

# How Mighty Is the Oak: Oaks for the Midwest Landscape

*Kenneth D. Cochran*

## Introduction

The oak genus *Quercus* (family: Fagaceae) has been the subject of numerous publications and presentations through the years. Even acorns, the fruits of oaks, are a household subject, at least in the eastern United States. Why another oak article? To reflect on the science and technology of oak growth and development, on the growing of oaks at The Ohio State University/Ohio Agricultural Research and Development Center's Secrest Arboretum, and to budge the reader to use, preserve, and plant the "mighty oak."

Oaks are valued for sturdy growth, truly large size, and grand character. They often enhance the landscape with staying power for centuries. Approximately 300 species of deciduous and evergreen trees (very few shrubs) constitute the genus. More than 500 oaks have been named, but many have been suggested as being varieties or hybrids and not species. There are 20 important oak tree species in the eastern states.

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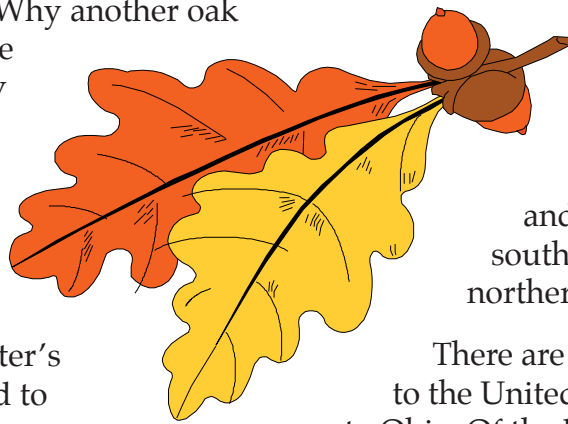
Geographically, oaks are widely distributed, though not worldwide in occurrence. They are common across North America, Europe, and Asia. Most species are found in the cool and warm temperate parts of the northern

hemisphere, extending as far north as the limits of the deciduous forests. A few species are found at high elevations in the tropics and subtropics, extending south to Cuba, Columbia, northern Africa, and Indonesia.

There are 55 oak species native to the United States and 14 native to Ohio. Of the large, native-Ohio trees, there are twice as many oak species as maple species.

## Utilization of Oak

While many mature oak stands have great aesthetic landscape value, many oaks have been noted for their functional use. The chinkapin oak is valued for split rail fences, railroad tie construction, and steamboat fuel. The wood of the white oak is used for furniture, flooring, interior finishing, boat building, and wine and whiskey casks. The wood of red oak, although not as prized as white oak, is used in the manufacture of furniture and flooring. Chestnut oak has a sweet tasting



acorn that is relished by the gray squirrel, black bear, white-tailed deer, and many other forms of wildlife.

Today, oak forests contribute various resources beyond aesthetics such as watershed management, recreation, and wildlife management, as well as trees for the improvement of urban environments. Oak is a component of ecological landscaping with whitetail deer showing a preference for dried oak leaves and with acorns as a great contributor to the welfare of forest wildlife. Stands of pin oak in sites flooded in autumn often serve as feeding grounds for wild ducks that pick the acorns off the bottoms of such temporary lakes or ponds. Since the earliest settlers, oak has been basic to life in America.

## Oaks at Secrest Arboretum

There are 23 selections of oaks growing as specimen trees or in forest-type plantings in the Secrest Arboretum. Some trees in the Arboretum remain from native stands and include the following species — white oak, *Quercus alba*; scarlet oak, *Q. coccinea*; shingle oak, *Q. imbricaria*; and black oak, *Q. velutina*. There are more individual oak trees growing natively in the Arboretum than trees of any other genus.

Of all the oaks growing at Secrest, the tree with the greatest diameter is a black oak measuring 57.5" diameter at breast height (DBH), 84' in height, and 66' in width, and a red oak *Q. rubra*, 67.5" DBH and 68' in width. These trees remain from the original mixed hardwood forest of the Arboretum and are in average condition.

The late John E. Ford, Arboretum curator until his retirement in 1984, recorded in 1981 that, in contrast to other oak species in the natural woodlands at Secrest, black oak is mostly past the peak of development and is beginning to decline.

A significant black oak at Secrest was struck by lightning in 2004. At this date, it is still surviving, measuring 46.1 DBH, 64' in height, and 72.5' in width.

This may substantiate reports indicating black oak is a relatively short-lived oak, living 150 to 200 years. Some of the black oaks growing in the Arboretum today are second growth from clear cutting of black oak in 1895.

