak woodlands are some of its most scenic areas. Unfortunately for many people, oak woodlands are not accessible because public land ownership is more limited than in other parts of California. Less than 20 percent of oak woodlands are publicly-owned and much of that is in military bases.

Regardless of the actual acreage of your property, chances are you have more land than most Californians who live in urban or suburban settings. People who live in "developed" areas most likely have less than 1/4 of an acre they can call their own. This type of high-density development, so common throughout California, has given rise to the need for people to find *space*. People's need for space is evident on any Friday afternoon as millions of Californians travel from large urban and suburban centers to the rural parts of the state. The need for space is a driving force that brings people to the quiet, open and uncrowded lands that many hardwood rangeland owners call home.

Capitalizing on your ownership of space can unlock a number of economic opportunities. For example, does your land have enough space to allow people to come and enjoy your land while having a picnic and perhaps fishing in your pond? Is there enough space for a horse riding club? Have you ever thought of owning and operating a dude ranch? How do you feel about hunting clubs? Would you be willing to allow guided hunts of ground squirrels at $50/shooter/day? Would you be willing to establish a trap range, sporting clays course, or even a game bird preserve and allow controlled shooting and/or hunting? These are just some of the successful approaches that some landowners have implemented to increase the economic opportunities from their lands.



Hardwood rangelands provide excellent habitat for a variety of wildlife species including wild turkeys.

An additional method of increasing economic opportunities is through cooperation with neighboring properties. Although you need not enter into a joint project, it might be best if neighboring projects are complementary. Perhaps your neighbor has a water source that wildlife living on your property use. Communication with your neighbor informs them of your goals and objectives, limiting complaints and hard feelings, while offering an opportunity for collaboration. In some instances, collaboration between neighbors has increased the economic benefits for all those involved.

Questions you need to ask yourself

As with any new business venture, you must ask yourself some serious questions. These new, alternative forms of recreational enterprises do not fit the traditional approaches to ranching. In most cases, the landowner must first realize that some recreational programs are focused on offering a *service* rather than a *product*. **In order to determine if some of these programs could work for you, ask yourself these questions that were identified in chapter 2:**

1. How do I like working with people?
2. Do I enjoy providing a service rather than product?
3. Am I comfortable allowing strangers onto my ranch?
4. Can an alternative economic program become part of my on-going ranch operations?
5. Am I willing to meet the needs of my customers?
6. Do my family, friends, employees and/or neighbors favor the idea?
7. Do I enjoy meeting people and making new friends?
8. Do I enjoy the idea of taking on a new challenge?

As you can see, these are questions designed to help you decide if you're willing to change from being a primary producer (i.e. livestock producer) to someone who might be willing to provide a service (i.e. a hunting guide, resort manager, etc.). Often, this service-oriented approach is not suited for every member of the ranch family, but may be for one or two members who enjoy close interactions with people.

Fortunately, there is no right or wrong way to develop a recreational program. The most successful programs have been those where the landowner:

- has been innovative
- has been willing to provide a good product/service at a fair price
- has focused on quality not quantity.

There is no question that people are willing to pay to come and enjoy your space. The real question is, are you willing to let them?

Management Options

We will present three options for a landowner who wishes to develop alternative economic programs. *Option one*, the landowner develops, manages and markets the program(s) themselves or hires someone to do them, but still maintains close control over the operation. *Option two*, the landowner leases the property to an outside interest who does the management, bookings and marketing for a set fee while the landowner has little to do with day-to-day operations. *Option three*, the landowner leases to a club and allows the club to do the management. For any of these options, the landowner can enter into an agreement with the California Department of Fish and Game in the **Private Lands Wildlife Habitat Enhancement and Management (PLM) Program** to develop a comprehensive management plan. As a result, the landowner can extend both seasons and bag limits for selected species. This program is discussed in detail below. Innovative landowners may be able to develop other options they wish to explore.

Option One - Landowner Managed Programs.

Traditionally, a simple form of economic diversification was seen in the presence of "deer clubs" that began in the 1920s and have been very common throughout the state from the 1950s to the present. In most cases, the "club" was comprised of members and their extended families who returned year after year to hunt and enjoy the ranch. A benefit of such an approach was the peace-of-mind given to the landowner who:

- knew the people hunting on the property,
- was afforded some protection from trespassers and vandalism, and
- got a modest return from set fees that seldom increased.

This approach is still sound, and depending on the individuals involved, may still provide a favorable approach to resource and people management. However, the income generated is often not reflective of the full potential for the property.

Recently, some ranchers have taken it upon themselves to expand the "deer club" approach and offer memberships that allow rights to hunt not only deer, but also turkeys, feral hogs, migratory birds, and fish. In this approach, the concept of limited access is still strongly evident. However, the number of species being marketed has greatly increased. While the income generated is often substantially more than the traditional "deer club" approach, the amount of work involved is also proportionately increased. This expanded approach still allows limited access and protection against trespass and vandalism, but also offers an increased rate of return. Other variations which have been tried include: 1) Hire a guide and sell guided hunts on a per-day or per-weekend bases; and 2) Charge a daily access fee.

For example, a rancher in the foothills of the San Joaquin Valley in the mid-1990s had several permanent ponds intermixed among some beautiful, spreading valley oaks. He marketed trespass rights to fishing clubs, most notably to fly fishing clubs in the San Francisco Bay area, for $10/day/angler. A limit of 10 anglers/day was permitted. The clubs provided their own liability insurance for their members. All fish, in this case largemouth bass, were to be released unless the owner specified otherwise. In a very short period of time, he got to know the members who frequented his ponds. The members helped him develop a picnic area under some of the larger trees, and he received the benefit of some additional income. This was an opportunity for the anglers to enjoy the beauty of the property at a minimal cost to each member.

In some cases, private ranchers have contracted with guides to actually take the clients out into the field. An agreement between the landowner and the guide is made in advance. The guide is then responsible for bookings, guiding and game care. In this way the landowner is dealing with only one person (the guide), and the number of people on the property at any one time is limited. Additionally, you should insist that the guide has a business license and is bonded, giving an added layer of liability protection to the landowner. This is a common approach to hunting turkeys and feral hogs in the north coastal counties. In this case, the rancher receives a pre-determined fee regardless of whether the guide and client are successful. In this scenario, the landowner receives a fee for the trespass rights, while the guide charges for services rendered.

Option Two - Lease Options.

This is a more recent approach to helping an urban-based public obtain access rights to private land. It relies on a partnership between a landowner and a recreational organization which has developed large membership lists by securing a number of properties that offer a wide choice of options for its members. Typically, under this type of arrangement, a portion of the ranch is leased on a per acre basis (e.g. $1.75/acre/year). The price received will depend on the quality of the habitat. The actual duration of the lease is often negotiable to minimize conflicts with other ranching operations, and the ranch is then marketed to the organization's membership. In this way, the recreational organization can assemble a number of ranches that may offer a variety of recreational opportunities, such as hunting, fishing, camping, or horseback riding. The recreational organization schedules reservations to limit use of each property to a number agreeable to the property owner. This approach provides a form of recreational one-stop-shopping to a public that otherwise would have very few options.

The landowner is relieved of costs associated with liability insurance, marketing, and reservation bookings. This option is based on a partnership between the landowner and the recreational organization that shares the cost of providing the recreational opportunity to a limited, albeit large, membership. The landowner receives a pre-determined fee for the property; the organization charges an annual fee to its membership; and the members have access to private-land recreation.

Option Three - Management by a Hunting Club.

Landowners who want some income, but also want control over who uses the ranch, and not too much effort, choose this option. They contract with a local hunting organization that agrees to lease the ranch for hunting, and to manage the hunting enterprise. The rancher holds the hunting organization personally responsible for all activities on the ranch. There may be limits on the number of people on the ranch at one time, on the number of game removed, on seasons of use, and on the amount of habitat enhancement the club does. Often, the club will be required to purchase insurance at an agreed-upon value, naming the rancher or one of the insured parties as beneficiary. In one variation of this option, the rancher's contract is with one individual representing the club. This simplifies administration for the rancher and avoids the problems of shared responsibility.

This approach has similar characteristics and benefits as option two, but tends to be conducted on a more personal level. The price received is sometimes lower, but need not be. The rancher has the opportunity to become personally acquainted with those who use the ranch as they return throughout the seasons over the years. From the club's viewpoint, this option provides less variety than option two, but the experiences of members are more consistent. They have the chance to be well-acquainted with the area they hunt and with their hunting partners. This type of arrangement can be a bonding experience for the club members.

The PLM Program

A voluntary program exists for landowners who want to develop a more aggressive wildlife management program. It can increase their economic returns and extend bag limits and seasons. The Private Lands Wildlife Habitat Enhancement and Management (PLM) Program, administered through the California Department of Fish and Game, allows an individual landowner to develop a wildlife management plan that identifies:

- habitat improvement actions,
- population trends of wildlife species being managed, and
- overall planning, monitoring and wildlife harvest for the property.

The plan must be updated annually and renewed after a predetermined period of time. As part of the plan, the landowner and the California Department of Fish and Game agree to the number of animals to be harvested and the season when the harvest can occur. It provides an opportunity for a landowners to increase their income by offering an increased probability of harvest for the hunter and reducing hunter density at any one time, thereby providing a high quality experience. For a fee schedule and examples of how and where the program has been successful, contact the PLM program, California Department of Fish and Game, Wildlife Management Division, 1416 9th Street, Sacramento, CA 95814.

An example: The PLM program helped generate income while not severely impacting the resource on a ranch in northern Mendocino County. The PLM plan of this rancher proposed an archery-only approach for marketing late season trophy buck black-tailed deer hunts. It called for hunting in October and November with a limited number of bucks harvested each year. The landowner chose to market the hunts through various archery shops, sporting goods shops and the newspaper. Each hunt was 5-days with food and lodging provided for a cost of $1,600.

Legal Considerations

Every landowner or manager who collects a fee for hunting, or for access or rental that includes hunting privileges, is required to obtain a commercial hunting club license. In addition, if you charge to take people out on the property, you must be licensed as a "guide" and maintain a log of all your activities. Before getting started with a new hunting enterprise, you should check with the local representative of the California Department of Fish and Game's Wildlife Management program (usually this person is the local wildlife biologist).

Liability and Insurance

Liability insurance is expensive. As an example, premium costs for 1996 are in excess of $2,000/year for a hunting operation. This would vary by location, acreage hunted and number of hunters. While expensive, you should not consider developing a recreational program without exploring various insurance options. Beginning in the early 1990s, an increase in availability of insurance providers offering recreational insurance coverage began and has continued in California. You should shop among various providers to secure the best coverage for your particular needs.

Some methods to reduce premium costs include:

- Allow only members to have access to the land. Sell memberships, even to guests. Provide a membership card and other benefits, such as an off-season newsletter, Christmas cards, decals, hats, etc. For a hunting program, some type of membership system that allows for screening of unsafe hunters is often a prerequisite to obtaining an insurance policy.
- Place safety warning signs. Provide safety orientation and specifically warn of any known hazards. You can never over-emphasize safety.
- Have written procedures which include safety. Have employees (including guides) trained in CPR and First Aid with annual updates. Have necessary safety equipment available.
- For big game hunting, provide a guide with three hunters/guide maximum.
- Invite insurance underwriters to your land to see how safe your programs are. Your broker may be able to help arrange this.
- Waivers are a good idea. They may not hold up in court but they may prevent a case from getting to court.

Permits and Licenses

If you are considering a new recreational enterprise you must determine what county and state restrictions apply, and permits and licenses that are required to conduct a commercial enterprise. A tentative checklist for your convenience is provided.

County level

- ❑ business license
- ❑ zoning restrictions
- ❑ fictitious name statement (optional)

State level

- ❑ Commercial hunt club license (hunting only-California Department of Fish & Game)
- ❑ Guide license (all guiding for a fee-California Department of Fish & Game)
- ❑ Game bird breeders license (optional, only if game birds are bred and sold).

Recreational Enterprises

Hunting

A more recent type of landowner program involves providing access or guiding individuals or small groups for selected hunts. An example of fees being charged in 1995 are (prices are per hunter):

- regular season deer (buck) hunt $600-$800
- late season deer (buck) hunt $1200-$1500
- feral hog $350
- spring turkey hunt $350

Some hunting enterprises charge an additional fee only if the hunter is successful. In that case, a kill fee is charged to help remove the carcass from the field and dress and prepare the carcass for storage or transport.

The landowner/guide may only see an individual hunter or hunting party once per season. In this case, the hunter(s) would call in advance to make a reservation similar to reserving a hotel room or any other vacation destination.

Economic Considerations

As with any new economic venture, serious attention should be given to developing a budget as part of your business plan. A business plan should clearly define the proposed business. What will it provide, how and for whom? Where will materials and supplies come from? What start-up and working capital will be required to sustain the business? What needed skills must I hire? How much capital is required to start and sustain the business? The plan should be flexible and be written in such a fashion that allows you to adjust and amend it to meet your personal needs. As an example, Table 6-1 is provided to assist you in identifying items of importance that can help you determine the feasibility of a hunting program for your property. (Not all of the listed items may be necessary in your particular situation.)

Table 6-1. An example budget worksheet to determine hunting program feasibility.

Gross Income	
big game hunts (deer, elk, feral hog, etc.)	$_____
example: (# of hunts x $ fee/hunter)	
upland bird hunts (turkey, quail, etc.)	
small game & predator control (ground squirrels, coyotes, etc.)	_____
migratory birds (mourning doves, waterfowl)	_____
Total Gross Income	$_____
Direct Expenses	
Advertising	$_____
magazines	_____
trade journals	_____
mass media-	
newspapers	_____
radio	_____
Marketing (optional)	
trade shows	_____
recreational shows	_____
brochures	_____
Leasing land (optional)	_____
Wages, salaries and benefits ($/hour x # of employees)	_____
Professional fees (guide fees)	_____
License & permits (annual fees)	_____
Liability Insurance (annual fee)	_____
Family Labor	_____
Office Supplies	

computer software _____

office supplies _____

postage _____

utilities (phone, electricity, etc.) _____

Maintenance

trash clean-up _____

roads & gates _____

seeding & fertilizing _____

habitat improvement _____

fencing _____

Service Supplies and Equipment

lodging (laundry, janitorial, etc.) _____

food _____

Misc. _____

Gross Margin

Gross Income $_____

Direct Expenses _____

Initial Gross Margin $_____

Estimating Harvest Levels

To determine gross income from a hunting operation and to insure a sustainable approach to management, you must estimate the number of harvestable animals in advance. Setting harvest limits for any property can be challenging. If a record or history of harvests exists, this can be used as a starting point. For example, if a ranch has consistently harvested 15-20 bucks/year over a 10-20 year period, it would be safe to assume that an equal level of harvest can be sustained. If the enterprise is new, a survey of the deer herd should be considered. The local California Department of Fish and Game biologist can provide advice and may have local data concerning the buck to doe ratio and can provide a starting point for determining a harvest goal. U.C. Cooperative Extension can provide a manual that includes monitoring methods, and can also provide advice.

For any free-ranging wildlife species, harvest levels should be revisited, and if possible, revised annually to ensure sustainable herd levels are being maintained. This is particularly important during times of drought or other extreme environmental conditions which may increase mortality or decrease reproduction and thereby reduce population numbers. Similar approaches can be used for turkey, hogs and other resident wildlife populations.

Managing for Scale

Some landowners who have small to moderate (40-1,000 acres) holdings are sometimes reluctant to consider a hunting program for their lands. Serious concerns are often expressed regarding the use of high-powered firearms on relatively small parcels. Also, under normal conditions, a small parcel will not provide enough harvest to cover costs of the enterprise. Specialty hunts are one solution for small parcel owners. With the recent popularity of "primitive" styles of hunting (e.g., archery or black powder rifles), landowners with relatively small parcels have the ability to develop a niche market. Additional income can be generated with such intensive uses as trap ranges or shooting clays courses.

Example:

A private landowner who owned a 40-acre island in the middle of Clear Lake, Lake County, was concerned over the expansion of a herd of Barbados black-bellied sheep that were detrimentally impacting the oak resources on the island. The oldest members of the herd were 13 years old. The older rams exhibited very large and multi-curled horns.

The issues:

1) There were too many sheep on the island (70 head on 40 acres),
2) The older animals had definite market values as trophies, and
3) Capturing and transporting live animals off the island would pose a significant problem.

The solution:

The landowner developed a fee-sharing agreement with a local archery shop. The shop owner served as the marketing agent, bookings agent and guide. The guide sold hunts to selected clients for a price of $400/hunter. In this case, only the oldest rams with the largest horns were selected as "trophy" animals. Through this approach, the landowner was able to market individual animals to hunters who were willing to pay a very high price for the chance to harvest an exotic species. This partnership provided a lucrative solution for the landowner, while allowing the guide to provide an attractive service to his customers. This is what is meant by the slogan "turning lemons into lemonade".

Similar approaches can be used for owners of smaller properties who are interested in selling rights for black-powder only hunts (deer and hogs) and archery hunts (deer, hogs, and turkeys). These types of approaches generally focus on providing a quality hunting experience for the customer and do not necessarily focus on the need to harvest an animal.

Economy of Scale

The cost of start-up for any new recreational hunting program is often similar regardless of how big the initial size of the program. The cost of insurance, licenses and permit fees are constant regardless of the size of the operation. These baseline costs can impede some small landowners from getting into a hunting program. This may be a situation when a cooperative approach with neighbors may help justify the initial start-up costs.

Moderate to large scale landowners (> 1,000 acres) may have more options available to help defer the initial start-up costs. Owners of smaller parcels may want to consider working with adjoining landowners to form a cooperative approach to hunting. A multi-species or multi-activity program should be considered.

Examples of multi-activity approaches (in addition to a big game program) for larger land holdings are:

- a membership list that allows selected shooters to come out to the ranch and pay for the opportunity to shoot ground squirrels or other small game for a day,
- a trap range or sporting clays course that has regularly scheduled events with a family theme (i.e., barbecues, father-daughter days, etc.).
- day hunts for turkeys, morning doves or waterfowl.

The multi-activity approach limits the numbers of days hunters or shooters are on the ranch and limits the time that the landowner has to invest, while increasing the gross margin to help off-set the annual costs and fees.

Non-Hunting Programs - Fishing, Camping, Hiking and Riding

If you have camped in private, state or federal campgrounds in California, you are aware of the popularity of these destinations for vacationers. Lands that can provide aesthetically pleasing camp sites, nature trails, swimming holes, and/or quality fishing spots (ponds or streams) are marketable.

Collaboration between landowners and organizations, such as riding clubs or conservation organizations, is another way to minimize trespass problems, minimize advertising/marketing investments, and reduce costs and fees. A collaborative effort could also be used to reduce insurance costs, if the collaborator is willing to provide its own insurance.

An example of such an innovative approach is a group of ranches located on the Sutter Buttes in the Sacramento Valley that came together to form a Natural History Association. Every weekend between March and May, a naturalist leads nature hikes for a fee of $25/person. The guide and landowners have an agreement on how to share the fees, what portions of the ranches are available on any given day, and the Association serves as the reservation agent. The weekend trips are usually sold-out.

Innovative Approaches

Do not be afraid to explore new and innovative approaches. A newly emerging idea is a concept known as *eco-tourism*. Landowners working with travel agents are beginning to provide eco-tours to bird watchers and wildflower enthusiasts from around the world. People are willing to pay for a tour to visit geographical regions of the state to view California's unique fauna and flora. An example of how this might work is: An agreement between a landowner(s) and a travel agent allows the agent to market tours to foreign individuals or small groups who want personalized service to view wildflowers in the spring and birds throughout the year. The landowner could then work with a local Audubon Society or Native Plant Society chapter (as volunteers or paid employees) to serve as docents or guides.

Case History

A successful example of an individual who developed a recreational program that complemented an existing livestock operation is a 4,000 acre ranch in Potter Valley, Mendocino County. The recreational program was started to increase revenues on a family-owned ranch which was struggling due to static livestock prices and increasing business costs. The owner put together a program that utilized neighboring ranches, multi-species and multi-activity components that maximized the use of his "space".

In 1980, tule elk were released on public lands adjacent to the ranch, and were afforded total protection for a number of years. The elk were responsible for a number of problems, including the need to reduce the number of livestock on the ranch to off-set the impacts of the mobile elk which quickly abandoned the public lands and began foraging on private land, reducing the availability of food for livestock.

Fortunately, for the ranch, the re-introduction of tule elk into Potter Valley was so successful that the herd reached a manageable size in the early 1990s. A fee-hunting business was formed with three neighboring landowners to begin marketing and harvesting surplus elk. The group developed a PLM plan and had it approved by the California Department of Fish and Game. The plan has been revised annually as needed. During the first two

years, a guide was hired to do most of the marketing and guide service. For the past three years, the association of landowners has assumed these activities.

In addition to the tule elk hunts, the rancher began to raise game birds (pheasant, chukar and bobwhite quail) and established a game bird preserve. The birds are sold to members who hunt between September and May. He and his family book all of the reservations and work directly with the clients. In 1994, he raised nearly 4,000 birds and is now exploring marketing the birds to local wineries and gourmet restaurants that are interested in offering their customers more exotic choices.

In addition to the ranch's elk and game bird programs, a shooting program was initiated about the same time as the game bird program. "Sporting clays" is a trap shooting course in a natural setting where the shooter is confronted by unexpected artificial flying targets in a natural setting. A sporting clays course was established and offers monthly competitive shoots to the public. Collaborative events have been held with the Rocky Mountain Elk Foundation and the California Waterfowl Association as a marketing tool to serve as a fund raiser and as a source of advertisement.

Most recently, the ranch has developed two new programs. Family packages offer camping, fishing, and shooting activities and are aimed at attracting clients who are interested in a quality experience. Secondly, as most ranchers can attest, ground squirrels can often be a serious nuisance to rangelands. To minimize the use of rodenticides, the ranch now offers small game shoots to members for $50/day/shooter. The program has been so successful the landowner is now negotiating with more ranches to expand this small game hunting program.

It is not difficult to imagine the amount of work and time this landowner has put into developing these new programs. However, after nearly two years of effort, he has increased his gross income by $90,000. His annual costs include business licenses, permits and fees, insurance premiums, guide licenses, and cost of marketing. Cooperating with neighbors on the elk program has reduced insurance, marketing, and advertising costs. Additionally, by looking at various markets for his game birds, he is expanding sales while still meeting the needs of his customers. The shooting program allows him to collaborate with a number of conservation organizations to help promote his business while helping them raise funds for their organizations. In a very short amount of time and with a great deal of work, he has demonstrated the tremendous potential for landowners who are interested in developing alternative recreational programs on their oak woodlands.

Balancing Needs

Concepts of sound multiple-use management should be applied to any land base on which recreational enterprises may be undertaken along with grazing and more traditional land uses.

Multiple-use management requires a balancing act by landowners and land managers to meet the needs of a variety of resources including livestock and wildlife. Quality hunting opportunities for which clients will pay considerable amounts of money largely depend upon healthy game populations, good habitat conditions and minimal human disturbance. You cannot expect to have a successful recreational program if these three characteristics are lacking.

For example, too much livestock grazing, particularly in key wildlife habitats such as riparian areas, wetlands and meadows, may reduce habitat quality, thereby causing declines in the health and number of desired game species. Furthermore, wildlife habitats that have been adversely modified through vegetation removal, water diversions, agricultural operations, etc. likely will not support large and healthy wildlife populations. Recreational programs based on quality hunting opportunities will certainly suffer under these circumstances.

Juggling a variety of land uses can be challenging, given the ups and downs of economic markets, weather and land conditions. However, recreational programs in California's oak woodlands have demonstrated value. Recent research by the University of California's Integrated Hardwood Range Management Program found that on relatively low quality grazing lands, net income from hunting can exceed that of livestock grazing and firewood cutting. On high quality grazing lands, hunting values can be comparable to that of grazing.

Landowners should look at their lands much like an investment professional looks at a stock or mutual fund portfolio. Diversification is the key to successfully handling the ups and downs of today's economy and land conditions. Landowners operating a diversified multiple-use program incorporating livestock grazing and recreational programs should be in a better position to reap the financial and personal rewards of a well managed property.

Chapter Seven

Open Space and Private Land Oportunities for Hardwood Rangeland Conservation

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Don't discount the value of your woodlands just because they occur in suburban settings. Individual trees and small stands may not serve as a true biological reserve, but the value of these areas for wildlife habitat, and as a bank for maintaining ecosystem function, may surprise you. Oak stewardship can be expressed by planting backyard trees for nesting birds. It can be a neighborhood program to create a vacant-lot woodland or to leave a woodland winding though a row of backyards. Stewardship can mean community -organized clean-up of woodlands to promote ecosystem structure and function. None of these oak woodlands will deliver all the resources our society demands, but in a cumulative sense, they all contribute bits and pieces of a conservation continuum.

Suburbanization is shifting California's population out of cities and into hardwood rangeland areas. Highway accessibility and the new infrastructure of California's economy have created entire new cities and ranchette communities in outlying regions. Further expansion of industry and commerce in the foothills could alter large areas of oak woodland, but the timing and nature of this expansion are unpredictable. Woodlands are desirable to relocating industries both for their aesthetic appeal and relative low cost..

Most woodlands around urban areas are already highly fragmented, in private ownership, and likely to be developed in some manner over the next 50 years. Woodland management in suburban areas is increasingly influenced by local interest groups and public policy. Woodland owners along the wildland urban interface often find that their management options track public demand for specific values. If woodland conversions trigger a public demand for amenity protection, the solutions typically must be found on private lands, since state and local governments are unlikely to be able to afford to develop a system of large, publicly-owned preserves. Open space or conservation easements, and other deed restrictions such as transfer of development rights (TDR), can provide financial, tax, or development incentives for the voluntary maintenance of public amenity values on private lands. These should be evaluated very carefully, however, in that there are costs involved since there are permanent changes in a landowner's property rights.

With the continued large influx of new residents into California's hardwood rangelands, application of conservation principles will go a long way towards maintaining healthy hardwood rangeland ecosystems. For owners who possess significant amounts of hardwood rangelands within a region, the use of conservation easements or TDR's can help improve their economic well-being through tax incentives, or through direct payment from land trusts, developers, or recreationists.

Historically, the market value of hardwood rangelands for subdivision near urban areas has exceeded their value for amenities and ecological functions. The recent human population increase in hardwood rangelands, however, has raised the potential values of woodland amenities to a point where conservation is often a financially viable alternative to land development. Landowners may find that marketing the woodland conservation values provide the best financial scenario, especially if they own woodlands with high conservation value. Conversely, land owners outside of the suburban fringe may find that their properties are not increasing in development potential and are unlikely to be considered for designation as woodland open space.

Current Constraints and Woodland Conversions

Conversion of hardwood rangelands to urban landscapes is seldom a complete process. More often, the landscape created by conversion is a mosaic of woodland resources imbedded within other land uses. Woodlands often remain, while the area around them is converted and fragmented, because of oak protection ordinances or because they occur on steep slopes or drainages. However, the value of these oak ecosystems can decline as ad-

joining habitats are lost. If wildlife movements between stands are altered by barriers such as housing, then populations may also decline. The ultimate examples of isolation are oaks left in turf or garden, where single canopies become islands of habitat. All remnant woodlands provide some conservation opportunities; however, the opportunities provided by native oaks in Pasadena gardens are profoundly different from those provided by landscapes east of Sacramento dominated by blue oaks.

