Quercus macrocarpa Michx. Bur Oak

Fagaceae Beech family

Paul S. Johnson

Bur oak *(Quercus macrocarpa)*, also known as blue oak, mossycup oak, mossy-overcup oak, and scrub oak, has the largest acorns of all native oaks and is very drought resistant. It grows slowly on dry uplands and sandy plains but is also found on fertile limestone soils and moist bottomlands in mixture with other hardwoods. In the west, it is a pioneer tree invading prairie grasslands, and it is planted frequently in shelterbelts. The acorns become an important source of food to wildlife. The wood is commercially valuable and marketed as white oak. The comparative ease with which bur oak can be grown makes it a fine tree for streets or lawns.

Habitat

Native Range

Bur oak (figs. 1, 2) is widely distributed throughout the Eastern United States and the Great Plains. It ranges from southern New Brunswick, central Maine, Vermont, and southern Quebec, west through Ontario to southern Manitoba, and extreme southeastern Saskatchewan, south to North Dakota, extreme southeastern Montana, northeastern Wyoming, South Dakota, central Nebraska, western Oklahoma, and southeastern Texas, then northeast to Arkansas, central Tennessee, West Virginia, Maryland, Pennsylvania, and Connecticut. It also grows in Louisiana and Alabama.

Climate

Bur oak is one of the most drought resistant of the North American oaks. In the northwestern part of its range, the average annual precipitation is as low as 380 mm (15 in). Here, the average minimum temperature is 4" C (40° F), and the average growing season lasts only 100 days. To the south bur oak grows in areas having an average precipitation exceeding 1270 mm (50 in) per year, minimum temperatures of -7" C (20" F), and a growing season of 260 days. The best development of the bur oak occurs in southern Illinois and Indiana, where the average annual precipitation is about 1140 mm (45 in), minimum temperature is -29" C (-20" F), and the growing season is 190 days (5).

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Soils and Topography

Bur oak on uplands is often associated with calcareous soils. In the "driftless" area of southwestern Wisconsin, it is commonly found on limestone ridges; in Kentucky, it is more prevalent on limestone soils than on soils derived from shales and sandstone *(5)*. In western Iowa, it can be found as a dominant on soils of either limestone or sandstone origin. Throughout much of the prairie region of the Midwest, bur oak is found on droughty sandy plains, black prairie loams, and on loamy slopes of south and west exposure. Toward the western edge of its range, such as in eastern Kansas, it is more abundant on the more moist north-facing slopes than on south-facing slopes (2). Bur oak often dominates severe sites with thin soils, heavy claypan soils, gravelly ridges, and coarse-textured loessial hills. The predominant soil orders on which bur oak is found include Alfisols in the central and southern parts of its range, and Mollisols and Spodosols in the western and northern parts of its range, respectively.

Bur oak is also an important bottom-land species throughout much of its range. In the Central States Region and southward, it is found on moist flats and on hummocky bottoms. Northward, in southern Michigan, it has been found in high densities on slightly elevated ridges within wet bottom-land forests occupying old glacial lake beds and drainage ways (20).

Bur oak frequently forms a fringe between the prairie and upland forest in northern Illinois and eastern Iowa, notably at the outer edges of "breaks" and bluffs along streams and around limestone outcrops. It is a valuable timber species on favorable bottom-land sites within this region.

Within the Great Plains Region, it is frequently found in stream bottoms and stream terraces. In North Dakota, bur oak is a major component of the flood-plain forests of the Missouri River *(11)*. Here it may predominate in old stands on high terraces near the edge of the flood plain. It is absent in low terraces near the center of the flood plain. Along adjacent draws and upper slopes, it becomes the first tree established along prairie edges. Bluffs along the Missouri River and its tributaries in eastern Nebraska are frequently covered with bur oaks that range in size from small trees near the base of bluffs to shrublike growth near the top.

