United States
Department of
Agriculture

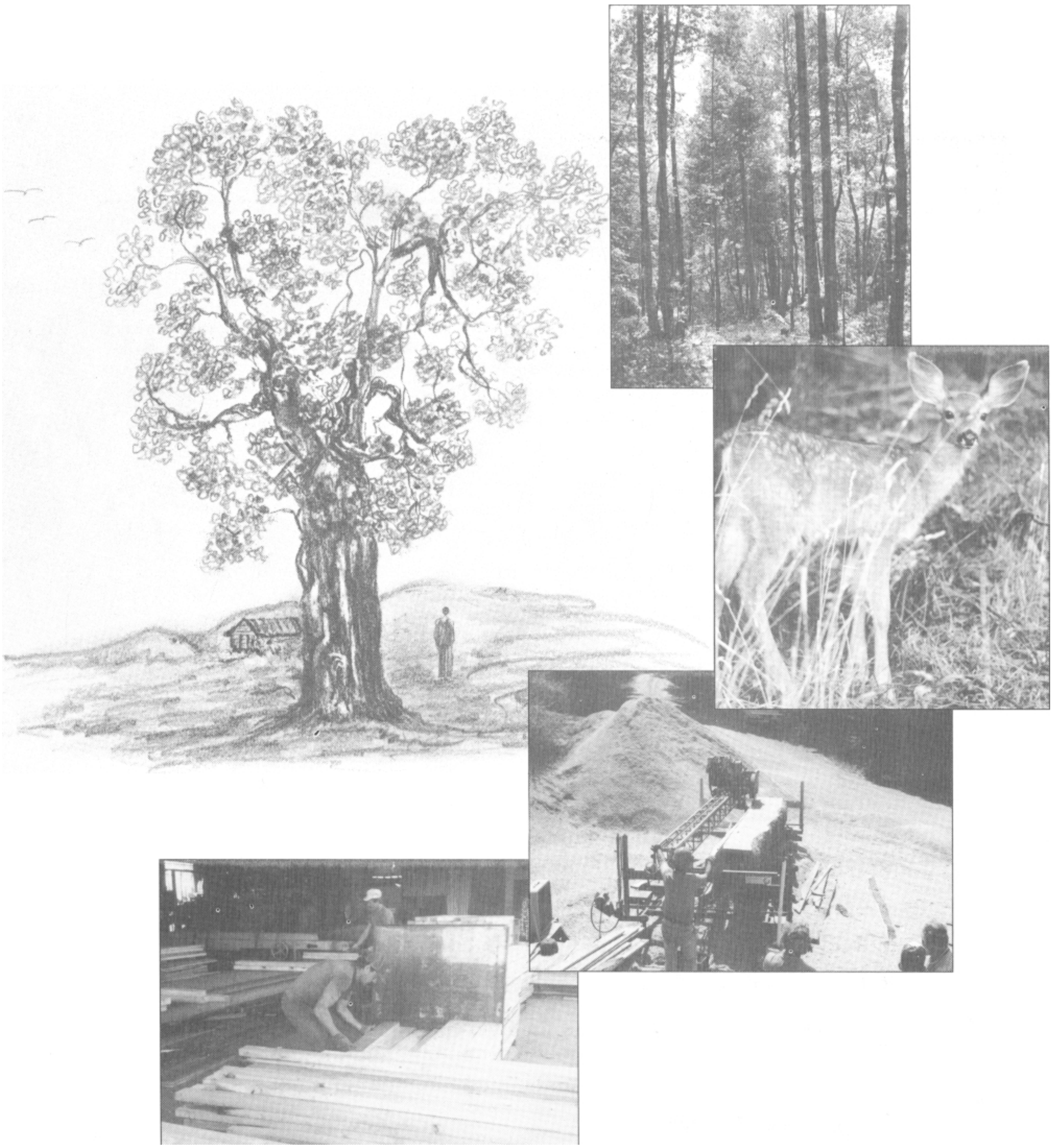
Forest Service

**Pacific Southwest
Research Station**

General Technical
Report PSW-GTR-153

California's Hardwood Resource: Status of the Industry and an Ecosystem Management Perspective

Philip M. McDonald **Dean W. Huber**



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In an earlier publication on California's forest-zone hardwoods, 22 reasons were offered for the failure of a sustained hardwood industry to develop. This report presents knowledge developed over the past 18 years on each of these reasons. Progress is reflected in society's shift from a negative to a positive attitude towards the hardwood industry, better estimates of the inventory base and resource values, the advent of small portable sawmills, better lumber drying schedules and equipment, and recognizing the need to furnish promotional material to architects, wholesalers, retailers, and consumers. Realization that the many and complex hardwood ecosystems have value far beyond wood products has led to a new management perspective with four essential parts: emphasis, scheduling, silviculture, and total yield. Hardwood management in the near future will reflect a broadened emphasis on wildlife, water, esthetics, and wood. Desired ecological types will be needed on a schedule involving their timely creation, maintenance, and manipulation over the landscape in perpetuity. Silviculturists will achieve these ecological types, and the resulting amenities and commodities should serve rural California well.

Retrieval Terms: California forest-zone hardwoods, management, utilization, wildlife, wood, water, esthetics

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Cover: The California hardwood forest ecosystem is biologically complex, esthetically pleasing, and a source of raw material for wood product industries. In descending order these pictures reflect a typical forest stand, a home for wildlife (Frank Kratofil photo), a source of jobs in rural America, and a valuable wood product (Cal Oak Company photo).

Publisher:

Pacific Southwest Research Station
Albany, California

(Mailing Address: P.O. Box 245, Berkeley, CA 94701-0245
Telephone: 510-559-6300)

September 1994

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In Brief...

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Burdened by a general lack of knowledge on almost every phase of hardwood extraction, manufacturing, and marketing, and buffeted by strong competition and the inherent weakness of a fragmented industry, processors of forest-zone hardwoods in California faced a difficult and precarious future. Virtually none of them survived for long, and an established hardwood industry failed to develop. However, by the mid- 1970s, several factors combined to revitalize the industry. These included an acknowledgment of the realities of hardwood processing, a broad range of new developments, new organizations and interested people, and the realization that the widespread and complex hardwood ecosystems had value far beyond wood products. This led to a broader, more value-based management perspective.

Some realities had to be recognized and addressed. Hardwoods were scattered over the landscape as single trees, clumps, and groves. Volume per acre was low, and the heavy logs were costly to extract. Although the trees were large, many had excessive defect and sweep, and the amount of high-value wood was low. The necessity of different and expensive equipment for manufacturing and the difficult and costly drying of hardwood lumber to minimize degrade were significant issues.

Many new developments have affected the hardwood industry in California since the mid 1970s. These include a major shift from negative to positive attitudes as manifest in a host of meetings and conferences, new support organizations, marketing studies, management plans, and the outlook of landowners and processors. Expanded estimates of the inventory base and resource values were a major advance. Better appreciation of hardwood anatomy led to new and better drying schedules and equipment and constituted progress toward solving a major problem.

New organizations and interested people were concerned with a broad range of hardwood industry activities. Probably the most important were the trade associations, which helped the formerly isolated hardwood processor, wholesaler, and retailer with the task of manufacturing and marketing.

A broadened and more ecologically based perspective suggests that forest-zone hardwoods have a bright future in the California landscape and that ultimately they will contribute significantly to the state's economy. Conversion to conifers or pasture land should decrease as the total worth of the hardwood resource becomes more apparent. Concomitantly, as hardwoods become managed on a large-area/long-term basis, the usual boom and bust of forest operations will no longer happen—a variety of products and values will be obtained from the hardwood landscape in a scheduled manner. The "yield" will be a broad assemblage of plant communities (ecological types) that promote stable populations of desired wildlife species, increased amounts of water, pleasing scenery, and a wide range of wood products. A well-developed, stable, and profitable hardwood industry is crucial—the wood from managing the ecological types needs to be converted to products of value. Silviculturists will create, maintain, and even enhance these desired types. The art of hardwood silviculture in California should enjoy its finest hour.

Introduction

California's forest-zone hardwoods constitute a major natural resource that currently is poorly managed and scarcely utilized for lumber and wood products. It is not that no one has tried to manufacture wood products from forest-zone hardwoods. At least 50 processing and manufacturing operations have begun in the past 140 years, and all but one have failed. Reasons for lack of success are numerous and often complex. In an earlier report on the California hardwood industry (Huber and McDonald 1992), we critically analyzed the historical aspects of the commercial hardwood industry in terms of logging, sawmilling, and marketing. We offered 22 reasons to explain the underdevelopment of a sustained commercial hardwood industry. We tried to determine the reasons for the low rate of success: whether failure in hardwood utilization was a foregone conclusion and whether lessons could be learned from the past to improve future chances of success in developing a commercial hardwood industry.

Embedded in these reasons for lack of success, however, was a wealth of information on what does work, what should be done, and some insights on how a sustained operation can be achieved. Some factors are particularly noteworthy. For instance, hardwoods differ from softwoods in many ways and must be handled and processed differently in nearly every phase from harvesting to marketing. Processing costs for hardwoods often are higher than for softwoods. Some hardwood products are profitable; others can be profitable with skilled manufacturing and marketing, and still others, especially secondary products like bark, chips, and fuelwood, can help pay the way for sawlog processing and contribute toward overall profitability. New organizations (trade associations, cooperatives, companies) and new information (inventory, ecology) add to the upwelling of interest in California's hardwood resource. The prevailing consensus is that management of this resource can no longer be neglected. A further consensus is that the rural way of life is valuable and an asset to the welfare of the United States. Small towns with stable industries and permanent jobs are visualized as a product of enlightened hardwood management.

About 80 percent of forest-zone hardwoods occur on private land (Bolsinger 1988), and management prerogatives may differ from those on public land. Managers of private land, for example, may want to emphasize timber and wood products; managers on public land may feel that wildlife and pleasing scenery provide the most value. In this report, we discuss the expanding vision of resource managers on both public and private land, and introduce some key ideas on management philosophy and guidelines. We also examine changes that have affected the hardwood industry during 1976-1993. These changes, which hold promise for the development of a sustained hardwood industry, include better knowledge of the resource base, improved processing techniques (especially in drying of the lumber), an influx of new organizations and people, and a broadened outlook for managing natural resources.