Pin oak, *Q. palustris*, is common in the Arboretum. In fact, more pin oak trees have been planted on OARDC's Wooster Campus than any other oak species. Ford also recorded that this species was showing signs of decline in plantings 60 to 70 years old. He found many trees having decayed wood in butts and boles, with decay fungus fruiting bodies on the trunks. Several such trees are located along Secrest Road.

One of the most significant losses of oak in the Arboretum has been from the infestation over time of the twolined chestnut borer, *Agilus bilineatus*, in all eight *Q. robur* 'Fastigiata' in the Shade Tree Evaluation Plot. This cultivar with its tall architectural accent has great appeal in the landscape.

## Cold Injury

Through the years, willow oak, *Q. phellos*; English oak, *Q. robur*; and sawtooth oak, *Q. acutissima*, have been found not reliably hardy at Secrest. The tops of many of the remaining trees of these three species have been damaged through winter injury (-20°F). These oaks should be more adaptable in southern Ohio.

In the Arboretum nursery, we are currently growing *Q. phellos* from the seed of five large landscape trees growing in Wayne County (survivors of -25°F).

Through this study, we are testing seed of an undetermined geographic origin, but because of the survivability over the last 25-plus years in Wooster, these trees could possibly be a seed source for hardy genetic material. I have been surprisingly pleased to find a few large *Q. phellos* growing in northeastern Ohio and am planning to continue this work of selection for genetic material of known hardiness.



In a limited way, we are evaluating turkey oak, *Q. laevis*, from seed of a northern source. Dr. George Olsen, a recently retired professor of the College of Wooster, favors this oak and has convinced me to try the species in the Arboretum to determine cold hardiness of specific seed sources.

Cold hardiness of oaks can be determined by understanding the climatic conditions of the natural range of the various species. Oak species that have been unable to survive cold temperatures at Secrest include Arkansas oak, *Q. arkansana*; bushes oak, *Q. x bushii*; bluejack oak, *Q. cinerea*; daimyo oak, *Q. dentate*; southern red oak, *Q. falcata*; bear oak, *Q. ilicifolia*; California black oak, *Q. kelloggii*; water oak, *Q. nigra*; and oriental oak, *Q. variabilis*.

While I like to dabble at trying my luck with growing oaks of various regions of the world, I recommend landscape oaks according to known adaptability to the extremes of the region where they will be grown (heat and cold hardiness zones). There is a great amount of truth in the philosophy expressed by the great plantsman Sir Peter Smithers: "I consider every plant hardy until I have killed it myself."

## Soil and Drainage

In general, oaks grow and develop best in deep, loamy soil, though they're often found growing in a wide variety of soils. Many of the growing sites in Secrest

Arboretum contain a soil stratum composed of silty-clay underlain by clay. While many oaks will grow in these conditions, this type of soil impedes internal drainage

(extends soil wetness after precipitation) and soil aeration, and affects the growth of oaks.

Poor internal drainage and soil aeration usually limit the depth to which tree roots penetrate soils and result in reduced tree vigor and possibly death. Some Arboretum species growing under these conditions have developed a shallow root system, and trees have been liable to windfall. While these soil conditions have resulted in wind-fallen trees of conifers, ash, and tuliptree, these conditions have not resulted in wind-fallen oaks. This suggests that even though oaks may have a shallow depth of fine roots in the upper stratum of poorly drained soil, they have sufficient depth of anchor roots to support the tree.

Observations indicate that swamp white oak, *Q. bicolor*, and pin oak, *Q. palustris*, will tolerate wet sites with poor internal drainage better than other oak species. One of the attributes favoring the use of these two species in the landscape is that growth is actually maximized under wet soil conditions.

The moisture requirement of a species is an important environmental factor in optimizing tree growth and development.

Many oaks will not tolerate poor soil drainage (poor soil aeration) but grow best in a moderately moist soil environment. Know the soil requirement of a species before deciding which species to use for a specific site.

Drought is often associated with the decline of oaks, especially when combined with other detrimental factors such as insect defoliation and late-spring frost. It's been reported that bur oak, *Q. macrocarpa*, and chestnut oak, *Q. prinus*, are more tolerant of drought conditions than other oaks. The mean annual precipitation of 37 inches at Secrest Arboretum seems adequate for these species.

Some oaks are specific to an acid or alkaline soil condition. Pin oak requires an acid soil while bur oak and red oak are tolerant of an acid or alkaline soil.

Like many woody plants, oaks are slower in overall growth and weaker in development as favorable conditions of moisture, soil drainage, and sufficient soil depth become limited. The less-favorable conditions are stress conditions that limit the growth and development of some oak species.