In the Black Hills of western South Dakota and the Bear Lodge Mountains of northeastern Wyoming,

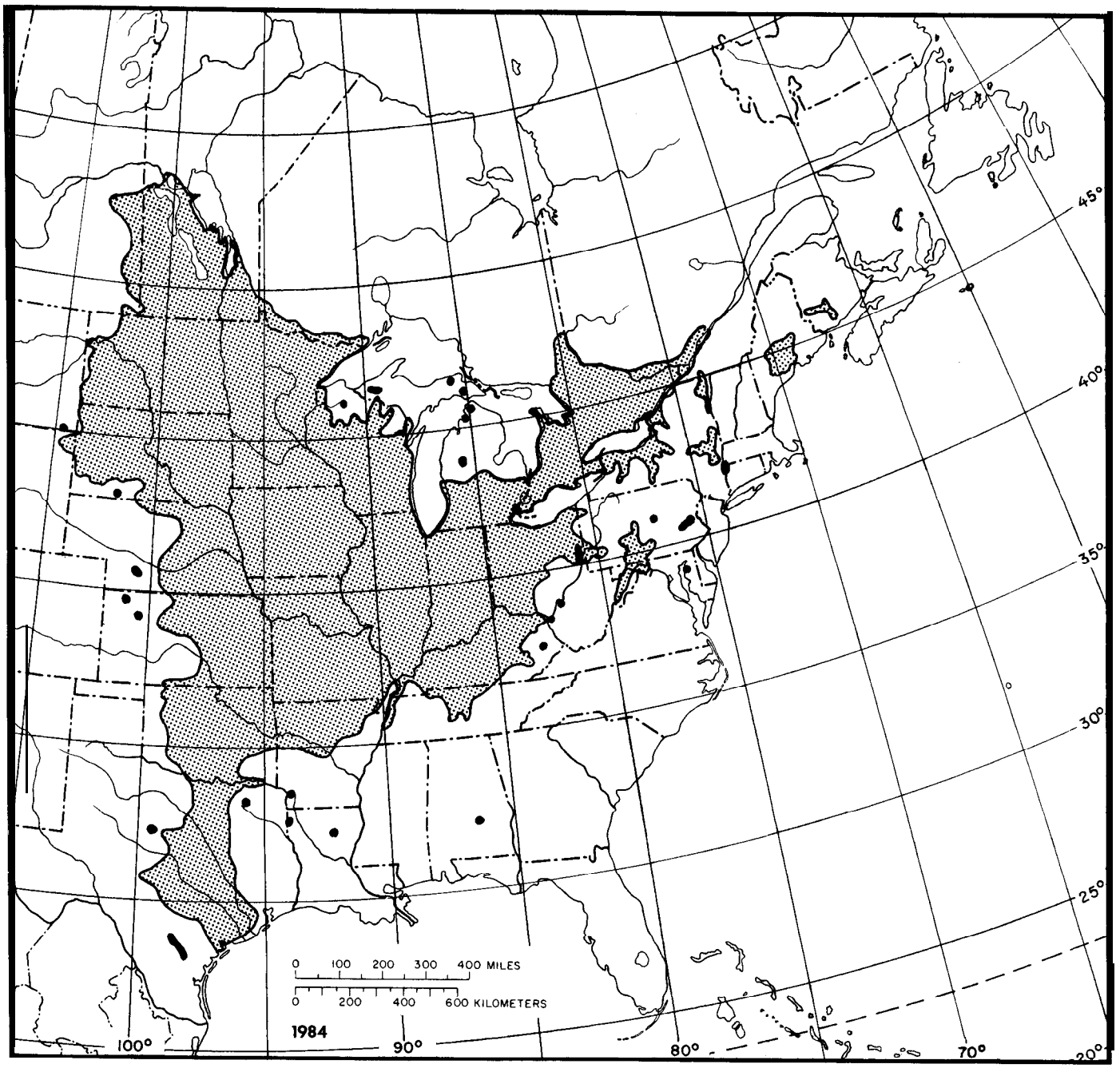

Figure *1-The native range of* ***bur*** oak.

bur oak grows at low elevations between the ponderosa pine forest and the grasslands (21). Here, it ranges in size from a shrub under a pine canopy at higher elevations to a tree up to 21 m (69 ft) tall along stream bottoms at lower elevations.

