

# A Literature Review of California Domestic Cork Production<sup>1</sup>

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**Abstract:** As early as 1858 there were attempts by the federal government to assess the potential of developing domestic cork production in the United States. Between 1939 and 1949 cork oak (*Quercus suber* L.) seedlings were distributed to cooperators in more than 30 California counties to assess the possibility of relieving this nation's dependence on foreign production of the raw material. Information collected from earlier field trials supports the contention that this renewable raw material can be produced in California. This paper briefly reviews earlier work but concentrates on a more recent analysis of domestic cork development on the Central California Coast.

During 1993, the Central Coast Resource Conservation and Development (RC&D) Council was awarded funds from USDA Soil Conservation Service (now Natural Resources Conservation Service) and the California Department of Forestry and Fire Protection (Rural Forest Improvement Program). These funds were targeted to further explore the literature and the potential of domestic production of cork from cork oak (*Quercus suber* L.). The RC&D Council contracted with Professor James E. Wilen, Department of Agricultural Economics, University of California, Davis. Dr. Wilen and his students conducted an extensive review of literature accessible through the University of California system. Except where otherwise noted, this review paper is largely abstracted from the study they conducted to examine factors that might determine the feasibility of culturing cork oak trees and products from cork oak.

## Early Use of Cork

Cork has been a useful product for at least 2,000 years of written history. The Greek botanist Theophrastus referred to cork bark stripping in the fourth century B.C. Pliny, the Elder, in his *Naturales Historia* describes its bark as "extremely thick and which when cut grows again and is used chiefly for ships' anchor drag ropes and fishermen's drag nets and for the bungs of casks and also to make soles for women's winter shoes." Cork has been used as an insulating material for several centuries. According to Cooke (1961), early monasteries used cork on walls and ceilings to insulate from heat. Inhabitants of cork-growing regions used cork slabs for roofing materials.

The greatest stimulation to expansion of the cork industry began with the broad use of glass bottles in the 17th century. The widespread use of stoppers for glass bottles capitalized on cork's resistance to deterioration and its high coefficient of friction.

The botanist John Bartram observed a cork oak tree near Charleston, South Carolina in 1765, and Thomas Jefferson started plantings of cork oak in 1787. During 1858, the U.S. Patent Department bought a limited quantity of seed. From this effort some cork oak seedlings were started in the southeastern states and California. Most of these seedlings died from lack of proper care. In 1880, more acorns were obtained and distributed to many places in the southern states, Arizona, and California. From 1913 to 1931, the U.S. Bureau of Plant Industry distributed cork oak seedlings to selected locations in San Francisco and Central

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and Southern California. From 1930 to 1941, the average distribution was 260 trees per year to these locations. In 1941, Professor Woodbridge Metcalf (University of California) joined with Charles McManus (President, Crown Cork and Seal Company, Baltimore, Md.) in a project to develop plantations throughout California "to add to the natural resources of our country and to provide in the United States a source for at least a part of the nation's cork requirement."

Before World War II, all cork used in the United States was imported from Portugal, Spain, France, Italy, and northern Africa. Status of supplies, perilously close to the European conflict, were termed "critical." In 1941, 15,000 cork oak seedlings were planted by cooperators in 37 California counties. In 1942, 50,000 seedlings were planted. During 1943-44, in cooperation with the USDA Forest Service and the Spanish Ministry of Agriculture, cork oak acorns were imported from Spain, French Morocco, and Algiers and distributed in 20 states.

An important discovery in the early 1900's led to composition cork, a significant step toward the utilization of the large amount of waste byproduct which had begun to accumulate. Composition cork was first produced by grinding and screening cork pieces and then binding them together with small amounts of adhesive and heat. Such products include washers, gaskets, and oil seals.

Today, cork is still the only material used for high-quality champagne and wine bottle stoppers although the industry has been considering synthetic substitutes for years. The list of uses also includes insulation, sound absorption, sporting goods, and bottle caps.