Although many hardwood rangelands in urban areas have become isolated islands, some still view them as vast, unspoiled landscapes. There was a time when hardwood rangelands could absorb all of society's needs to picnic, hunt, ride horses, and hike. While demand for outdoor recreation has dramatically increased, woodlands have declined in acreage and became increasingly isolated. There is a clear danger that demand will exceed supply; nature enthusiasts will literally love woodlands to death! For example, approximately 700 persons per year used woodlands at Whiting Ranch, Orange County, in 1990. When the area was declared a park in 1992, the observed number rose to over 30,000 hikers and bikers per year. Meeting the demand for outdoor recreation, from bird watching to mountain biking, promises to be one of the biggest challenges in the future. However, it can also create a market opportunity for some landowners who are willing and able to supply these outdoor opportunities for a fee (see Chapter 6).

Development and Conservation Options

If you wish to subdivide, brush, grade, or alter your parcel, a permit will likely be required by the county. Through this permitting process, you and the county officials may be obligated to disclose your plan under the California Environmental Quality Act (CEQA) or other environmental laws. In most counties, the process can be streamlined if you can prove that your project has no significant impacts. In the best of circumstances, your project may be able to coexist with sensitive woodland resources on your property and a negative declaration of significant impacts may be granted through this streamlined process.

In many cases, however, mitigation plans may be built into your plan in order to reduce any possible impacts below a significant level, thereby avoiding the need for a full environmental impact report. Under the CEQA process, a Negative Declaration, where no significant environmental impacts are expected, may suffice in lieu of an environemntal impact report. Given the cost and time commitment of a full environmental review, it is almost always in your best interest to file a mitigation plan along with your development plan. Mitigation actions may be necessary if your project is to get a Negative Declaration. It must be shown that your proposed mitigations are feasible. It is recommended that consulting biologists and other environmental professionals be retained to develop the environmental documents and mitigation plans. Proposed mitigations should have proven success that are acceptable to your county and other government officials. Untested concepts and unsubstantiated statements are the primary reasons for denial of projects. Furthermore, environmental documents and land management plans should be linked.

The most straightforward forms of mitigation are onsite guarantees that impacts to sensitive resources are avoided and won't be damaged either in the process of completing your work or with future activities. One of the oldest and most successful ways to avoid impacts is the conservation easement. This deed restriction defines an area of the property that is set aside to conserve resource values. By accepting this condition to your deed, the value of your property may be altered because future owners will not be able to manipulate the easement area. Woodlands are a highly desirable commodity in most urbanizing areas, and buyers purchasing ranchettes may seek properties with woodlands, even when the properties come with conservation easements or other conservation deed restrictions.

Given the growing number of parcel divisions and subdivisions in oak woodlands, it may be difficult for the county or appropriate local jurisdiction to accept conservation easements as mitigation. However, local jurisdictions are more apt to accept easements if public trust agencies, such as the California Department of Fish and Game, accept them. Typically, the most acceptable easements are linked to other easements or with adjacent or nearby public woodlands. Since the ecological value of small, isolated habitats has been questioned in the scientific literature, counties are less apt to justify negative declarations because of the logistics involved with managing many small easements.

If you don't plan to develop your woodlands, you can still apply for tax relief by donating a conservation easement to a public trust, such as the Trust for Public Land or local land trusts. The process does limit your ability to alter your woodlands at a later date. However, if you wish to see your woodlands conserved for future generations, then a deed restriction is your best guarantee. The advantage here is that a wide variety of deed restrictions can be negotiated, while still having the option of using many different governmental or non-govern-

mental organizations to receive the easement. A local land trust may want to receive an up front fee or an annual payment to cover the cost of monitoring compliance with the easement.

The sheer volume of land development hardwood rangelands in the 1970s and 1980s, especially in southern California, the central Coast, and the central Sierra Nevada, resulted in a number of creative mitigations involving the purchase or protection of off site resources. Mitigation banking was initially designed to concentrate protection in large areas of sensitive and important wildlife habitats, thereby allowing land developers to mitigate habitat losses by purchasing and protecting off site lands with equivalent or similar habitat. Mitigation banks allow landowners to maintain rare, sensitive habitats because the landowners assume that land value will rise in the future as fewer areas are available for offsite mitigation. Developers acquire mitigation credits by purchasing all or some portion of the bank. There are several mitigation banks already in operation on private lands near urban areas, principally involving wetland habitats. In several areas, hardwood rangeland owners have received lump sum cash payments or annual rental fees in exchange for agreeing to allow their land to serve as a mitigation bank for a project. The practice has been most successful for large impacts, such as dam construction, that are mitigated on even larger parcels of land. The future use of this benefit is expected to increase for smaller-sized parcels, as resources become increasingly scarce. Mitigation banks are carried when the land ownership changes hands.

Management Considerations

Your management goals, derived from the worksheets in Chapter 1, combined with an assessment of the property's resources (see Chapter 3), can help you derive your management options. If you are interested in developing or enhancing the conservation value of your hardwood rangeland property, options will be strongly influenced by what's happening in your region and on adjacent properties. Developing and understanding the interaction between your management actions and the surrounding landscape is an ongoing process. Your initial management goals will define the extent of landscape interactions. In turn, knowing how the landscape may affect or be affected by your goals may lead you to change some of your plans. Chapter 4 helps describe some of the landscape and habitat relationships that need to be considered. For example, if you are managing for wide-ranging bird or mammal species, the landscape unit of interest to you may be hundreds of square miles. If you are managing for salamanders, the landscape unit of interest to you may be only a few acres.

Look through the questions and issues raised below to get a feel for how your woodland property fits into the landscape and the conservation goals you have in mind. The assessment you carried out in Chapter 3 and the maps and aerial photos you collected will help you to address these issues.

1. *How many acres of woodland do you have?* If you have less than 10 acres of woodland, you likely have joint management issues with adjoining parcels. Most of the woodland management carried out by your neighbors will affect your options. In addition, your acreage is not large enough to support most wildlife species without including your neighbor's woodlands. If you live in a community of small ranchettes, it may be useful to form habitat or ecosystem management groups to address cross-property habitat issues. The flexibility of these groups can often be more effective in meeting conservation goals and regulatory conditions mandated by various agencies. With 10 to 50 acres of woodland, you begin to have some independence from the actions of your neighbors, but they are still a very large part of your management landscape. With greater than 50 acres, you can begin to see species, ecological processes, and habitat structures that may be contained completely within your property's boundaries.

2. *Set a boundary around the region that influences your property.* The watershed is a commonly used perimeter of influence for many ecological values. However, animal and plant distributions may encompass parts of many watersheds. You should use whatever boundaries best encompass the processes or species activities you wish to manage on your property. If you are trying to ensure the survival of a pair of golden eagles, you may want to use their home range as a region; if you are managing for a species of tree, you may want to include all the adjacent watersheds where the species occurs. You should seek the advice of local resource professionals to help you decide on the regional boundaries that best encompass ecosystem structures and processes that may be affecting your woodland management.

3. *What proportion of your region is in woodlands?* Are your woodlands surrounded by grasslands, other vegetation types, or urbanization; or are you in a large, undeveloped woodland area? Woodlands with lower proportions of other land-uses typically require smaller reservoirs of woodland resources (such as animal species, pollen,

or seeds) to reestablish and re-colonize woodlands after disturbance. The smaller the proportion of woodland, the greater probability that any action you undertake will affect all of your region's woodland resources. Higher proportions of intact woodlands create increased opportunities for land restoration and can diminish the need for intensive individual management.

4. *What is the pattern of woodlands in the region?* Are your trees part of a large, natural expanse of regional woodland, or do the woodlands in your region occur as scattered stands? Naturally scattered woodlands are typically well connected to surrounding vegetation, so the woodlands on your property may share species, structure, and processes with these adjoining ecosystems. Large areas of undivided woodland typically have species, structure, and processes that are dominated by oaks or other hardwoods. More importantly, historically large woodlands can be dominated by woodland processes that can't continue to function in fragmented landscapes.

5. *How does your woodland fit into the regional woodlands?* Is your woodland the last patch of trees scattered in a suburban landscape? If so, you have few opportunities for woodland conservation and it may take an enormous amount of energy to hold off external influences such as development pressures of disturbances from fire, windthrow, or insect outbreaks. Is your property part of a scattered woodland landscape that is separated by houses, roads, or fences? Trees and probably some species of birds can be maintained, but it may be difficult to restore ground-dwelling wildlife species that may have become lost in the development process. Is your property on the edge of a woodland? If so, you may have a gradient or mixture of two very different sets of species, structures, and processes. Does your property form a connection between two regional woodlands or is it part of a linear woodland (such as a riparian corridor)? Then it may be an important link for wildlife or pollen movement between regional or local woodlands.

6. *Do you have resources of regional significance on your property?* The resources discussed in chapters 3 and 4 do not necessarily occur across landscapes. In many cases, springs, cliffs, nest sites, snags, mineral licks, or other important wildlife resources may be highly localized. Do you have the major source of surface water for your region? If so, you may be responsible for the welfare of many of the region's wildlife species. In contrast, all of your efforts to enhance wildlife habitats will mean very little if your neighbors decide to remove a regionally significant resource from their property.

Suggestions for Open Space and Easement Design

Shown below are some general ideas for planning for open space and conservation easements on your hardwood rangeland property.

- Always attempt to link your easements with those of adjoining properties.
- Avoid small easements in high density housing unless you have the resources to protect woodlands from external forces.
- Manage your woodland ecosystems as a comprehensive unit rather than by component parts such as specimen trees or individual species.
- Take advantage of the wide variety of deed restrictions and assistance from stewardship agencies to achieve your specific goals for woodland conservation.

Chapter Eight

Resource Evaluation for Forest Products

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Historically, rangeland hardwood trees of California were a local resource for specific needs. The indigenous cultures were aware of the value of these trees for basket materials, fuel, and food (acorns). Some of the higher density hardwoods were also recognized for their excellent strength and carving characteristics, making them a good resource for various implements. Early European settlers relied on local materials, including rangeland hardwoods, for building structures, making implements, and fuel.

Population growth in the state has had a definite impact on the rangeland hardwoods. Throughout history, rangeland hardwoods were a source of fuel. They provided some of the fuel required to operate the steam engines of the early 19th century, particularly along the larger navigable rivers and along the railways. Firewood has always been an important source for home heat in many rural communities. Beginning in 1972, firewood consumption for home heating increased dramatically in response to a nationwide energy crisis and the increasing availability of efficient wood burning stoves. Hardwoods were also cleared for population centers and agricultural needs; by the middle of the 20th century over a million acres of rangeland hardwoods had been removed to clear the land.



As we move into the 21st century, societal pressures are causing a reevaluation of our natural resources with an emphasis on sustainable production and improving rural economies. In certain situations, rangeland hardwoods may be a viable resource for local needs or specialty products. Availability and quality concerns make it unlikely that any rangeland hardwoods could supply a commodity market; however, based on the properties and characteristics of the wood, successful niche markets are possible. Local products made by artisans, woodworkers and hobbyists prove that high value products can be made. In fact, value-added products can be produced from any type of wood, but special manufacturing techniques and innovative marketing strategies may be required to do it economically.

The desire for increased utilization must be balanced with the valid concerns for wildlife needs, areas with poor regeneration, and the inherent slow-growth of most rangeland species. In some cases, these concerns may result in the inability to maintain sustainable production. This chapter summarizes the available information and offers guidelines that can help resource managers assess the economic potential and sustainability of utilizing rangeland hardwoods.

Potential for Utilization as Timber-Based Forest Products

A general requirement for evaluating the potential to produce a wood product is to understand the relationship between wood quality and manufacturing requirements. Tall, straight trees with few branches on the main stem are the ideal lumber tree. Grain deviations in wood, such as spiral grain, diagonal grain or the deviation of grain around knots, are the leading cause of warped lumber. There are numerous limitations to the utilization of rangeland hardwoods, including:

- low proportion of stem to branch wood,
- unknown or poorly understood wood properties, and
- unproven product performance.

The spreading, highly-branched tree form of most rangeland hardwoods creates numerous grain deviations making them a low quality timber tree by standard log and lumber grading rules. The low proportion of stem to branch wood results in a low yield of usable material. Although many of these branches may be large enough to produce lumber, branches produce poor quality lumber, since they have high percentages of reaction wood which is highly susceptible to severe drying defects.

Very little scientific research has been performed on the wood properties of most California hardwood species because of the lack of a strong commercial interest. The exceptions are California black oak, tanoak and madrone. These are primarily timberland species but they can also be found in some rangeland regions. Of all California hardwoods, these three species have the greatest utilization potential. Inherent variation in properties and the high density of most of the other species makes them difficult to process with current technology.

Because of the dearth of information and the undocumented performance of wood products made from rangeland species, it is difficult to predict product performance. Although machining studies have not been performed on most of these species, it is expected that the higher density, fine-textured woodland species [such as the live oaks (canyon, coast and interior live oaks) and California white oaks (valley, blue, and Oregon white oaks)] will machine well. However, the higher frequency of knots and grain deviations in these woodland species may result in a higher percentage of surface defects than found in timberland species. Sometimes the best information available is that passed down by local woodworkers and crafts people who have experience working with these woods. Generally their comments support the contention that the higher density hardwoods work well. The limitations discussed above do not mean that valuable products are unattainable, but rather that extra processing steps and great care are necessary.

Potential Products

While most manufactured wooden products could be made from the rangeland hardwoods, some species are particularly suited for specialty products. For example, wine barrels and implement handles have very special property requirements that can be met with some of these woods. Wine barrels require an impermeable wood with flavor components compatible with wine. White oaks from the Eastern US and Europe are the preferred species due in part to the presence of tylosis which plug the wood pores. Two native California white oak species, valley oak and Oregon white oak, also exhibit these properties. Implement handles require species with the high strength properties of impact bending and toughness. These properties are common in most of the high density rangeland hardwoods, especially the oaks.

Based on wood property considerations, other categories of potential wood products can be identified. Table 8-1 presents a partial list of potential products and material property requirements which can serve as a guide for identifying potential uses for rangeland hardwoods. Trees can be used to make solid wood products where the wood grain and texture qualities are readily apparent, or the wood can be broken down into particles or fibers and used in this form or reconstituted into a composite product. These products have been grouped on the basis of the potential value for the raw material.

Based on the information summarized in Table 8-1, and a knowledge of basic wood properties, it is possible to identify some possible uses for rangeland species. Table 8-2 is a compilation of the best available information for some rangeland species, tempered by the experience of past and present woodworkers. The information in this table should be considered only a starting point for determining the viability of using particular woods for various products. Because of the inherent variation in wood properties and the small sample sizes used in many of the studies referenced, the properties may be noticeably different from location to location. When considering this information for developing new enterprises, it is important to remember that species can be matched to products on the basis of the properties of the material, but the limiting factors are usually availability, size, and quality of the resource.

Table 8-1. Requirements for various types of wood products on hardwood rangelands.

Economic Value	Wood Product	Product Requirements
Low Value	Firewood	High density species unsuitable for higher products, cut to standard lengths (10 - 16"), air dried (preferred moisture content <20%)
	Chipped or hogged for fuel	No specific requirements, high density and low moisture content (<20%) is preferred
	Chipped for compost or mulch	Most species (some have herbicidal properties)
Moderate Value	Non-grade lumber	Any species, log length, quality, can be used, but creative marketing sometimes needed
	Pallets, dunnage, shipping containers, etc.	High strength/weight ratio desired, low quality wood acceptable
	Fencing & landscape timbers	Species resistant to decay, or wood that can be effectively pressure treated with preservatives
	Chemical feedstock (producing wood extractives or ethanol)	Clean, dry chips of a single species are preferred
	Pulp or composite panel chips	Clean chips of specific species and particle size, low to moderate density species required
	Charcoal – (activated or lump for cooking)	High density hardwoods of any quality or species, activated requires special processing
	Animal bedding or litter	Low density wood, clean chips, shavings, or sawdust (some woods may have chemicals injurious to some animals)
	Excelsior – specialized wood shavings for packaging	Low density wood, dried
	Flavor wood – chips added to cooking fire for smoke or flavor	High density hardwood with interesting aroma or flavor characteristics
	Molded products, e.g. densified fuels (fuel pellets or firelogs)	Mixed species acceptable, uniform particle size and moisture content required
High Value	Grade lumber for finished products such as furniture	Commercially recognized species, log lengths of 8' or greater with at least 2' lengths of clear wood between knots on one face of log, kiln-dried to 8% moisture content
	Grade lumber for flooring	Clear wood (no knots) of various lengths, high degree of hardness, good dimensional stability, kiln-dried to 8% moisture content
	Non-grade lumber or burls for custom furniture, picture frames, artistic woodworking, and other specialty uses	Attractive appearance and character, various lengths, clear (knots sometimes acceptable for special appearance), good machining and finishing characteristics
	Cooperage staves for wine barrels	Wood with low permeability (e.g. white oak), favorable flavor characteristics
	Tool handles	High density, high impact strength (toughness), straight grain, knot free, standard handle lengths

Table 8-2. Properties and utilization potential for some rangeland hardwoods.

Genus	Common Name	Density at 12% moisture content (g/cm^3)	Machinability	Drying Difficulty	FIREWOOD	PULP CHIPS	COMPOST	NONGRADE LUMBER	PALLETS	FENCING	CHEM FEEDSTOCK	PULP & COMPOSITE	CHARCOAL	BEDDING	EXCELSIOR	FLAVORWOOD	MOLDED PRODUCTS	GRADE LUMBER	FLOORING	CUST. FURNITURE	COOPERAGE	TOOL HANDLES
Acer	CA Box-elder	<0.5	?	?				x						x	x	x						
Aesculus	CA buckeye	<0.5	Fair	Easy		x	x			x					x		x					
Alnus	Red alder	0.43	Good	Easy			x		x		x	x		x	x		x	x				
Arbutus	Madrone	0.68	Excellent	Difficult	x	x	x	x					x			x		x	x	x		x
Castanopsis	Chinkapin	0.50	Good	Easy	x	x	x	x				x					x	x		x	x	
Eucalyptus	Blue gum	0.80+	Good	Difficult	x	x		x			x	x	x						x			x
Fraxinus	Oregon ash	0.61	Good	Moderate	x	x	x	x					x					x	x	x		x
Juglans	CA black walnut	>0.50	Good	Difficult				x											x	x		
Lithocarpus	Tanoak	0.67	Good	Difficult	x	x	x	x			x	x	x					x	x	x	x	x
Platanus	Sycamore	0.58	Poor	Moderate		x	x		x					x	x		x					
Populus	Cottonwood (poplar)	0.38	Poor	Easy			x		x		x	x		x	x		x					
Salix	Willow	0.48	Good	Easy			x		x							x						
Quercus	CA black oak	0.60	Good	Moderate	x	x	x	x	x		x							x	x	x	x	
	Blue oak	>0.60	?	Difficult	x	x	x			x			x							x	x	x
	Engelmann oak	>0.60	?	?	x	x							x									
	Live oak	>0.60	?	?	x	x							x						x	x		
	Valley oak	0.68	Good	Moderate	x	x	x	x		x			x					x	x	x	x	
	Oregon white oak	0.74	Dead	Difficult	x	x	x	x		x			x					x	x	x	x	x
Umbellularia	CA bay laurel	0.62	Dead	Easy	x	x	x	x					x						x	x	x	x

Manufacturing Considerations

As a general rule, lower density California hardwoods present fewer manufacturing difficulties than higher density hardwoods. These difficulties must be considered in processing the higher value, solid wood products. In most situations, the extra effort and care required to deal with these difficulties will not pay off for most of the low and moderate value products. The following discussion refers specifically to high value uses, but many of the same ideas can be applied to the lower value uses.

Processing Recommendations

The hardwood industry in the United States developed around large diameter, high quality trees of the Northeast and a minimum log length of 8 feet. The decreasing quality of the available resource has led to new innovations in processing aimed at maximizing quality lumber production from small diameter, low grade trees. A basic knowledge of wood behavior and processing techniques is important to help minimize the problems associated with lumber production from high density California hardwoods. Processing lumber can be considered as three steps: harvesting, sawing, and drying.

Harvesting.–It is important to recognize the utilization potential of trees before they are cut. Some trees will have very little potential and should be left in the forest or removed as firewood or other low value product. Of the trees that are selected for removal to be processed as lumber, it is important to cut log lengths that maximize the highest quality lumber. This means cutting to lengths that maximize straight grain and minimize the presence of knots or other defects such as decay or insect damage. For rangeland hardwoods, this often means short log lengths of 6 feet, or if your sawmill can handle it, even 4 feet.

Sawing.–The goal of any sawmilling operation should be to produce the greatest number (maximum yield) of uniformly thick, high quality boards possible in each log. To maximize yield, it is important to carefully select a rough/green thickness and to remove as little as possible when squaring up the round log. The rough/green thickness must take into account the amount of thickness reduction due to planing (about 3/16 inches) and the loss to shrinkage when the board is dried (about 5%). As an example, to produce a surfaced, 1-inch thick, kiln dried board the rough/green thickness should be 1.25 inches (0.19-inch planing allowance + 0.06-inch shrinkage allowance). To maximize quality, it is helpful to visualize how the boards can be cut from a log before sawing it into lumber. In most cases, the highest quality boards will be obtained by positioning the log so that the knots are positioned on the edges of a board so that they can be removed by edging the lumber.

Drying.–California hardwoods have a reputation for being hard to dry. However, with the proper care, good results can be obtained. Knowledge of physical properties provides a basis for predicting how wood will dry and how it will perform in service. Density is a good predictor of ease of drying and dimensional change. Changes in wood moisture content are a good predictor of the potential for warp. The higher density woods are generally more difficult to dry and less dimensionally stable than woods with a lower density.

Most of the problems encountered in drying are related to stresses that develop during drying. The high degree of grain deviations expected in most rangeland hardwoods suggests that lumber cut from them would have a tendency to warp. Warp can be minimized by drying lumber in thicker dimensions or placing restraint on the boards to keep them flat during drying.

Collapse, honeycomb, and casehardening are drying defects that occur because stresses are created inside wood as the water leaves and the wood shrinks. Although these defects are not apparent until the wood is nearly dry, they actually begin developing very early in drying. This critical stage is from the initial green moisture content down to about 25%. Once the average moisture content (MC) reaches about 25%, then more severe drying conditions can be used safely.

With a knowledge of drying principles and adequate control over the drying conditions, quality dry lumber can be produced with any drying method. If long drying times are not a concern, air drying can be an effective method for the critical drying stage. But, even in an air yard, the drying conditions can be too severe. Avoiding direct sun exposure on the wood and positioning lumber stacks (relative to wind direction) to increase or decrease the amount of air that passes through the lumber stack are ways to gain some control over nature's drying conditions. Ideally, the drying method should be capable of drying wood to 8% MC, achieving a temperature of 160° F (the temperature required to sterilize insect-infested wood), and having a method to reintroduce moisture at the end of drying so that casehardened lumber can be conditioned to relieve the drying stresses. A kiln is needed to accomplish these goals.

A solar kiln is the least expensive kiln method, but it is difficult to achieve 160° F and to condition the lumber without auxiliary equipment. A dehumidification kiln is generally less expensive than a steam-heated kiln, unless

an inexpensive steam source is available. Some dehumidification units have a maximum operating temperature of only 120° F but units are available that can reach 160° F. A small steam generator should be added to a dehumidification kiln in order to condition the lumber and minimize the problem of casehardened lumber. A steam-heated kiln gives you the most control over the drying conditions but it is also the most expensive unit to purchase.

Market and Economic Considerations

Identifying Markets

As discussed above, many of the common hardwood consumer goods could be manufactured from rangeland hardwoods based on their physical and mechanical properties. Obviously, some woods are better suited for particular products than other woods. Also, factors such as resource availability, cost of production, and quality of the end product are important in determining the long term viability of a business venture. An important question to address when considering a new enterprise is the character of the market being targeted. Examples of the types of markets that may be targeted include:

- Commodity lumber
- Crafts and local woodshops
- Local wholesalers/retailers
- Manufacturers

Although there is a commodity aspect to all of the above markets, the niche market holds the most promise for the rangeland hardwoods. The commodity lumber markets demand large volumes of lumber, readily available at a competitive price and manufactured to existing industry standards. In contrast, the niche market is more flexible because a specific product or customer is targeted and the product is tailored to the customers needs.

In addition to the classic commodity and niche markets, the emerging market of "environmentally friendly products" has real potential for California's hardwoods. Recent surveys indicate that many consumers would like to be able to buy products made from wood obtained from sustainably managed forests that are sensitive to environmental concerns. However, the message is mixed; it is not clear if consumers are willing to pay more for these products. In California, there are at least two organizations with certification programs for "environmentally friendly" wood products: Scientific Certification Systems in Oakland, California, and the Institute for Sustainable Forestry in Redway, California.

Quality Control

A key to the success of any processing enterprise is to produce consistent quality products. For wood product operations using rangeland hardwoods targeted to niche markets, this usually means a definition of product quality needs to be created. Once defined, in terms of moisture content, size tolerances, surface quality, etc., a method of measuring quality parameters during production should be created. Any materials not meeting the quality standards should be reprocessed to achieve desired quality, or marketed as a below-grade product.

Economic Considerations

In addition to identifying the target market(s), determining the quality and volume needs of customers, and determining the resource availability to meet these needs, it is imperative to prepare a thorough business plan that includes realistic estimates of product value and manufacturing costs. These are difficult estimates to come up with in a new enterprise using an unproven resource in an untested market. The following list is intended as a quick summary of the types of capital and operating costs that need to be considered in a business plan:

- Equipment – harvesting (including hauling) the resource, manufacturing
- Labor
- Energy – fuel, electricity, etc.
- Cost of carrying inventory
- Transportation – distance between resource, manufacturing facility, and market
- Marketing – packaging, advertising, etc.
- Insurance
- Miscellaneous business expenses
- Planning and regulatory costs – CEQA, permits, consultant

In addition, the following harvesting and environmental considerations should be evaluated:

- The wood harvesting site should generally have less than 30 percent slopes. Potential environmental damage and harvesting costs increase on steeper areas.
- Avoid areas with high erosion potential, large riparian corridors, and wetland habitats. Environmental damage may result and these areas are expensive to harvest.
- Areas with low tree-growth potential, such as shallow soils or low rainfall (less than 12 inches), probably cannot be managed for sustained cutting.
- Consider how trees affect the overall real-estate value of your land. For example: About 40 mature trees per acre gives the highest property value. Therefore, if you are thinking about subdividing, do not overcut.
- Avoid "taking" state and federally-listed threatened and endangered species.
- Concentrate harvesting in denser areas, where tree canopy is at least 50 percent. For stands with less than this, harvesting costs are higher, growth rates are lower, and resulting net returns are lower.
- Check on local tree-cutting ordinances or regulations.
- Consider local opinion toward tree harvesting. Your decision may be to forget cutting wood!

Although most of the enterprises discussed in this chapter can be established as small businesses with few employees, there are definite economies of scale associated with most of these costs. As the size of the operation increases, so does the need for more expensive equipment and the overall complexity of the business plan. Assistance in developing business plans can be obtained from various sources, including local economic development agencies, and private and public business consultants.

Although there are exceptions, of all the above factors, availability of the resource and the associated cost of transportation are often the limiting factors, particularly for the low and moderate value products listed in Table 8-1. Rangeland hardwoods are not concentrated in high density stands the way they are in the timberland regions; therefore, the hauling distance to obtain an adequate supply of the rangeland hardwoods could be too large to justify the relatively low value. A careful assessment of the resource is necessary to complete the enterprise evaluation.