Associated Forest Cover

Because of its tolerance to a wide range of soil and moisture conditions, bur oak is an associate of many other trees. In pure or nearly pure stands, it forms

Figure 2—*Bur oak.*

the forest cover type Bur Oak (Society of American Foresters Type 42, eastern forests; Type 236, western forests) (6). It is also an important associate in six other types: Northern Pin Oak (Type 14), Aspen (Type 16), Black Ash-American Elm-Red Maple (Type 39), White Oak (Type 53), Pin Oak-Sweetgum (Type 65), and Hawthorn (Type 109).

In southern bottom-land cover types such as Pin Oak-Sweetgum, important associates of bur oak are pin oak *(Quercus palustris)*, sweetgum *(Liquidambar styraciflua)*, red maple *(Acer rubrum)*, American elm *(Ulmus americana)*, blackgum *(Nyssa sylvatica)*, swamp white oak *(Quercus bicolor)*, willow oak *(Q. phellos)*, overcup oak *(Q. lyrata)*, green ash *(Fraxinus pennsylvanica)*, Nuttall oak *(Quercus nuttallii)*, swamp chestnut oak *(Q. michauxii)*, white oak *(Q. alba)*, shellbark hickory *(Carya Zaciniosa)*, and shagbark hickory (C. *ovata)*. Associated shrubs and vines on these sites include possumhaw *(Ilex decidua)*, poison-ivy *(Toxicodendron radicans)*, and trumpetcreeper *(Campsis radicans)*.

In more northerly bottom-land types, such as Black Ash-American Elm-Red Maple, important associates of bur oak include black ash *(Fraxinus nigra)*, American elm, red maple, American basswood *(Tilia americana)*, silver maple *(Acer saccharinum)*, swamp white oak, sycamore *(Platanus occidentalis)*, and eastern cottonwood *(Populus deltoides)*. Common shrub associates include speckled alder *(Alnus rugosa)*, vacciniums *(Vaccinium* spp.), red-osier dogwood *(Cornus stolonifera)*, and poison-sumac *(Toxicodendron vernix)*.

Important associates of bur oak in the cover type White Oak include northern red oak *(Quercus rubra)*, black oak *(Q. velutina)*, chestnut oak *(Q. prinus)*, scarlet oak *(Q. coccinea)*, and post oak *(Q. stellata)*, mockernut hickory *(Carya tomentosa)*, pignut hickory *(C. glabra)*, and bitternut hickory *(C. cordiformis)*. In this type, associated shrubs and vines include vacciniums, sumacs *(Rhus* spp.), witch-hazel *(Hamamelis virginiana)*, wild grape *(Vitis* spp.), Virginia creeper *(Parthenocissus quinquefolia)*, and poison-ivy.

On the drier sites in the northwestern part of its range, bur oak grows in mixed stands of American elm, green ash, bitternut hickory, and white oak, and sometimes as nearly pure oak stands. In North Dakota, for example, the cover type Bur Oak accounts for about 19 percent of the forest land. Bur oak is also the major tree of oak savannas ("oak openings") of the prairie-forest transition zone in Wisconsin, Minnesota, Iowa, and Illinois *(3,5,8,12)*.

Shrubs are especially abundant in the bur oak forest of the plains region. Predominant among them are American hazelnut *(Corylus americana)*, coralberry *(Symphoricarpos orbiculatus)*, and smooth sumac *(Rhus glabra)*; common associates on the prairie borders are hawthorn *(Crataegus* spp.), wolfberry *(Symphoricarpos occidentalis)*, and prairie crabapple *(Malus ioensis)*.

Life History

Reproduction and Early Growth

Flowering and Fruiting-Bur oak is monoecious; **male** and female flowers in separate catkins are borne on the current year's branchlets. It flowers shortly after the leaves appear, from about the first of April in the southern part of its range to about mid-June in the north (5). Pollen from one tree appears to germinate better on the stigmas of another, favoring cross pollination.