Acorns are a source of nutrition for such wildlife species as bear (*Ursus americanus*), deer (*Odocoileus hemionus*), and quail (*Callipepla californica*) in California. In Portugal, as an agroforestry practice, the large cork oak acorns are fed to hogs and are available at a time when annual grasses are at their lowest nutritional value. Acorn-fed hogs are especially favored in Italy. The factors that made acorns a major source of food in California for indigenous peoples in the past make them attractive candidates for greater use in the future (Bainbridge 1987).

The evergreen foliage of the cork oak provides shade, and the tree has significant landscape and windbreak attributes. Pruned cork oak tree branches or bark also provide a highly desirable media for growing orchids and other epiphytes. Commercial orchid growers say it is possible to use a variety of tree barks or branches, but the most popular is cork bark. It has a rough, attractive appearance, the orchid roots can get a good grip, and it is long-lasting. Good prices are offered for cork oak prunings.

## Developing Domestic Sources

Since the 1800's there has been periodic interest in developing domestic sources of cork in California. Cork oak trees are hardy in a wide range of Mediterranean conditions found in California, including land not well suited to other uses such as agriculture. The most important sources of literature in English on cork, with a focus on the United States, came out of the interest generated during World War II as part of the McManus Project mentioned earlier.

The McManus Project had several objectives:

1. To study growth characteristics of the tree and the quality of cork using existing trees in the United States. Results can be found in Metcalf's (1947) *The Cork Oak Tree in California*. Metcalf concluded that cork oak production was feasible in several locations with

- Mediterranean climate and that the quality of North American grown cork was equal to that from Europe.
2. To examine areas of potential production feasibility in the U.S., Victor Ryan (1948), Crown Cork and Seal Co., studied the economic and geographic aspects of cork production. He concluded that conditions were close to the Mediterranean ideal in California and were generally favorable in parts of 27 other states.
  3. To launch a planting project with the intent of increasing the potential cork production from domestic sources.

Historically and presently, the world's production of cork has been dominated by Spain and Portugal. In 1990, the two countries together produced 88 percent of the world's exports of natural cork. Cork oak makes up 22 percent of Portugal's forests (40 percent of the world's cork forests), 60 percent of the world's cork production, and 80 percent of the world's production of cork stoppers (Wilen 1993a). According to Lisbon's Agronomy Institute, the soil fungus *Phytophthora cinnamoni*, the blight which also attacks eucalyptus (*Eucalyptus* spp.) trees, has decimated up to 20 percent of Portugal's cork oaks, aided by years of "excessive bark stripping, neglect, poor forest management and prolonged drought" (Smith 1993).

Wilen (1993a) summarizes world production by stating that while both raw cork and the stopper business are still dominated by Portugal and Spain, important changes are occurring in both countries. He notes that while the value of Portugal's exports has doubled, its market share of total exports has dropped from 60 percent to 40 percent since 1970 (*table 1*). During the same period, Spain's exports of cork have risen 10 fold. This is explained in part by noting that Portugal has become a more important user of raw cork in bottle-stopper production and consequently imports more raw material from Spain. Another trend is towards modernization of a process which for many years discouraged good management practices by tenant farmers. This in turn means that Portugal and Spain are becoming more efficient and competitive in the world market, producing a product which is of better quality and probably cheaper in real terms. The price of raw cork has increased from the equivalent of about 9 cents a pound in 1982 to about 50 cents a pound in 1993 (Smith 1993). Smith also reported that as much as 30 percent of a \$31 million reforestation program

*Table 1—Imports and exports of cork as a percentage of the total world value.<sup>1</sup>*