A unified management philosophy—one that emphasizes a variety of "yields" such as wildlife, water, esthetics, and wood products and combines them in an operational framework—is still needed. As Huber and McDonald (1992) noted, California hardwoods and hardwood ecosystems never had a management philosophy, nor even general management guidelines. An ecosystem management perspective for managing California's forest hardwoods is needed and timely.

This paper reports the past and current status of industrial practices for timber and wood products, expands the "yield" of the hardwood forests in California to several amenities and commodities, and presents these yields from an ecosystem perspective.

Forest-Zone Hardwoods

California's indigenous hardwood species can be divided into two basic groups: those that grow in the rangelands and woodlands in the foothills at lower elevations and those that grow in the forest-zones at higher elevations. We have limited this discussion to the forest-zone species. These include tanoak (*Lithocarpus densiflorus* [Hook. & Arn.] Rehd.), California black oak (*Quercus kelloggii* Newb.), golden chinkapin (*Castanopsis chrysophylla* [Doug1.] A. DC.), Pacific madrone (*Arbutus menziesii* Pursh), California-laurel (*Umbellularia californica* [Hook. & Arn.] Nutt.), red alder (*Alnus rubra* Bong.), and canyon live oak (*Quercus chrysolepis* Liebm.). All of these species, with the possible exception of canyon live oak, have an established history of utilization for wood products and other yields (Economic Development Administration 1968).

Current Status of the California Hardwood Industry

In 1961, Henry Vaux noted: "it is quite apparent from the amount of detailed knowledge that has been discussed among you here that we can look forward to an expanded California hardwood industry" (Vaux 1961). In spite of a few scattered successes, Vaux's anticipated hardwood industry never developed; at least not as an integrated industry with multiple producers, suppliers, and products. Nevertheless, interest in California hardwoods began to increase in the mid-1970s, and progress has been made in many diverse phases of the industry. To show this progress, a brief summary of the "PAST" status for each of the 22 reasons affecting hardwood logging, manufacturing, and marketing listed in Huber and McDonald (1992) is presented, followed by the "CURRENT" status of each.

Negative Attitudes

PAST: California was endowed with an extensive resource of old-growth softwood timber resource of great value. In contrast to the softwoods, the hardwoods were of lower volume, found in scattered stands, difficult to process, and low in profit. These characteristics caused a negative attitude toward California hardwoods that was shared by resource managers, foresters, loggers, processsors, and consumers.

CURRENT: The widespread negative attitudes of the past are being replaced by a trend toward positive attitudes. A variety of indicators substantiates this trend. These indicators include the significant number of conferences and symposia, the development of several new support organizations, the increased activity of landowners and processors, and the development of marketing studies or strategic plans. Each is discussed below.

Conferences and Symposia

Since 1974 at least 25 workshops, field trips *(fig. 1)*, conferences, and symposia have directly focused on hardwoods. A sampling of statements from these meetings seems to capture the trend in changing attitudes. In 1974, a Tanoak Utilization Meeting was held in Humboldt County by the University of California Cooperative Extension. The intended audience was forest landowners, forest managers, and operators. The announcement (Smith 1974) for this meeting stated:

> *Today, there is again a growing interest in the utilization of tanoak. The purpose of this meeting is to look at and discuss the efforts now being made to utilize this species.*

In 1979, an even larger meeting, the Symposium on the Ecology, Management, and Utilization of California Oaks, in Claremont, California, comprehensively examined California's native oak resource. It attracted more than 200 participants and 52 reports "... to share information about our native oaks, one of California's most important natural resources" (Plumb 1980). In his preface, Plumb noted:

> *Because of the poor stein form and the relatively slow growth of most oak trees, professional foresters have generally concentrated their efforts on managing other trees, mainly conifers. Recently, however, broad-scale interest in oaks has developed. The public has become aware of the limitations of our natural resources. The potential of the oak woodlands in meeting energy shortages and wildlife needs, as well as the great immediate value of these woodlands to recreation, are now being recognized.*

By 1986, interest had increased as indicated by attendance at the Symposium on Multiple-Use Management of California's Hardwood Resources, held at California Polytechnic State University in San Luis Obispo, California. Attended by more than 500 participants, the symposium presented 72 reports and 12 posters. In their preface to the published proceedings of the conference, Plumb and Pillsbury (1987) stated:

> *All in all, interest and concern about hardwoods has increased dramatically. Potential use and value of the hardwood resource for all types of forest products--energy to wildlife--will continue to grow as the population increases, the resource diminishes, and new uses for hardwoods develop.*

Support Organizations

Another indicator of positive attitude has been the development of new support organizations. Some of these organizations were developed specifically to service the hardwood industry; others had a broader charter that included hardwoods.

Figure 1—The strong response of forest-zone hardwoods to thinning was evident to visitors in a 1968 field trip on the Challenge Experimental Forest, Yuba County, California. This response fostered positive visitor attitudes toward native tree species.

In 1983 the Northwest Hardwood Association (NHA) changed its name to the Western Hardwood Association (WHA). This indicated a change in attitude by an industrial association to expand and encompass all commercial species of western hardwoods (Sweitzer 1983).

In 1989, the California Hardwood Foundation (CHF) was formed to create and foster an industry based upon the State's forest-land hardwoods. The CHF was to provide a legal entity and a nucleus for information transfer, education, research, and the coordination needed to develop and maintain a hardwood industry (Randolph 1991). Although hampered by lack of funds, the CHF continues to serve the hardwood cause.

In 1990, the California Timber Industry Revitalization Committee (CTIRC) was formed by a consortium of State and Federal agencies to better manage economic change in the timbered rural economy. The effort of this Committee was to focus on the discovery of potential innovative uses of forest resources (including native hardwoods), regular communication between involved agencies, outreach, and planning. Before disbanding in 1993, the CTIRC served as a catalyst and facilitator between the public and private sectors.

In 1991, the Institute of Sustainable Forestry (ISF) was formed to promote "the ecological and economic sustainability of the earth's forest resources" (Anonymous 1992). The ISF "is committed to creating new forest management paradigms by providing programs in ... public education; professional training in all facets of the ecological forest products industry; research and development into various aspects of forest management for the long-term productivity and health of the forest; and a certification and labelling program for ecologically harvested forest products..." Much of the effort by ISF has been oriented toward the hardwood resource and its subsequent products.

In 1991, the California Forest Products Commission (CFPC) was established (Crow 1992). This is a nonprofit commodity board which is funded solely by its members who pay an assessment on their products. The CFPC is a clearinghouse for scientific research and other information about forest products. It provides information to build public recognition and awareness of the economic and environmental significance of the forest products industry in California. Although supported by the softwood industry, the Commission strives to promote all forest products, including those of the hardwood industry.

In 1992, the California Hardwood Producers Cooperative in north central California was formed (Roan and Bales 1992). According to Moore (1992):

> *The primary objective of this marketing cooperative is job creation especially for unemployed or underemployed people in the four county area. The cooperative could contribute value-added activities such as making hardwood lumber out of timber that would have otherwise gone for firewood, generating additional income for the study area. Additionally, it is expected that this new stream of income will stay in the area and generate additional income through the ripple or multiplier effect.*

The mission of this cooperative was "to provide a stable supply of California hardwood to the marketplace and to increase demand for the product, ultimately resulting in increased production" (Riley 1993).

Landowners and Processors

Perhaps the most significant example of changing attitudes are from the landowners and processors themselves. This was exemplified by a conference sponsored by the Forest Landowners of California (FLC). The conference was titled: "How To Profit from Your California Hardwoods." The target audience was the non-industrial timberland owners who are members of the FLC. The conference was held at the University of California Forest Products Laboratory in Richmond, California, in 1990.

At the local level, a similar meeting on "Opportunities in Northcoast Hardwoods" was held in Redway, California, in 1991. The target audience area was southern Humboldt County specifically, and most of the northern redwood country in general. The subtitle for this conference was "Moving Ahead with Strategies to Enhance Existing Businesses and Create New Opportunities." The announcement stated: "The workshop is geared toward timberland owners, lumber producers, woodworkers, and representatives of pertinent government agencies."

Another local meeting was the California Hardwood Resource Seminar held in Rocklin, California, in 1989. The target audience was from those counties comprising the Sierra Economic Development District, and the Central Sierra region. According to the meeting announcement, the audience was invited to "attend a seminar on hardwood resources, management, potential products and markets."

Marketing Studies and Strategic Plans

Two additional indicators of the change in attitude toward California hardwoods are the effort to conduct a hardwood marketing study, and the development of a strategic plan for hardwood products.

In a survey conducted by the Pacific Gas and Electric Company (Lopez 1991), over 1,000 California furniture and wood product manufacturers were contacted: 80 percent indicated they would consider using California hardwoods, but only 10 percent could recall ever being contacted by a sales representative or lumber supplier about the hardwood species. The same survey indicated that, for furniture and other wood products manufacturers, the decision to substitute California hardwoods for currently existing species depended primarily upon consumer attitude. This marketing survey recommended the development of a Hardwood Commercialization

Action Plan in order to promote a California hardwoods industry. The Action Plan addressed five broad areas: technology development, an industry awareness campaign, a comprehensive industry analysis, a comprehensive marketing analysis, and a financial plan.

In another effort to develop a comprehensive strategic plan, the California Department of Commerce (1992), also working through the California. Timber Industry Revitalization Committee, prepared a draft document on “A Hardwood Products, Development Strategy for California.” The intended purpose of the strategic plan was “To promote community stability in California’s forest based communities.” Several goals were proposed:

- Promote timber utilization and forest management practices that enhance stable forest environments, biodiversity and ecologic productivity.
- Favor the harvesting, manufacturing and marketing of forest products that optimize employment growth, job retention and economic stability.
- Identify and assist entrepreneurial ventures that are consistent with local economic and environmental stability.
- Facilitate technology transfer to entrepreneurs and a tinker industry in transition.
- Provide training, reemployment, and education to the timber industry labor force.
- Foster communication and coordinated effort of involved public agencies.