Field Assessment of the Wood Resource

Deciding Whether to Cut

Even though the case can be made for the utilization of some of the rangeland hardwoods, it is still necessary to decide whether harvesting is a wise choice based on characteristics particular to your land and what you want to achieve on your property. Is the main objective to generate income? Do you want wildlife on your property because you like to see wildlife, for income–or both? Do you plan to subdivide for houses? And, how important is livestock production? Your decision of whether or not to harvest wood depends on the location, size, and physical characteristics of your land; and the kind, number, size, and quality of hardwood trees that grow there. It is also important to determine whether harvesting is consistent with sustainable management.

If, after carefully evaluating the economic and environmental constraints, the decision is to proceed, more specific information about the harvesting site must be collected. You must determine the location and size of the area to be harvested, the current volume of wood available, and the potential number of trees to be cut. For the stand to be managed on a sustainable basis, the amount of wood removed should (over the long run) equal the amount grown and there should be adequate regeneration through seedlings or stump sprouts (see Chapter 9). The process for collecting stand inventory information is described below. Most of the examples are specifically for oak trees, but similar principles apply to other species of hardwoods as well. The examples and descriptions are oriented to fuelwood operations, which is the most likely rangeland hardwood utilization scenario.

Equipment and Materials Checklist

Before you begin, have in hand the items listed below:

- Aerial photograph (stereo pair if available)
- Topographic map showing property
- Compass
- Tree Measuring Stick
- Pencil
- Hardwood Range Tree Inventory Form

- Clipboard
- String
- Stake
- Chalk
- Tree-marking Paint

Determining Location and Acreage

In developing a plan of wood harvesting, describe the woodland where harvesting is to occur. For this purpose, aerial photos can be used for the following:

- Locate important physical and topographic features such as buildings, roads, ridges, and riparian areas.
- Estimate the acreage of the stand.
- Locate potential inventory points in the stand.

Aerial photos may be purchased for $5 to $15 from the CFSA (Consolidated Farm Service Agency - formerly ASCS) or NRCS (Natural Resource Conservation Service) Office in you area, or the USGS (US Geological Survey) (see Sources of Assistance section for addresses).

You will need to know how many acres there are in your harvest area shown on your aerial photo. If you do not know the approximate acreage of this area, you could phone the ASCS office in your area and request assistance. The office probably would ask you to come to the office to point out your property on one of their aerial photos, and they would calculate the acreage while you wait.

Determining Tree Volume

Laying Out the Plots.–In the interest of saving time and money, usually only a sample of the trees on the property is measured. Once acreage has been calculated, the amount of cordwood in the stand can be determined. One relatively simple–but effective–inventory procedure requires measuring trees within *tenth-acre circular plots* systematically spaced throughout the hardwood stand. The number of tenth-acre plots, or the *intensity* of the inventory, depends on the *percentage* of the property that must be measured to get a reasonably accurate estimate of wood volume and quality. The higher percentage measured, the more accurate will be the estimate–but accuracy requires more of your time. Generally, a measure of 2 to 10 percent is adequate. More intensive inventories may be needed for properties varying greatly in topography and tree species or sizes.

To determine the number of tenth-acre plots needed, multiply the number of acres to be surveyed for potential harvesting by the percentage of inventory desired and divide by plot size.

Example: Your property is 116 acres.

For a **2% inventory** the calculation is:

116 acres X 0.02 ÷ 0.1 acres per plot = 23 plots

For a **5% inventory** the calculation is:

116 acres X 0.05 ÷ 0.1 acres per plot = 58 plots

For a **10% inventory** the calculation is:

116 acres X 0.10 ÷ 0.1 acres per plot = 116 plots

Because measuring more plots generates more reliable information, take as large a sample as you think is reasonable. The overall variability of the stand should be considered. In general, the more variable a stand, the more plots which should measured.

Lay out the proposed number of plots on the aerial photo or map of the stand being inventoried. It works well to draw lines parallel to each other on the photo or map and space the plots along the lines at equal distances from each other. Using the map scale, calculate and record the distance between plot centers and the compass bearing of the lines. To ensure a representative sample, lay out the plots across ridges, rather than parallel to them. Plots should also include a range of tree types and densities. You want plots to fall in areas with many trees, few, or even none. Concentrating plots only where trees grow densely distorts your estimate of wood per acre; plots that fall in openings should be included.

If the property has fairly large stands (greater than 10 acres) with distinct species composition and canopy cover, these should be outlined on an aerial photo or map and separately sampled. The more you separate or

stratify your stand, the more accurate your estimate of wood volume will be. However, stratifying may make record keeping more difficult.

Measuring the Tenth-acre Plots.–With your aerial photo as a guide, locate the beginning of your first line of plots. Sight down the line with a compass and pace distance between plots. At the center of the first plot, place a stake, and tie a piece of light rope cut to the distance of the radius of the plot. For tenth-acre plots, the radius is 37 feet. Within the circle made by the rope, measure diameter in inches and height in feet of all trees greater than 4 inches in diameter at breast height (**DBH**) (**D**iameter **B**reast **H**eight, or 4.5 feet from the ground) with a Tree Measuring Stick. (Instructions for making and using a tree measuring stick are given in *Harvesting Firewood for Sustained Yield on Oak Rangelands*, UC Leaflet 21487, or one can be purchased from a company supplying forestry equipment). Trees are considered in the plot if they are at least half in. Those that fall on the line are alternatively counted in and out. A general strategy to keep track of where you are would be to begin with the tree on the north side of the plot, and proceed clockwise around the plot. Keep track of the trees you have already measured by marking them with chalk.

DBH is measured on the uphill side of the tree. If the tree has an unusual swelling at breast height, move the measurement slightly up or down to a more normal spot on the tree. If the tree forks below breast height, measure it as two separate trees. If it forks above breast height, measure it as one tree. Height is measured from the tallest point on the tree to ground level. In tenth-acre plots, each measured tree represents 10 identical trees per acre. Hence, accurate measurements are important since errors can distort results.

Tree quality is one of the factors to consider in deciding whether the tree is best suited for firewood or a higher-value product. Two criteria to consider in quality are the diameter and straight length of the stem from base to first branches and the number of straight-stem sections in the tree. In each case, the lengths of wood must be at least 16 in diameter and 6 feet long. Count the number of sections of stem with these dimensions.

Record species, tree diameter, height, and number of merchantable (i.e., at least 16 inches diameter at small end and 6 feet long) stem sections on a Hardwood Range Tree Inventory Form (Worksheet 8-1). Photocopy the blank form so you can use one sheet per tenth-acre plot. If no trees occur within the plot boundaries, check in the space provided that there are no trees on the plot.

Using the Information

Using the Volume Tables

Next calculate the volume of the measured trees. For most oak species, volume tables have been constructed to calculate volume (Table 8-3). The volume table gives DBH in 2-inch increments down the left side of the table and total height in 10-foot increments across the top. Round your DBH measurements to the nearest even number, and your height measurement to the nearest 10 feet. The numbers in the table at the intersections of the DBH row and total height column are the volumes of wood in solid cubic feet of a single tree.

Example: The volume of a 6-inch DBH, 20-foot-tall blue oak has 2 cubic feet of wood (see Table 8-3).

Figure 8-1 is an example of a completed Hardwood Rangeland Tree Inventory Form (Worksheet 8-1). The merchantable volume for each of the 15 trees from this plot is determined from the DBH and height in Table 8-3.

Next, the plot data is summarized to a per-acre basis. For a tenth-acre plot, each tree represents 10 trees. For this example, there are 15 trees (7 blue oak and 8 coast live oak), which means that this plot represents 150 trees per acre (15 x 10 = 150). The average DBH of these trees is found by summing the DBH column and dividing by the number of trees in the plot (108 ÷ 15 = 7.2 inches). The total volume for the plot is found by summing the tree-volume column (60 cubic feet per tenth-acre plot). This is converted to a per-acre basis by multiplying by 10 (10 x 60 = 600 cubic feet per acre).

These volumes are in cubic feet of wood. Another commonly used measure for wood, especially firewood, is the cord. A cord is a pile of wood, closely stacked, measuring 8 by 4 feet, with logs cut to 4-foot lengths, or a total of 128 cubic feet of wood, bark, and air (8 x 4 x 4 feet = 128 cubic feet). The actual wood volume averages between 80 to 90 cubic feet, depending on how well the pile is stacked. Dividing the cubic-foot volume by 85, estimates the number of cords of wood on the plot. The example has an estimated 7.1 cords of oak wood (600 cu. feet/acre ÷ 85 cu. feet/cord = 7.1 cords/acre).

This process is repeated for each tenth-acre plot in the sample. The average number of trees and wood volume for the stand can be found by adding both the estimated number of trees and the volume for each sample plot and dividing each sum by the number of plots. Remember to include any plots with no trees on them in your count. You may wish to separate your data into the various species found, so you can determine the volume by species.

Worksheet 8-1 – HARDWOOD RANGELAND TREE INVENTORY FORM

Plot # 1 **Plot Size 1/10 acre** **Location Doe Ranch, Field A**

Tree #	Species	Diameter at Breast Height (DBH - in.)	Total Tree Height (feet)	Tree Quality (no. straight stems)	Tree Volume (cubic feet) (see Table 8-3)
1	Blue	6	20	2	2
2	Blue	6	20	1	2
3	Blue	4	20	1	1
4	Blue	4	20	1	1
5	Blue	6	20	3	2
6	Blue	4	20	1	1
7	Blue	4	20	1	1
8	Coast	6	20	2	1
9	Coast	10	30	2	7
10	Coast	8	40	1	4
11	Coast	10	40	1	8
12	Coast	10	30	2	7
13	Coast	10	40	1	8
14	Coast	12	30	3	11
15	Coast	8	30	1	4
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
	sum 15 trees/ac 150 % bl. oak 47 % live 53 % other ____ Check here if no trees on plot	sum 108 Average 7.2"		sum 23 Average 1.5	sum 60 cu. ft/ac. 600 Assuming 85 cu. ft. solid wood in a cord, calculate cords/ac. 7.1

Oak Regeneration Survey
Plot Size 1/100 acre

Class	#/Plot	#/Acre
1-year seedlings	3	300
Seedlings over 1-year		
Saplings (> 3' tall)	1	100

Field Notes:

Riparian zone located adjacent to harvest area

Maintain downed woody debris on site

Protect seedling and sapling regeneration

Protect stumps to encourage resprouting

Table 8-3. Blue oak, coast live oak, and interior live oak merchantable wood volume (cubic feet per tree). From: N.H. Pillsbury and M.L. Kirkley. 1984. *Equations for total, wood, and sawlog volume for thirteen California hardwoods.* USDA Forest Service Research Note PNW-414. 52 pp.

dbh	TOTAL TREE HEIGHT (ft.)														
	20			30			40			50			60		
(in)	Blue	Coast	Interior	Blue	Coast	Interior	Blue	Coast	Interior	Blue	Coast	Interior	Blue	Coast	Interior
4	1	1	1	1	1	1	1	1	1	1	1	2	1	1	2
6	2	1	2	2	2	3	3	2	3	3	2	4	3	3	5
8	4	3	4	5	4	5	5	4	6	6	5	8	7	6	9
10	7	5	6	8	7	8	9	8	10	11	9	12	12	10	14
12	11	8	9	13	11	12	15	13	15	17	14	18	18	16	21
14	16	12	12	19	16	17	22	18	21	25	21	25	27	24	29
16	22	17	16	27	22	23	31	26	28	35	30	34	38	33	39
18	30	23	21	36	29	29	42	35	36	47	40	43	52	45	50
20	39	30	27	48	38	36	55	46	46	62	52	54	68	58	62
22	49	38	33	61	49	45	70	58	56	79	67	66	86	74	77
24	62	48	39	76	61	54	88	72	67	98	83	80	108	93	92
26	76	58	47	93	74	64	107	89	80	120	102	95	132	113	110
28	91	70	55	112	90	75	130	107	94	145	123	112	159	137	129
30	109	84	63	134	107	87	154	127	109	173	146	129	190	163	149
32	128	98	73	157	126	100	182	150	125	204	172	149	223	192	171
34	149	115	83	183	147	114	212	175	142	238	200	169	261	224	195
36	173	133	94	212	170	129	245	202	161	275	232	191	301	259	221

Management Considerations for Wood Products

Chapter 9 will present a discussion of the volume of wood which can be harvested, given various objectives for wildlife habitat, tree regeneration, and long-term sustainability. Cattle production, hunt clubs, or maintenance of wildlife and aesthetic values may compete with tree harvesting for wood products. Careful consideration should be given to other enterprises and to natural resource values. At the least, it will be necessary to give careful consideration and balance competing goals. For example, if you wish to favor quail hunting and forage enhancement for livestock, you may want to sustain the hardwood stand at a lower tree canopy level than a landowner who favors turkey hunting and requires shading for livestock. A heavier wood harvest can be justified only if you want to adjust the stocking of the trees to a lower level. Chapter 9 provides a general discussion of the implications of setting different stand volume-level goals to sustain the resource over time.

Marking the Stand

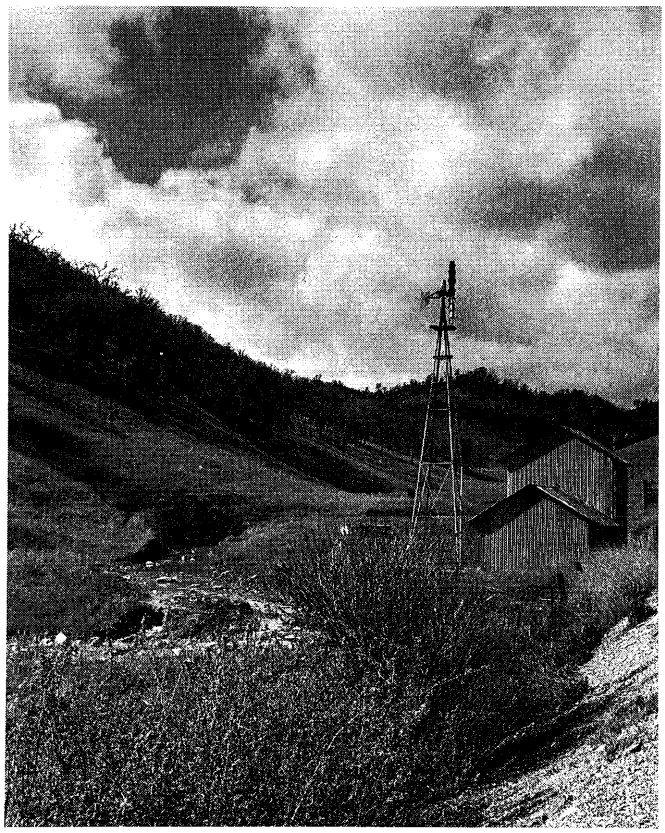
Once a decision has been made on the volume of wood that can be harvested, individual trees must be marked for harvest. Mark trees with a spot of tree-marking paint at about eye level for the logger to see easily and a small spot near the base of the tree to show later that only marked trees were harvested. As you go through the stand, record the DBH and height of the trees you marked for harvest on the Hardwood Range Tree Tally Sheet (Worksheet 8-2). Look up the volume of each marked tree in table 8-3, and record this on the Tree Tally Sheet. Keep a running tally of cumulative volume. Periodically, calculate the number of cubic feet or cords of wood you have marked by dividing the cumulative wood volume figure by 85. Continue to mark and tally trees until your desired wood harvesting objectives have been met.

Consideration of biodiversity, wildlife habitat and aesthetic values is of increasing importance. During design of the harvest plan and marking the stand, be sure to follow these general guidelines:

- Acorn production differs greatly between years and trees. Therefore, identify the outstanding acorn producers on your property for at least two good acorn-production years. The best acorn producers in a given year are usually the best in other years too. Once identified, mark these acorn trees with plastic flagging or paint SAVE on the trees and leave them uncut during wood harvesting.
- Many kinds of wildlife depend on hardwood snags or cavities in dead or living trees for food, cover, and breeding. Retain a minimum of one snag per acre. A recent study concluded that 10 snags or 16 cavities per 10 acres of oak woodland is sufficient to provide for breeding populations of cavity-nesting birds.
- Zones of vegetation along or around water provide important habitat for wildlife on rangeland. These riparian zones provide habitat for cover, food, and reproductive needs. Maintain a buffer strip, 200 feet wide, or at least the width of the distinctive riparian vegetation. In this area do not harvest, or harvest very lightly.
- To perpetuate needed wildlife cover after harvesting, use branches from cut trees to construct brush piles for cover, especially for many species of songbirds and quail (see *How to Increase California Quail Populations*, UC Leaflet 21325).
- Wildlife do best in a variety of habitat types. Mark trees to create wildlife corridors and small openings. Wildlife will use the corridors to travel safely to and from feeding and watering sites. The forbs and grasses that grow in the openings provide food for wildlife and cattle.
- Maintain 25 to 50 percent canopy cover for wildlife.
- Remove dead or dying trees that are unmerchantable, but leave some dead trees for cavity-nesting wildlife.
- Remove trees with poor crowns that may be competing with vigorous, immature trees.
- Where possible, encourage a mixed-species and uneven-aged stand to encourage habitat diversity and to ensure regeneration.
- Protect sprouting from stumps and existing small seedlings and saplings.

Legal, Political, and Public Concerns

Ordinances.–The State Board of Forestry has authority in California to regulate cutting and stocking of trees on commercial forest lands. They have not exercised this authority over the state's 10 million acres of oak woodland. Several of species listed on Table 8-2, however, are considered by the State Forest Practices Act. You should check with your local CDF office to see if the regulations of the Forest Practices Act apply. County tree cutting ordinances may be in effect in your area, however. Many counties have also adopted voluntary guidelines on hardwood rangeland harvesting operations. Consult your County Planning Department for information on permit requirements and any voluntary guidelines which might exist.



Threatened and Endangered (T&E) Species – There are a variety of T&E plant and animal species in oak woodlands. Appendix A lists several wildlife species with special status. When these T&E species are present, make sure your actions do not further threaten these species.

Water Quality – Under normal rainfall and a sustained-yield cutting regimen, tree cutting and removal processes are not expected to have a significant impact on the soil structure or to its exposure to erosion forces of wind and water. Tree cutting is therefore unlikely to affect water quality or substantially increase flooding, erosion, or siltation on- or off-site. Chapter 11 gives suggestions on protecting hardwood rangelands from erosion.

Figure 8-1 – HARDWOOD RANGELAND TREE INVENTORY FORM (example)

Plot # _____ **Plot Size** _____ **Location** _____

Tree #	Species	Diameter at Breast Height (DBH - in.)	Total Tree Height (feet)	Tree Quality (no. straight stems)	Tree Volume (cubic feet) (see Table 8-3)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					
	sum ____ trees/ac ____ % bl. oak ____ % live ____ % other ____ Check here if no trees on plot	sum ____ Average ____		sum ____ Average ____	sum ____ cu. ft/ac. ____ Assuming 85 cu. ft. solid wood in a cord, calculate cords/ac. _____

Oak Regeneration Survey
Plot Size _____

Class	#/Plot	#/Acre
1-year seedlings		
Seedlings over 1-year		
Saplings (> 3' tall)		

Field Notes:

Worksheet 8-2 – HARDWOOD RANGELAND TREE INVENTORY FORM

Plot # _____ **Acres in Harvest Unit** _____ **Location** _____

Tree #	Species	Diameter at Breast Height (DBH - in.)	Total Tree Height (feet)	Wood Volume(from Table 8-3)	Cumulative Volume Marked (cu.ft.)	Cords (Cumulative volume/85)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
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Potential for Non-Timber Forest Products

Hardwood forests are also a resource for many products that are not primarily based on processing the wood. Numerous enterprises have developed across the country that are based on gathering plant materials from the forest for a wide variety of uses. Several examples of collected materials that have found established markets are:

- Wild mushrooms
- Berries and wild fruit
- Acorns, nuts, and seeds
- Decorative branches and other plant materials, such as Spanish moss, for floral displays
- Bark, leaves, and roots for flavoring, medicinal, or pharmaceutical uses
- Wild plants for nursery stock
- Basket making and weaving supplies
- Plant materials for natural dyes

Typical characteristics of these enterprises are that they are usually small, labor intensive, cottage industries with few equipment needs and low capital costs. All forms of marketing can be found, from roadside stands, direct sales to wholesale/retail vendors, or to catalog ventures. The hunter/gatherer life style is attractive to many people as an apparent hassle-free occupation. However, there are restrictions and regulations that apply to gathering. For example, any activity that affects the habitat of threatened and endangered species is subject to regulation. Gathering on public lands usually requires a permit and adherence to additional local restrictions.

Many of these products have specific market requirements. For example, food materials can be marketed as freshly harvested or dried, but most of the other products require some type of drying process, packaging, and guarantee that they are free of insects and pathogens. As these requirements often vary with location, it is imperative to learn the market specifications for your location. An excellent source for additional contacts, a list of references and more information about these non-timber possibilities is found in the United States Department of Agriculture, Forest Service, Agriculture Information Bulletin 666, "Income Opportunities in Special Forest Products – Self-Help Suggestions for Rural Entrepreneurs".

In every community with a forest resource there probably exists an example of a non-timber based, forest products enterprise in most of the above categories. One example of an enterprise that has received a lot of attention in recent years is the cultivation of mushrooms.

Mushroom Cultivation

The past decade has seen a phenomenal growth in the cultivation of mushrooms. Many of these grow very well on hardwood logs and sawdust. The most common is the shiitake (*Lentinus edodes*), a forest mushroom with folk medicine qualities that has become a staple mushroom in many cuisines of the world. It is the third most popular mushroom in the world market. Although other wild mushrooms can usually be grown on a variety of substrates, including wood sawdust and shavings, the shiitake requires solid wood as the primary component of its substrate. Oak species are the preferred wood of most growers, but other hardwoods such as alder and maple have been used successfully.

Cultivating mushrooms is tricky business. They have very specific growth conditions (water, light, and temperature) for optimum production. But these conditions are also favorable for the growth of other fungi and bacteria which could easily contaminate the operation. A procedure that works well for shiitake is to inoculate freshly cut, bark-intact, small hardwood logs (4 inches diameter 4 feet long) with numerous "spawn" plugs (previously infected plugs). The logs can be stem or branch material as long as they have very little heartwood, since the heartwood of some species has fungicidal properties. The inoculated logs must be prevented from drying; periodic sprinkling may be necessary in dry climates. After about 3 months, fruiting can be stimulated with extra watering and exposure to light. Once inoculated, logs can produce for 4 or 5 years. The details for optimum growth are more specific than described here. For more information consult one of the numerous books available on mushroom cultivation; a few are listed in Appendix D.

Conclusion

This chapter has described some potential forest products on California's hardwood rangelands and the economic and natural-resource considerations in deciding whether to harvest oak trees, and the step-by-step process for harvesting oak trees. Two additional steps that need to be considered are the amount that can be harvested while still maintaining a given stand volume over time and whether there is adequate oak regeneration to maintain the desired level of tree canopy. Detailed information on these considerations (sustained-yield harvesting) is given in Chapter 9.

Chapter Nine
Sustainable Management of Hardwood Rangelands: Regeneration and Stand Structure Considerations

Primary authors: Richard Standiford, Univ. of California, Berkeley; and Douglas McCreary, Univ. of California, Berkeley

In implementing any of the various enterprises in the previous chapters, it is important to develop management programs that will sustain hardwood rangelands over the long term. For the purpose of these "Guidelines" we will define *sustainable* as:

- Maintaining ecosystem processes at multiple scales;
- Maintaining the diversity of biological organisms;
- Maintaining hardwood rangelands within the natural range of variability appropriate to the site; and
- Maintaining economic viability of the hardwood rangeland property over the long-term.

Ecological principles should be incorporated into management practices to ensure that woodland values are sustained. Any management practice, whether it is production of wood products or livestock, or managing for a recreational enterprise, needs to ensure that woodland stands replace themselves. Sustainable management also involves control over the structure of the stand (species and distribution of trees by size class) to maintain tree vigor and to ensure continued presence of important habitat components such as snags, cavity sites, and large woody debris to maintain ecological processes on the site.

Oak Regeneration

One of the key concerns that landowners, policy makers, and the public have about the state's hardwood rangelands is whether there is adequate oak regeneration to sustain current woodlands and savannas. Several statewide surveys of oak regeneration have shown a shortage of trees in the sapling size class for certain species (especially blue oak, Engelmann oak, and valley oak) in certain regions of the state (sites at low elevation, on south- and west-facing slopes, on shallow soils, with excessive populations of natural or domesticated herbivores). If this shortage of small trees continues over time, then the oak stands will gradually be lost as natural mortality factors take their toll on the large, dominant trees in the stand.

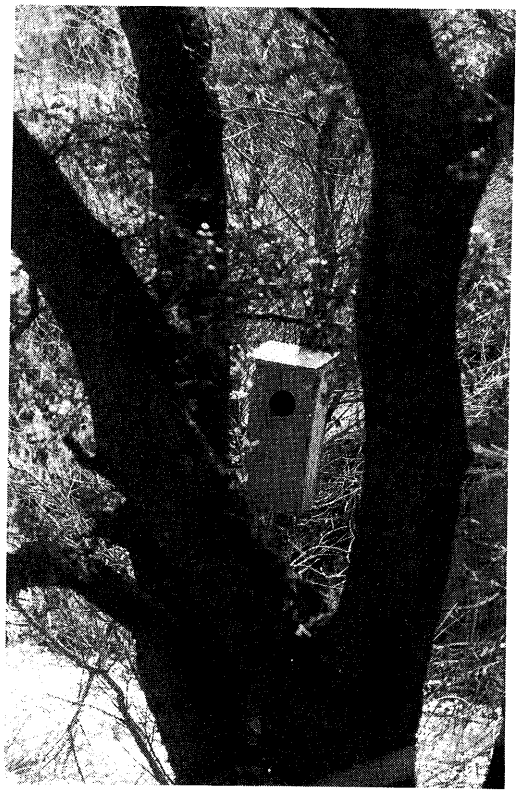
If poor regeneration exists, current oak population densities may go down and some areas that historically have been oak woodlands may convert to other vegetation types such as brushfields or grasslands. Generally this "regeneration problem" is exacerbated by land management practices which directly remove trees (firewood harvesting, clearing associated with construction, agricultural conversions), as well as by activities such as excessive grazing, heavy vehicle use or yearly burning. These situations may create conditions that make it more difficult for oak seedlings to become established and grow.

Owners and managers of hardwood rangelands need to have a systematic way to evaluate their oak stands to determine if there is adequate regeneration to sustain the stand of trees over time. Shown below are some considerations to be made in evaluating the regeneration status of a stand.

Ecological Principles

When assessing if oak regeneration is adequate to sustain a stand over time, a definition of what is meant by the term "regeneration" is needed. This requires an understanding of the ecological concepts of reproduction, recruitment, mortality, and regeneration. *Reproduction* is the biological process that controls the production of offspring by flowering, production of seed, dispersal of seed, and seed germination, as well as sprouting from dormant

buds on the stump or root collar following the death of the stem of a tree. *Recruitment* is the process which adds individual plants to a population, while *mortality* removes plants from a population. *Regeneration* is the net effect on stand structure from trees gained by recruitment and lost to mortality. Since the oaks that occur on California's hardwood rangelands are quite long-lived, a regeneration assessment cannot focus solely on the presence or absence of seedlings at one point in time. Sporadic recruitment of seedlings into the sapling and overstory size class may be all that is needed to balance mortality and maintain the oak stand over time. The absence of seedling reproduction and recruitment does not indicate a "failure" in regeneration if mortality is not occurring in the stand.