Year	Exports		Imports			
	Spain	Portugal	United States	Portugal	France	Italy
1990	48.4	39.5	7.4	35.6	9.5	10.2
1989	44.4	40.8	10.7	31.9	7.1	9.1
1988	47.0	39.8	10.8	31.6	7.6	10.8
1987	46.4	41.9	10.5	26.8	6.8	16.3
1986	38.9	49.6	12.0	17.9	5.6	19.6
1985	34.6	54.1	14.1	13.8	5.7	14.6
1984	34.9	53.9	15.8	17.7	5.1	11.5
1983	30.4	59.4	13.5	8.3	6.8	13.7
1982	29.5	57.7	10.4	19.5	7.9	10.7
1981	32.7	56.2	10.1	21.9	7.8	8.6
1980	37.2	51.7	6.5	23.7	10.4	14.2
1975	22.3	57.7				
1973	17.2	59.8	10.9	2.3	8.6	5.7
1970	16.0	58.3	12.2	-	7.4	5.0

<sup>1</sup>Source: After Wilen 1993a

funded by the European Community and the Portuguese government should find its way into cork oak farmers' pockets over the next 10 years as incentives to plant more cork oak.

The U.S. market for cork products is primarily one dominated by raw cork and by cork bottle stoppers. Raw cork is a low-value product that is further processed into a variety of value-added cork products, mostly on the east coast. Such products include linoleum products, apparel, and cork and rubber composition products. Cork stoppers are much valued and supply the wine industry on the west coast.

## **Cork Oak Growth in California**

Wilen (1993a) reviewed two major studies completed in the 1940's which assessed potential growth success in California. The available evidence on the success of growing cork oak trees on the Central California Coast is conclusive over a wide range within the region. Murray and Munns (1943) concluded that the Bay Area (100 miles south of San Francisco to about 30 miles north) confined to the rather narrow belt along the coast was among the five best areas in the State. Other areas were in the southwest of the State, the Russian River area, the Sierra Nevada foothills, and northwestern parts of the State. Cork oak does best in deep gravelly or sandy soils that are of granitic origin. The tree also does well in sandy loams or rocky soils with moderate acidity. Ryan (1948) found that most cork oak grew in areas with soils characterized as "brown steppe" soils. These have a zone of accumulated lime or other alkaline substances just below the surface. Ryan's study was comprehensive in bringing together soil, rainfall, and temperature data. Both studies conclude that California has several regions capable of supporting cork oak. These include, but are not limited to, a large part of the Central Coast Region.

## **Cork Production in California**

Professor Wilen's basic strategy was to put together a cost-benefit approach to forecasting the present value of a cork oak forest started from scratch. This meant combining the best information available on tree growth, harvest values, and costs. The problem is complicated because little information is available on very basic parameters such as optimal spacing, optimal timing of harvests, and other plantation information. Mediterranean cork production takes place mostly in natural forests rather than plantations. Harvesting therefore takes place in an irregular manner depending upon the natural distribution of trees. There is little current information about what plantation configuration should be used to maximize profitability. Wilen and his students use the best available data to compute the economic potential of a cork oak plantation in California, using "averages" as best data, rather than best cases, in order to provide a conservative assessment of possibilities. Further study of foreign sources and of raw data reported in existing sources would probably have allowed the determination of more precise estimates.

The primary source of information on cork yield as a function of tree age for California comes from Metcalf (1947) and is derived from his study of about 500 oaks that were stripped in California during the 1940's. The Metcalf estimates of production form the bases for Ryan's quantitative study (1948) of cork potential in the United States which also included estimates of regional cork yield rates in California. The highest cork yield rate is in the northwestern, high-rainfall area around Eureka, with estimated rates between 1.2 and 1.6 percent per year. The lowest projected rates are in the warmer valley areas, the southeastern desert

area, and the coastal area south of Monterey to Los Angeles with rates less than 0.8 percent per year. San Francisco Bay area, North Bay, and the Sierra Nevada foothills are projected to have cork yield rates between 0.8 to 1.2 percent.

Wilen reminds us that slow yield rates are not undesirable. Ryan noted in his study that “the finest textured and highest quality cork” comes from Spain and Portugal which have the slowest rates of yield in the Mediterranean region, namely 0.8 and 0.9 percent, respectively. Slow yield results in finer-textured cork with cell structures that are dense and hence suitable for the higher-valued products such as champagne and wine corks.