These efforts are still in development and draft form. When completed, they will constitute significant steps toward addressing the need or a hardwood industry infrastructure.

Logging Logistics

PAST: In contrast to the abundant supply of softwoods growing in almost-pure, heavily-stocked, nearly-continuous stands, hardwoods were scattered, grew intermixed with softwoods, and lacked both concentration and volume. This resulted in difficult logistics for both timber sales and harvesting practices.

CURRENT: Difficult logging logistics will always be a reality because of the natural habitat of forest-zone hardwood species that generally grow intermixed with softwoods. Better understanding of this reality will allow for improved harvesting plans and more efficient companies.

High Logging Costs

PAST: Hardwood logging is more difficult and expensive than for softwoods because of widely dispersed trees and stands, lack of concentrated stocking, and the intermixed relationship with conifers. In addition, the mechanics of skidding and loading the heavy, not-always-straight hardwood logs often cause additional expenses. Logging costs could not be spread over the entire log because much of it was not merchantable.

CURRENT: Coincident with the softwood industry is the phrase that timber needs “to pay its way out of the woods.” Thus, softwood timber is often harvested and sold at a profit in log form without any additional processing for added value. However, because of the high cost of harvesting hardwood sawlogs, many companies have found it necessary to ameliorate some of the logging costs through the higher sales value of processed lumber (Iris 1990). One attempt to cover the higher costs of harvesting and processing is to certify that the hardwood products have been manufactured through an environmentally safe process, thus warranting higher value-added prices through niche marketing. Other developments are improved markets for pulp chips, biomass, and fuelwood, which allow more of each tree and log to be merchantable, thus reducing operating costs in general.

Concurrent Logging Practices with Softwoods

PAST: Most of California’s forest-zone hardwoods that are suitable for producing lumber and wood products grow intermixed with softwoods. Consequently, the supply of hardwood logs usually is dependent on softwood timber sales. Where the hardwood tree density was low, logging costs almost always were excessive if the hardwoods were harvested alone. However, where the hardwood density was high, the hardwoods could be harvested separately (Hall 1987-1993).

CURRENT: The most cost-effective hardwood harvest method is still incidental to softwood timber sales. Through concurrent harvesting, the cost in essence is a “sunk cost” in the softwoods. This sunk cost may or may not be passed onto the hardwoods (Whitney 1993). The vast majority of hardwood logs are yarded and decked to be sold for firewood, without consideration for potential value as lumber, veneer, or other products. Some small sawmill owners have arranged with firewood cutters to sort out and deliver the higher quality logs for processing into lumber (Godden 1993).

Inconsistent Estimate of Inventory Base and Resource Value

PAST: Reliable statewide estimates of hardwood resource inventory data were slow to develop because they were not included in timber surveys. For those surveys that were made, the volume estimates often varied considerably and it was difficult to reconcile the differences between sources. As noted by McKay (1987):

> *...volume tables poorly represented many of the species tallied and several were declared noncommercial regardless of individual size, shape, or soundness.*

And because of limited commercial use of hardwood species, there was a lack of organized market information on stumpage values and log prices.

CURRENT: Estimates of the California hardwood inventory base have improved since the first California Vegetative Type Map (VTM) project, which was conducted between 1928 and 1940 (Wieslander and Jensen 1946). A sequence of events spanning four decades brought improvements in resource mapping through the Cooperative Soil-Vegetation Survey (SV) (California Department of Forestry 1980), the California Vegetation Classification System (CALVEG) (Parker and Matyas 1980), the Forest and Rangeland Resource Assessment Program (FRRAP) of 1986, and the more recent efforts using Geographic Information Systems (GIS) (American Society of Photogrammetry and Remote Sensing 1992). Concurrent with these improvements in mapping were improvements in the development of species volume equations and tables (Hornibrook and others 1950, McDonald 1983, McKay 1987, Pillsbury and Brokhaus 1979, Pillsbury and Kirkley 1984, Pillsbury and Stephens 1978, Pillsbury and others, in press).

Improvements in mapping technology and species-specific volume equations coalesced into an improved comprehensive statewide resource inventory for trees and stands (Bolsinger 1988). Improved procedures and volume equations were developed for the major California hardwood species. Among other categories, Bolsinger's report included details on area and volume of hardwoods by ownership, growth and mortality of hardwoods on timberland, hardwood tree cutting on timberland and woodland, and the extent of forest types and species occurrence. Bolsinger estimated that 2.2 million acres of hardwoods were classified as timberland and capable of growing industrial wood. The volume of hardwood sawlogs suitable for lumber was 5.3 billion cubic feet or about 25 billion board feet.

A more localized estimate of hardwood inventory in the north central Sierra Nevada was provided for Sierra, Nevada, Placer, El Dorado, and Amador Counties (McCaskill 1990). Its primary use was for determining the quantity and quality of hardwoods available for the development of a value-added hardwood industry. McCaskill concluded that the Pacific madrone association had a high volume of total wood available for utilization, the California black oak-canyon live oak association had a moderate level, and the blue oak-interior live oak association had a low volume level. Among other issues included in this assessment were the development of a local tree-grading system for the major hardwood species in the area and an inventory of the hardwood resources. The use of a tree-grading system to estimate resource quality, in addition to quantity, was a substantial improvement over previous estimates of resource volume.

Although assessments of resource inventory are improving, forest landowners need assistance to obtain and understand this information and to determine the value of hardwoods on their property (McCaskill 1990). As we noted earlier, several workshops and conferences have been held in an effort to provide information on hardwood values to local landowners.

Operating a hardwood timber business requires accurate information about both the quantity (volume) and quality (grade and potential yield) of the available resource. In spite of recent improvements in estimating resource quantity, "what appears to be missing are localized data that expresses volume by log grade" (Stephens 1990). Stephens quotes Karen Kenna, Marketing Specialist. USDA Forest Service, Atlanta, Georgia about the need for detailed inventory data by log grade:

> *A good overview of a hardwood resource begins with a discussion of volumes by grade. This is the core data necessary for an analysis. All other information is secondary. Only when you know what proportion of the standing resource qualifies as grade timber, and what proportion does not, will you be able to legitimately begin an analysis of California's hardwood resource utilization.*

However, accurate estimates of volume are only part of the need. Volume denotes "how much," but quality suggests "what value." To the landowner, quality pertains to the trees; to the logger, quality pertains to the log grade of the trees; to the sawmiller, quality pertains to lumber recovery by log grade; and to the secondary manufacturer quality pertains to the yield of usable cuttings from each lumber grade. Thus, accurate information on the timber resource in terms of both quantity and quality sets the stage for the continuum of processing from harvesting through primary processing to secondary processing to marketing (*fig. 2*).

Timber resource inventories are generally based on tree measurements and grades as related to expectant lumber yields. Thus the inventory almost always is predicated on a single product—lumber—or occasionally on cordwood (Dost 1984). A more accurate system would allow for a multi-product evaluation of the amount of usable wood in each log. According to McCaskill (1990):

> *a multi-product grading system has been researched for eastern hardwoods. If this system were adapted to California hardwoods, information could be collected about the primary and secondary wood manufacturing potentials that exist.*

Low Quality of Hardwood Trees

PAST: In contrast to the high quality of local softwoods, California hardwoods were not known for their quality. The boles were usually short, crooked, and often defective, particularly in over-mature trees of large diameter. Consequently, there were limited volumes of high grade lumber such as FAS (Firsts And Seconds) and Select, with a predominance of lower grade lumber in

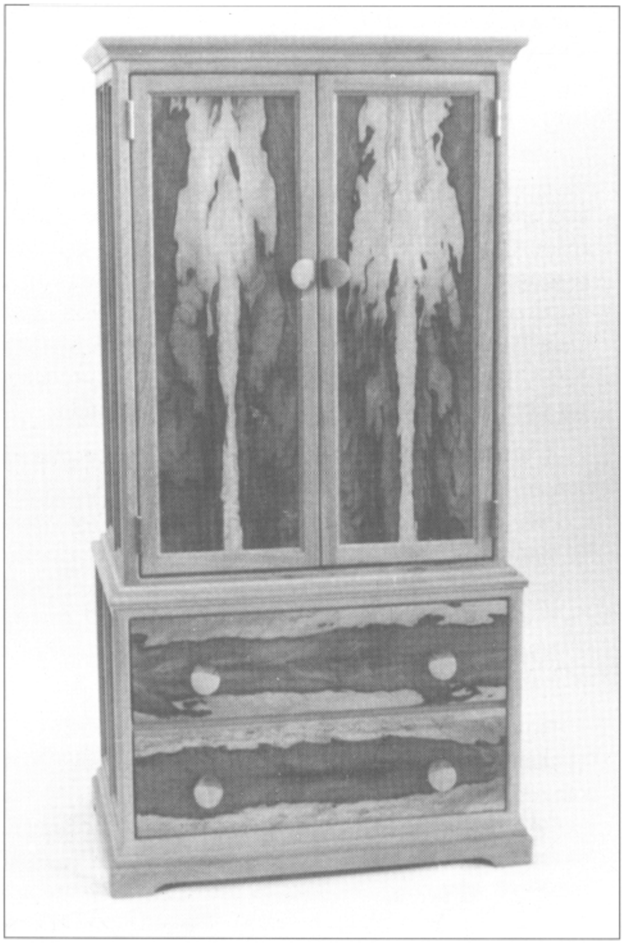


Figure 2—Accurate identification and appraisal of the unique natural character of California hardwoods, as featured in the unique figure and grain of this armoire made by fine-wood worker James Ward of Eureka, Calif., is key to estimating value.