A Decision Key

Figure 9-1 below shows a decision key for hardwood range landowners and managers to use to assess oak regeneration. This shows that there are several questions to be raised in considering the process of oak regeneration. First, there needs to be an assessment of the current stand structure and whether this is consistent with the objectives for the stand, and the natural range of variability for the site. Secondly, the health and vigor of the existing trees need to be assessed to determine if recruitment of small trees is needed to replace future tree mortality. Thirdly, the number of seedling and sapling trees should be evaluated. As part of the sampling procedure described in the previous chapter, data on tree condition and seedling and sapling presence can also be collected. In areas where trees are dying or are being removed, seedlings and saplings will be needed to replace lost trees. When overstory tree density is below the desired level for management objectives, seedlings and sapling trees will be needed to increase tree density.

Shown below are two examples using this key.

Example 1

- Current oak cover = 40 percent canopy cover (mix of interior live oak and blue oak)
- Current oak cover is consistent with management objectives of a hunt club and livestock grazing
- Overstory trees appear healthy and vigorous, with only isolated mortality
- No seedlings or saplings are found in the understory at this time

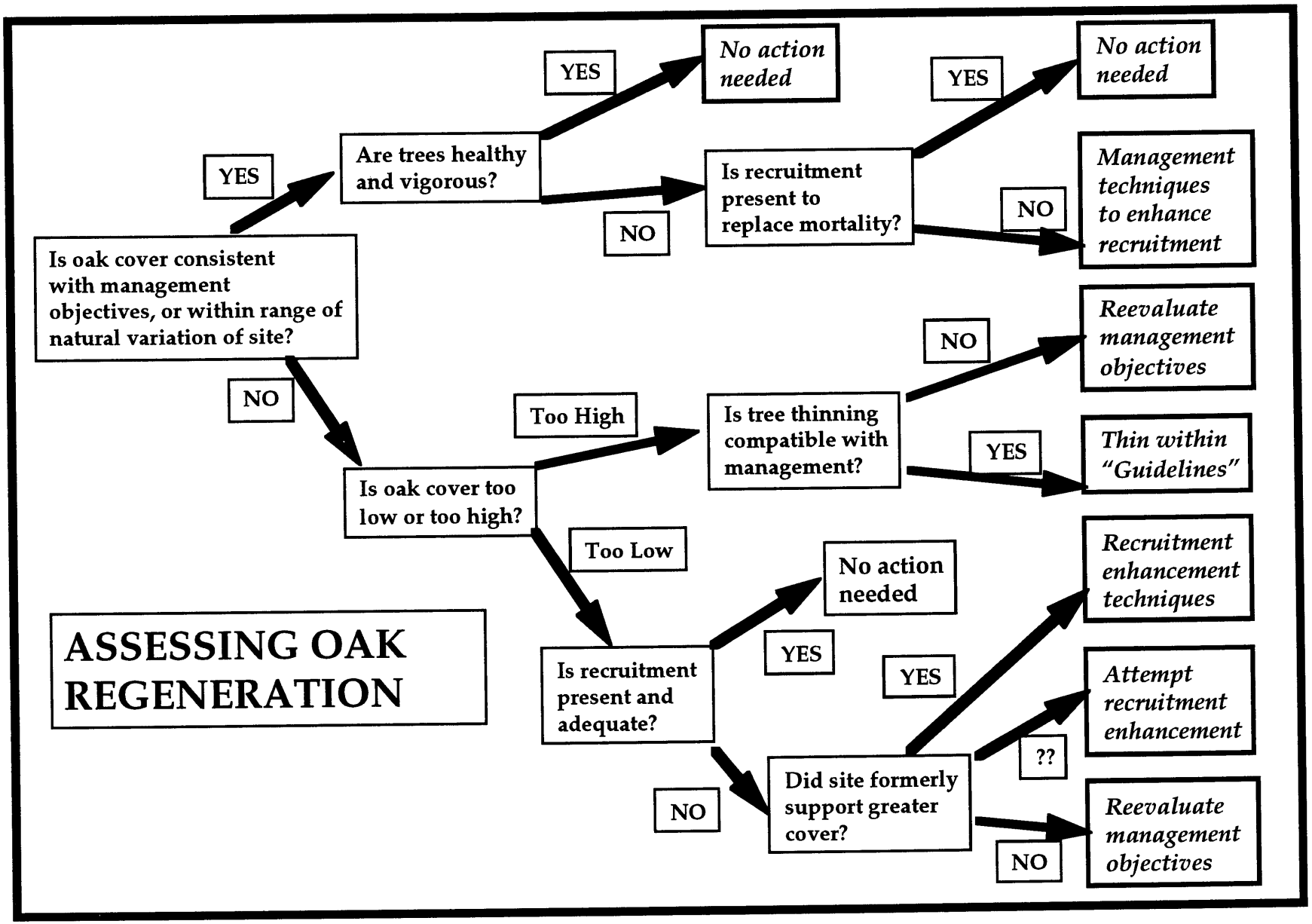
Applying these criteria to the decision key gives an initial assessment of the regeneration status of this hardwood rangeland stand. Figure 9-2 shows the pathway in the regeneration decision key based on this information. As this shows, the recommendation is that no action is needed at this time, since the overstory oaks appear to be healthy and vigorous. Even though there are currently no naturally occurring seedlings, there is not a regeneration problem in this stand.

Example 2

- Current oak cover = 15 percent canopy cover (mix of blue oak and foothill pine) after a firewood harvest that took place on the property 15 years ago.
- There was poor stump sprouting observed and few seedlings are established on the site.
- The owners would like to maintain a canopy cover of 25 to 35 percent, which they are quite confident the site previously supported prior to the firewood operation

Figure 9-3 shows the pathway in the regeneration decision key based on this information. For this case, the management recommendation calls for recruitment enhancement techniques to restore the oak cover to higher levels. Since there are few naturally occurring seedlings and stump sprouting is poor, a seedling or acorn planting operation is called for (see discussion below).

Figure 9-1. Decision key for evaluating oak regeneration on hardwood rangeland.



Example 9-2. Example 1 pathway for regeneration assessment.

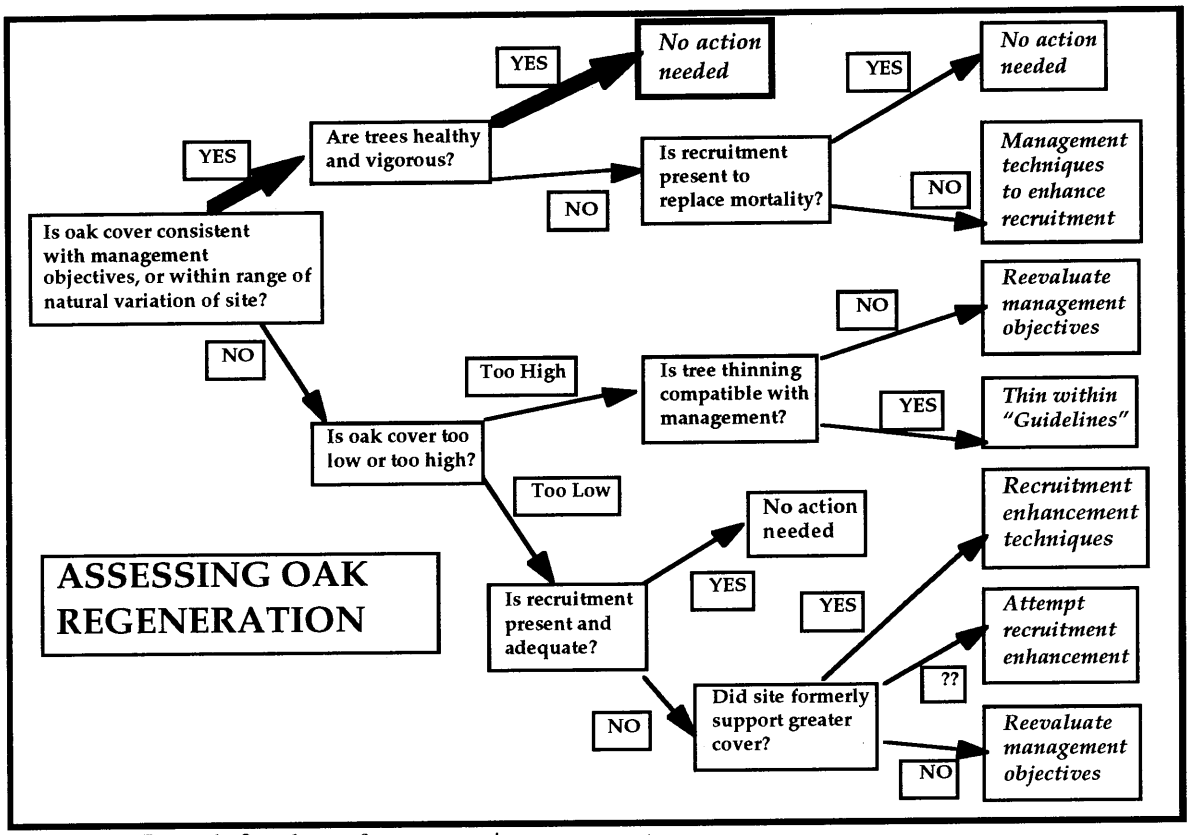
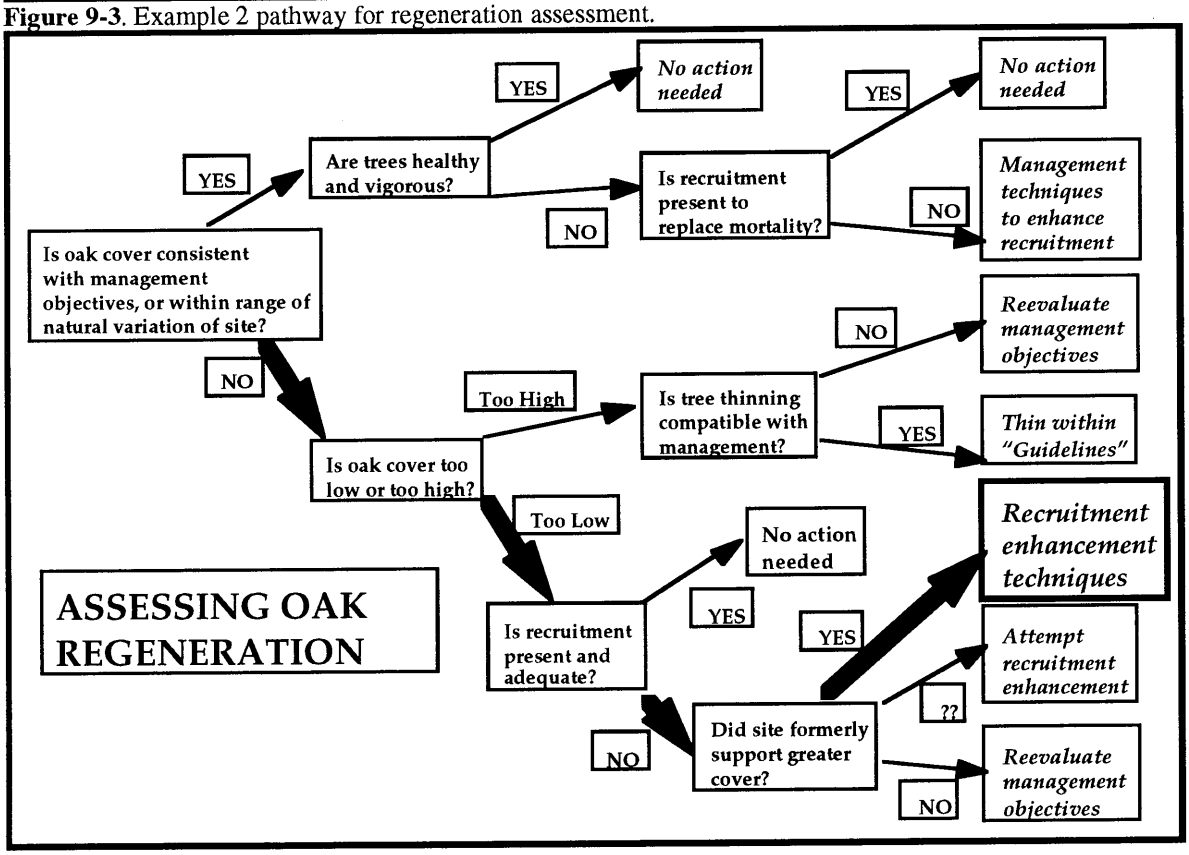


Figure 9-3. Example 2 pathway for regeneration assessment.



Is There a Regeneration Problem?

Regeneration is not a problem if there is sufficient reproduction that survives to replace trees lost to mortality or to increase the overstory to some desired density. Regeneration may not be a problem if the overstory is at its desired level, and all overstory trees appear healthy and not in danger of being lost to mortality in the next 5 to 10 years.

Regeneration is considered to be a problem if there is a large amount of mortality or anticipated mortality with insufficient seedling and sapling reproduction to replace trees being lost. Regeneration is also a problem if a higher oak stand density is desired, but there is inadequate potential recruitment to achieve this higher stand density. In areas where regeneration is determined to be a problem, it may be necessary to take actions to ensure that seedlings survive in the stand. This may involve protecting naturally occurring young seedlings in the stand from browsing and from grass competition. These actions may increase the number of seedlings that are recruited into the sapling height class. It may also merit consideration of artificial regeneration techniques, such as seedling or acorn planting efforts.

Assessment of regeneration should be an ongoing process. The decision key should be used at least every five years in an oak stand to determine if there is adequate regeneration, and to provide mitigation for reproduction in cases where problems do develop that would create problems in the long-term sustainability of the stand.

Disagreement exists about the severity of the regeneration problem, and whether field studies reflect real population declines or normal long-term fluctuations in recruitment levels. It is clear, however, that levels of recruitment vary widely among oak species, in different locations in the state, and even over small distances within individual stands. No single cause or factor is responsible for poor regeneration, but a number of factors, including animal grazing, acorn depredation, plant competition and environmental extremes, can differentially affect recruitment success at different locations. Shown below are some management considerations that can be applied to increase the number of seedlings and saplings if necessary.

Artificial Oak Regeneration

On areas that have been determined to have a "regeneration problem" it may be necessary to take steps to establish more oaks. Planting acorns or seedlings may be necessary where recruitment is inadequate and we desire to retain woodlands that can be sustained on a long-term basis. This is not an easy task, since those same factors which limit natural regeneration can make it difficult to successfully artificially regenerate native oaks. In general, substantial care must be taken to plant, protect and maintain young oaks in the field to ensure success. While there are many approaches for establishing oaks, the procedures described herein have proved successful for a variety of oaks in a variety of environments.

Collecting and Storing Acorns

The starting point for any oak regeneration project is to collect acorns - the seeds of oak trees. It is recommended to only collect acorns from fairly near the planting site, or from a very similar environment. Since oaks have adapted to the specific conditions where they grow, if they are planted in a different environment, they may grow slowly or even die. Thus you would not want to plant coast live oaks in the Sierra foothills, since they are not adapted to those conditions, nor do they naturally occur there. Similarly, you would not want to plant blue oaks collected in the low-elevation Sierras in the coastal foothills, even though this species naturally occurs in both environments.

Acorns can be collected directly from the trees or from the ground beneath. Generally, the healthiest acorns are those collected from the tree branches, since acorns that fall to the ground can dry out and be damaged - especially if they lie exposed for more than a few days during hot, dry weather. For trees with very high branches, however, it may be impossible to collect directly from the tree. When acorns are collected from the ground, leave behind those that are small, cracked, have obvious insect holes, or feel light and hollow. Acorns still on the tree can be picked like apples, or knocked to the ground using long poles. It's easy to collect them 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 starting to fall to the ground. It's 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.

After the acorns are collected, it is important to place them in cold storage at temperatures just above freezing. A normal refrigerator is fine, as long as you don't put them in the freezer, which will kill them. Refrigeration slows the metabolic activity and prevents the acorns from heating up and drying - both of which can decrease

viability. Before storage, take the caps off those that still have them by gently twisting them. Acorns collected from the trees can be placed directly in the refrigerator, while those collected from the ground should be soaked for several hours in a large bucket of water before 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. Place the acorns in plastic bags and refrigerate. Leave the bag slightly open to allow some air circulation. Check the acorns weekly for molds. If you do notice the development of these harmful fungi, take the acorns out and rinse them off and return them to storage (but plant them as soon as possible).

Planting Acorns and Seedlings

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 the acorns early in the season since research has shown that the earlier they are placed in the ground, the earlier they start to grow a root system. Developing a large, deep root system can help the seedlings take up moisture from the soil as it dries in the spring and summer. Early planting also reduces the storage problems associated with harmful fungi and premature germination.

Plant the acorns one-half to one inch deep. Dig a hole using a hand trowel, hoe or shovel. It's best to dig the holes several inches deeper than the acorn is actually planted, and then fill the holes back up with loose soil. This gives the new root system 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 (though even if you do, the new root should develop), and position it in such a way that the root is pointing down. Place ungerminated acorns on their sides in the holes and cover with soil.

Another way to establish oaks is to grow seedlings in containers, or purchase seedlings from a commercial nursery, and then transplant them. Directly planting seedlings has both advantages and disadvantages. On the plus side, you know you're starting with an established plant, and you're less likely to have problems with animals that are intent on digging up and eating directly sown acorns. Depending on the size and age of the seedling you plant, you're also getting a substantial head start on getting an oak tree established. On the down side is cost. Acorns are much cheaper to procure and plant than seedlings. Oaks grown in containers can also become "pot bound", since oak roots grow so rapidly and can easily outgrow small containers. This can cause the seedlings to grow very slowly after they are outplanted, and in some cases, never fully recover. Finally, if you buy seedlings, it can sometimes be difficult to find out where the acorns were collected, so there may be uncertainty as to whether you're planting "off- site" plants that are likely to be poorly adapted to the planting area.

Planting seedlings requires a little more care than planting acorns since there is a risk of transplant shock and root injury. Seedlings should be planted between December and February, when the soil is wet, but not frozen. Try to keep the potting medium from falling off the root ball, and place the seedling in the ground such that the top of the soil from the container is level with the ground line. Planting either too shallow or too deep can cause problems later. After the seedling is planted, tamp the soil down in the planting hole. If possible, water the seedlings in after planting. This settles the soil, ensures there is adequate moisture, and helps eliminate air pockets around the roots. Creating a small basin around the planting spot can make it easier to water them, and can also help capture rainfall. Recent studies have shown that augering 1-2 foot deep holes below planting spots can help seedlings grow faster by breaking up hard, compacted soil to promote deeper root development. Placing a slow-release fertilizer tablet a few inches below and to the side of the root can also help ensure that the seedling will have plenty of nutrients for its initial growth.

Natural Oak Regeneration

On some sites, encouraging natural regeneration of oaks may be the most effective way to ensure that sustainable regeneration processes are maintained. Conditions on the site need to be conducive to the germination of the acorn, and the survival and growth of the young seedling. A general understanding of the basic physiological requirements of the various oak species helps to design a management program that encourages natural oak regeneration.

Good acorn crops occur on a periodic basis. Research on acorn productivity of various hardwood rangeland oak species indicates that for most species, good acorn production years occur about every 4 or 5 years. A good acorn year for one species is not necessarily a good acorn year for some other species. This points to the importance of maintaining as diverse a mix of oak species as possible to ensure that there is some acorn production in as many years as possible

Preparing a good seed bed may be necessary to maximize acorn germination and to reduce moisture competition between the seedling and herbaceous plants. Site preparation to encourage natural regeneration should be restricted to areas where there is good acorn production. If an area does not have good acorn production, then it is

necessary to plant acorns or seedlings for sites where regeneration problems exist. On areas where you would like to encourage germination of naturally occurring acorns, a light prescribed burn, or a higher level of utilization by livestock prior to acorn drop, may help prepare the site for good germination.

Germinating acorns and developing natural seedlings require different amounts of sunlight for survival. For example, blue oak and valley oak are quite intolerant of shady conditions. The absence of young blue and valley oak seedlings in many stands is not surprising, since seedlings do not survive well in shade. There is some evidence to suggest that many blue oak stands today have higher canopy densities and shadier understories than was prevalent in the 1800s, due to current fire suppression policies. Interior and coast live oaks are much more tolerant of shady conditions, and may persist for a number of years in the understory of fairly dense stands. However, natural regeneration of all oak species do require sunlight to survive and serve as replacement trees to those lost to mortality. If there are oak seedlings in the understory of an area about to be harvested, the seedlings should respond well to the additional sunlight created by canopy removal.

Some general principles which can be followed for a natural regeneration program are:

- Harvest trees only in good acorn years, or just after a good acorn year
- Prepare the site for acorn germination with prescribed fire or scarification (scraping the soil surface)
- Carefully monitor natural seedling establishment and growth and supplement with planted seedlings or acorns
- Thin the stand so there is adequate light available to the germinating acorns. This should be within one or two years for blue and valley oak, and within five years for interior live oak.

Stump Sprouting

Oaks have an adaptive feature which allows them to sprout from their stump after main trunk of the tree has been killed by fire, cut off, or broken. This ability is very important ecologically, since it provides an alternate method of replacing trees that are killed. However, the ability to sprout varies by oak species, tree size and location. In general, live oaks sprout better than deciduous oaks, and small trees are more likely to sprout than big ones. Also, for a given species, trees growing in higher rainfall areas are more likely to sprout than those growing in the drier portion of their range. For example, almost all of the blue oak stumps less than 16" in diameter will sprout after harvest in the northern part of the Sacramento Valley (Shasta and Tehama Counties), while few stumps of any size will sprout after cutting in the drier foothills of the southern Sierra Nevada.

In some locations, most of the mature trees currently growing in stands have originated as stump sprouts following some kind of disturbance. While all of these plants initially started from acorns, stump sprouting is now the primary means that these stands replace themselves. In these areas, seedling origin plants are extremely rare, and without sprouting, the oaks would have a hard time sustaining themselves.

Stump sprouts have several distinct advantages over seedlings originating from acorns. First, they already are connected to a massive root system which provides an enormous surface area - compared to the emerging root of a germinating acorn - for extracting moisture and nutrients from the soil. This root also has substantial quantities of stored carbohydrates which can be used as a source of food for the plant while it is developing photosynthetic tissue. Finally, the sprout origin plant is, in general, less vulnerable to animal damage - at least from the many animals that eat acorns, or clip off tender young shoots. For all these reasons, sprout-origin plants initially grow much faster than seedlings originating from acorns.

On the negative side, stump sprouts usually start as clumps or bushes comprised of many sprouts, and while these usually self-thin to several stems by the time they get to tree-size, these trees will likely never attain the single trunk form of oaks growing from acorns. While we often view these multi-stemmed trees as less aesthetically pleasing, they may also be weaker and more likely to be damaged from wind and snow. Although some research has shown that thinning the sprouts back to several main shoots enhanced diameter and height growth, this practice cannot be justified economically because of its very high cost. There is also a greater likelihood that these sprout trees will have some wood decay organisms in them, since the stump they have originated from is vulnerable to attack by pathogens. Finally, the process of top death and resprouting can not go on forever, and sooner or later, the plant will die. We don't know exactly how many times a tree can die and resprout, but we think this cycle can only be repeated 4 or 5 times.

In some situations, the promotion of stump sprouting can be incorporated into a harvest system to provide adequate recruitment. If stands are densely stocked, and sprouting is likely, then enough stumps may sprout to provide desired stocking levels after harvest.

Seedling Protection and Maintenance

One of the most critical factors affecting young oak seedlings, whether naturally occurring or planted, is competing vegetation. Adjacent plants, especially grasses, can use up so much of the available soil moisture that none is left for the seedling. Dense thatch can also create a favorable environment for animals such as field mice and grasshoppers that can devastate young seedlings by eating leaves and stripping bark. It is therefore recommended that a 2-3 foot radius circle around seedlings be kept free of weeds for at least 2 years (but preferably longer) after planting. This can be done by hand weeding, hoeing, scalping, or by spraying herbicides. With any of these methods, it will probably be necessary to check back in the spring and early summer to remove any additional weeds that have grown up. Another way of reducing weeds is to place some type of mulch around the planting spots. Bark chips, straw, compost, weed mats, or even tar paper or black plastic can be used. Mulches have an added benefit in that they help conserve soil moisture by reducing evaporation from the soil surface. In areas where water is available, several deep irrigations (approx. 2 gallons per seedling) during the late spring and summer of the first two years can also help ensure that seedlings aren't damaged by drought.

Since acorns are an important food source for host of animals, there is a risk that some of the planted acorns will be dug up and eaten. As the seedlings start to grow in the spring, there is also a chance that the foliage will be chewed on by livestock, deer, insects and/or rodents. The risk of such injury to acorns and seedlings can be reduced by using protective cages. One type of cage that has worked well in research plots consists of an 18 by 18 inch piece of aluminum window screen formed into a 5 inch cylinder and stapled to a 24 inch wooden stake. The cylinder is placed over the seedling or planting spot and folded at the top. The stake is driven into the ground to hold the screen in place. It is important to secure the screen closely to the ground by burying it or using large staples so that insects and rodents cannot crawl underneath.

A relatively new type protector is a rigid translucent plastic tube called a tree shelter. There are several brands on the market which vary in size from one to six feet in height. They are somewhat more expensive than screen cages ($1-2 for a 4 footer) but are much more effective in preventing animal damage to seedlings for a longer period of time. They effectively protect plants from insects, rodents, deer and even cattle if they are secured with a metal fence post. They also require relatively little upkeep and facilitate chemical weed control by protecting the tree from spray contact. One of their most remarkable features is their ability to stimulate initial height growth. Research studies have shown that seedlings in tree shelters often have more than twice the height growth of seedlings in screens during their initial establishment period. Some blue oaks in tree shelters at the Sierra Foothill Research and Extension Center have grown more than four feet from acorns their first year without irrigation!

Grazing and Oak Regeneration

Some research studies have shown how grazing management can be applied to actually encourage the development of young seedlings. These studies have shown that early season grazing, with cattle removed from the area prior to the drying up of the annual forages, actually improves moisture available to the developing seedling and results in higher rates of growth. This grazing activity also reduces the habitat available for rodents which may be a major source of seedling depredation. These same grazing studies also show that if cattle are left on an area late into the spring and summer, that they will preferentially seek out the young oaks, which are often the only green plants on the site. On areas that have been planted or where naturally occurring seedlings are found, grazing should be managed in such a way as to use these pastures early in the season to reduce the competition from annual grasses and forbs. The cattle should then be moved in the spring to other pastures where regeneration is not a problem. This rotational system can be continued for several years until the seedlings have grown sufficiently large to withstand grazing pressure.

Stand Structure Considerations

A hardwood rangeland stand provides a number of structural components that are important in sustaining ecological processes. Shown below are some general considerations involved in sustaining acorns, snags, cavity trees, and woody debris in a stand. A general discussion of the diameter distribution of a stand and the implications for developing sustainable management practices is also presented.

Acorns

Acorns are an important component of hardwood rangeland stands. They are necessary for regeneration, and are an important food source for a variety of wildlife species. Acorns make up at least 15 to 20 percent of the diet of some resident deer herds during the 6-month, summer-fall period. For migratory deer, acorns may represent 50

percent of their food on winter range in years of good acorn production. Other wildlife feeding studies reveal that acorns may constitute half the diet of California quail over 3 months or half of the diet of gray squirrels, feral pigs, and wild turkeys for as much as 6 months in a year of abundant acorns. Other bird species that rely heavily upon acorns include the acorn woodpecker, scrub jay, and band-tailed pigeon. Management practices need to ensure that acorns are maintained in the stand.