Seed Production and Dissemination-The acorns ripen within the year and drop from the tree as early as August or as late as November. Germination usually occurs soon after seedfall, but acorns of some northern trees may remain dormant through winter and germinate the following spring (5).

Bur oaks bear seed up to an age of 400 years, older than reported for any other American oak. The minimum seed-bearing age is about 35 years, and the optimum is 75 to 150 years *(5,16).* Good seed crops occur every 2 to 3 years, with no crops or light crops in intervening years. The acorns are disseminated by gravity, by squirrels, and to a limited extent by water.

Seedling Development-Various conditions influence seedling development (5). In Iowa uplands, germination of acorns and early development of bur oak were best where litter had been removed. Germination is hypogeal ***(16).*** When covered by litter, acorns were most susceptible to pilferage by rodents, and the newly developed seedlings were more liable to fungus and insect attack. In a Nebraska study, about 30 percent of acorns germinated within 1 month after seedfall, and the new seedlings were less susceptible to freezing than those of white oak. Under controlled environment, bur oak seedlings grew fastest at a daytime temperature of 31" C (88° F) and a nighttime temperature of 19" C (66" F) (23). The relatively high daytime temperature and a high (70 percent) relative humidity were necessary to obtain more than one flush of shoot growth during the first growing season. When grown under continuous light, bur oak also produced a greater number of shoot flushes than under normal light *(19).*

As a bottom-land species, bur oak is relatively intolerant of flooding, and a mesic, fertile environment is required for seedling establishment *(11,14).* In open bottom lands, reproduction of bur oak may be prolific, but first-year mortality may be 40 to 50 percent when seedling submersion is 2 weeks or longer during the growing season. For shorter periods of growing-season submersion, seedling mortality is only about 10 to 20 percent. Although bur oak seedlings can endure flooding for up to 30 consecutive days during the growing season, root growth is greatly reduced, thus reducing drought tolerance after flood waters have receded (22).

Bur oak seedlings have also been found to be efficient users of water, based on studies of the ratio of transpiration resistance to CO_2 uptake resistance (25). In this characteristic, it was slightly exceeded by black oak but was more efficient than northern red oak, white oak, and sugar maple for leaf temperatures up to 35" C (95" F). The large number and area of stomata per unit leaf area in bur oak are associated with potentially high transpiration rates *(4).*

Root growth of juvenile bur oaks is rapid, and the taproot penetrates deeply into the soil before the leaves unfold. At the end of the first growing season, bur oak roots have been found at depths of 1.37 m (4.5 ft), with a total lateral spread of 76 cm (30 in). This strong early root development, along with high water-use efficiency, may explain why bur oak can pioneer on droughty sites and can successfully establish itself in competition with prairie shrubs and grasses (5).

Vegetative Reproduction-Vigorous sprout growth follows the burning or cutting of pole-size or smaller bur oaks; but except for seedling sprouts, the quality and form of sprout stems are poor. Some sprout growth is also produced by larger trees, but the effect of size and age of parent tree on sprouting vigor and quality has not been determined *(5).* Five years after prescribed burning in Minnesota, 60 percent of bur oaks 10 to 41 cm (4 to 16 in) d.b.h. had produced sprouts. Sprouts occurred in clumps averaging 21 live stems and the three tallest live stems per clump averaged 2.5 m (8.2 ft) tall *(18).*

Sapling and Pole Stages to Maturity

Growth and Yield-Bur oak is a slow-growing tree (5). In 12- to 16-year-old plantations on Iowa upland sites, average annual height growth ranged from 0.09 to 0.52 m (0.3 to 1.7 ft) and diameter growth from less than 2.5 to 6.4 mm (0.1 to 0.25 in). In the shelterbelts of the northern Great Plains, an annual height growth of about 0.3 m (1 ft) was reported for trees kept under clean cultivation.

In Iowa, lo-year d.b.h. growth of bur oak averaged 3.0 cm (1.2 in) for 10- to 20-cm (4- to 8-in) trees, 3.6 cm (1.4 in) for 25- to 36-cm (10- to 14-in) trees, 4.6 cm (1.8 in) for 41- to 51-cm (16- to 20-in) trees, and 5.6 cm (2.2 in) for trees 56 cm (22 in) and larger.