#2 and #3 common. Species such as California black oak, tanoak, chinkapin, and Pacific madrone generally produced short logs 8 to 12 feet long. This situation was new to a softwood industry accustomed to log lengths of at least 20 feet in redwoods and 16 feet or longer for other species.

CURRENT: The perception of hardwood timber quality has generally been based on the presence of high quality softwood timber and the quality of imported hardwood lumber from eastern or foreign sources. Over time, new inventory data have provided a different perspective on these perceptions. For example, Bolsinger (1988) noted that the net "volume of trees more than 29.0 inches in d.b.h. on California's timberland is 19 percent of the total for that diameter class in the Nation." In the diameter range of 21 inches and greater, California hardwoods constitute 10 percent of the total national net hardwood volume (Bolsinger 1988). To the extent that larger size and age of trees are indicators of higher yield and quality of lumber, this would imply that California's hardwoods may have higher quality than earlier perceived. However, log-to-lumber yield studies *(fig. 3)* conducted by industry and supported by daily operating experience provide a rule of thumb: when comparing average #1 grade sawlogs with identical exterior appearances and dimensions for California and eastern species, expect a 20- to 40-percent lower grade recovery from the California log. Furthermore, the average log would yield a decideedly lower volume recovery (underrun) (Hall 1987-1993). Godden and others (1993) reported volume recoveries that were 71 to 75 percent of net log scale.

Logs Bought "Woods Run"

PAST: Because adequate information on hardwood log grades and yield studies was lacking, logs were often bought "woods run" with limited knowledge of what to expect in quality or lumber recovery value. Some companies eventually developed their own standards for weight scaling and log grades.

CURRENT: Most hardwood logs continue to be sold and bought "woods run" based on weight, rather than on log scale. Logs were generally bought on the basis of dollars per ton; burls on the basis of dollars per pound. Weight was used because both timber owners and lumber producers were suspicious of the heavy deductions made by traditional log scaling methods. However, log scaling continued to serve as a basis for assessing merchantability. Weight was also used because a certified weight slip provided trust, and thus became a common unit of transaction between landowners, foresters, timber fallers, truckers, and processors (Williams 1993). Due to the lack of a sawlog industry, this mode of exchange also stemmed in some degree from the dominance of the hardwood pulp chip and biomass markets that use weight as their unit of measure.

Log Grade and Lumber Yield Recovery Studies

PAST: Log grade and lumber yield studies were conducted for most of the abundant forest-zone hardwood species of California. These studies generally followed a standard format using former Forest Service rules for hardwood log grades and National Hardwood Lumber Association rules for hardwood lumber grades. Test procedures accounted for lumber yield based on "green" grades and estimated dry volumes (tally) adjusted for a 5 percent loss from shrinkage. Published yield studies did not follow each processing step of kiln drying and surfacing. Final recovery in surfaced dry shipping grades, volumes, or values was not determined. Consequently, the actual amount of degrade and loss during these manufacturing steps was not accounted for in the results.

CURRENT: A study by Sullivan (1987) followed the lumber from the log through sawing and drying, thus identifying dry lumber quality while accounting for volume and value losses in the drying process. Although a step in the right direction, more studies with larger samples are needed (Hall 1993). Two new studies have been started on California black oak. In the first, the lumber was dried in a dehumidification type kiln (Godden and others 1993). In the second, more extensive study, the data will be based on dry lumber (Lowell 1992), but the method of drying has not yet been decided.

Lower Production Rates and Lumber Yield

PAST: The established softwood industry was accustomed to high production rates and lumber yields, but because of the hardwood log characteristics noted earlier, production rates and product yields were lower for both veneer and lumber.

CURRENT: Lumber yields and production rates are inherently lower in hardwood sawmills because of log characteristics and emphasis on lumber quality. To utilize a larger percentage of the hardwood timber resource, a company in Oroville, Calif. built an innovative mini-mill to handle short logs from 3.5 to 10 feet long and 7 to 48 inches in diameter. This capability to saw shorter logs allowed utilization of material that would otherwise have been unused because of crook. Logs were purchased by weight, with about 60 percent of log weight converted into rough green lumber (Hall and Allen 1980). However, this estimate may have been misstated: 45 to 50 percent may be more reasonable (Hall 1987-1993).

The growing development of efficient portable sawmills has increased the local demand for hardwood sawlogs. Thus, the larger centralized sawmills are being joined by smaller mills. Although these mills have lower individual capacity, their cumulative advantages are a new force in the hardwood industry. Some of the advantages of small processors include:

1. primary processing performed closer to the supply of logs because of disbursed (rather than concentrated) sawmilling;
2. a reduction in loss because of the increased number of mills;
3. lower capital requirements, hence lower start-up costs;
4. vertical integration from logs to finished products, even to the point of wooden crafts being sold in small shops.

Use of Softwood Processing Methods

PAST: To many operators, the basic harvesting and manufacturing process appeared similar for both softwood and hardwood logs. However, these processes actually had many significant differences and it was difficult to integrate the harvesting and manufacturing of hardwoods into the existing softwood industry. A primary reason for failure to profitably harvest and manufacture western hardwoods was a general reluctance to recognize that fundamental differences between softwoods and hardwoods required the use of different equipment and techniques.

CURRENT: Not only have attitudes improved regarding hardwoods as a source of wood products, but harvesting and processing techniques have improved as well. Much has been learned about the difference between hardwood and softwood harvesting. For instance, Hall (1987-1993) noted that softwoods generally are tall and straight and the faller decides where to buck: but the hardwoods, in contrast, are short and crooked and they “tell” the faller the best place to “make” logs. According to Garland (1984), harvesting of hardwoods is similar to harvesting softwoods, but with some fundamental differences: felling and bucking are substantially more dangerous, the wood may be brittle and break unpredictably, tree form may be poor, lean and limb-loading are highly variable, and felling patterns are hard to determine. In addition, Garland found that:

> *Skidding or yarding logs is difficult in brush, limbs and debris. Hardwood logs and trees also break during the process. At the landing, there is generally a substantial amount of remanufacturing needed to make logs suitable for transport. Truck loading and heading are more difficult when hardwoods are not uniform for building loads. They (logs) may be heavy when fresh and could limit load sizes due to limits on axle loadings. By volume, an up-to-weight hardwood load may be 15 percent less than a comparable load of softwoods.*

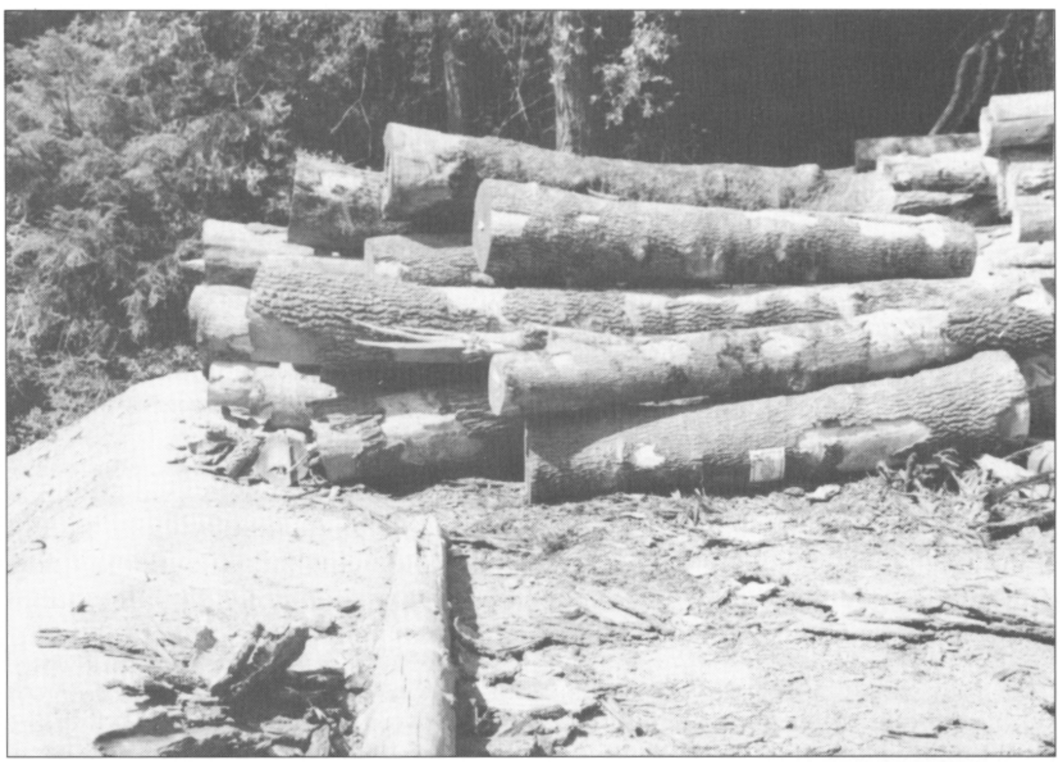
For processing, stationary sawmill designs range from band-saw headrigs (Hall and Allen 1980), to circle-saw headrigs (Chick 1979), to scragg-saw headrigs (Winkel 1992). In addition, an influx of smaller portable sawmill designs that use circle-saws (Bales 1992) or bandsaws (Iris 1990) has been observed. Whatever the equipment, “softwood sawing methods and systems are generally used until someone comes along and shows us differently” (Boone 1993). However, knowledge and understanding of the relationship between sawing pattern and final lumber grade are increasing largely because many hardwood sawmillers (primary processors) are also the manufacturers of hardwood cabinets, furniture, and other value-added products.

Lumber Drying Problems

PAST: The drying (seasoning) process was one of the principal obstacles to satisfactory utilization of western hardwoods. Early research and practical experience showed that western hardwoods were more difficult and expensive to season than associated softwood species.

The wood of most California hardwoods is refractory and thus requires considerable care in seasoning. Among the requirements to reduce drying degrade is a need to expose green lumber to very mild conditions in the initial drying stage. Tanoak and chinkapin, for example, require

A



B

Figure 3—Knowledge of lumber recovery grade and volume from California black oak logs is valuable to the landowner, logger, sawmill operator, and secondary manufacturer. This four-step process depicts California black oak (A) deck of skidded trees, (B) logs sorted and decked by grade, (C) logs sawn for grade by a minimill, and (D) stack of green lumber ready for drying.