In evaluating acorn production in a stand, a classification system has been developed by the Department of Fish and Game (see Table 9-1). This can be used to assess the general production in a stand, and to select good acorn producing stands and individual trees. The table below and the following example shows this classification system and how it can be used.

Table 9-1. Acorn class descriptions and estimated acorn production.

Acorn Class	Class Description	Production (lbs/10 sq. ft. of canopy)
1	No acorns visible on tree	0.0
2	Acorns visible only after close examination. Maybe one or two are observed	0.1
3	Acorns are readily visible, but do not cover entire tree	0.7
4	Acorns are readily visible, cover entire tree. Limbs appear to sag from weight of acorns	2.3

Example

A large blue oak with a uniform, live crown diameter of 30 feet that has an acorn rating of "Class 3" could yield about 50 pounds of acorns.

Formula: (crown area)/10 x acorn production = production/tree
Crown area = $(30 \text{ ft.}/2)^2 \times 3.14 = 706.5$ sq. ft.
$706.5/10 \times 0.7 = 49.5$ lbs.

Prior to initiating any management activity, it is recommended that the acorn production in the stand is evaluated using this system. Although acorn production is highly variable from year to year, the best acorn-producing trees in the stand will continue as the best acorn producers. These should be identified and every effort should be made to maintain the health and vigor of these trees because of the wide range of benefits that acorns provide. One study estimated that 5 percent of the trees provided 95 percent of the acorn production in the stand. Thinning out the competing trees around the best acorn-producers so the crowns of the trees have plenty of sunlight and are free to grow will help to maximize acorn production and ensure the maximum longevity for the tree. Good acorn production seldom occurs in trees less than 75 years in age, so any management activity should seek to recruit older trees to serve as possible sources of acorn production for the future.

Snags, Cavities, and Woody Debris

Snags, cavity sites, and large woody debris are important components of a stand. Management activities need to ensure that a continuous supply of these elements are found across the landscape. It is necessary to balance the maintenance of these elements against concerns about catastrophic wildfire and management considerations for livestock.

Although there has been limited research on the exact number of snags desirable for hardwood rangelands, one study in the North Coast has shown that 10 snags or 16 cavities per 10 acres in a woodland provide sufficient habitat to sustain a population of cavity-nesting birds. As trees age, they decay and develop more cavities, soft wood, and dead limbs which serve as habitat locations for a variety of wildlife species. When trees finally die, they still serve an important ecological function in the stand as standing snags. Maintaining one snag every one to

two acres helps to provide habitat for the various wildlife species that rely on snags. When snags age and decay, they eventually fall down and become large woody debris. Large woody debris is an important habitat element for various species of mammals, amphibians and reptiles.

The schematic below shows how various stages in a tree's life serve as important structural components in a stand. All management activities should seek to ensure that the various stages are present somewhere on the landscape.

Acorn —> Seedling —> Sapling —> Young Tree —> Mature Tree —> Cavity Site —> Snag —> Woody Debris

Thinning and Tree Harvest Considerations

Chapter 8 provided a general discussion of wood product enterprises. Any tree harvest activity needs to carefully consider whether regeneration is likely to be a problem, and seek to ensure that adequate habitat elements are provided after harvest. The level and frequency of tree harvest are tempered by the landowner's or manager's objectives for oak canopy level, as well as the expected growth rate of the residual trees. Table 9-2 gives a general idea of what levels of tree harvest can be sustained for various oak canopy objectives.

Example

- A stand has around 20 cords per acre and a 50 percent canopy cover
- Overall management goals are to improve grazing capacity and reduce canopy to 75 percent of its existing level (35 to 40 percent) and maintain this level over the long-term
- Seedling regeneration is plentiful but sapling regeneration is lacking

Table 9-2 shows that for these stand conditions and management objectives, 5 to 7 cords of wood per acre can be harvested every 20 years to accomplish these goals. Cutting higher volumes than this will mean that it will not be possible to re-enter the stand after 20 years if you wish to regrow to a 35 to 40 percent canopy cover. Thinning less than this will allow dense cover to re-establish itself and require a more frequent entry to accomplish the forage production goals. The growth rate of the seedlings following the tree harvest will need to be closely monitored. If survival is poor, or if browsing pressure is too great, it will be necessary to implement some of the seedling protection or grazing management strategies described earlier in this chapter.

The distribution of trees by diameter class should be closely evaluated. For shade intolerant species such as blue or valley oaks, the number of trees by diameter class will closely resemble Figure 9-4 below. You will note that there are few trees in the smallest size class. Given this pattern, ensuring regeneration and recruitment of saplings and small trees into the stand requires that some small openings exist. Most of these openings are naturally created through tree mortality, windfall, disease, or fire. Management activities can attempt to mimic this pattern of small openings in the stand. These openings allow sunlight to reach seedlings, which show improved growth and survival. Seedlings and small trees of shade intolerant oaks would not be expected in denser stands.

Live oaks stands tend to have a distribution of trees more closely resembling that shown in Figure 9-5 below. The higher number of trees in the smaller diameter classes is a reflection of the higher shade tolerance of live oaks. Tree harvest in a live oak stand can be a selective thinning to encourage the recruitment of small trees to larger size classes.

Studies evaluating changes in hardwood rangeland stand structures over the last 60 years indicate that for areas not converted to another use, current oak stands may have higher stem and crown densities than existed historically. A thinning program may help to maintain the vigor of individual trees in a stand, improve forage production, and enhance acorn production. Harvest levels should be set so that they do not exceed the expected growth rate of the residual trees, and the capacity of young trees to replace those trees harvested or lost to mortality.

Figure 9-4. Diameter distribution of typical blue oak stands.

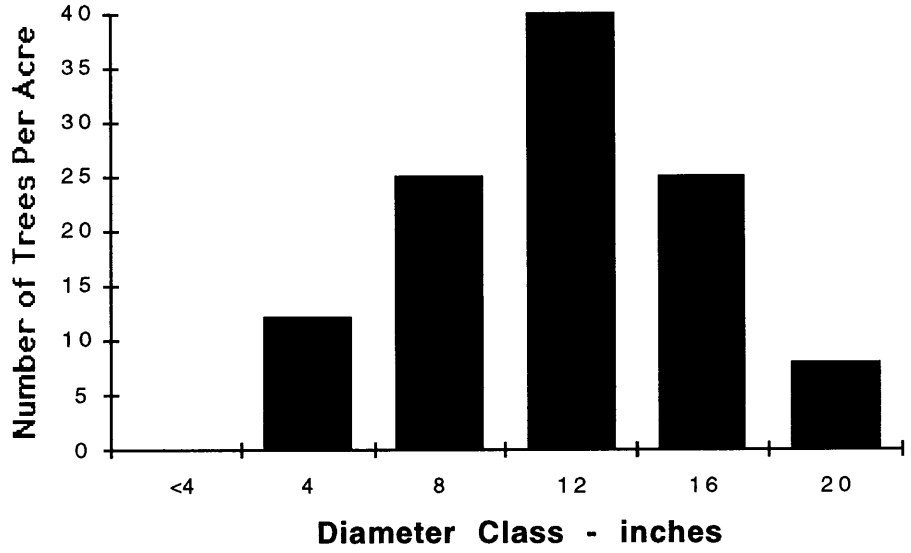


Figure 9-5. Diameter distribution of typical live oak stands.

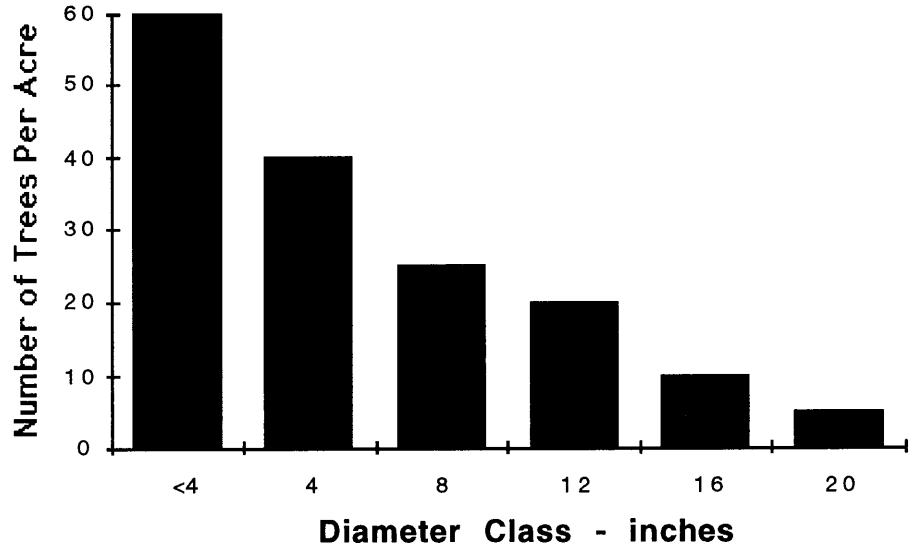


Table 9-2. General guidelines for selecting long-term oak canopy goals and general sustainable tree harvest levels.

Long-term Oak Canopy Goals	Initial Standing Volume			
	10 cords/Ac	20 cords/Ac	30 cords/Ac	40 cords/Ac
Maintain **100%** of existing oak cover over long-term	33 to 66% cover Good oak density for diverse management objectives **20 year harvest:** *1.5 to 2.5 cords/Ac*	45 to 80% cover Some forage production sacrificed for other resource values (wildlife, aesthetics) **20 year harvest:** *2 to 4 cords/Ac*	50 to 90% cover Dense oak cover; poor forage production; good for wildlife requiring dense cover **20 year harvest:** *2.5 to 5 cords/Ac*	60 to 100% cover Dense oak cover; poor forage production; good for wildlife requiring dense cover **20 year harvest:** *3 to 6 cords/Ac*
Maintain **75%** of existing oak cover over long-term	30 to 50% cover Open stand; good oak density for diverse management objectives **20 year harvest:** *3 to 4 cords/Ac*	35 to 70% cover Good oak density for diverse management objectives **20 year harvest:** *5 to 7 cords/Ac*	45 to 80% cover Some forage production sacrificed for other resource values (wildlife, aesthetics) **20 year harvest:** *7.5 to 9.5 cords/Ac*	50 to 90% cover Dense oak cover; poor forage production; good for wildlife requiring dense cover **20 year harvest:** *10 to 12 cords/Ac*
Maintain **50%** of existing oak cover over long-term	25 to 40% cover Unsuitable for commercial tree harvest on poor sites; good forage production; wildlife requiring open stands **20 year harvest:** *4 to 5 cords/Ac*	33 to 60% cover Good oak density for diverse management objectives **20 year harvest:** *8 to 10 cords/Ac*	40 to 70% cover Good oak density for diverse management objectives **20 year harvest:** *12 to 14 cords/Ac*	45 to 80% cover Some forage production sacrificed for other resource values (wildlife, aesthetics) **20 year harvest:** *16 to 18 cords/Ac*

Chapter Ten

Fire in California's Hardwood Rangelands

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Fire is a natural part of California's hardwood rangeland ecosystem. It has also served as an important management tool since Native Americans first inhabited these areas. Fire plays a role in the development of oak woodland stand structure, oak regeneration processes, the development of wildlife habitat, nutrient cycling, and economic uses of oak woodlands for domestic livestock. The ecological effects of fire will vary depending on the frequency, duration, intensity, and seasonality of fires, as well as the size of patches that occur from fire-induced mortality of mature trees. Adjacent vegetation types, such as grasslands, chaparral, and montane forests, influence fire effects in oak woodlands.

Fire protection officials are in agreement that the vegetative fuel load on most wildlands, including hardwood rangelands, has increased to dangerous levels since the 1950s when fire suppression effectiveness improved with the introduction of advanced fire fighting technology, allowing fuel which once burned up to build up. The recent increase in wildfire intensity and acreage of stand destroying fires in oak woodlands has resulted from decades of attempting to exclude fire. This trend illustrates the need to develop strategies in which fire is included in management activities in order to sustain the hardwood rangeland economic and ecological values.

Fire Relationships on Hardwood Rangelands

Fire behavior and effects are linked closely with climate. The climate in California's hardwood rangelands can be classified as Mediterranean-like, with cool, moist winters and long hot summer drought periods. Plants have adapted to this climate, where seasonal fire was historically a relatively common event, by developing survival strategies that accommodate both climate and recurrent fire. Lightning-caused fires originating from major storms coming northward from Mexico have played a major role in shaping oak woodlands.

Because of the long period of human habitation of oak woodlands, it is extremely difficult to separate the "natural" role of fire from the human use of fire as a management tool. Native Americans made frequent use of fire in oak woodlands. There are numerous accounts of burning by native Americans in woodlands to enhance habitat for game species, to improve access for hunting and gathering acorns, and to maintain plant materials in an appropriate growth form for making materials such as baskets and tools. It is almost impossible to document the frequency, intensity, and extent of burning by Native Americans from existing fire ecology studies. However, the pre-European landscape appears to have been a mosaic of small fire areas that effectively prevented most large, catastrophic fires.

The first European settlers continued the burning practices of Native Americans. Burning in oak woodlands and chaparral lands was a common management strategy to keep stands open for livestock production and to encourage forage production. Surveys indicated that oak woodland burning on a 8 to 15 year interval was the common management strategy of ranchers until the middle part of the 1900s. Prescribed burning associations were set up in various locations around the state, where neighbors came together annually to help conduct burns in the highest priority areas.

The use of burning as a management tool to mimic the effects of nature ceased on the state's conifer forest lands in the early part of the century. However, ranchers continued the extensive use of burning in oak woodlands until the 1950s. At that time, the use of fire as a management tool in oak woodlands declined, driven by economics, negative urban attitudes towards fire, increasing housing density in rural areas of the state, concerns about liability from escaped prescribed fires, and air quality concerns. Fire suppression became the standard management strategy on oak woodlands, as it had become decades earlier on conifer lands.

One study at the University of California's Sierra Foothill Research and Extension Center in Blue Oak Woodland and Blue Oak/Foothill Pine Woodland showed that fire frequency was around 25 years prior to settlement by Europeans in the mid-1800s. After settlement by Europeans, the use of fire as a management tool can be

observed, with a fire frequency of about every 7 years. Since the mid-1950s, however, no fires were observed on this area. This same kind of information on fire frequency is needed for other areas of the state in order to develop fire plans that sustain hardwood rangeland ecological values.

Today, most wildfires are quickly suppressed. However, fire suppression technology has become so effective that the resulting high fuel loads have dramatically increased. This has greatly increased the likelihood of large-scale catastrophic wildfires. More than three-quarters of the acreage burned each year in California can be attributed to less than one percent of the wildfires. The total acreage burned annually appears to be increasing in peak years, as well as the size of individual large wildfires. Two of the three largest wildfires in California history were recorded during the 1970s.

Each year the number of fires related to human activity is increasing. From 1966-80, California's population increased by nearly 25 percent. On areas protected by the California Department of Forestry and Fire Protection (CDF), wildfires caused by people during this period increased by over 100 percent. Similar trends are observed on United States Forest Service lands, revealing a clear correlation between the risk of wildfire and demographics. This increases the threat to developed areas and natural resources.

Effects of Fire on Oak Woodland Sustainability

Oak woodlands are extremely well adapted to fires, and fire is a critical component of oak woodland ecology. Mature oaks can survive regular low intensity ground fires, and most woodland oak seedlings and saplings have the capacity to resprout after being top-killed by fire. Fire contributes to the health of hardwood rangeland plant communities by recycling plant nutrients, and removing substances of plant origin that accumulate in the duff and litter and are toxic to some plants and other organisms. Indeed, without fire, the character of vegetation would change, and the health of plant communities would decline. Many of the plant species on hardwood rangelands are maintained and perpetuated by fire; it stimulates seed germination in some brush species and creates the necessary disturbance conditions for seedling establishment of others. Some plants recently considered uncommon in California have been found in abundance following fire.

Studies have shown that higher fire frequencies in the past may have created conditions more conducive for oak regeneration. On Sierra Nevada hardwood rangelands, oak recruitment events were shown to be associated with fire events, with most current oak recruitment occurring during periods of high fire frequency in the 1880s to 1940s. Oak recruitment has been rare since fire suppression.

The importance of fire on oak regeneration may be shown by the enhanced postfire oak sprout growth documented by several researchers. In areas of moderate grazing with fire intervals of around 7 years, seedlings taking up to 18 to 20 years to grow taller than the livestock browse line (around 5 feet) survived to become saplings and persist in the stand. In heavily grazed areas, only those trees that exceeded the browse line in 10 to 13 years were recruited. Other factors affecting oak regeneration which would be influenced by the timing of fire events include: seedbed preparation for acorns; competition for moisture from herbaceous species; and availability of wildlife habitat for species that feed on acorns and seedlings.

Fire also has a major affect on the structure and composition of oak woodland stands. In southern California, fire has a differential effect on coast live oak and Engelmann oak. Coast live oak seedlings had a higher mortality than Engelmann oak seedlings following fire. Although coast live oak had greater height growth in unburned areas, Engelmann oak had greater height growth following fire. The decline of Engelmann oak habitats in Southern California might be mitigated by reintroduction of fire to encourage Engelmann oak in these mixed stands.

Fire Risks on Hardwood Rangelands

Although natural fire is a regular part of the oak woodland ecosystem, wildfires today often pose a major risk because of the unnaturally high fuel accumulations and resulting high intensity fires. The greatest risk of wildfire on hardwood rangelands occurs where urban development encroaches upon and mixes with the wildlands. This so-called "interface" has been defined as a zone, perhaps 20 miles wide, that exists everywhere there is contact between urban development and the vast expanses of California's natural vegetation. This encompasses a sizable percent of the state's hardwood rangelands.

Wildfires on hardwood rangelands have a major effect on water quality and water supply. The reservoirs storing water for hydroelectric power for California's human population, economy and aquatic resources through the long summer drought, lose capacity each year as sediments from natural erosion accumulation. The increasing size and frequency of catastrophic wildfires can accelerate this erosion and sedimentation process. As reser-

voir storage capacity is lost, water rationing may become necessary, and the cost of water may increase.

Large fires result not only in increased runoff and associated erosion, but movement of sediment in streambeds. This sediment and that produced by the impacts of storm events on bare soil can negatively affect the form and function of streams. When this occurs, water quality, measured by total dissolved and suspended solids, may deteriorate. The adverse effect on fish populations is well documented. Possible health hazards and the water turbidity associated with these changes interfere with water supply and add to the costs of water treatment.

High intensity, catastrophic wildfires can lead to accelerated soil loss that may exceed the rate of soil formation. Where this occurs, sites may be unable to sustain the existing diversity of native plant communities. Where plant communities are degraded, the habitat they represent may no longer support some animals present before fire. The new environment may include community structures where only reduced populations of a limited number of animal life forms can exist.

Whether or not accelerated soil loss occurs, frequent wildfire can adversely impact the structure of wildland plant communities. Often, fires that recur too soon will interfere with normal recovery of these communities. Many are composed of plants that dominate the landscape in sequence after fire. Under natural conditions, this succession is present both as growing plants and seed. However, too frequent fire can eliminate plants that dominate later stages of recovery. When this occurs, a plant community can be changed (for example, from an oak woodland to an annual grassland), and elements of diversity are lost. Other plants that dominate early in the cycle may become unnaturally abundant and encourage frequent fire. This condition can produce irreversible changes in plant communities and the wildlife populations that depend on them.

Just as too frequent fire can adversely affect natural communities, so can fires that are too intense. Such fires are caused by unnatural accumulations of dead and senescent vegetation where wildfire suppression has been most effective. Intense, very hot fires can kill plants and animals that would survive fires recurring in a natural cycle.

Wildfires also affect recreational resources, property values, wildlife habitat values and forage resources for livestock. When grasslands burn, forage production can be depressed for two years. Generally, these losses can be expressed in economic terms.

Assessing Fire Damaged Oaks

The recent increase in large-scale, high intensity fires has had a major effect on mature oaks. Immediate visual effects range from complete tree consumption, to wounding of the cambium area (the conducting tissue under the bark), to death of the leaves. Longer term effects may include introduction of rot-causing fungi to the structural part of the tree through fire scars, increasing probability of future tree failure. However, oaks are well-adapted to natural, low intensity fires, and have a tremendous capacity to resprout from the base, trunk, and branches to allow recovery of the tree following fire.

The major effect of fire on oaks is determined by the temperature reaching the living cells of the cambium beneath the bark. The thick bark on most oaks on hardwood rangelands provides good insulation for living cambium cells. Since bark thickness increases with tree diameter, larger trees are much more resistant to high temperature fires than thin-barked small trees. Bark texture also affects the severity of fire injury. Coast live oak has relatively smooth-textured bark, which actually inhibits the fire from being carried up the trunk of the tree, while the coarser-textured valley oak bark is more susceptible to fire injury.

Burned tree leaves and small stems are not a major source of concern, as new leaves can be regenerated if the cambium area is not severely damaged. The most critical factor to evaluate is the amount of damage to the cambium of the trunk. This is done by the classifying the level of char from the fire into one of the following three classes: *light* – spotty char or scorch with scattered pitting of bark; *medium* – continuous charring with minor reduction in bark thickness; *heavy* – continuous charring with pronounced reduction in bark thickness with underlying wood sometimes exposed. The greater the amount of charring, the more likely that the tree will die. Oaks with light or medium char, especially in trees over 12 inches in diameter at breast height (DBH), will often survive fire damage. In general, trees with heavy char die, although coast live oaks over 6 inches DBH have been shown to survive, even with heavily charred trunks.

In areas around home sites or heavily used recreational sites, it is wise to remove oaks with over 40 percent of their circumference in a heavily charred condition. This minimizes the possibility of future tree failure. In other areas, the snags and large cavities of these "damaged" trees may actually provide a good source of wildlife habitat. If you do cut a damaged tree, there is an excellent possibility that the stump will resprout and form a new tree.

Oaks that are left after wildfires should continue to be evaluated for several years to determine if they have

been able to survive the fire's effects. Once the tree has resprouted from the branches or trunk, you will have a good idea of how extensive the final damage is. Resprouting may begin within a few weeks, or may take until the following spring. You should plan to prune off dead wood of damaged trees around home sites to minimize future safety concerns. You should also assess whether trees resprout from the root crown to determine if the resprouting will provide adequate regeneration on the site, or if supplemental planting is required (see chapter 9).

Fuel Management Options

Recent losses due to large wildfires have shown the devastating effect of attempting to remove fire from the oak woodland ecosystem. The probability of large-scale fires due to fuel accumulations increases each year. Stagnant oak stands with little sapling recruitment are, in part, a result of the unnatural removal of fire. Landowners and managers concerned with sustainability of oak woodland economic and ecological values need to find ways in which fire can be reintroduced into the system.

Livestock grazing is often looked to as a tool for reducing fuel build-ups on hardwood rangelands. At the urban interface, suburban residents and homeowner associations have entered into grazing leases with livestock operators.

A considerable base of knowledge exists on how to manage hardwood rangelands to reduce wildfire hazard and reintroduce the natural role of fire into the ecosystem. Management based on this knowledge is supported by law and agency policies. However, implementation of effective management has some problems. The principal fuel management tool on large areas has been prescribed fire. Control and use of prescribed fire now is complicated by increased hazard, air quality considerations, urban development in wildland areas and the threat of liability associated with its use under existing conditions.

For nonfederal lands, the CDF administers the Vegetation Management Program (VMP) to assist land owners and managers with fuels management. This cost-share program employs prescribed fire as its principal tool. The intent of the VMP is to develop age class mosaics, landscapes composed of patterns of old and younger plant communities created through rotational prescribed burning. Such mosaics reduce hazard, inhibit spread of wildfire, limit damage and erosion, and maintain balanced plant and animal populations. Effective use of the VMP is curtailed by the factors identified above that limit employment of prescribed fire.

Shown below are a series of steps that one should take in the design of a prescribed burning program.

Set management objectives — An important preliminary step in any management activity is to determine the objectives for an area. It may be to enhance the economic value of a ranching enterprise, improve wildlife habitat, maintain water quality, reduce the probability of large fire losses, or a combination of all of these. All the stakeholders in a project area need to decide upon these objectives as discussed in Chapter 1.

Develop partnerships — Areas in the state where prescribed burning activities are being successfully implemented are those where partnerships in the community have been developed and maintained. Groups of landowners, adjacent public land managers, conservation groups, and representatives of resource management agencies should all be brought together. The Coordinated Resource Management Planning (CRMP) process is a useful mechanism to bring people together. Experience and expertise can be shared, and resources can be pooled to reduce costs. Assistance programs such as the Vegetation Management Program, the Forest Stewardship Program, and cost-share programs administered by the Consolidated Farm Service Agency (CFSA), should be evaluated and utilized whenever feasible.

Develop an assessment of current vegetation and fuel conditions — A survey of the project area should be carried out to prioritize areas for treatment. Existing vegetation cover types should be mapped out, and the fuel loads of each assessed. Important ecological zones such as riparian areas, locations of sensitive species, and areas prone to erosion should be identified. Houses, roads, and other improvements should also be located. Geographic information systems (GIS) and remote sensing technology, coupled with ground surveys, can help in this task. The assessment should also consider historical fire frequency and intensity so the fire plan can match management goals and local ecological conditions.The assessments carried out in chapter 3 and 4 can help with this.

- Design the burn program — Given this background information, a plan for annual burning activities can be designed. This should consider the size of the burn unit, the time of year for burning, weather condi-

tions necessary to obtain the appropriate fire intensity, and the location of firebreaks and equipment. CDF and other fire management organizations have the expertise to assist in this.

- Conduct the burn — Once all of the preceding steps have been accomplished, the actual burn can be carried out. Make sure all participants and equipment are lined up well in advance, and all background work has been completed. Build enough contingency into planning so that the project can respond to weather variability that will certainly affect when the burn takes place.

- Monitor the results — Information on the effects of different prescribed burning strategies on oak woodland systems is lacking. There must be a system to evaluate whether the impacts of the burn meet the objectives for the area. This provides feedback for future years and helps to refine future management decisions.

What Homeowners Can and Must Do

Homeowners and other owners of small parcels of land within the zone of mixed urban development and wildlands, the interface, are confronted with the greatest threat from wildfire. Scattered urban development hampers efforts by wildfire protection agencies to effectively employ their fire suppression expertise. Often, they can no longer fight fire at the flame front. Instead, protection of life and property becomes a first priority, and the limited fire fighting resources are diverted in attempts to save individual homes. This inefficient defense in an environment that is becoming more threatening contributes to fire spread and endangerment of other property.

The CDF has developed a checklist to help wildland residents make their homes fire safe. This checklist, *Fire Safe, California!: How to Make Your Home Fire Safe,* is available from local CDF offices. It directs evaluation of interior and exterior conditions to help homeowners assess their vulnerability. The checklist should be used together with *Fire Safe, Inside and Out,* another CDF publication, to help identify measures that will reduce fire danger. The UC publication, *A Property Owner's Guide to Reducing Wildfire Threat* is another useful guide for homeowners. There are also a number of other publications, listed at the end of this chapter, which can help landowners assess wildfire risk and develop strategies to protect their property.

Chapter Eleven

Erosion Control on Hardwood Rangelands

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Erosion is a natural process that involves the weathering of parent materials, the precursors to soil, and the movement of these materials and existing soil to places of accumulation where plants grow. This process also provides many of the minerals that help support aquatic ecosystems. However, when erosion exceeds natural rates of weathering and accumulation, it can have a negative impact on both terrestrial and aquatic environments. Accelerated erosion degrades soil productivity and can result in excessive production of sediments, the principal water pollutant.