More rapid growth has been reported in Kansas where trees 35 to 40 years old averaged 2.5 cm (1 in) growth in d.b.h. in 3.8 years. Approximately the same growth rate has been observed in the northern Mississippi Delta region.

Bur oak is said to have reached a height of 52 m (170 ft) and a d.b.h. of 213 cm (84 in) in the lower Ohio Valley. On the better sites, mature trees generally grow 24 to 30 m (80 to 100 ft) tall, 91 to 122 cm (36 to 48 in) in d.b.h., and live 200 to 300 years. Characteristically, they have a massive, clear trunk and a broad, open crown of stout branches.

In the oak openings of southern Wisconsin and in the prairie border areas to the south and west, bur oak often is found in nearly pure stands *(3,5)*. The trees are widely spaced, short-boled, and often uniform in size. Trees in a 50- to 65-year-old stand in eastern Nebraska were 9 to 12 m (30 to 40 ft) tall and spaced at intervals of 3 to 12 m (10 to 40 ft). Bur oak grows 21 m (70 ft) tall on the fertile soils in this region, but on dry, limestone ridges, the trees may be less than 7.6 m (25 ft) tall at 150 years of age. In Minnesota, bur oak is short lived on the poorer sites.

Timber volumes in the bur oak type of Iowa were estimated to be 15.4 m^3/ha (1,100 fbm/acre), three-fourths of which were bur oak.

Rooting Habit-In the sapling stage, taproot development continues to be rapid, with abundant lateral growth as well. The taproots of 8-year-old saplings in upland clay soils of Missouri were more than 4.3 m (14 ft) long, and primary laterals extended up to 3.4 m (11 ft) (5). In prairie areas, roots of bur oak and hackberry have been found at depths of 3 to 6 m (10 to 20 ft); and a 43-year-old bur oak tree had a lateral spread of 12.5 m (41 ft) although the tree was only 6 m (20 ft) tall. A study of a tree 36 cm (14 in) in d.b.h. revealed that the weight of the roots equaled that of the tops, and root volume was only about 10 percent less than top volume.

Reaction to Competition-Bur oak is classed as intermediate in tolerance to shade (5). Some consider it more tolerant than northern red and white oaks; but on the prairie margins, bur oak stands are often invaded by black oak, white oak, and bitternut hickory. Bur oak reproduction in old white pine-bur oak stands in Minnesota reaches only sapling size before dying from suppression, and these stands are being replaced by maple-basswood communities.

In the wet bottom lands of northern Ohio, bur oak is a secondary species in the cover type Black Ash–American Elm-Red Maple, together with shellbark hickory, green ash, white ash *(Fraxinus americana),* pin oak, and swamp white oak. On the better drained bottom lands, bur oak may be successfully replaced by more tolerant species such as sugar maple *(Acer saccharum),* American basswood, and American beech *(Fagus grandifolia).*

On the prairie edges, bur oak is a pioneer tree, commonly succeeded by northern pin oak *(Quercus ellipsoidalis),* black oak, white oak, and bitternut hickory, The climax trees on these sites are sugar maple and basswood or sugar maple and beech. Bur oak may be a climax tree with hickory on extremely dry southern aspects and on thin, stony soils. In general, it is a species well adapted to sites ranging from droughty to moderately wet. But, on any given site, it is largely restricted to plant communities in early successional stages *(17).*

Damaging Agents-Bur oak is attacked by several insects including the following defoliators: redhumped oakworm *(Symmerista canicosta)* in the Northeast, *S. albifrons* in the South, oak webworm *(Archips fervidana),* oak skeletonizer *(Bucculatrix recognita),* a leaf miner *(Profenusa lucifex),* variable oakleaf caterpillar *(Heterocampa manteo),* June beetles *(Phyllophaga* spp.), and oak lacebug *(Corythucha arcuata) (1,5).* The latter species may heavily defoliate bur oaks in shelterbelt plantings, especially during dry weather. Attacks from bur oak kermes *(Kermes pubescens)* may distort leaves and kill twigs of bur oak.