C

D

starting at 105 °F dry bulb and 90 percent relative humidity (Torgenson 1947). These drying conditions are about the lowest that can be maintained in most commercial dry kilns. Consequently, hardwood drying problems are also related to kiln design and equipment limitations.

CURRENT: Properly dried lumber is absolutely necessary for hardwood manufacturers to compete in established lumber markets such as flooring, furniture stock, and cabinetwork. To reduce degrade, current lumber drying operators must maintain very mild conditions during early drying stages. Generally, these mild conditions are achieved through the practice of air-drying fresh-sawn lumber before kiln drying. Air-drying periods of 3 to 6 months, depending on species and season of year, are typically used to reduce the moisture content below the fiber saturation point. This technique was used by Sullivan (1987) in his tanoak recovery study. Regardless of the final drying system, air drying before final kiln drying is now the general practice used throughout the state for most of the indigenous hardwood species. The exception is perhaps red alder, which dries quite well without prior air drying (Winkel 1992).

The engineering design of steam-heated dry kilns has not changed significantly over the years, and the mild drying conditions needed during initial drying are still difficult to achieve. Interestingly, perhaps the best existing steam-heated kilns for drying hardwoods are vintage kilns designed for processing air-dried redwood. These old kilns were under-designed for heating capacity and consequently work quite well for hardwoods. At least one operator has reported success for drying tanoak, Pacific madronc, chinkapin, and red alder with this equipment (Winkel 1992). Ultimately, drying degrade of California hardwoods is probably reduced more if a moisture-content philosophy, rather than a time-based philosophy, is used (Bois 1975).

Although the design of steam-heated dry kilns has not changed much over the years, new types of kilns are being tested. A major change in dry kiln design has come in the form of alternate heating and drying systems. Since the 1980s, an influx of dehumidification kilns has occurred. Small hardwood producers are attracted to dehumidification kilns because they are relatively inexpensive and are essentially a “mail order” system. The hardware and control systems can be ordered from the manufacturer and delivered in crates. The drying chamber is then built by the buyer according to the supplier’s plans. Less costly and easier to order, these dehumidification drying systems are available for processing the small volumes of lumber commensurate with the production capacity of the operators. Unfortunately, they too have limitations. Some dehumidification kilns cannot reach high enough temperatures to kill beetles or other insects that degrade lumber; most are not equipped with steam spray systems to recondition the lumber at the end of the drying period. Nevertheless, after some trial-and-error experience, dehumidification kilns have been used to dry California black oak, tanoak, and Pacific madrone (Bales 1992, Bosco 1990, Iris 1990).

Another change in design is the vacuum dry kiln (Wise 1987), which has been tried on several California hardwood species with varying results. These kilns are also available as a “mail order” system. In this instance, however, the entire system arrives from the supplier. Buyers need only supply the electrical power required to operate the system. However, in contrast to the dehumidification kilns, the vacuum kilns are quite expensive.

A third type of new design is a form of solar kiln. Early designs relied on thermal convection to circulate the air through the lumber and past the solar heating collectors. These kilns had the advantage of being inexpensive, but the disadvantage of working poorly due to the inadequacy of air circulation, temperature control systems, and drying uniformity (Leon 1989). Gradually fans were incorporated to circulate the air. The most recent development in solar kilns has been a sophisticated electrical system to control fans and vents (Ellis 1992). And, despite the elaborate electrical system, the overall cost has been relatively low due to the “off the shelf” items.

Considerable research has been conducted to assist industry in understanding how to dry western hardwood species. In their research report describing the drying problems of bacterially infected California black oak, Ward and Shedd (1979) stated:

> *For a single oak species, the drying of California black oak was studied more intensively than were similar problems in some of the more plentiful species of eastern oaks. From the late 1940s until the early 1960s, a series of drying studies was carried out to promote the utilization of California black oak.*

No Experienced Hardwood Labor Pool

PAST: Because of the dominance of the softwood industry, virtually no experienced labor pool was available for work in hardwood mills. Both loggers and manufacturers needed trained workers who understood the unique nature of the hardwood industry.

CURRENT: The labor pool of experienced people for work in both the hardwood forest and the mills is still limited. Hardwoods often are harvested before and after softwood operations by workers trained only in softwoods, or by relatively unskilled fuelwood cutters. In one operation, the loss was about 10 percent from improper felling, bucking, and skidding techniques. Most hardwood processors are small owner-operator businesses (Bales 1992, Bosco 1990, Chick 1979, Hall and Allen 1980, Iris 1990, Winkel 1992). These entrepreneurs have learned their trade by trial-and-error experience.

Several efforts have been made to provide training in hardwood logging and lumbering operations. The

California Department of Forestry and Fire Protection has sponsored two hardwood lumber grading short courses through the National Hardwood Lumber Association (NHLA). In addition, the Institute for Sustainable Forestry has developed a series of training sessions on hardwood forest management, harvesting, and processing.

Limited Working Capital

PAST: Some hardwood lumber producers tended to he small operators with limited financial resources who were unable to obtain a steady supply of softwood logs. To stay operating, they would purchase hardwood logs, which were relatively inexpensive, because little or no competition existed. These operators were gambling that a market would develop for their hardwood lumber products. They lacked the working capital needed to finance an efficient operation with adequate inventory and marketing. Many undercapitalized mills sold green lumber in order to develop a cash flow. However, except for pallet stock, few markets existed for green lumber. Other mills operated on a "firm" order basis because their working capital did not permit carrying an inventory of logs or lumber. A major difficulty arose if large volumes were ordered.

CURRENT: California hardwood lumber producers and manufactures continue to be small operators with limited working capital. "Most of the sawmill owners lacked the capital to purchase sawlogs, saw the lumber, and sell it on their own account. The majority did sawing on a custom basis" (Moore 1992). Consequently, few locally owned and operated sawmills have established steady cash flow and accumulated financial reserves. However, some loggers, truck drivers, and sawmillers are beginning to organize into cooperatives to overcome the problems of "smallness" and limited working capital (Moore 1992, Riley 1993, Roan and Bales 1992). The need for a monetary line of credit has been expressed by others (Faison 1992). But because credit usually is based on collateral, which is normally lumber inventory, it is hard to secure. Furthermore, California hardwoods, which are not yet established in the marketplace, arc often perceived as non-commodity species with low collateral value.

Variable Product Quality

PAST: Many problems were related to poor product quality. The lack of mutually satisfactory product standards for seller and buyer and the general lack of uniformity within the industry were especially serious. A common customer complaint was the failure to have lumber separated into standard grades and sizes. Although some companies attempted to use established lumber grading rules from the Northwest Hardwood Association, hardwood lumber generally was sold without regard to accurate grading rules.

CURRENT: The NHLA standard rules have become recognized and used for grading hardwood lumber, as well as to fulfill the requirements for accurate sawing, proper drying, and quality surfacing. This is especially important when selling large volumes of lumber into the established hardwood market.

In contrast, low volume sales of natural "character wood" with pleasing figure and grain are often made at the local level. This type of lumber (usually graded #1 common or lower by NHLA) has unique patterns of figure and grain. Lumber with these characteristics has a ready market for specialty products, fine woodwork, and crafts. A number of woodworking guilds on California's west coast have members who frequently seek out this material for special projects (McClasskey 1990). Although these are low-volume sales, they are highly profitable.

Marketing Issues

PAST: The problems related to marketing of California hardwoods are varied and numerous. Huber and McDonald (1992) listed 14 issues that contributed to the marketing problem of forest-zone California hardwoods. These ranged from minor (Lining to keep promised delivery dates) to major (industry instability). That western hardwoods were regarded as inferior was particularly daunting. As Overholser (1968) noted:

> *Milling and drying practices ... resulted in producing hardwood lumber of low quality, which caused losses in manufacturing in finished products and gave rise to the prevalent belief that western hardwoods were inferior ...*

CURRENT: Progress has been achieved on many of these issues. For example, various marketing directories have been developed, NHLA grading rules are being utilized, consumer information has improved, and prejudice toward western hardwoods is ameliorating.

However, much work needs to be done. In a conference on alder, for example, Whittier (1984) addressed the issue of use in subsequent manufacturing, and noted that sawmillers and their products must satisfy four needs of the secondary manufacturers: stability of the company, consistency of grade, reliability of supply and delivery, and stability of prices.

In an effort to encourage improved marketing of California hardwoods, Huber (1989) recommended that industry produce a quality product, take pride in its product, and market its quality product with pride (*fig. 4*). This approach contrasts with prior marketing of indigenous hardwoods as low-cost substitutes for eastern species. Pacific madrone, for example, was once marketed as California cherry.

Another example of improved marketing is the decision of the Western Hardwood Association's Board of Directors "to help develop a market for under-utilized species such as California black oak, tanoak and bigleaf maple. These species have the potential to serve a market niche of their own" (Sweitzer 1992).

Recently, unique niche markets are being developed for products that meet certified standards of environmentally safe processing. It is believed that "certification of forest product operations is one way to promote sustainable forest management practices worldwide. A market-driven certification initiative would provide economic rewards to forestry operations that voluntarily subscribe to management practices that are ecologically sustainable, socially beneficial, and economically viable" (Ervin 1993). Several organizations, which include the Institute for Sustainable Forestry's "Pacific Certified Ecological Forest Products" process (Katelman 1992), the Rogue Institute for Economy and Ecology (KenCairn 1992), and the Forest Stewardship Council (Ervin 1993), are pursuing this approach.