Less favorable conditions can be compensated for somewhat during the first few years of establishment with early attention to fertilization and irrigation during prolonged drought, but one has to ask, what are the possibilities for the long term establishment of oaks under local climate and soil conditions?

Construction work around oak trees can lead to oak decline caused by modification of soil sites that will affect root growth and development. Dieback of oak branches is usually associated with root and soil problems and is the start of oak decline. Although the effect of soil site

modifications may not be immediate, decline is inevitable when construction work disturbs the root system of oaks.

Many cultivated oaks are vulnerable to human-induced stresses (abiotic diseases). These stresses include soil compaction over roots, cultivation around established root systems, and changes of existing soil grades that the roots are growing under.

Ironically, one of the reasons for building homes among existing oak trees is the desirability of the trees, yet sufficient attention is not given to the requirements of a particular species. Good arboricultural technology should receive high priority for preservation of oaks during site development and construction around established trees, since many existing oaks are sensitive to soil and root disturbance.

## Descriptions of Selected Oak Species

### *Quercus macrocarpa* — Bur Oak or Mossy Cup Oak

A mature bur oak has a broad open crown that rises from a massive straight bole with grand, stout lower branches. It begins life as an awkward, irregularly branched sapling, transforming into beauty at about 3" caliper. Sometimes the branching of young trees and almost always of older trees provides a thick, irregularly ridged, corky, dark-gray winged bark — a massive winter framework.

The expanded leaves are deeply lobed and rounded and the summer foliage displays a dark, leathery, lustrous deep green with a grayish underside (a felt of fine hairs) that flashes in the wind. The autumn foliage of mature trees lacks ornamental brilliance, typically dull yellow to brown, but leaves do fall in autumn.

Bur oak is a picturesque but useful, hardy oak for the heat and cold of the Midwest (it is well adapted to the Northern Plains). Bur oak has a high water-use efficiency, putting down particularly deep tap roots. This long-lived species is adaptable to marginal soils from droughty, rocky hillsides to limestone-derived soils to dry clay sites, yet it is found on moist sites, such as flats and river bottoms, adapting in the pH range of 5.6 to 8.0

In seedling production under field soil conditions and by the end of the first growing season, the tap root of bur oak may be 4.5' deep with a total lateral spread of 30", which is one of the reasons that this species is drought resistant. This taproot description helps explain observations that bur oak is difficult to transplant and reestablish from field-grown nursery stock, especially when transplanting caliper size greater than 3".

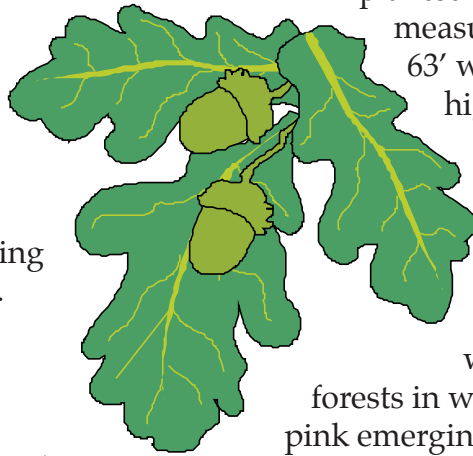
Observing grand bur oak trees growing as adaptable inhabitants of many landscapes does not necessarily translate into the ability of this species to establish callipered trees in newly created landscape sites. Remember that many native and naturalized trees have established well from spontaneous direct seeding, rather than transplants of callipered trees. We see many grand bur oak trees from native habitats, but our experience indicates that this species is not so readily transplanted from larger callipered trees, unless technology has produced an adequately fibrous root system.

At the Secrest Arboretum Nursery, we have observed that bur oak seedlings produced from large acorns and from

seeds of trees with exceptionally large leaves exhibit exceptional vigor in the first years of production.

### *Quercus alba* — White Oak

From Maine to Florida and west to Minnesota and Texas, white oak is one of the most noble of the oaks throughout the year. When grown in full sunlight and isolated from other trees, white oak surpasses many other trees in its majesty. One of three white oaks planted on the OARDC campus in 1957, as 1-3/4" caliper, measured 18.5" DBH and 41' in height in 1985, and today it measures 33" DBH, 51' in height, and 71' in width. Two other trees planted as 1-3/4" caliper in 1957 measure 34.1" DBH, 58' high by 63' wide, and 30.7" DBH, 55' high by 72' wide.



An aged white oak is a dramatic feature throughout the year. Its striking gray silhouette dominates against the winter blue sky in white oak

forests in winter. In spring, the silvery-pink emerging leaves create a delicate spring tapestry in the woodlands. The summer foliage is almost a bluish-green and with some variability changes to shades of bronze to red in autumn. After the foliage fades to brown, it falls over an extended period into winter.