Accelerated erosion on hardwood rangelands can degrade soil productivity and impact water quality for domestic use and aquatic life. It is important for managers of hardwood rangelands to be aware of the possible causes of accelerated erosion, and to develop management approaches to stop or minimize accelerated erosion. This chapter discusses some common activities on hardwood rangelands that can lead to erosion, and suggests methods for reducing their effects. There is a great deal of additional information on erosion and related subjects from the Natural Resources Conservation Service (NRCS) and the Resource Conservation Districts, as well as the local UC Cooperative Extension offices (see Appendix D). Contact local offices for a list of what is available.

Roads

Ranch roads on hardwood rangelands can be responsible for up to 50 percent of all erosion, although they commonly represent less than 10 percent of the land area. Road construction is a major initial source of accelerated erosion, but improper road location and alteration of natural surface drainage often create patterns of overland water flow that concentrate the erosive force of water. The net result is an erosion rate that can be five times that caused by other disturbances. Accelerated erosion may become a chronic problem due to road maintenance. Described below are some general road construction and maintenance ideas. It is also a good idea to examine lightly and more heavily trafficked roads in your local area to evaluate the effectiveness of different practices.

Drainage Control

Minimizing erosion from roads depends on two key elements: 1) proper design; and 2) construction to control drainage. Provision for control of drainage from the road surface and the roadbed must be incorporated during construction, and drainage from adjacent slopes must be allowed free passage. Roads can be crowned or raised at the center, sloped inwards, or sloped to the outside to permit rapid surface drainage. On straight sections of road, crowned construction is commonly used. On curves, a slope to the inside or outside can be used. Where light use is anticipated, roads with small cuts and fills can be sloped to the outside for most of their length.

Waterbars. A "waterbar" has been shown to be one of the cheapest and most effective structures to control and divert surface drainage from lightly used unsurfaced (unrocked) roads. It is constructed by excavating a four foot wide ditch in the road surface, about one foot deep. The waterbar should be situated about 45 degrees downgrade from a line perpendicular to the road centerline. Soil from the excavated ditch is piled on the downgrade side to a height of 1 to 2 feet to create a berm. The upslope ends of berms should be tied into road cuts to prevent drainage water from escaping around the ends and developing excessive erosive energy. Where drainage exits a waterbar, the erosive energy of running water can be great. Rock or other nonerodible material should be placed at this point to dissipate energy by slowing and spreading the flow of water.

It is important to properly space waterbars to control the erosive energy of running water. A general rule suggests dividing 1,000 by the road grade (the rise or fall of a road in feet over a horizontal distance of 100 feet

with the result expressed as a percent). The answer gives an estimate of proper spacing.
Example: A road has a 10 percent grade (a rise of 10 feet in 100 feet). The waterbar spacing is determined by the formula:

$$1000/10 = 100$$

Therefore, waterbars should be spaced about every 100 feet.

Proper spacing of waterbars also can be estimated by examining unsurfaced roads in the local area. The distance it takes running water to create a rill (miniature gully) 1 inch deep on the road surface gives a good estimate of waterbar spacing for a particular grade.

Inside Ditches. If roads are sloped to the outside over their entire length, there is no need for inside ditches to carry water from the road surface and the hill slope above. However, on all but the most lightly trafficked roads protected with waterbars, inside ditches and ditch relief culverts are necessary to control runoff. These ditches permit more intensive road use by providing subsurface roadbed drainage and intercepting ground water from the uphill side of the road.

Ditches should have adequate cross sections and grades to carry any anticipated flows without washout of the road. Grades should be at least 2 percent. Steeper ditches (over 10 percent) will need rock or other surfacing material to prevent ditch scouring and road damage. Depending on soil erodibility, water velocity in the ditch should not be allowed to exceed 2 to 8 feet per second. (about 1 to 5 miles per hour or no faster than a brisk walk).

Ditch Relief Culverts. As water volume in ditches accumulates over distance, it can damage roads and accelerate erosion. Controlling water volume requires use of properly spaced relief culverts with energy dissipators. These culverts transport water beneath the roadbed from the inside ditch. They are angled about 30 percent downslope measured from a perpendicular to the center of the road. The bottom of the culvert on the ditch side is at or slightly below the bottom of the ditch. Each culvert is installed with a minimum grade of 3 to 4 percent and should have a grade 1 to 2 percent more than the entering ditch grade. Culverts with grades of 10 percent will usually remain clear of sediment.

Road Maintenance

Good road maintenance helps to minimize accelerated erosion impacts. This involves regular inspection of all roads on the ranch to evaluate if problems exist. Some of the common maintenance items to consider include:

- Checking and cleaning culverts on a regular basis, to ensure that they allow free movement of water beneath the road surface, helps keep roads from washing out in high intensity rainfalls;
- Cleaning waterbars helps to maintain their effectiveness in removing water from the road surface;
- Grading the road surface to remove ruts and potholes that develop, and keep these from contributing to sediment movement from the road surface into watercourses;
- On some highly erodible areas, or areas with minimal design provisions for erosion control, it may be necessary to limit access during wet periods;
- Road closure may be necessary if a particular road is a chronic source of accelerated erosion, and the costs of maintenance are excessive.

Bare Slopes

Hardwood rangeland properties with bare soils on slopes along roadways and around new homes are subject to erosion. Without a dense cover of plants to protect the soil surface, the energy in falling rain and running water can gully surface soil and wash mud onto landscaped or paved areas and into storm drains and streams.

Slope Protection

Slopes that have been artificially created and are too steep, too rough or too remote to be intensively landscaped can best be protected against erosion by growing plants that completely cover the soil surface. Such cover can be permanent or applied as a temporary measure to reduce erosion. In either case, the following are essential for erosion protection using plants: proper slope design, diversion of water away from slopes, use of adapted plant material and appropriate planting and cultural practices, and application of a temporary mulch to protect soil until an effective vegetative cover becomes established.

Slope Construction. A cover of plants grown to protect the soil surface will be effective only if the site is geologically stable and the slope is properly designed. Slopes must not be so steep that gravity alone will cause loose soil to move. A good rule of thumb is to construct slopes so that each foot of rise or fall takes place over a horizontal distance of 2 or more feet (a 2:1 slope). A 5:1 slope is preferred. Slopes 20 feet or longer should be broken up with small ditches or flat benches on the contour. Some situations may require even shorter slope segments.

Water Diversion. Water must not be allowed to cascade uncontrolled down long or steep slopes that have been disturbed. Diverting water at the tops of slopes with dikes, ditches and raised berms will help prevent serious erosion and reduce soil saturation, a condition that often causes land and mud slides. It is important to understand that once a slope is badly eroded, plants are of little help. Damage then must be corrected mechanically. Conditions must be created for plants to grow and produce effective cover. The diversion must be well-constructed and armored against the force of the concentrated flow. You must carefully assess where the diverted water will flow to when planning the diversion to make sure you are not contributing to an even worse accelerated erosion problem.

Vegetation Value and Choices

Vegetation cover planted for erosion control has four major functions:

(1) to absorb the impact of raindrops;
(2) to allow more rainfall to enter the soil rather than to run down the slope;
(3) to bind soil particles together; and
(4) to reduce the velocity of runoff and the amount of soil carried down the slope.

Since bare slopes are often rocky or infertile, plants for ground cover are difficult to start and grow slowly. However, the costs of establishing plant cover are small compared with the costs of building permanent sediment basins or dredging streams, lakes and reservoirs.

Seeding Annual Grass. This is the most rapidly growing plant material that will produce a complete ground cover. Annual grass, adequately fertilized, establishes quickly from seed and can provide complete erosion protection more rapidly than any other ground cover. After 3 to 5 years, other types of plants, such as native shrubs, may take over an area that was seeded with annual grass. This represents a natural stage in plant succession, the replacement of one group of plants by another. If desired, erosion control plants can be replaced later by permanent landscaping, after the soil has been completely stabilized.

Seeding Perennial Grass. Native perennial grasses can sometimes provide effective, long term erosion protection. They may be more effective than the exotic annual grasses that now dominate California's hardwood rangelands. However, they: (1) grow more slowly than annuals, (2) establish poorly in the presence of competition from annual grasses, (3) require more culture and supplemental practices to ensure establishment, and (4) may be poorly adapted to highly modified sites. The use of native grasses requires careful evaluation of site conditions and economic resources.

Seedbed Preparation

Preparation of a loose seedbed is desirable to allow the seed to lodge and be covered with soil. Construction activities or tree and brush removal generally leave sites sufficiently disturbed to permit the seed to reach mineral soil. Graded slopes should be left rough. Rainfall will help cover much of the seed, but raking or dragging the seeded areas with tire chains, sections of cyclone fence, heavy boards, etc., covers the seed much better.

Mulch Protection

If soil is heavily disturbed or has little surface debris (branches, roots, leaves, etc.) to retard water runoff, protection with mulches of grass hay, grain straw, or synthetic mulch mats will be necessary to ensure initial protection against erosion while plants are getting started. It may be as long as 3 to 4 months after seeding (during the late September to early October period) and after the first fall rains before ground cover provides effective protection.

Other Information Sources

Detailed information on site preparation, seeding recommendations, plant culture and supplemental practices is presented in 3 UC leaflets: (1) Erosion Control on Bare Slopes Around Your Home (Leaflet 21137), (2) Seeding for Erosion Control in Coastal and Central California (Leaflet 21304), and (3) Seeding for Erosion Control in Mountain Areas of California (Leaflet 21356).

Range Residue Management

Livestock grazing management can sometimes have an impact on the extent of erosion on hardwood rangelands. The annual grasses and forbs, most of them exotics introduced from the Mediterranean region, germinate in the fall of each year at the beginning of the rainy season. Although fall weather has the most impact on early annual plant growth, residue (dry plant material left on the ground) from the preceding season's production also has considerable influence. This residue also retards runoff and enhances water infiltration, both of which influence erosion rates. It is important to recognize that minimum levels of fall residue are needed to protect against accelerated soil erosion. However, too much residue can retard germination and seasonal forage production. Livestock management practices determine the amount of residue remaining at the end of a forage season (see chapter 5).

Residue Levels

Minimum recommended levels of fall residue have been developed for broad regions of the state. These range from 200 pounds per acre on lower or flat slopes in Southern California where annual precipitation is 10 inches or less to over 1,200 pounds per acre on steep slopes along the North Coast where precipitation exceeds 40 inches annually.

UC Leaflet 21327 (Guidelines for Residue Management on Annual Range) lists the recommended minimums and describes techniques for estimating residue, both visually and quantitatively. These recommendations are intended as guidelines only and should be tested by ranchers and range managers to develop levels that meet requirements for specific sites and conditions. Criteria for evaluation of desired levels of residue include total forage production, the desired mix of plant species, livestock performance, percent ground cover, and maintenance of natural erosion rates.

Balancing Livestock Needs & Forage Protection

Periodic heavy grazing has short-term effects. Such effects are produced in planned short-term, high intensity grazing programs, and in unplanned situations when spring precipitation is too low to sustain normal production and livestock cannot be moved. However, season-long heavy grazing maintained over time can have longer lasting effects by reducing total forage production, increasing the amount of low-growing plants, and increasing erosion. Flexible livestock stocking rates are needed to insure retention of minimum residue levels each fall at the beginning of the rainy season. Balancing livestock needs against forage availability achieves two goals: (1) maximum sustained benefit from the forage resource through maintenance of an optimum environment for early growth of a desired mix of forage plants and (2) protection of the soil surface for prevention of accelerated soil erosion.

APPENDICES
A - E

Appendix A. Vertebrate Wildlife Species and Habitat Associations[1]

The following table gives a list of the 313 species of amphibians, birds, mammals, and reptiles that are predicted to use California's hardwood rangeland habitats. This list is derived from Version 5.0 of the California Wildlife Habitat Relationships System (CWHR) and includes those species that are predicted to use one or more hardwood rangeland canopy cover classes for breeding, feeding, and/or cover. Most waterbirds like ducks, geese, gulls, and shorebirds were not included in the CWHR predictions because they are mostly associated with lakes, ponds, and rivers. The CWHR System is managed by the California Department of Fish and Game, and has information for 647 species of "regularly" occurring resident and migratory wildlife.

The table also indicates which of these hardwood rangeland species are predicted to use several important habitat elements of the California hardwood rangeland habitats. The elements listed include: acorns; riparian habitat; logs, slash, and brush piles; snags; burrows, rocks, talus, caves and cliffs; and vernal pools and wetland.

Also included are those species which have special status designation by the California Department of Fish and Game and/or the U.S. Fish and Wildlife Service. Most of these species, particularly mammals and reptiles, have locally restricted subspecies that have a special status designation. If you have a species with a special status, you need to get more detailed local information on whether your population is in a subspecies with this special designation. You need to ensure that there is adequate protection for these species, and to make sure that you are not in violation of state or federal endangered species regulations.

Landowners and managers using these lists can get a general idea of which species might be located on a particular property, and which important habitat elements are important to their use of an area. This list should not substitute for local-based surveys. Landowners may wish to consult with local CDF&G biologists, or consulting wildlife biologists for more detailed local surveys of their lands.

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[1]Primary author is: Barry Garrison, Calif. Dept. of Fish and Game

Common Name	Scientific Name	Hardwood Habitat					Habitat Elements						Special Status (see key at end of table)		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Acorns	Riparian Habitat	Logs, slash, brush piles	Snags	Burrow rocks, talus, caves, cliffs	Vernal pools, wetland	Federal Status	State Status	Harvest Species
AMPHIBIANS															
Arboreal Salamander	*Aneides lugubris*	x	x	x	x			x	x	x	x				
Black Salamander	*Aneides flavipunctatus*	x	x	x	x	x		x	x		x				
Black-Bellied Slender Salamander	*Batrachoseps nigriventris*	x	x	x	x			x	x		x	x			
Bullfrog	*Rana catesbeiana*	x	x	x	x			x				x			x
California Newt	*Taricha torosa*	x	x	x	x			x			x	x		Spec. conc.	
California Slender Salamander	*Batrachoseps attenuatus*	x	x	x	x			x	x		x				
California Treefrog	*Hyla cadaverina*	x	x	x	x	x		x			x				
Ensatina	*Ensatina eschscholtzi*	x	x	x	x	x		x	x		x		Cand.	Spec. conc.	
Foothill Yellow-Legged Frog	*Rana boyleii*	x	x	x	x			x			x				
Kern Canyon Slender Salamander	*Batrachoseps simatus*	x	x	x					x		x		Cand.	Threat Prot.	
Limestone Salamander	*Hydromantes brunus*	x	x					x			x		Cand.	Threat Prot.	
Long-Toed Salamander	*Ambystoma macrodactylum*	x		x	x			x	x		x	x	End.	End., prot.	
Northwestern Salamander	*Ambystoma gracile*	x		x	x	x		x	x			x			

Common Name	Scientific Name	Hardwood Habitat					Habitat Elements						Special Status (see key at end of table)		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Acorns	Riparian Habitat	Logs, slash, brush piles	Snags	Burrow rocks, talus, caves, cliffs	Vernal pools, wetland	Federal Status	State Status	Harvest Species
Pacific Giant Salamander	*Dicamptodon ensatus*					x		x	x		x				
Pacific Slender Salamander	*Batrachoseps pacificus*	x	x	x	x	x		x	x		x	x	Cand.		
Pacific Treefrog	*Hyla regilla*	x	x	x	x	x		x			x	x			
Red-Bellied Newt	*Taricha rivularis*	x	x	x	x	x		x	x		x				
Red-Legged Frog	*Rana aurora*	x	x	x	x	x		x			x	x	Prop.	Spec. conc., Prot.	
Rough-Skinned Newt	*Taricha granulosa*	x	x	x	x	x		x	x		x				
Shasta Salamander	*Hydromantes shastae*		x						x		x		Cand.	Threat Prot.	
Tehachapi Slender Salamander	*Batrachoseps stebbinsi*	x	x	x	x			x	x		x		Cand.	Threat Prot.	
Tiger Salamander	*Ambystoma tigrinum*	x		x	x			x	x		x	x	Cand.	Spec. conc., prot.	
Western Spadefoot	*Scaphiopus hammondii*	x		x	x			x			x	x	Cand.	Spec. conc., Prot.	
Western Toad	*Bufo boreas*	x	x	x	x	x		x	x		x	x			

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REPTILES															
Blunt-Nosed Leopard Lizard	*Gambelia silus*	x	x		x			x			x		End.	End., Prot. (c)	
California Legless Lizard	*Anniella pulchra*	x	x	x	x			x	x		x		Cand.	Spec. conc., Protc.	
California Mountain Kingsnake	*Lampropeltis zonata*	x	x	x	x	x		x	x		x		Cand.	Spec. conc., Prot.	
California Whipsnake	*Masticophis lateralis*	x	x	x	x			x	x		x		Cand.	Threat Prot.	
Coachwhip	*Masticophis flagellum*	x	x	x	x			x			x		Cand.	Spec. conc., Prot. (c)	
Coast Horned Lizard	*Phrynosoma coronatum*	x	x	x	x			x	x		x		Cand.	Spec. conc., Prot.	
Common Garter Snake	*Thamnophis sirtalis*	x	x	x	x	x		x	x		x	x	End., Cand.	End., Prot. (a)	
Common Kingsnake	*Lampropeltis getulus*	x	x	x	x	x		x	x		x				
Desert Night Lizard	*Xantusia vigilis*	x	x	x									Cand.	Spec. conc.	
Desert Spiny Lizard	*Sceloporus magister*		x					x			x				
Giant Garter Snake	*Thamnophis gigas*			x				x			x	x	Threat	Threat Prot. (a)	

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Gilbert's Skink	*Eumeces gilberti*	x	x	x	x	x		x	x		x				
Glossy Snake	*Arizona elegans*	x		x	x						x				
Gopher Snake	*Pituophis melanoleucus*	x	x	x	x	x		x	x		x		Cand.	Spec. conc. (b)	
Granite Night Lizard	*Xantusia henshawi*				x						x		Cand.	Spec. conc., Prot. (c)	
Granite Spiny Lizard	*Sceloporus orcutti*				x						x				
Long-Nosed Snake	*Rhinocheilus lecontei*	x	x	x	x						x				
Lyre Snake	*Trimorphodon biscutatus*	x		x	x			x			x				
Night Snake	*Hypsiglena torquata*	x	x	x	x			x	x		x				
Northern Alligator Lizard	*Gerrhonotus coeruleus*	x		x	x	x		x	x		x				
Orange-Throated Whiptail	*Cnemidophorus hyperythrus*				x								Cand.	Spec. conc., Prot.	
Racer	*Coluber constrictor*	x	x	x	x	x		x	x		x	x			
Red Diamond Rattlesnake	*Crotalus ruber*				x			x			x		Cand.	Spec. conc. (c)	

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Ringneck Snake	*Diadophis punctatus*	x	x	x	x	x		x	x		x		Cand.		
Rubber Boa	*Charina bottae*					x		x	x		x		Cand.	Threat Prot.	
Sagebrush Lizard	*Sceloporus graciosus*					x			x		x		Cand.		
Sharp-Tailed Snake	*Contia tenuis*	x	x	x	x	x		x	x		x				
Side-Blotched Lizard	*Uta stansburiana*	x	x	x	x			x	x		x				
Small-Scaled Lizard	*Urosaurus microscutatus*				x						x				
Southern Alligator Lizard	*Gerrhonotus multicarinatus*	x	x	x	x			x	x		x				
Speckled Rattlesnake	*Crotalus mitchelli*	x	x	x	x	x		x			x				
Western Aquatic Garter Snake	*Thamnophis couchi*	x	x	x	x	x		x	x		x	x			
Western Black-Headed Snake	*Tantilla planiceps*	x	x	x	x			x	x		x				
Western Blind Snake	*Leptotyphlops humilis*	x		x	x			x	x		x				
Western Fence Lizard	*Sceloporus occidentalis*	x	x	x	x	x		x	x	x	x				
Western Patch-nosed Snake	*Salvadora hexalepis*	x	x	x	x			x					Cand.	Spec. conc.	

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Western Pond Turtle	*Clemmys marmorata*	x	x	x	x	x		x	x			x	Cand.	Spec. conc., Prot. (a)	
Western Rattlesnake	*Crotalus viridis*	x	x	x	x	x		x	x		x	x			
Western Skink	*Eumeces skiltonianus*	x	x	x	x	x		x	x		x		Cand.	Spec. conc. (c)	
Western Terrestrial Garter Snake	*Thamnophis elegans*	x	x	x	x	x		x			x	x			
Western Whiptail	*Cnemidophorus tigris*	x	x	x	x			x	x		x		Cand.		

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BIRDS															
Acorn Woodpecker	*Melanerpes formicivorus*	x	x	x	x	x	x	x		x					
Allen's Hummingbird	*Selasphorus sasin*	x	x	x	x	x		x							
American Crow	*Corvus brachyrhynchos*	x	x	x	x	x		x				x			
American Goldfinch	*Carduelis tristis*	x	x	x	x	x		x							
American Kestrel	*Falco sparverius*	x	x	x	x	x		x		x	x	x			
American Robin	*Turdus migratorius*	x	x	x	x	x		x							
Anna's Hummingbird	*Calypte anna*	x	x	x	x	x		x							
Ash-Throated Flycatcher	*Myiarchus cinerascens*	x	x	x	x	x		x							
Bald Eagle	*Haliaeetus leucocephalus*	x	x	x	x	x		x		x	x	x	Threat	End., Prot.	
Band-Tailed Pigeon	*Columba fasciata*	x	x	x	x	x	x	x		x					x
Bank Swallow	*Riparia riparia*			x				x			x	x		Threat (a)	
Barn Owl	*Tyto alba*	x	x	x	x	x		x		x	x	x			
Barn Swallow	*Hirundo rustica*	x	x	x	x	x		x			x	x			
Bewick's Wren	*Thryomanes bewickii*	x	x	x	x	x		x	x		x				
Black Swift	*Cypseloides niger*	x	x	x	x	x		x			x			Spec. conc.	

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Black-Chinned Hummingbird	*Archilochus alexandri*	x	x	x	x			x							
Black-Crowned Night Heron	*Nycticorax nycticorax*	x	x	x	x	x		x				x			
Black-Throated Gray Warbler	*Dendroica nigrescens*	x	x	x	x	x		x							
Black-Headed Grosbeak	*Pheucticus melanocephalus*	x	x	x	x	x		x							
Blue Grouse	*Dendragapus obscurus*					x		x	x						x
Blue-Gray Gnatcatcher	*Polioptila caerulea*	x	x	x	x			x							
Brewer's Blackbird	*Euphagus cyanocephalus*	x	x	x	x	x		x				x			
Brown Creeper	*Certhia americana*	x	x	x	x	x		x		x					
Brown-Headed Cowbird	*Molothrus ater*	x	x	x	x	x		x				x			
Burrowing Owl	*Speotyto cunicularia*	x	x	x	x			x			x		Cand.	Spec. conc.	
Bushtit	*Psaltriparus minimus*	x	x	x	x	x		x							
California Condor	*Gymnogyps californianus*	x	x	x	x	x				x	x		End.	End.	

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California Gnatcatcher	*Polioptila californica*				x			x					Threat	Threat	
California Quail	*Callipepla californica*	x	x	x	x	x	x	x	x						x
California Thrasher	*Toxostoma redivivum*	x	x	x	x	x		x							
California Towhee	*Pipilo crissalis*	x	x	x	x	x		x	x				Threat	End. (c)	
Calliope Hummingbird	*Stellula calliope*	x	x	x	x	x		x							
Cassin's Kingbird	*Tyrannus vociferans*	x	x	x	x	x		x							
Cattle Egret	*Bubulcus ibis*	x	x	x	x			x				x			
Cedar Waxwing	*Bombycilla cedrorum*	x	x	x	x	x		x							
Chestnut-Backed Chickadee	*Parus rufescens*	x	x	x	x	x		x		x					
Chipping Sparrow	*Spizella passerina*	x	x	x	x	x		x							
Cliff Swallow	*Hirundo pyrrhonota*	x	x	x	x			x			x	x			
Common Nighthawk	*Chordeiles minor*	x	x	x	x			x				x			
Common Poorwill	*Phalaenoptilus nuttallii*	x	x	x	x	x			x		x				
Common Raven	*Corvus corax*	x	x	x	x	x		x			x	x			
Cooper's Hawk	*Accipiter cooperii*	x	x	x	x	x		x		x				Spec. conc.	