Lack of Consumer Information

PAST: Much of the research and most of the lumber yield studies on California hardwoods were developed in the 1950s and 1960s. Along with these technical data, and the enthusiasm for utilizing hardwoods, came a warning that: "... insufficient information is available to consumers in the market place" (Vaux 1961). Other authors and speakers also began to encourage development of consumer information:

> *The secret to the success of these woods will be the type of promotion used to launch the various species. For the most part, these woods are unknown to the public, and practically any of the present knowledge is of the negative nature (Koehler 1960).*

In addition:

> *a raw material producer can help get a good price for his products by passing on information that can be used by the maker of the consumer article that will help sell it. Point out to your customers the fine features of the wood you are processing. Get the facts to enable you to point out the uses for which local species are superior (Sauvie 1960).*

CURRENT: At a conference on alder, Edlund (1984) addressed the larger issue of how to increase western hardwood uses in public and commercial buildings. According to Edlund, an architect: "we are currently unaware that western hardwoods are suitable and available for use. Sales will not increase until western hardwood manufacturers promote the use of their products and provide the needed technical information to architects." He then identified a number of specific types of information pertinent to architects, such as availability, appearance, relative cost, appropriate uses, inappropriate uses, manufacturer's recommendations for installation, technical assistance sources, and effective distribution of product data and samples. Information on California hardwoods is crucial to architects because current software programs contain lists of alternative products, dimensions, and grades. The architect, for example, selects a desired product, such as window frames, and incorporates it into the "plan" for a new home. If a California hardwood product is not listed, it cannot be selected.

Several organizations have begun responding to the need for consumer information. An early report, published by the Forest Research Laboratory at Oregon State Univer-

Figure 4—A quality "high end" product, attractively displayed, facilitates sales and profits, and helps counter the marginal return from low-grade material in each hardwood tree. (Cal Oak Company photo)

city (Overholser 1977), consolidated research information for many western hardwoods. More recently, the results of this and other research have been packaged into popularized consumer information brochures such as:

- Discover Western Hardwoods, Oregon's New Growth Opportunity (*Western Hardwood Association*).
- Species sheets (*Western Hardwood Association* in partnership with *Oregon Economic Development and Oregon Lottery*)
- Western Hardwoods, The Way To Grow (*Western Hardwood Association*)
- Hardwood fact sheets (*Oregon Forest Research Laboratory*)
- Species information sheets (*California Hardwood Foundation*)

Limited Use of Low-Grade Logs, Lumber, and Residues

PAST: High-grade hardwood logs and lumber could be processed and marketed at a profit. However, large amounts of low-grade material were typical of the hardwood resource. The problem was a lack of secondary markets for lower quality materials, too much lower-grade material in high-value species, and the large volume of low-grade species. Together, these created an economic burden on the processing system because the low percentage of high-grade material could not carry the deficit from high volumes of low-grade material.

CURRENT: The lack of markets for secondary processing of low-grade lumber continues to be a problem (Dolt 1984, Wade and Hall 1987). However, markets have been developing for hardwood firewood (*fig. 5)* and fuel pellets, as well as shook for pallets, dunnage, and other industrial uses, in which strength rather than appearance is important (Wade and Hall 1987). Unfortunately, some of these markets tend to be seasonal or cyclic, according to national and international conditions.

Another possibility for marketing low-grade material is to implement a new technology from the eastern United States that creates high-end hardwood products from low-grade material (Reynolds and Gatchell 1979, 1982). Briefly, this new development is a system that produces blanks from small logs and even large branches, and by using hyperbola cutting laminations, joins them together to form larger material.

Effective Competition

PAST: Competition to California's incipient hardwood industry was consistent and strong. Although some of this competition was from imported hardwoods, most came from domestic eastern hardwoods.

CURRENT: The California hardwood industry continues to face stiff competition from well-established eastern and foreign suppliers. Quarles (1987) noted the significance of this competition: "In general, California hardwoods are single species. California black oak does not look like a typical eastern red oak. The same can be said for tanoak and Pacific madrone, in that they show little resemblance to eastern hardwoods. These species must stand alone, and really cannot be used as a look-alike for the better known species." And Behm (1984) found that "Even the most aggressive firms with big national budgets have not been able to introduce a new wood and sustain its use." Thus, developing ways to make western hardwoods competitive challenges the hardwood industry.

Lack of Companion Building Products

PAST: Lack of companion building products and secondary materials such as moldings, trim, and veneer has hampered attempts for commercial use of lumber products from California hardwoods.

CURRENT: A void exists in the supply of companion building products manufactured from California hardwoods such as veneer and moulding stock (Wade and Hall 1987). Although some woodworking shops and cabinet builders will make their own molding stock for specific projects, no suppliers of standard molding shapes are known. Likewise, some woodworkers will produce limited quantities of sawn veneer for special projects, but there are no commercially available supplies of veneer from California hardwoods. In 1985, Cal Oak assessed the potential for production of rotary-cut veneer from California black oak. Although the operation was generally successful, the grade recovery and value of the veneer did not warrant further work (Wade and Hall 1987). However, development of a sliced veneer market has evoked considerable interest, especially for high-quality decorative veneer such as burl and straight-grain stock (Franklin 1989, Klein 1991). According to Franklin (1993), the quality and value of sliced burl veneer from California hardwoods has been known since the mid 1930s. Veneer, then, is a viable market in need of development.

Lack of Integrated Problem Solving

PAST: Because a singular cause for failure of the California hardwood industry could not be isolated, a simple solution could not be found. The typical hardwood landowner, processor, and marketer was often independent and engaged in only one or two phases of the total utilization operation. Consequently, common problems were not solved. A need existed for information sharing and integrated approaches for addressing common issues. The lack of a unified organization and an industry association was vexing.

A

B

Figure 5—Developing markets for “low-end” products help each tree to “pay its way,” contribute to resource utilization, and create local jobs and incomes: (A) branches and tree tops ready to be sawn into a suitable length for sacking, and (B) sacks of small round and split wood ready for transport and sale as firewood at the local super market.

CURRENT: During the past decade, a number of organizations have been formed to represent the hardwood industry and to facilitate the process of integrated problem solving. Some of these organizations, such as the Western Hardwood Association and California Hardwood Foundation, are focused entirely on hardwood activities. Other organizations, like the California Timber Industry Revitalization Committee, the Institute of Sustainable Forestry, and the California Forest Products Commission, have a broader focus that includes the hardwood industry.

In addition to the development of industry associations, numerous workshops and conferences have served as a forum to identify and address problems related to the hardwood industry.

The War Years

PAST: Because of high demand for timber and wood products, California hardwoods were used for military purposes during World War II, the Korean conflict, and in Viet Nam. Labor shortages and equipment restrictions constituted the primary restrictions.

CURRENT: During the time period covered by this report (1976-93), military conflicts have not adversely affected the hardwood industry in California.

Lack of Industry Image

PAST: Because of the low number of hardwood producers and their lack of unity, the early California hardwood industry never mustered enough “mass” to portray an established and stable industry. In contrast, the producers and wholesalers of red alder and maple in the Pacific Northwest formed the Northwest Hardwood Association. This allowed them to “pool their efforts to arrive at workable grades for lumber and logs, to gain favorable freight rates and to achieve a uniformly high-quality product that would merit demand” (Overholser 1968). Today, the red alder industry is thriving and has a prominent place in the hardwood market.

CURRENT: Image and identity are important to any sector of industry. Having an industry association or foundation, a logo, and a directory are important components for developing a favorable image and identity. After the Northwest Hardwood Association changed its name to the Western Hardwood Association, the producers and manufacturers of hardwoods in California became represented by an association. If the California Hardwood Foundation were better funded, it too could contribute to a more positive industrial image.

In 1991, the Pacific Gas and Electric Company provided funds to design a logo for the California Hardwood Foundation. This logo is a wooden hand plane, perhaps the most nostalgic symbol of the woodworking craft. In addition, a display booth was designed for use in industrial trade shows, at conventions, and during woodworking fairs. This booth features a large back-lit photograph of antique woodworking tools on a work bench.

The California Manufacturers Directory of Wood Products and Furniture was assembled by the California Hardwood Foundation (1991) and uses the same photograph described above on its cover. This directory of secondary wood product manufacturers complements the California Forest Products Directory of primary processsors, compiled by the California Department of Forestry and Fire Protection. These two directories contribute to the image of the hardwood industry.

Industry image is often denoted by a slogan designed to present a desired perception of the product. California hardwoods need an image boost. For this purpose, Huber (1989) proposed a number of slogans for consideration including “Hardwoods of California: Quality—Class—Character.” However, image is not based solely on promotional material, logos, and directories. A lasting image must be built on the reputation of the producers and the quality of their products. Such factors as stability of the company, consistency of product quality, reliability of supply, and stable prices are important. Although the image of the California hardwood industry has improved, much more needs to be done.

A New Beginning for Managing Hardwood Ecosystems

Knowledge on individual plant species, plant and animal communities, and wildlife habitats/populations associated with California hardwoods has broadened in the past decade (Passof 1987). Although far from complete, much information is now available that indicates which animals are where, and what in their surroundings is critical to the stability of their populations. The need to “inventory” the wildlife resource is as critical for its management as the need to know the amount and location of the hardwood timber resource. A big step forward has been the creation of the Wildlife Habitat Relationships program by many public and private agencies concerned with the management of natural resources. Program goals were to develop a system to provide land managers with quantitative information on the responses of wildlife species to management alternatives, particularly those that manipulate vegetation. Vegetational, aquatic, and substrate habitats (defined as dominant vegetation, vegetative diversity, and physiographic character) have been matched to wildlife populations (Mayer and Laudenslayer 1988, Verner and Boss 1980, Verner and others 1986). De Becker and Sweet (1988) have matched the wildlife habitats defined in Mayer and Laudenslayer to nine vegetation classification systems used in California today. This cross-referencing system is user-friendly and can be easily augmented in the future.

Much new silvicultural information on forest-zone hardwoods has been developed in the last decade. We now have some basic knowledge by species on seedfall, regeneration, sprout development, and growth of natural and manipulated stands. Much of this information is presented in Volume II of *Silvics of North America, Hardwoods* (Burns and Honkala 1990). Some important findings are that California's forest-zone hardwoods are difficult to artificially regenerate. A new forest is best accomplished through even-aged management and manipulating root crown sprouts *(fig. 6)*. And sprouts from nearly all forest-zone hardwood species grow best in open environments free of overstory trees (McDonald 1978).