Densities of around 130 trees per acre are suggested (Natividade 1950) in a forest of trees about 50 years old. A technical planting guide prepared for the Central Coast RC&D Council by Ron Adams (1994) suggests an initial planting of 10 feet by 10 feet (435 trees/acre) with final growing space rogued to no closer than 20 feet by 20 feet between trees (109 trees/acre) when trees are 6 inches or more in diameter.

Yield per acre was computed assuming that density is adjusted in an optimal manner that keeps the canopy maximized. Using Ryan’s regional yield rate ranges, Wilen presents yield data which show yield per acre highest where actual cork growth is lowest (*table 2*). This occurs because the reduction in density needed to compensate for faster tree growth is greater than the corresponding increase in yield per tree. Both cork quality and quantity (pounds per acre) are inversely related to the regional rate of cork yield. Those areas with slowest cork growth, like the coastal areas south of Monterey to Los Angeles, appear to be the best on both accounts.

*Table 2—Cork yields per acre for various growth rates.<sup>1</sup>*

Stand age	Cork yield rates as a percentage of annual cork yield.		
	0.8	0.8 -1.2	1.2 -1.5
	-----lb/yr/acre -----		
20	83.52	55.34	41.70
30	132.35	87.70	66.09
40	264.10	175.00	131.80
50	324.25	214.85	161.90
60	425.50	281.90	212.40
70	584.70	387.35	292.90
80	831.60	550.90	415.10
90	1,216.00	805.60	607.00
100	1,811.00	1,200.00	904.10

<sup>1</sup>Modified from Wilen 1993a

Natividade (1950) concludes that mature groves (50 to 60 years old) might be able to produce as much as 320 to 366 pounds per year/acre but that only in groves with very old trees could one ever expect production as high as 460 pounds per year/acre. Wilen concludes that production levels of 340 pounds per year/acre are possible in California. This may be optimistic given what we know about data from actual plantations, or it may be pessimistic given that so little information exists about silvicultural practices under plantation conditions.

In a follow-up study, Wilen (1993b) reexamined the Metcalf data in order to assess subsequent uses of it by Ryan and others and in order to re-estimate the potential for cork production in California. The yield estimates computed by Ryan as potential for California are much larger (more than 1000 pounds per year/acre) than any actual experience in any of the major cork-growing areas of

the world. Natividade (1950) cites several studies that place estimates of reasonable production from mature forests close to 350 pounds per year/acre.

Metcalf apparently did not do any statistical analysis of the raw data derived from the World War II experimental stripping of trees from various places around California. Wilen extracted raw data on 300 trees from the Metcalf paper. A yield model for the Metcalf data was developed with the aim of examining more precisely what data reveal about real cork growth in California. The estimation Ryan derived based on Metcalf's tentative estimates overpredicts the weight/age relationship. Wilen and his students derive the same relationship on the basis of more careful statistical analysis of the original Metcalf data. The degree of overprediction by Ryan almost doubles those weight/age relationships derived by Wilen. Wilen also notes Metcalf's conclusion that if trees "were stripped every 8 to 10 years beginning at about 20 years, it seems likely that the resultant stimulation may increase the estimated yield" in the data presented "by one and one half to two times." Most studies by cork experts reviewed during Wilen's study now believe that stripping traumatizes cork trees rather than stimulating them.

The issue critical to the feasibility question in California is how much could be produced under optimal conditions of soils, climate, early-period care, and spacing. Wilen concludes it is likely that production potential is higher than his study estimates (340 pounds/year/acre), but it is not clear by how much.

With a planting guide (Adams 1994) having been developed, the Central Coast RC&D Council is now seeking to establish provenance trials on selected sites within the central coast to further examine the social, economic, and environmental compatibility of the place cork oak may have in California.

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