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Cordilleran Flycatcher	*Empidonax occidentalis*					x		x			x				
Dark-Eyed Junco	*Junco hyemalis*	x	x	x	x	x		x	x					Spec. conc. (c)	
Downy Woodpecker	*Picoides pubescens*	x	x	x	x	x		x		x					
Dusky Flycatcher	*Empidonax oberholseri*	x	x	x	x			x							
European Starling	*Sturnus vulgaris*	x	x	x	x	x		x		x		x			
Evening Grosbeak	*Coccothraustes vespertinus*	x	x	x	x	x		x							
Ferruginous Hawk	*Buteo regalis*	x	x	x	x			x		x	x	x	Cand.		
Flammulated Owl	*Otus flammelous*					x		x		x					
Fox Sparrow	*Passerella iliaca*	x	x	x	x	x		x							
Golden Eagle	*Aquila chrysaetos*	x	x	x	x	x		x		x	x	x		Prot.	
Golden-Crowned Kinglet	*Regulus satrapa*	x	x	x	x	x		x							
Golden-Crowned Sparrow	*Zonotrichia atricapilla*	x	x	x	x	x		x	x						
Great Blue Heron	*Ardea herodias*	x	x	x	x	x		x				x			

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Great Egret	*Casmerodius albus*	x	x	x	x			x				x			
Great Horned Owl	*Bubo virginianus*	x	x	x	x	x		x		x	x	x			
Greater Roadrunner	*Geococcyx californianus*	x	x	x	x			x							
Green Heron	*Butorides virescens*	x	x	x	x	x		x				x			
Green-Tailed Towhee	*Pipilo chlorurus*					x		x							
Hairy Woodpecker	*Picoides villosus*	x	x	x	x	x	x	x	x	x					
Hammond's Flycatcher	*Empidonax hammondii*	x	x	x	x	x		x							
Hermit Thrush	*Catharus guttatus*	x	x	x	x	x		x							
Hermit Warbler	*Dendroica occidentalis*	x	x	x	x	x		x							
Horned Lark	*Eremophila alpestris*	x	x	x	x									Spec. conc.	
House Finch	*Carpodacus mexicanus*	x	x	x	x	x		x			x				
House Sparrow	*Passer domesticus*	x	x	x	x			x		x					
House Wren	*Troglodytes aedon*	x	x	x	x	x		x	x	x					
Hutton's Vireo	*Vireo huttoni*	x	x	x	x	x		x							
Lark Sparrow	*Chondestes grammacus*	x	x	x	x	x		x							

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Lawrence's Goldfinch	*Carduelis lawrencei*	x	x	x	x	x		x							
Lazuli Bunting	*Passerina amoena*	x	x	x	x	x		x							
Lesser Goldfinch	*Carduelis psaltria*	x	x	x	x	x		x							
Lesser Nighthawk	*Chordeiles acutipennis*	x	x	x	x			x				x			
Lewis Woodpecker	*Melanerpes lewis*	x	x	x	x	x	x	x		x					
Lincoln's Sparrow	*Melospiza lincolnii*	x	x	x	x	x		x				x			
Loggerhead Shrike	*Lanius ludovicianus*	x	x	x	x	x		x		x			End.	Spec. conc. (b)	
Long-eared Owl	*Asio otus*	x	x	x	x	x		x	x	x	x			Spec. conc.	
MacGillivray's Warbler	*Oporornis tolmiei*					x		x							
Mallard	*Anas platyrhynchos*	x	x	x	x			x				x			x
Merlin	*Falco columbarius*	x	x	x	x	x		x		x		x		Spec. conc.	
Mountain Bluebird	*Sialia currucoides*	x	x	x	x			x		x	x				
Mountain Chickadee	*Parus gambeli*	x	x	x	x	x		x		x					
Mountain Quail	*Oreortyx pictus*	x	x		x	x	x	x		x					x

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Mourning Dove	*Zenaida macroura*	x	x	x	x	x		x							x
Nashville Warbler	*Vermivora ruficapilla*	x	x	x	x	x		x							
Northern Flicker	*Colaptes auratus*	x	x	x	x	x	x	x	x	x					
Northern Goshawk	*Accipiter gentilis*	x	x	x	x	x		x		x			Cand.	Spec. conc.	
Northern Harrier	*Circus cyaneus*	x	x	x	x	x		x				x		Spec. conc.	
Northern Mockingbird	*Mimus polyglottos*	x	x	x	x			x							
Northern Oriole	*Icterus galbula*	x	x	x	x	x		x							
Northern Pygmy-Owl	*Glaucidium gnoma*	x	x	x	x	x		x		x					
Northern Rough-Winged Swallow	*Stelgidopteryx serripennis*	x	x	x	x	x		x			x	x			
Northern Saw-Whet Owl	*Aegolius acadicus*	x	x	x	x	x		x		x					
Nuttall's Woodpecker	*Picoides nuttallii*	x	x	x	x	x		x		x					
Olive-sided Flycatcher	*Contopus borealis*					x		x		x					
Orange-Crowned Warbler	*Vermivora celata*	x	x	x	x	x		x							

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Osprey	*Pandion haliaetus*	x	x	x	x	x		x		x		x		Spec. conc.	
Pacific-Slope Flycatcher	*Empidonax difficilis*	x	x	x	x	x		x			x				
Peregrine Falcon	*Falco peregrinus*	x	x	x	x	x		x			x	x	End., Threat	End., Prot.	
Phainopepla	*Phainopepla nitens*	x	x	x	x			x							
Pileated Woodpecker	*Dryocopus pileatus*		x			x		x	x	x					
Pine Siskin	*Carduelis pinus*	x	x	x	x	x		x							
Plain Titmouse	*Parus inornatus*	x	x	x	x	x		x		x					
Prairie Falcon	*Falco mexicanus*	x	x	x	x	x		x			x	x		Spec. conc.	
Purple Finch	*Carpodacus purpureus*					x		x							
Purple Martin	*Progne subis*	x	x	x	x	x		x		x		x		Spec. conc.	
Red-Shouldered Hawk	*Buteo lineatus*	x	x	x	x	x		x		x		x			
Red-Breasted Nuthatch	*Sitta canadensis*	x	x	x	x	x		x		x					
Red-Breasted Sapsucker	*Sphyrapicus ruber*	x	x	x	x	x		x		x					
Red-Naped Sapsucker	*Sphyrapicus nuchalis*				x	x		x		x					
Red-Tailed Hawk	*Buteo jamaicensis*	x	x	x	x	x		x		x	x	x			

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Rock Dove	*Columba livia*	x	x	x	x		x	x			x				x
Rock Wren	*Salpinctes obsoletus*	x	x	x	x	x					x				
Rough-Legged Hawk	*Buteo lagopus*	x	x	x	x			x		x	x	x			
Ruby-Crowned Kinglet	*Regulus calendula*	x	x	x	x	x		x							
Ruffed Grouse	*Bonasa umbellus*					x		x	x						x
Rufous Hummingbird	*Selasphorus rufus*	x	x	x	x	x		x							
Rufous-Sided Towhee	*Pipilo erythrophthalmus*	x	x	x	x	x	x	x	x				Cand.	Spec. conc. (b)	
Savannah Sparrow	*Passerculus sandwichensis*	x	x	x	x			x					Cand. (c)	End. (a), Spec. conc. (c)	
Say's Phoebe	*Sayornis saya*	x	x	x	x						x				
Scott's Oriole	*Icterus parisorum*	x		x	x										
Scrub Jay	*Aphelocoma coerulescens*	x	x	x	x	x	x	x				x	Cand.	Spec. conc.	
Sharp-Shinned Hawk	*Accipiter striatus*	x	x	x	x	x		x		x				Spec. conc.	
Short-eared Owl	*Asio flammeus*	x	x	x	x			x				x		Spec. conc.	

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Solitary Vireo	*Vireo solitarius*	x	x	x	x	x		x							
Song Sparrow	*Melospiza melodia*	x	x	x	x	x		x	x			x	Cand.	Spec. conc. (a)	
Spotted Owl	*Strix occidentalis*		x			x		x		x			Threat	Spec. conc.	
Steller's Jay	*Cyanocitta stelleri*	x	x	x	x	x	x	x							
Swainson's Hawk	*Buteo swainsoni*	x	x	x	x	x		x				x		Threat	
Swainson's Thrush	*Catharus ustulatus*	x	x	x	x	x		x							
Townsend's Solitaire	*Myadestes townsendi*		x			x		x	x		x				
Townsend's Warbler	*Dendroica townsendi*	x	x	x	x	x		x							
Tree Swallow	*Tachycineta bicolor*	x	x	x	x	x		x		x		x			
Turkey Vulture	*Cathartes aura*	x	x	x	x	x		x		x	x				
Varied Thrush	*Ixoreus naevius*	x	x	x	x	x	x	x							
Vaux's Swift	*Chaetura vauxi*		x		x	x		x		x		x		Spec. conc.	
Vesper Sparrow	*Pooecetes gramineus*	x	x	x	x										
Violet-Green Swallow	*Tachycineta thalassina*	x	x	x	x	x		x		x	x	x			
Warbling Vireo	*Vireo gilvus*	x	x	x	x	x		x							

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Western Bluebird	*Sialia mexicana*	x	x	x	x	x		x		x					
Western Kingbird	*Tyrannus verticalis*	x	x	x	x	x		x		x		x			
Western Meadowlark	*Sturnella neglecta*	x	x	x	x	x			x						
Western Screech-Owl	*Otus kennicottii*	x	x	x	x	x		x		x					
Western Tanager	*Piranga ludoviciana*	x	x	x	x	x		x							
Western Wood-Pewee	*Contopus sordidulus*	x	x	x	x	x		x		x					
Whip-Poor-Will	*Caprimulgus vociferus*					x		x							
White-Breasted Nuthatch	*Sitta carolinensis*	x	x	x	x	x	x	x		x					
White-Crowned Sparrow	*Zonotrichia leucophrys*	x	x	x	x	x		x	x						
White-Throated Swift	*Aeronautes saxatalis*	x	x	x	x	x		x			x				
White-Headed Woodpecker	*Picoides albolarvatus*					x		x		x					
White-Tailed Kite	*Elanus leucurus*	x	x	x	x			x		x		x		Prot.	
Wild Turkey	*Meleagris gallopavo*	x	x	x	x	x	x	x							x

Common Name	Scientific Name	Hardwood Habitat					Habitat Elements						Special Status (see key at end of table)		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Acorns	Riparian Habitat	Logs, slash, brush piles	Snags	Burrow rocks, talus, caves, cliffs	Vernal pools, wetland	Federal Status	State Status	Harvest Species
Wilson's Warbler	*Wilsonia pusilla*	x	x	x	x	x		x							
Wood Duck	*Aix sponsa*	x	x	x	x	x	x	x		x		x			x
Wrentit	*Chamaea fasciata*	x	x	x	x	x		x							
Yellow Warbler	*Dendroica petechia*	x	x	x	x	x		x				x		Spec. conc.	
Yellow-Rumped Warbler	*Dendroica coronata*	x	x	x	x	x		x							
Yellow-Billed Magpie	*Pica nuttalli*	x	x	x	x		x	x							

Common Name	Scientific Name	Hardwood Habitat					Habitat Elements						Special Status (see key at end of table)		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Acorns	Riparian Habitat	Logs, slash, brush piles	Snags	Burrow rocks, talus, caves, cliffs	Vernal pools, wetland	Federal Status	State Status	Harvest Species
MAMMALS															
Allen's Chipmunk	*Tamias senex*	x	x	x	x	x		x	x	x	x				
American Badger	*Taxidea taxus*	x	x	x	x	x		x			x	x			x
Barbary Sheep	*Ammotragus lervia*	x		x	x						x				x
Beaver	*Castor canadensis*	x	x	x	x	x		x	x		x	x			x
Big Brown Bat	*Eptesicus fuscus*	x	x	x	x	x		x		x	x	x			
Black Bear	*Ursus americanus*		x			x	x	x	x	x	x	x			x
Black Rat	*Rattus rattus*	x	x	x	x			x			x				
Black-Tailed Hare	*Lepus californicus*	x	x	x	x	x		x						Spec. conc.	x
Bobcat	*Felis rufus*	x	x	x	x	x		x	x		x	x			x
Botta's Pocket Gopher	*Thomomys bottae*	x	x	x	x	x		x			x		Cand. (c)		
Brazillian Free-Tailed Bat	*Tadarida brasiliensis*	x	x	x	x	x		x			x	x			
Broad-Footed Mole	*Scapanus latimanus*	x	x	x	x	x		x					Cand.	Spec. conc. (a)	
Brush Mouse	*Peromyscus boylii*	x	x	x	x	x	x	x	x	x	x				
Brush Rabbit	*Sylvilagus bachmani*	x	x	x	x	x		x	x		x		Cand.	End. (a)	

Common Name	Scientific Name	Hardwood Habitat					Habitat Elements						Special Status (see key at end of table)		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Acorns	Riparian Habitat	Logs, slash, brush piles	Snags	Burrow rocks, talus, caves, cliffs	Vernal pools, wetland	Federal Status	State Status	Harvest Species
Bushy-Tailed Woodrat	*Neotoma cinerea*					x		x	x		x				
California Chipmunk	*Tamias obscurus*				x		x		x		x				
California Ground Squirrel	*Spermophilus beecheyi*	x	x	x	x	x	x	x	x		x				
California Kangaroo Rat	*Dipodomys californicus*	x	x	x	x	x					x		Cand.	Spec. conc. (c)	
California Mouse	*Peromyscus californicus*	x	x	x	x	x	x	x	x	x	x				
California Myotis	*Myotis californicus*	x	x	x	x	x		x		x	x	x			
California Pocket Mouse	*Chaetodipus californicus*	x	x	x	x	x					x		Cand.	Spec. conc. (c)	
California Vole	*Microtus californicus*	x	x	x	x	x		x			x		End., cand.	End., Spec conc. (a)	
Coyote	*Canis latrans*	x	x	x	x	x		x	x	x	x	x			x
Deer Mouse	*Peromyscus maniculatus*	x	x	x	x	x	x	x	x		x	x	Cand.	Spec. conc. (b)	
Desert Cottontail	*Sylvilagus audubonii*	x	x	x	x		x	x							x
Desert Woodrat	*Neotoma lepida*		x			x	x		x		x		Cand.	Spec. conc. (c)	

Common Name	Scientific Name	Hardwood Habitat					Habitat Elements						Special Status (see key at end of table)		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Acorns	Riparian Habitat	Logs, slash, brush piles	Snags	Burrow rocks, talus, caves, cliffs	Vernal pools, wetland	Federal Status	State Status	Harvest Species
Douglas' Squirrel	*Tamiasciurus douglasii*					x	x	x	x	x	x				x
Dusky-Footed Woodrat	*Neotoma fuscipes*	x	x	x	x	x	x	x	x				Cand.	Spec. conc.	
Elk	*Cervus elaphus*	x	x	x	x	x	x	x				x			x
Ermine	*Mustela erminea*					x		x	x	x	x				x
Fallow Deer	*Cervus dama*	x	x	x	x				x			x			x
Feral Goat	*Capra hircus*	x	x	x	x			x			x				x
Fox Squirrel	*Sciurus niger*	x		x	x		x	x		x					x
Fringed Myotis	*Myotis thysanodes*	x	x	x	x	x		x			x	x			
Golden-Mantled Ground Squirrel	*Spermophilus lateralis*					x		x	x		x				
Gray Fox	*Urocyon cinereo-argenteus*	x	x	x	x	x		x	x	x	x	x			x
Heermann's Kangaroo Rat	*Dipodomys heermanni*	x	x	x	x	x		x			x		End.	End., Prot. (c)	
Himalayan Tahr	*Hemitragus jemlahicus*	x		x	x	x					x				x
Hoary Bat	*Lasiurus cinereus*	x	x	x	x	x		x		x		x			
House Mouse	*Mus musculus*	x	x	x	x			x	x		x	x			
Island Fox	*Urocyon littoralis*	x		x	x		x		x		x		Cand.	Threat (b)	

Common Name	Scientific Name	Hardwood Habitat					Habitat Elements						Special Status (see key at end of table)		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Acorns	Riparian Habitat	Logs, slash, brush piles	Snags	Burrow rocks, talus, caves, cliffs	Vernal pools, wetland	Federal Status	State Status	Harvest Species
Kit Fox	*Vulpes macrotis*	x	x	x	x			x			x		End.	Threat (c)	
Little Brown Myotis	*Myotis lucifugus*	x	x	x	x	x		x		x	x	x	Cand.	Spec. conc. (c)	
Little Pocket Mouse	*Perognathus longimembris*			x	x						x		End., Cand.	Spec. conc. (c)	
Long-eared Myotis	*Myotis evotis*	x	x	x	x	x		x		x	x	x			
Long-Legged Myotis	*Myotis volans*	x	x	x	x	x		x		x	x	x			
Long-Tailed Weasel	*Mustela frenata*	x	x	x	x	x		x	x	x	x	x			x
Marsh Shrew	*Sorex bendirii*				x			x	x			x			
Merriam's Chipmunk	*Tamias merriami*	x	x	x	x	x	x	x	x	x	x				
Mountain Beaver	*Aplodontia rufa*					x		x			x		End., Cand.	Spec. conc. (a)	
Mountain Lion	*Felis concolor*	x	x	x	x	x		x		x	x	x	Cand.	Spec. conc., Prot.	
Mule Deer	*Odocoileus hemionus*	x	x	x	x	x	x	x				x			x
Narrow-Faced Kangaroo Rat	*Dipodomys venustus*	x	x	x	x						x				
Northern Flying Squirrel	*Glaucomys sabrinus*	x	x	x	x	x	x	x	x	x			Cand.		

Common Name	Scientific Name	Hardwood Habitat					Habitat Elements						Special Status (see key at end of table)		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Acorns	Riparian Habitat	Logs, slash, brush piles	Snags	Burrow rocks, talus, caves, cliffs	Vernal pools, wetland	Federal Status	State Status	Harvest Species
Norway Rat	*Rattus norvegicus*	x	x	x	x			x			x				
Ornate Shrew	*Sorex ornatus*	x	x		x			x	x		x	x	Cand.	Spec. conc. (a)	
Pacific Kangaroo Rat	*Dipodomys agilis*	x	x	x	x	x		x			x				
Pallid Bat	*Antrozous pallidus*	x	x	x	x	x		x			x	x		Spec. conc.	
Pinyon Mouse	*Peromyscus truei*					x	x	x	x	x	x				
Porcupine	*Erethizon dorsatum*	x	x	x	x	x		x	x	x	x	x			
Racoon	*Procyon lotor*	x	x	x	x	x	x	x	x	x	x	x			x
Ringtail	*Bassariscus astutus*	x	x	x	x	x		x	x	x	x	x		Prot.	
River Otter	*Lutra canadensis*	x	x	x	x	x		x	x	x	x	x	Cand.	Spec. conc. (a)	
Sambar	*Cervus unicolor*	x		x	x	x									x
San Joaquin Kangaroo Rat	*Dipodomys nitratoides*	x		x							x		End., Cand.	Spec. conc. (c)	
San Joaquin Pocket Mouse	*Perognathus inornatus*	x		x	x						x		Cand.	Spec. conc. (c)	
Shrew-Mole	*Neurotrichus gibbsii*					x		x	x			x			
Silver-Haired Bat	*Lasionycteris noctivagans*	x	x	x	x	x		x		x	x	x			

Common Name	Scientific Name	Hardwood Habitat					Habitat Elements						Special Status (see key at end of table)		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Acorns	Riparian Habitat	Logs, slash, brush piles	Snags	Burrow rocks, talus, caves, cliffs	Vernal pools, wetland	Federal Status	State Status	Harvest Species
Siskiyou Chipmunk	*Tamias siskiyou*					x	x		x	x	x				
Sonoma Chipmunk	*Tamias sonomae*	x	x	x	x	x	x	x	x	x	x				
Southern Yellow Bat	*Lasiurus xanthinus*				x			x							
Spotted Bat	*Euderma maculatum*	x	x	x	x			x			x	x	Cand.	Spec. conc.	
Striped Skunk	*Mephitis mephitis*	x	x	x	x	x		x	x		x	x			x
Townsend's Big-Eared Bat	*Plecotus townsendii*	x	x	x	x	x		x			x	x	Cand.	Spec. conc.	
Trowbridge's Shrew	*Sorex trowbridgii*	x	x	x	x			x	x						
Vagrant Shrew	*Sorex vagrans*	x	x	x	x	x		x	x			x	Cand.	Spec. conc. (a)	
Virginia Opossum	*Didelphis virginiana*	x	x	x	x	x	x	x	x	x	x	x			x
Western Gray Squirrel	*Sciurus griseus*	x	x	x	x	x	x	x	x	x					x
Western Harvest Mouse	*Reithrodontomys megalotis*	x	x	x	x	x		x				x			
Western Mastiff Bat	*Eumops perotis*	x	x	x	x	x		x			x	x	Cand.	Spec. conc.	
Western Pipistrelle	*Pipistrellus hesperus*	x	x	x	x	x		x			x	x			

Common Name	Scientific Name	Hardwood Habitat					Habitat Elements						Special Status (see key at end of table)		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Acorns	Riparian Habitat	Logs, slash, brush piles	Snags	Burrow rocks, talus, caves, cliffs	Vernal pools, wetland	Federal Status	State Status	Harvest Species
Western Pocket Gopher	*Thomomys mazama*					x		x			x				
Western Red Bat	*Lasiurus blossevillii*	x	x	x	x	x		x		x	x	x			
Western Small-Footed Myotis	*Myotis ciliolabrum*	x	x	x	x	x		x		x	x	x			
Western Spotted Skunk	*Spilogale gracilis*	x	x	x	x	x		x	x	x	x	x	Cand.	Spec. conc. (b)	x
Wild Horse	*Equus caballus*	x	x	x	x	x		x				x			
Wild Pig	*Sus scrofa*	x	x	x	x	x	x	x	x		x	x			x
Yellow-Pine Chipmunk	*Tamias amoenus*					x		x	x	x	x				
Yuma Myotis	*Myotis yumanensis*	x	x	x	x	x		x		x	x	x			

CODES

Cand. = candidate species
Spec. conc. = species of special concern
Prot. = protected species
End. = endangered species
Threat = threatened species
(a) = Species or subspecies with special status primarily associated with wetlands, marshes, and riparian areas
(b) = Species or subspecies with special status occurs on the Channel Islands
(c) = Species or subspecies with special status primarily associated with shrub,, sandy, scrub, and desert habitats

Appendix B. Sensitive Plant Species on Hardwood Rangelands[1]

The following table lists 130 sensitive plant species that occur on oak woodland habitats. "Sensitive" plants are those species that are considered rare, threatened, or endangered within California, whether or not they are state or federally listed. Sensitive plant species are listed in three categories: federally listed, state listed, and California Native Plant Society (CNPS) categories 1B and 2. Eight oak woodland plant species are federally listed as threatened or endangered, while the State of California has listed 42 as rare, threatened, or endangered. The federal Endangered Species Act establishes protection for federally listed species. Plants state-listed as rare, threatened, or endangered are protected under the Native Plant Protection Act or the California Endangered Species Act. CNPS maintains an inventory that evaluates native plants on their rarity, endangerment, and distribution. Only two of their five categories are included in this table: 1B and 2. Category '1B' is defined as *rare or endangered in California and elsewhere*, while category '2' is defined as *rare and endangered in California; more common elsewhere.* For a more thorough list of sensitive plant species and a detailed explanation of CNPS's inventory system, you may refer to the electronic or printed California Native Plant Society's INVENTORY of Rare and Endangered Vascular Plants of California (5th. Edition). You may also wish to attain a copy the California Department of Fish and Game's (CDFG) *Special Plants List* (see reference list in appendix D).

[1]Primary author is: Kevin Shaffer, Calif. Dept. of Fish and Game

Scientific Name	Common Name	Hardwood Habitat					Unique Ecological Traits			Special Status		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Blooming Period	Life-Form	Special Habitat or Soil	State-listed	Federally listed	CNPS List
Allium tuolumnense	Rawhide Hill onion		x				May	perennial herb; bulbiferous 1	serpentinite			1B
Amsinckia grandiflora	large-flowered fiddleneck		x		x		April to May	annual herb		E	E	1B
Antirrhinum subcordatum	dimorphic snapdragon	x	x				April to July	annual herb	sometimes serpentinite soils			1B
Arctostaphylos auriculata	Mount Diablo manzanita	x	x				January to March	evergreen shrub	sandstone			1B
Arctostaphylos montereyensis	monterey manzanita				x		February to March	evergreen shrub	sandy			1B
Arctostaphylos myrtifolia	Ione manzanita		x				November to February	evergreen shrub	Ione clay or sandy			1B
Arctostaphylos nissenana	nissenan manzanita					x	February to March	evergreen shrub				1B
Arctostaphylos pallida	pallid manzanita				x		December to March	evergreen shrub	siliceous shale	E		1B
Arctostaphylos pilosula	Santa Margarita manzanita	x					December to March	evergreen shrub	shale			1B
Astragalus oocarpus	Descanso milk-vetch				x		May to August	perennial herb				1B
Berberis (=Mahonia) nevinii	Nevin's barberry				x		March to April	evergreen shrub	sandy to gravelly	E		1B
Brodiaea coronaria ssp. rosea	Indian Valley brodiaea		x				May to June	perennial herb; bulbiferous	serpentinite	E		1B
Brodiaea filifolia	thread-leaved brodiaea					x	March to June	perennial herb; bulbiferous	clay; sometimes vernal pools	E		1B

Scientific Name	Common Name	Hardwood Habitat					Unique Ecological Traits			Special Status		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Blooming Period	Life-Form	Special Habitat or Soil	State-listed	Federally listed	CNPS List
Brodiaea insignis	Kaweah brodiaea	x	x			x	April to June	perennial herb; bulbiferous	granitic or clay	E		1B
Brodiaea orcuttii	Orcutt's brodiaea				x		May to July	perennial herb; bulbiferous	clay or sometimes serpentinite; sometimes vernal pools			1B
Calochortus dunnii	Dunn's mariposa lily					x	May to June	perennial herb; bulbiferous	gabbroic	R		1B
Calochortus palmeri var. palmeri	Palmer's mariposa lily	x				x	May to July	perennial herb; bulbiferous	mesic			1B
Calochortus westonii	Shirley Meadows star-tulip					x	May to June	perennial herb; bulbiferous	granitic			1B
Calycadenia hooveri	Hoover's calycadenia	x					July to September	annual herb	rocky			1B
Calycadenia villosa	dwarf calycadenia	x					May to October	annual herb	rocky			1B
Calyptridium pulchellum	mariposa pussypaws		x			x	April to May	annual herb	sandy			1B
Camissonia benitensis	San Benito evening-primrose		x				May to June	annual herb	serpentinite alluvium		T	1B
Camissonia hardhamiae	Hardham's evening-primrose	x					May	annual herb	decomposed carbonate			1B

Scientific Name	Common Name	Hardwood Habitat					Unique Ecological Traits			Special Status		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Blooming Period	Life-Form	Special Habitat or Soil	State-listed	Federally listed	CNPS List
Carex obispoensis	San Luis Obispo sedge				x		April to June	perennial herb; rhizomatous	often found in serpentinite seeps			1B
Carpenteria californica	tree-anemone		x				May to July	evergreen shrub	granitic	T		1B
Castilleja campestris ssp. succulenta	succulent owl's-clover	x					April to May	annual herb; hemi-parasitic[2]	vernal pools	E		1B
Ceanothus confusus	Rincon Ridge ceanothus					x	February to April	evergreen shrub	volcanic or serpentinite			1B
Ceanothus masonii	Mason's ceanothus				x		March to April	evergreen shrub	serpentinite	R		1B
Ceanothus ophiochilus	Vail Lake ceanothus				x		February to March	evergreen shrub	gabbroic or pyroxinite-rich	E		1B
Ceanothus roderickii	Pine Hill ceanothus				x		May to June	evergreen shrub	often gabbroic or serpentinite	R		1B
Ceanothus sonomensis	Sonoma ceanothus				x	x	February to April	evergreen shrub	sandy, volcanic, or serpentinite			1B
Chlorogalum grandiflorum	Red Hills soaproot		x			x	May to June	perennial herb; bulbiferous	gabbroic or serpentinite			1B
Chlorogalum purpureum var. purpureum	purple amole	x					May to June	perennial herb; bulbiferous				1B
Chorizanthe pungens var. pungens	Monterey spineflower				x		April to June	annual herb			T	1B
Chorizanthe robusta var. robusta	robust spineflower				x		May to September	annual herb			E	1B
Cirsium fontinale var. obispoense	Chorro Creek bog thistle				x		February to July	perennial herb	serpentine seeps	E	E	1B

Scientific Name	Common Name	Hardwood Habitat					Unique Ecological Traits			Special Status		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Blooming Period	Life-Form	Special Habitat or Soil	State-listed	Federally listed	CNPS List
Clarkia gracilis ssp. albicaulis	white-stemmed clarkia		x			x	May to July	annual herb	sometimes serpentinite			1B
Clarkia mosquinii ssp. mosquinii	Mosquin's clarkia					x	May to July	annual herb				1B
Clarkia rostrata	beaked clarkia	x					April to May	annual herb				1B
Clarkia speciosa ssp. immaculata	Pismo clarkia				x		May to June	annual herb		R	E	1B
Clarkia springvillensis	Springville clarkia	x	x			x	May to July	annual herb		E		1B
Cordylanthus rigidus ssp. littoralis	seaside bird's-beak				x		May to September	annual herb; hemiparasitic	sandy	E		1B
Cupressus arizonica ssp. nevadensis	Piute cypress	x				x	Cone-bearing	evergreen tree				1B
Delphinium hesperium ssp. cuyamaca	Cuyamaca larkspur				x		June to July	perennial herb	mesic	R		1B
Delphinium inopinum	unexpected larkspur	x					May to July	perennial herb	rocky			1B
Delphinium recurvatum	recurved larkspur		x				March to May	perennial herb	alkaline			1B
Dichanthelium lanuginosum var. thermale	Geyser's dichanthelium					x	June to August	perennial herb	hydrotherm-ally altered soil	E		1B
Downingia pusilla	dwarf downingia	x					March to May	annual herb	mesic or vernal pools			2
Dudleya multicaulis	many-stemmed dudleya				x	x	May to July	perennial herb	often clay			1B
Dudleya setchellii	Santa Clara Valley dudleya			x	x		May to June	perennial herb	serpentinite		E	1B