This new information has management implications. It indicates that California's forest-zone hardwoods are found in a large variety of soils and vegetation types and are components of many plant and animal communities. The hardwoods are also well adapted to a host of biotic and abiotic agents, are resistant to lasting damage from these agents, and even can benefit from them. Dissemination of acorns and berries by animals, for example, enables the species to colonize new areas distant from seed sources. Consequently, the ecosystems of which the hardwoods are a part are highly complex and dynamic in both space and time. This dynamicism challenges the forest land manager and mandates that the manipulation of ecosystem components be thoughtfully and carefully applied.

Needed Management Perspective

Forests in California, whether softwood or hardwood, have some overriding problems and needs. These include the propensity for catastrophic wildfire, the burgeoning human population and urban/wildland interface conflicts, and the need to expand management emphasis to the landscape level (McDonald and Fiddler 1993).

Figure 6—Rapidly growing 6-year-old, 2-foot tall root crown sprouts of California black oak show promise of becoming the next hardwood forest.

The past policy of fire exclusion on forested lands is threatening the health and very existence of the forest in many areas. Fundamental tasks will be to reduce fuel levels and fuel ladders across the landscape, create innovative management programs to incorporate people in the urbanized forest, and to manage natural resources on large areas for much longer timeframes. The viability of landscape management to enhance a wide range of "yields" is inescapable: water flows through large areas, animals migrate over long distances, pleasing scenery often reflects the contrast and variability in a long hike or long drive, and trees often grow in one place and wood products from them are manufactured and sold in another miles away. Landscapes often are managed by owners who have different styles and goals. Sometimes these cause conflict, and sometimes the cumulative effects of conflict cause overall harm to the land and its creatures. The sheer size and complexity of a landscape almost mandates that the owners and other interested parties resolve their conflicts through working compromises.

California hardwoods have been used as charcoal for fuel, tannin as a chemical feedstock, and logs for cooperage and lumber (Huber and McDonald 1992). Little thought was given, and even fewer plans were made, to replace the harvested trees or to manage the hardwood resource in perpetuity. The accepted practice was either to let nature reproduce the forest or occasionally to convert it to pines and firs. The effect of conversion on the animals, reptiles, and birds in hardwood ecosystems was of little concern.

In addition to lumber and wood products, California's forest-zone hardwoods were used by wildlife and for water and esthetics. Twigs and shoots were recognized as valuable fodder, and acorns and berries furnished critical foodstuffs to a host of birds and other animals (Barrett 1980, Grinnell 1936, Raphael 1987, Verner 1980). Although water and streamflow had always been recognized as critical in summer-dry California, few people realized that up to 30 percent more water is yielded from a watershed covered with deciduous hardwoods than one covered with evergreen conifers (Swank and Douglass 1974, Uric 1977). Leafless crowns allow rain and snow to fall to the ground where evaporation is much lower than if lodged on evergreen branches exposed to wind and sun. Pleasing scenery, spring and fall colors, and the contrast and variability added to the landscape have also been recognized as a valuable yield from hardwoods (Heady and Zinke 1978, Litton and McDonald 1980, McDonald and Whiteley 1972, Plumb and McDonald 1981).

Should California's large hardwood resource be converted to softwoods or should it be regarded as a unique resource unto itself? The attitude of most natural resource managers has shifted toward managing ecosystems. Isn't it time that hardwood ecosystems be maintained and, even in some instances, restored? Wildlife, water, pleasing scenery, and rural industries are just as valuable as lumber and wood products. Given this shift in focus, plus that anticipated for the development of a sustained hardwood timber industry, the time has come to manage California's hardwood forests for all these uses. Development of a management perspective that incorporates ecological, silvicultural, cultural, and economic principles is needed (McDonald and Tappeiner 1987). Some key factors in this management perspective include emphasis, scheduling, role of silviculture, and the concept of total yield.

Emphasis

Most hardwood trees in California's forest zone originated as sprouts (rather than from seed) after periodic disturbance from logging and fire. Consequently, the hardwood forest of today often consists of a mosaic of even-aged stands (McDonald and others 1983). These stands tend to be too dense, grow too slowly, and are too homogeneous (McDonald 1980) to provide suitable habitats (ecological types) for the many species of California wildlife that depend on them for shelter and sustenance. A higher proportion of more open, less dense habitats is needed. Leaving the development of a wide range of habitats to nature is not the answer–at worst it will never happen and at best it will take too long (Plumb and McDonald 1981). A managed forest can provide the wide variety of ecological types that are needed and do so in less time. The emphasis today is on striving for and maintaining a future condition that sustains ecosystems and the resources in them. All resources are important, but on a given area and at a given time, one may be more important than another. For forest-zone hardwoods in the near future, and perhaps more on public than on private land, wildlife are perceived as the primary resource. They, of course, have a major recreational value to people–for hunting and *viewing* (McCollum 1991, Ohmann and Mayer 1987, Rockel and Kealy 1991) *(fig. 7)*.

In this management overview, the wildlife biologist would arrive at some idea of what animals are, or could be present, and what habitats are necessary for maintenance or even enhancement of their populations. Habitats are the key—they are that which will be strived for (Ohmann and Mayer 1987). Habitats will vary in space and time. For some birds, migrating animals, and wide-ranging animals like the marten (*Martel americana*), the habitat will be very large; for small resident animals, the habitat might be an acre or less. Of course no habitat is static; newer habitats with many early seral species eventually give way to habitats characterized by fewer, larger, and longer-lived species. If disturbance is lacking, a balance between the environment and the plant and animal communities ensues, and changes in species composition, density, and structure become smaller and take place over a longer timeframe. Eventually, however, the old trees fall apart, the habitat changes, and succession begins anew. Thus, emphasis should be placed not just on needed habitats, but on the *sequence* of habitats.

A special arrangement of linked habitats in a configuration called a "corridor" may be needed. Often a

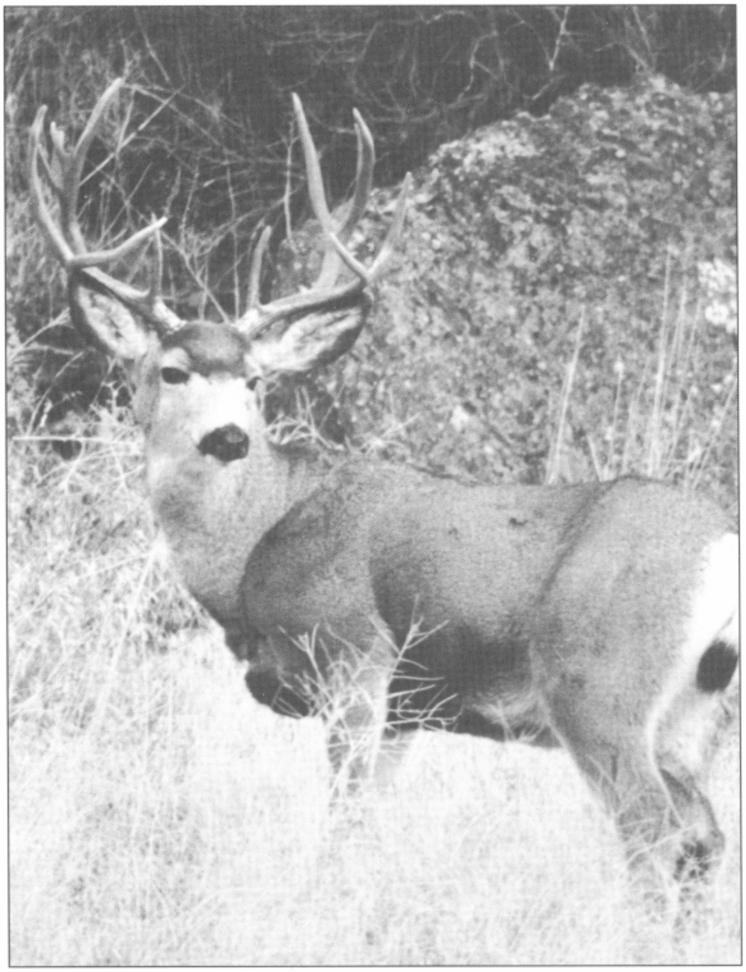


Figure 7—Wildlife in general, and especially a stately animal like this deer, give pleasure to many people. (Frank Kratofil photo)

specific corridor like a drainage will be common to many habitats. Riparian hardwoods, for example, will not only shade the watercourse—thereby maintaining the quality of the water resource—but also provide necessary habitat for resident and migratory animals. Drainages, especially those with permanent or periodic surface water must be emphasized for the richness of plants and animals in them, as well as for the valuable habitat that they provide for animals. In rough and broken terrain, ridgetops often form a corridor solely because they provide an area where migratory animals can move rapidly over long distances. Hardwoods seldom occupy ridgetops extensively, and this habitat almost always consists of a conifer-hardwood interface where shelter often is provided but food is lacking. Disjunct stands of hardwoods strategically located along the ridge or on adjacent upper sideslopes should be encouraged to fulfill this need.

The hardwood component of the forest, however, cannot fulfill the needs of all species of wildlife—other major vegetative categories like softwoods, brushfields, and grasslands also must contribute to the shelter and sustenance of wildlife. Consequently, emphasis needs to be placed on both the interface of conifers and hardwoods at the stand level, and on the role of pure stands of conifers at the landscape level. The interface or "edge" between conifers and hardwoods is a special habitat, with some evidence that more animals use it than stands of pure hardwoods or pure softwoods.

Water quantity, quality, and timing of delivery could be of major importance as a yield from forest-zone hardwood lands. Given the large and increasing human population in California, water use that is fast approaching the limit of supply, and large increase in projected needs, water may soon become a paramount need. In the near future, hardwood landscapes may be manipulated primarily for water with forest products and wildlife as secondary yields.