Oak wilt *(Ceratocystis fagacearum)* is a less serious problem in bur oak than in members of the red oak group *(5,10).* Although spread of the disease from infected bur oak to adjacent oaks is infrequent, the disease sometimes spreads through root grafts, and entire groves have been killed by the gradual expansion of the disease from one center of infection.

Bur oak is susceptible to attack by the cotton root rot *(Phymatotrichum omniuorum)* and Strumella canker *(Strumella coryneoidea).* Half of the trees in a 20-year-old plantation in Pennsylvania became infected with the latter disease; and nearly a fourth of these died. Other fungi that have been isolated from diseased parts of bur oak include Dothiorella canker and dieback *(Dothiorella quercina),* Phoma canker *(Phoma aposphaerioides),* Coniothyrium dieback *(Coniothyrium truncisedum),* and shoestring root rot *(Armillaria mellea).*

Large bur oak trees are resistant to injury by fire and this, together with resistance to drought and disease, probably account for maintenance of the bur oak "openings" over much of southern Wisconsin at the time of homesteading. The presence of large bur oaks in the sugar maple-basswood community of the Big Woods of Minnesota has been attributed to the tree's thick fire-resistant bark, which enabled it to

survive repeated burning and freed it from competition by less fire-resistant species (5).

In the northwest part of its range, bur oak is considered a drought-resistant tree. During severe drought conditions in Iowa, unpastured bur oak stands on dry, exposed slopes were not injured; however, in pastured woods, drought injury occurred, even on protected sites. This was attributed to reduced aeration (caused by trampling) that had limited the growth and efficiency of absorbing roots.

Bur oak is not resistant to flooding, and in two areas where it was permanently flooded it died within 3 years. The species tolerates urban pollution better than most oaks.

Special Uses

Acorns of bur oak make up much of the food of red squirrels and are also eaten by wood ducks, white-tailed deer, New England cottontails, mice, thirteen-lined ground squirrels, and other rodents (5).

On coal-mine spoils with a pH of 5.6 in eastern Kansas, planted bur oak was one of the better performers of several tree species tested (7). After 22 years, it attained a mean height of 8.5 m (28 ft) and a d.b.h. of 12.2 cm (4.8 in). The species is also widely planted in shelterbelts because of its drought tolerance.

Genetics

Population Differences

A northern form of bur oak, ***Quercus macrocarpa*** var. ***olivaeformis,*** has been recognized (5). Acorns of this form often germinate in the spring following seedfall rather than soon after falling, and germination is improved by stratification. Acorn size is about half that of the southern form, and the cup is much thinner and smaller. Cleaned seeds average 595/kg (270/lb) compared to only 165/kg (75/lb) for the typical species *(16)*. Where the two forms are found in the same locality, as in eastern Nebraska, the typical bur oak is more common on the moister sites *(5,13)*. Varietal crosses occur in such areas. Photoperiodic ecotypes of bur oak have also been recognized. In one study, shoot growth of a more northerly seed source was about two-thirds of that of a more southerly seed source under short days; under long days, shoot growth of both sources was nearly equal (24).

Hybrids

Bur oak has been known to hybridize with nine species as follows: white oak, Q. x ***bebbiana*** Schneid.; swamp white oak, Q. x ***schuettei*** Trel.; Gambel oak *(Q. **gambelii**)*; overcup oak, Q. ***x megaleia*** Laughlin; swamp chestnut oak, Q. ***x byarsii*** Sudw.; chinkapin oak *(Q. muehlenbergii)*, ***Q. x deamii*** Trel.; English oak *(Q. **robur**)*; post oak, ***Q. x guadalupensis*** Sarg.; and live oak *(Q. **virginiana**)*. The cross with white oak, Q. ***x bebbiana,*** Bebb oak, is one of the most frequent of the white oak hybrids and is widespread within the overlapping ranges of the two species (9). The hybrid formed with Gambel oak, a western species, is somewhat unusual in that the two species do not now have overlapping ranges ***(15)***.

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