Scientific Name	Common Name	Hardwood Habitat					Unique Ecological Traits			Special Status		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Blooming Period	Life-Form	Special Habitat or Soil	State-listed	Federally listed	CNPS List
Dudleya stolonifera	Laguna Beach dudleya				x		May to July	perennial herb; stoloniferous[3]	rocky	T		1B
Eriastrum brandegeae (=tracyi)	Brandegee's eriastrum	x	x				May to August	annual herb	volcanic	R		1B
Ericameria fasciculata	Eastwood's goldenbush				x		July to October	evergreen shrub				1B
Eriodictyon capitatum	Lompoc yerba santa				x		May to August	evergreen shrub	sandy	R		1B
Eriogonum apricum var. apricum	Ione buckwheat	x	x				July to October	perennial herb	Ione soil	E		1B
Eriogonum breedlovei var. breedlovei	Breedlove's buckwheat	x					June to August	perennial herb	often carbonate			1B
Eriogonum butterworthianum	Butterworth's buckwheat			x			June to July	perennial herb	sandstone	R		1B
Eriogonum kennedyi var. pinicola	Kern buckwheat	x					May to June	perennial herb				1B
Eriogonum nervulosum	Snow Mountain buckwheat		x				June to September	perennial herb; rhizomatous	serpentinite			1B
Eriogonum nudum var. murinum	mouse buckwheat		x			x	June to November	perennial herb	sandy			1B
Eriogonum nudum var. regirivum	Kings River buckwheat	x					August to November	perennial herb	carbonate			1B
Eryngium spinosepalum	spiny-sepaled button-celery		x				April to May	annual to perennial herb	vernal pools			1B
Erythronium tuolumnense	Tuolumne fawn lily					x	March to May	perennial herb; bulbiferous				1B
Fremontodendron decumbens	Pine Hill flannelbush					x	April to June	evergreen shrub	gabbroic or serpentinite	R		1B

Scientific Name	Common Name	Hardwood Habitat					Unique Ecological Traits			Special Status		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Blooming Period	Life-Form	Special Habitat or Soil	State-listed	Federally listed	CNPS List
Fritillaria brandegei	Greenhorn fritillary	x					April to June	perennial herb; bulbiferous	granitic			1B
Fritillaria eastwoodiae	Butte County fritillary	x					March to May	perennial herb; bulbiferous	sometimes serpentinite			1B
Fritillaria liliacea	fragrant fritillary				x		February to April	perennial herb; bulbiferous	often serpentinite; sometimes vernal pools			1B
Fritillaria pluriflora	adobe lily		x				February to April	perennial herb; bulbiferous	adobe; sometimes vernal pools			1B
Fritillaria striata	striped adobe lily	x					February to April	perennial herb; bulbiferous	adobe	T		1B
Galium californicum ssp. sierrae	El Dorado bedstraw					x	May to June	perennial herb	gabbroic	R		1B
Gratiola heterosepala	Boggs Lake hedge-hyssop	x					April to June	annual herb	lake margins & vernal pools	E		1B
Grindelia hirsutula var. hallii	San Diego gumplant				x	x	July to October	perennial herb				1B
Helianthella castanea	Diablo helianthella		x				April to June	perennial herb				1B
Hemizonia parryi ssp. congdonii	Congdon's tarplant				x		June to November	annual herb	alkaline			1B
Hesperolinon breweri	Brewer's western flax				x	x	May to July	annual herb	mostly serpentinite			1B

Scientific Name	Common Name	Hardwood Habitat					Unique Ecological Traits			Special Status		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Blooming Period	Life-Form	Special Habitat or Soil	State-listed	Federally listed	CNPS List
Hesperolinon congestum	Marin western flax				x		May to July	annual herb	serpentinite	T	T	1B
Hesperolinon didymocarpum	Lake County western flax	x					May to July	annual herb	serpentinite	E		1B
Hesperolinon drymarioides	drymaria-like western flax		x				May to August	annual herb	serpentinite			1B
Hibiscus lasiocarpus	California hibiscus (= rose hibiscus)		x				August to September	perennial herb; rhizomatous & emergent[4]	freshwater marshes			2
Holocarpha macradenia	Santa Cruz tarplant				x		June to October	annual herb	often clay	E		1B
Horkelia parryi	Parry's horkelia		x				April to June	perennial herb	Ione formation			1B
Horkelia truncata	Ramona horkelia					x	May to June	perennial herb	clay			1B
Juncus leiospermus var. leiospermus	Red Bluff dwarf rush		x			x	March to May	annual herb	seasonally mesic; sometimes vernal pools			1B
Layia discoidea	rayless layia		x				May	annual herb	serpentinite alluvial and talus terraces			1B
Layia septentrionalis	Colusa layia	x					April and May	annual herb	sandy or serpentinite			1B
Legenere limosa	legenere	x					May to June	annual herb	vernal pools			1B
Lepidium jaredii ssp. album	Panoche pepper-grass		x				February to June	annual herb	alluvial fans and washes			1B

Scientific Name	Common Name	Hardwood Habitat					Unique Ecological Traits			Special Status		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Blooming Period	Life-Form	Special Habitat or Soil	State-listed	Federally listed	CNPS List
Lewisia cantelovii	Cantelow's lewisia					x	May to June	perennial herb	mesic, granitic, sometimes serpentinite seeps			1B
Limnanthes gracilis ssp. parishii	Parish's meadowfoam				x		April to June	annual herb	seasonally mesic or vernal pools	E		1B
Linanthus orcuttii	Orcutt's linanthus				x		May to June	annual herb				1B
Linanthus serrulatus	Madera linanthus					x	April to May	annual herb				1B
Lomatium congdonii	Congdon's lomatium		x				April to June	perennial herb	serpentinite			1B
Lupinus citrinus var. citrinus	orange lupine		x			x	April to July	annual herb	granitic			1B
Lupinus citrinus var. deflexus	Mariposa lupine					x	April to May	annual herb	granitic	T		1B
Lupinus ludovicianus	San Luis Obispo County lupine				x		April to July	perennial herb	carbonate			1B
Lupinus spectabilis	shaggyhair lupine					x	April to May	annual herb	serpentinite			1B
Madia radiata	showy madia		x				March to May	annual herb				1B
Madia stebbinsii	Stebbin's madia	x					May to June	annual herb	serpentinite			1B
Malacothamnus abbottii	Abbott's bush mallow	x					June to October	deciduous shrub				1B
Mimulus norrisii	Kaweah monkeyflower		x				March to May	annual herb	carbonate			1B
Mimulus pictus	calico monkeyflower	x					April to May	annual herb	granitic			1B

Scientific Name	Common Name	Hardwood Habitat					Unique Ecological Traits			Special Status		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Blooming Period	Life-Form	Special Habitat or Soil	State-listed	Federally listed	CNPS List
Monardella hypoleuca ssp. lanata	felt-leaved monardella					x	June to July	perennial herb; rhizomatous				1B
Monardella macrantha ssp. hallii	Hall's monardella					x	June to August	perennial herb; rhizomatous				1B
Monardella nana ssp. leptosiphon	San Felipe monardella				x		June to July	perennial herb; rhizomatous				2
Navarretia leucocephala ssp.plieantha	many-flowered navarretia				x		May to June	annual herb	vernal pools (volcanic ash flows)	E		1B
Navarretia nigelliformis ssp. radians	shining navarretia	x					May to June	annual herb	vernal pools			1B
Navarretia setiloba	Piute Mountains navarretia	x					April to June	annual herb	gravelly or clay loam			1B
Neostapfia colusana	Colusa grass	x					May to July	annual herb	vernal pools	E		1B
Orcuttia tenuis	slender Orcutt grass	x					May to July	annual herb	vernal pools	E		1B
Paronychia ahartii	Ahart's paronychia	x					April to June	annual herb	sometimes vernal pools			1B
Penstemon californicus	California beardtongue				x		May to June	perennial herb	sandy			1B
Phacelia phaceliodes	Mount Diablo phacelia	x	x				April to May	annual herb	rocky			1B
Piperia yadonii	Yadon's piperia (= Yadon's rein orchid)				x		May to August	perennial herb	sandy			1B

Scientific Name	Common Name	Hardwood Habitat					Unique Ecological Traits			Special Status		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Blooming Period	Life-Form	Special Habitat or Soil	State-listed	Federally listed	CNPS List
Pseudobahia bahiifolia	Hartweg's golden sunburst	x					March to April	annual herb	clay	E		1B
Pseudobahia peirsonii	San Joaquin adobe sunburst	x					March to April	annual herb	adobe	E		1B
Rhynchospora californica	California beaked-rush		x				May to July	perennial herb; rhizomatous	sometimes meadow seeps or freshwater marshes			1B
Sagittaria sanfordii	Sanford's arrowhead	x				x	May to August	perennial herb; rhizomatous and emergent	shallow freshwater marshes or vernal pools			1B
Sanicula saxatilis	rock sanicle		x				April to May	perennial herb	rocky	R		1B
Senecio clevelandii var. heterophyllus	Red Hills ragwort		x				June to July	perennial herb	serpentinite seeps			1B
Senecio eurycephalus var. lewisrosei	cut-leaved ragwort					x	April to July	perennial herb	serpentinite			1B
Senecio layneae	Layne's ragwort		x			x	April to July	perennial herb	gabbroic or serpentinite	R		1B
Sidalcea robusta	Butte County checkerbloom		x				April to June	perennial herb; rhizomatous				1B
Streptanthus albidus ssp. peramoenus	most beautiful jewelflower				x		April to June	annual herb	serpentinite			1B
Streptanthus brachiatus ssp. brachiatus	Socrates mine jewelflower				x	x	June	perennial herb	serpentinite			1B
Streptanthus glandulosus ssp. pulchellus	Mount Tamalpais jewelflower				x		May to July	annual herb	serpentinite			1B

Scientific Name	Common Name	Hardwood Habitat					Unique Ecological Traits			Special Status		
		Blue Oak	Blue Oak-Pine	Valley Oak	Coastal Oak	Montane Hardwood	Blooming Period	Life-Form	Special Habitat or Soil	State-listed	Federally listed	CNPS List
Thermopsis californica var. semota	velvety false lupine				x		March to June	perennial herb; rhizomatous				1B
Thermopsis macrophylla	Santa Ynez false lupine				x		April to June	perennial herb; rhizomatous	granitic or sandy, disturbed areas	R		1B
Tracyina rostrata	beaked tracyina					x	May to June	annual herb				1B
Verbena californica	California verbena		x				June to September	perennial herb	mesic; usually creeks or serpentinite seeps	T		1B
Wyethia reticulata	El Dorado County mule ears					x	May to July	perennial herb	clay or gabbroic			1B
Total: 130 plant species		39	38	2	40	37				41 total: 13-R; 6-T; 22 E	8 total: 3-T; 5 E	130 total: 127-'1B'; 3-'2'

1 Bulbiferous - Plants produce and grow from bulbs.

2 Parasitic - Capable of carrying on photosynthesis but not sufficiently enough to meet all food needs.

3 Stoloniferous - These plants grow stolons, horizontal stems that are able to grow rootlets and new individual plants.

4 Emergent - Plants emerge from the water surface; roots and some plant below surface.

Appendix C. Sources of Assistance

University of California

Phone the University of California Cooperative Extension (UCCE) for answers to specific rangeland, forestry, livestock, or wildlife questions or for general information about some aspect of natural resource management. UCCE is the public-education agency of the Land Grant Colleges in the United States and the U.S. Department of Agriculture. UCCE provides limited on-the-ground services to individual landowners. It's primary mission is to bring the results of university research to landowners, professional land managers, and the general public through landowner workshops and courses, continuing education programs, demonstrations of applied research, and publications and newsletters.

Several UCCE forestry, wildlife, and range specialists are located at the University of California, Berkeley and Davis campuses, including forest, forest-product, wildlife-enhancement, range, and agronomy specialists. Farm advisors are located in most California counties. It is best to first contact the Natural Resource Specialist or Farm Advisor's Office in your county. They can provide you with answers or direct you to a person who can. In addition to the specialists noted above, UCCE has specialists and advisors in insect, disease, and weed control, soils and water, environmental horticulture and vegetable crops. Request a free *Agricultural Publications Catalog* that lists available publications on a variety of topics. There is a nominal fee for some of these pamphlets.

Cooperative Extension Publications are distributed by:

DANR Communication Services-Publications
University of California
6701 San Pablo Ave.
Oakland, CA 94608-1239
(510) 642-2431

Several Natural Resource Specialists are located in counties and have regional responsibilities for research and education programs specific to managing and maintaining oak resources on hardwood rangeland. Write or call the following address for the hardwood rangeland specialist nearest to you.

Integrated Hardwood Range Management Program
160 Mulford Hall
University of California
Berkeley, CA 94720
510-643-5429

Information concerning the utilization of rangeland species including wood properties and processing methods can be obtained from:

University of California Forest Products Lab
1301 South 46th St.
Richmond, CA 94804
510-215-4200

State Agencies

California Department of Forestry and Fire Protection (CDF).--CDF is the state agency responsible for wildfire suppression on state and private lands; enforcement of forest practice regulations governing timber harvest on private commercial forestlands; and forest management assistance to private, non-industrial, forest and rangeland owners. This forest and rangeland advisory function is designed to answer general questions and provide an idea of management options. For landowners requiring more detailed assistance, a CDF Service Forester in your county or area will provide referrals to private consulting foresters.

An important responsibility of the Service Forester is to oversee applications from landowners for federal and state cost-sharing in forest management. These include preparation of management plans, reforestation, stand improvement, erosion control, and fish and wildlife habitat improvement projects.

CDF operates seedling nurseries that sell tree seedlings, including oak seedlings, at competitive prices to landowners.

Forest-management assistance, further information about cost-sharing programs, timber harvest rules, seedling order forms, and addresses and phone numbers of CDF County Headquarters are listed in the white pages under Forestry Department or are available from the following office:

California Department of Forestry and Fire Protection
1416 Ninth Street
Sacramento, CA 95814
(916) 322-0623

Registered Professional Foresters (RPF).and Certified Rangeland Managers (CRM) --Especially for large firewood-cutting jobs, the rangeland owner may want to work with a RPF. To help ensure that the practice of forestry is based on proper skills and that they are properly used, the California State Legislature in 1972 enacted the Professional Foresters Law. This law requires that all practicing professional foresters, except on federal land, whether privately or publicly employed, be tested, registered, and licensed by the State Board of Forestry. In this manner, California is insured of a pool of qualified, trained professionals to oversee management of the State's forest resources. Currently, almost 1,800 RPF's are licensed in California. CRM's are resource professional certified by the Society for Range Management and the State Board of Forestry, and responsible for applying the scientific principles to the art and science of managing rangelands, including enhancement of the forage production for livestock and wildlife, assistance to landowners in perpetuating oak woodlands, and use of best management practices to protect riparian areas and beneficial uses of water.For further information and a list of RPF's and CRM's, contact the following office:

Professional Forester's Examining Committee
1416 Ninth Street, Room 1506-14
Sacramento, CA 95814
(916) 445-6834

California Department of Fish and Game (CDFG).-- CDFG is responsible for the protection and management of all the state's fish and wildlife resources, including their habitats. Technical assistance for private landowners who are interested in land and wetland management is available through the CDFG Private Lands Wildlife Management Program. For more information about CDFG services and programs contact the local CDFG office or the Regional Manager in your area. Regional CDFG offices are listed below:

California Department of Fish and Game
Region 1 - 601 Locust Street
Redding, CA 96001
(916) 225-2300

California Department of Fish and Game
Region 2 - 1701 Nimbus Road
Rancho Cordova, CA 95670
(916) 355-0978

California Department of Fish and Game
Region 3 - P.O. Box 47
Yountville, CA 94599
(707) 944-2011
Region 4 - 1234 East Shaw Avenue
Fresno, CA 94710
(209) 222-3761

California Department of Fish and Game
Region 5 - 245 West Broadway
Long Beach, CA 90802
(213) 590-5132

Federal Agencies

Resource Conservation Districts (RCD) and Natural Resource Conservation Service (NRCS).-- RCD's will assist a landowner with planning for the proper use for his or her land, and in developing a plan for the entire acreage. The plans cover more than forestland. Plans coordinate the best management of woodlots, wildlife habitat, cropland, pasture and range, water resources, and building sites.

The RCD's are the local sponsors of the NRCS, an agency of the U.S. Department of Agriculture. The NRCS provides technical assistance to landowners, including information on ponds, erosion control, the types and productivity of soils, and the responses of each soil type and management.

There are 123 RCD's in California. Look in the white pages of your phone book under U.S. Government, Department of Agriculture, Natural Resource Conservation Service, for the phone number of your local NRCS office.

Consolidated Farm Service Agency(CFSA).--The CFSA assists forest landowners through cost-sharing programs for practices that conserve woodland resources and ensure future productivity. The CFSA is an agency of the U.S. Department of Agriculture. The CFSA offers cost-sharing to landowners at various percentages of the total costs of the following:

- tree planting
- stand improvement-thinning, weed control
- erosion control, revegetation
- wildlife-habitat improvement

Project planning assistance is provided by a CDF or RCD/NRCS forester. To qualify for a given practice, the forestland must meet certain standards. Details are available from the CFSA office in your county, listed in the white pages of the phone book under U.S. Government, Department of Agriculture.

Geological Survey, U.S. Department of the Interior (USGS).--The USGS sponsors the National Mapping Program which publishes a variety of multipurpose maps to serve all map users. In addition to published maps, map data and map byproducts are available: aerial photographs, satellite images, advance maps, and digital map data. Its counterpart, the National Cartographic Information Center (NCIC) produces a number of map, photographic, and satellite-image products. NCIC is the national repository for all government sponsored aerial photography. A free *Index to Topographic and Other Map Coverage* and *Catalog of Published Maps* for California (or other state) is available at the following address:

U.S. Geological Survey
Western Distribution Branch
U.S. Geological Survey
Building 41
Box 252286, Federal Center
Denver, CO 80225

A free pamphlet, *How to Order Aerial Photographs*, is also available from the address below:

Western Mapping Center - NCIC
U.S. Geological Survey
345 Middlefield Road
Menlo Park, CA 94025

Other Organizations

A number of organizations provide a valuable resource for the management of oak woodlands. These groups are often staffed by volunteers who are very dedicated to the protection, enhancement, and future sustainability of California's hardwood rangeland resources. To locate the local contact person for your area or county, contact the statewide or regional offices of the following organizations:

California Oak Foundation
1212 Broadway, Suite 810
Oakland, CA 94612
(510) 763-0282

California ReLeaf
3001 Redhill Ave., Bldg. 4, Ste. 224
Costa Mesa, CA 92626
714-557-2575

The Nature Conservancy
785 Market St.
San Francisco, CA 94103
415-777-0487

California Cattleman's Association
1221 H St., Suite 101
Sacramento, CA 95814
916-444-0845

California Woolgrowers Association
1221 H St., Suite 101
Sacramento, CA
916-444-8122

California Native Plant Society
909 12th St., Suite 116
Sacramento, CA 95825

California Native Grass Association
P.O. Box 566
Dixon, CA 95620

California Farm Bureau Federation
1601 Exposition Blvd.
Sacramento, CA 95815

The Audobon Society
555 Audobon Pl.
Sacramento, CA 95825

Appendix D. Additional References

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Appendix E: Glossary of Terms

Animal Unit Month (AUM): Amount of feed or forage required by one animal unit (usually defined as one mature (1000 lb) cow) for one month.

Biodiversity: In a given area, the variety of life forms, the ecological roles they perform, and the genetic diversity they contain.

California Wildlife Habitat Relationships System (CWHR): A computerized database with information on legal status, geographic distribution, habitat relationships, and life history of almost 650 species of amphibians, birds, mammals, and reptiles that are known to occur regularly in California. CWHR is operated and managed by the California Department of Fish and Game.

Canopy: The upper portion of a tree that consists of the twigs, branches, and leaves.

Canopy or crown cover: The area directly under the live branches of the trees, often defined as a percent, of a given unit of land.

Carrying capacity: Average number of livestock and/or wildlife which may be sustained on a management unit compatible with management objectives for the unit. In addition to site characteristics, it is a function of management goals and management intensity.

Casehardened: Drying stresses in lumber that cause warp when the wood is resawn.

Certified Rangeland Manager: Resource professional certified by the Society for Range Management and the State Board of Forestry, and responsible for applying the scientific principles to the art and science of managing rangelands, including enhancement of the forage production for livestock and wildlife, assistance to landowners in perpetuating oak woodlands, and use of best management practices to protect riparian areas and beneficial uses of water.

Chaparral: Vegetation type characterized by low, mostly small-leaved, evergreen shrubs or small trees, which form dense, often impenetrable thickets in arid or dry environments.

Collapse: Drying defect in wood causing the cells to collapse, resulting in non-uniform thickness and wavy surface of the boards

Community: A group of several populations of different species that coexist and interact in the same habitats in the same area.

Continuous grazing: Grazing an area without rest periods or rotation.

Cord: A measure of firewood, pulpwood, or roundwood representing a 4 ft. x 4 ft. x 8 ft. (128 cubic ft.) tightly stacked pile of wood, generally containing 80-90 cubic ft. of solid wood.

Corridor: A defined area that allows for movement by wildlife between other different areas. Riparian areas can be corridors for wildlife movement.

Cottage industries: Small-scale industries, often run out of homes or very small establishments, with a limited number of employees.

Decadent: Age class of tree or shrub where growth has stopped or slowed down, and decay and mortality begin to replace growth.

Density: Number of individuals or stems per unit area.

dbh: Diameter at breast height; the standard point at which the diameter of a tree is measured, 4.5 ft. above ground on the high side of a trunk.

Diversity: The number and abundance of different species of plants and animals in a given community or area.

Ecology: The interrelationships between living organisms and their environment.

Economies of scale: Effect of firm or project size on unit production costs.

Ecosystem: An ecological unit defined by the interactions between the physical (non-living) and biological (living) worlds. Ecosystems may range in size from a small spring to an immense expanse of hardwood rangelands.

Edge Effect: Impacts of urbanization along wildland borders.

Edging: In milling, removing edges of rough-cut boards as part of primary processing.

Endemic: Plant or animal species occurring only in a given location.

Forage: Browse (shrubs) and herbage (grasses, forbs and legumes) which is available to, and may provide food for, grazing animals or be harvested for feeding.

Forb: A nongrass, seed-producing plant that does not develop persistent woody tissue.

Grazing management: Manipulation of grazing and browsing animals to accomplish a desired result.

Guild: A group of animals that use similar resources in similar ways. Guilds may also include species that are similar to each other. An example of a guild are bird species that feed on the ground for seeds and insects.

Habitat: The place where an animal or plant normally lives. This place is often characterized and described by the composition and structure of the dominant plant species.

Habitat generalists: Wildlife species that use a large number of different and varied habitats. Examples of habitat generalists include the coyote, black bear, and deer mouse.

Habitat specialists: Wildlife species that use a small number of different habitat types that typically are very similar. Examples of habitat specialists include the bank swallow and yellow-billed cuckoo.

Hardwoods: Trees that are broadleaved (without needles) and produce flowers. Typical hardwoods include oaks, maples, bay, madrone, tanoak, willows, cottonwoods, and sycamores. They may be evergreen or deciduous. Wood generally more dense than softwoods.

Hardwood rangelands: Areas of California that have a mixture of oaks and other hardwoods and grasses.

Heartwood: Non-living wood in the center of trees, often more prone to diseases.

Honeycomb: Presence of internal checks in wood caused by stresses created during drying.

Inventory: A collection of or process of collecting information on vegetation, wildlife, and other resources

Landscape: An arrangement of interconnected habitats or ecosystems over relatively large geographic areas. These areas can be specifically defined using viewsheds, watershed boundaries, and other distinctive groupings.

Linkages: connections between adjacent habitats that can be used by wildlife.

Mast: Another term for acorns from oaks and seeds of other trees and shrubs.

Mosaic: An arrangement of different habitats over a relatively large area, such as a watershed.

Patch: A homogeneous area with similar species and cover of vegetation.

Population: A group of individuals of the same species that interact together in a specific area.

Prescribed burning: Use of fire under controlled conditions to achieve specific objectives.

Private Lands Wildlife Habitat Enhancement and Management Program (PLM): A program administered by the California Department of Fish and Game whereby private landowners enter into an agreement to manage wildlife populations and habitats in exchange for enhanced hunting opportunities.

Reaction wood: Wood with unusual properties found in leaning trees and branches.

Recruitment: The process which adds individual plants to a population.

Regeneration: The net effect on stand structure from trees gained by recruitment and lost to mortality.

Registered Professional Forester (RPF): Resource professional certified by the State Board of Forestry, who performs services on forested landscapes and conducts forestry activities.

Residual Dry Matter: Dry plant material on a rangeland site that protects soil resources from erosion, serves as protection for newly germinating herbaceous material, and provides dry feed to livestock and wildlife.

Reproduction: The biological process that controls the production of offspring by flowering, production of seed, and dispersal of seed, as well as by sprouting.

Riparian Areas: Upland areas in close proximity to water in streams, wetlands, rivers, lakes, ponds, and other water bodies with characteristic plants and animals.

Saplings: An intermediate size class of oaks, between small seedlings and large trees. Actual range of sizes of saplings varies by authors and individual inventories.

Savanna: A grassland habitat with scattered trees.

Scarification: The process of disturbing and breaking up the surface of the soil, thus creating a more favorable seed bed and growing environment.

Snag: Standing dead tree or section thereof. Can be 'hard' or 'soft', representing various degrees of decay.

Softwoods: Evergreen trees with needle- or scale-like leaves, also referred to as conifers.

Species: A group of interbreeding populations that do not breed with other kinds of organisms. It is the basic biological unit which includes all populations that are similar in physical characteristics and habits.

Species composition: Proportions of various plant species in relation to the total on a given area. Proportions may be expressed in percentages based on weight, cover, density, etc.

Stand: A discrete area with a relatively homogeneous tree cover

Stocking (tree): The number of trees or volume of wood in a stand on a specific unit area.

Stocking rate (livestock): Number of specified kinds and classes of animals utilizing a unit of land for a specific time period.

Stump sprouting: New shoot growth originating from dormant buds on a stump or the root collar just beneath the soil surface, following the death of the top of the tree from cutting, fire or some other cause.

Successional stage: A distinctive stage of a plant community, such as seedling stage or mature stage, while it changes through time.

Sustainable: Maintaining ecosystem processes at multiple scales; maintaining the diversity of ecological organisms, and; maintaining economic viability of the hardwood rangeland property over the long term.

Sustained yield: The capacity of an area of forest land to consistently produce some amount of wood at a given intensity of management.

Timberland: Generally, land whose primary purpose is the production of timber and other wood products for commercial markets. Also, forest land capable of producing 20 cubic feet or more of industrial wood per acre per year, and not withdrawn by statute, ordinance or administrative order from timber utilization.

Transplant shock: The reaction of plants to being moved to a stressful environment, often manifested in reduced growth, lack of vigor or even death of certain tissues.

Tree shelters: Rigid, translucent, double walled, plastic cylinders that are placed over trees to protect them from a variety of potentially damaging animals, and to promote accelerated growth.

Vernal pool: Seasonally flooded depression underlain by a subsurface of clay soils and other impermeable substrates which limits drainage. Vernal pools result from an unusual combination of soils, climate, topography, and hydrology. Vernal pools support characteristic communities of unique plants and animals, which include some special status species.

Warp: Any distortion of lumber from a flat condition.

Wildlife habitat relationships: The patterns of use of habitats by wildlife species.

Woodland: A tree habitat with over 10% tree canopy cover.