Another factor in ecosystem management, too often forgotten, is that humans are key components of ecosystems. They too must derive basic substance from the hardwood forest not only in the sense of harvesting greenery, seeds, cones, and pollen, but also in the larger sense of having pleasant surroundings, stable industries, jobs, and communities that are the backbone of rural

California. Raw material from intensively managed hardwoods on private land, plus that from ecologically managed public lands, would provide the basic ingredient for wood-processing industries and enhance rural community stability.

Scheduling

Another key component of this management perspective is scheduling. The collective "yields"—such as key habitat for a given animal, several million cubic feet of woody material, many thousand acre-feet of water, or an area of exceptional scenery—need to be accomplished in a predictable manner. Suppose an area was occupied by undesired tree species. Their removal would increase water yield, provide an early seral stage of vegetation for wildlife, and the contrast needed for a pleasing view. Hardwood root-crown sprouts, augmented by natural or planted seedlings, would provide the basis for a new stand. Browse from some of the sprouts would be available to wildlife for the next few years. At age 20, the young trees would be thinned to decrease the number of hardwood stems, concentrate growth on desired trees, and provide habitat for different animals. At this stage, the yield of water would he decreasing, but contrasting scenery would be provided. The hardwoods removed during thinning would be raw material for fuelwood and pulpwood, or perhaps for an industry that would make cutting boards, toys, or golf-club heads from small-sized material. At age 50 similar thinning would provide similar yields, and allow the trees to develop tall straight boles and full crowns. After age 80, an increasing yield of acorns (McDonald 1969) and berries would provide sustenance to more and perhaps different species of wildlife. Crown expansion would mandate a light harvest of mature trees around age 120, and logs from these trees would provide a timely addition to the raw material needed by a sawmill, that product in turn to be manufactured into fine furniture by another mill. For the next century, this area and its trees, snags, and downed material could be relied on to provide a known habitat for wildlife, a consistent yield of water, and scenery characterized by old and stately hardwoods, but little or no harvesting of timber for firewood or sawlogs.

But because of a sequence in scheduling, trees on other areas in the landscape would be contributing a continuous flow of raw material to wood-dependent industries. All uses would have times of high and low contribution to yield, but the total yield would remain high. Timeframes and area sizes could be altered to enhance a particular animal population or yield, as desired. Eventually various areas in an entire watershed could be scheduled and a predictable flow of amenities, specific goods (products), and services would be provided at a known time. Several watersheds, making up a landscape, so managed, would ensure that ecosystems, large and small, would be sustained. Wildlife managers, hunters (with guns or cameras), sawmillers, water managers, and outdoor-enthusiasts would benefit because a predictable amount of "value" and "product" would always be available.

Practice of Silviculture

Silviculture is the mechanism for creating, maintaining, or even enhancing the desired ecological types needed over the landscape. Silviculturists will be the ones who accomplish this. Ecologists will provide the script but silviculturists will be the actors in the hardwood management drama. Ideally, a balanced community of key plants and animals would remain after a series of silvicultural operations. Plentiful options for maintaining or enhancing any use or yield would be available at any point in the series (*fig. 8*).

The goal of creating and sustaining desired ecological types should not override resource utilization. Rather, each of these factors should complement the other. However, all silvicultural tools must be retained because all are needed to achieve the desired level of community dynamics and stability. Patch cutting, even to large areas, use of herbicides, broadcast burning, and a host of other vegetation-manipulating techniques are needed. Of course, each must be properly applied at the appropriate time, but the silviculturist must have the *option* to use each and every one.

The art of silviculture needs to be intensified in many ways. On private forest land, future demand for hardwoods could mandate that they be managed as intensively as possible for timber and wood products, with due, but not overpowering, emphasis on water, wildlife, and pleasing scenery. Freedom from undue restrictions and flexibility to pursue the goal of maximizing wood fiber to generate income and employment are critical (McDonald and Fiddler 1993).

A closer tie to ecology, especially to understanding the dynamics and development of individual plant species and the community in which they live, will be necessary for successful silvicultural practice. Developing knowledge on the interaction of communities at the landscape level will be crucial. Realizing that vegetative components of ecosystems need to be manipulated to attain desired habitats for wildlife and ecological types for other uses, and that these manipulations will sometimes be accomplished by harvesting trees, is important. Employing harvest systems that create a desired level of disturbance will become standard practice in the near future. To link new silvicultural practices with innovative harvest techniques, Huber (1992) suggested a "Cut-N-Reuse" and a "Retain-N-Reuse" system based on the sprouting capability of the forest-zone hardwoods. Based on these systems, the harvest would provide jobs and income to rural Californians and, because the burgeoning sprouts quickly reoccupy the land, ecosystem disruption would be minimal.

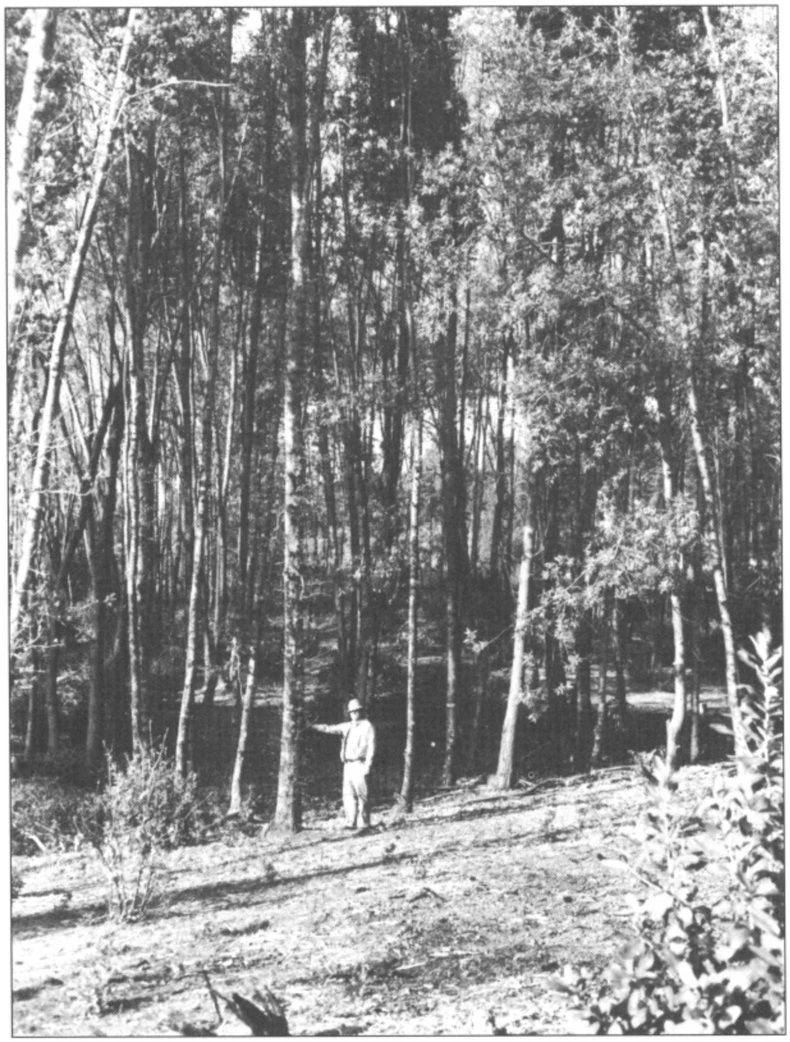


Figure 8—Through applied silviculture, this 60-year-old mixed hardwood forest has high potential to provide the amenities and commodities desired by society.

In the future, management of the plant and animal communities should be based not on past and present species abundance, but on the composition, density, and structure necessary for creating desired ecosystem values. Skill will be needed to accomplish vegetative manipulations rarely attempted in the past: critical seral stages will need to be maintained longer; some plants (those that fix nitrogen, for example) will need to be encouraged; open stands might need to be created and maintained; and mature, acorn-yielding stands may need to be kept vigorous for 200 or more years.

A human temptation to oversimplify must be avoided—biological complexity must be reflected in all operations. Mixed stands of various hardwood species and mixed stands of conifer and hardwood species can be extremely complex in terms of species composition and structure. A level of collaborative management and research, unattempted in the past, will be necessary to successfully manipulate plants and animals within the complex hardwood ecosystems (McDonald and Fiddler 1993).

Total Yield

A primary change in the management of forest-zone hardwoods is recognition that each of the major yields from the land has value. The worth of wildlife, wood, water, and pleasing scenery must be recorded and recognized. Basing management on any single factor is not realistic. When timber values are low, for example, the justification for cutting would not be based on the timber value alone, but include the increased worth of pleasing scenery, additional browse and berries, and additional habitat for wildlife. An increase in the population of an endangered or sensitive species of plant or animal would rate as a very high yield in this management perspective. The limitation of "below-cost timber sales" could be overcome in many instances because "cost" would be relative to the combined gains from wood, wildlife, water, and esthetics. A new dimension in planning might be achieved if benefits were calculated for interim manipulative actions that contributed toward goals, be they commodities or amenities. Interim gains could then be summed and the total worth of the hardwood resource calculated and realistically compared to alternative vegetation such as softwoods.

Modern-day pressures on the hardwood resource are increasing. Land is steadily being lost to developers of homes, shopping centers, and roads; power line and gas transmission rights-of-way exact their toll of acreage; and preserves of various kinds remove land from the manageable base. Hardwood management is needed, and steps to do so are being taken. Hardwoods are being recognized in USDA Forest Service forest management plans, California Department of Fish and Game biologists are asking that hardwoods be addressed in timber harvest plans, and at least one large public utility is preparing a report to provide a foundation for developing a California hardwood industry. Plainly, a new management philosophy is emerging. When combined with the principles of ecosystem management, the full worth and potential of California hardwoods should be realized.

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United States
Department of
Agriculture

Forest Service

**Pacific Southwest
Research Station**

General Technical
Report PSW-GTR-153

California's Hardwood Resource: Status of the Industry and an Ecosystem Management Perspective

Federal Recycling Program
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GPO 683-840/39048