White oak prefers an acid soil, moist and well drained. It does not have much of a tolerance to alkaline soils or to poorly drained soils as does its cousins, swamp white oak or swamp chestnut. Compaction due to construction as mentioned earlier is particularly negative to optimum growth and development of this species. White oak is native in Secrest Arboretum.

A reported limitation to acceptance of white oak is its difficulty in transplanting,

even as a young tree. This should not be a deterrent in outplanting this species as difficulty can be overcome somewhat with root development technology described under chinkapin oak.

The home of Abraham Lincoln in Springfield, Ill., is built largely of oak, including framework, flooring, and interior finish. It has been reported that the original shingles were made of hand-split white oak. Appropriately, the official state tree of Illinois is the white oak. Nineteen species of oak can be found growing throughout the state of Illinois.

### ***Quercus bicolor* — Swamp White Oak**

For moist, low-lying areas (soggy soils) and for ease of transplanting, try *Q. bicolor* (or *Q. michauxii*, swamp chestnut oak, and *Q. lyrata*, overcup oak). *Q. bicolor* is a cold-hardy species even more northerly in its origin than *Q. alba*, growing as far north as southern Ontario. As the common name implies, it is a lowland tree growing on the edge of swamps, low wet flats and meadows, and in areas where soil drainage is poor. Common companion trees include black ash, *Fraxinus nigra*; pin oak, *Q. palustris*; red maple, *A. rubrum*, and willows, *Salix* — all trees that can survive on wet sites. Swamp white oak will be adaptable to Midwest landscapes where it will grow well on higher ground without sensitivity to drought, but it does require an acid soil.

Nine plantings of this native tree have been made in the Arboretum since 1909. Their growth has been exceeded in average diameter growth by all the other oaks in the planting, including white oak, bur oak, pin oak, red oak, and black oak. Swamp white oak, when young, is an attractive symmetrical tree. With

advancing age, it becomes ragged, but picturesque.

In lawn plantings, where swamp white oak undoubtedly benefited from frequent lawn fertilization, a 30-year-old tree measured 19" in diameter, 50' in height, and 29' in crown spread. A 50-year-old tree measured 29" in diameter, 69' in height. Although present day swamp white oak seldom exceed 24" to 36" in diameter and 60' to 70' in height, an Ohio tree in Adams County was measured in 1957 to be 68" in diameter and 80' in height. This species is long-lived and may reach 300 to 400 or more years old. It is not reported significantly as a shade tree in the Midwest, but maybe it should.

The specific epithet name, *bicolor*, refers to the leaf characteristic of the contrasting upper green leaf surface with the velvety tomentose or grayish-green color beneath. The summer leaf changes to a tinge of yellow-bronze in autumn. Swamp white oak frequently has the bark peeling off the smaller branches in long, dark, papery layers. It sheds its bark on the upper branches, somewhat reminiscent of sycamore.

The paired acorns are unique in that they have a long stalk, unlike many other native oaks in which the acorns have very short stalks connecting them to the twig or are even sessile, with the acorn setting directly on the twig.

### ***Quercus muehlenbergii* — Chinkapin Oak or Yellow Chestnut Oak**

*Q. muehlenbergii* is native over much of the United States, from the northeast to the Midwest and as far southwest as Texas and New Mexico. The species occurs throughout Ohio, but it is more abundant in the southwestern portion.

The chinkapin oak is remarkably undemanding in cultural requirements. It tolerates droughty conditions and even prefers alkaline soil, not faring well in excessively acid soils, and it will suffer if planted in clay hardpans that do not drain well.

Conventional field-grown nursery trees do not transplant readily. Sturdy seedlings are produced in deep, bottomless containers for air root pruning in order to promote a fibrous root system. These can result in successful transplanting of 2" to 3" field-grown callipered trees.

The attractive leaves have rounded toothed margins, with dark to yellow-green lustrous foliage on the upper surface and with fine silvery hairs on the underside, contrasting well in the wind. Ornamental autumn foliage is an orange-brown.

Chinkapin oak is not used extensively for landscape development in Ohio, but from all observations, it should make a good shade tree.

### ***Quercus imbricaria* — Shingle Oak**

Lowland areas and poorly drained soil conditions present challenges for landscape development. However, some large tree species, such as *Q. imbricaria*, are not only tolerant of water-logged soils but also thrive under such conditions and enhance the landscape. Shingle oak is an underused species for landscape use.

Leaves of this species are often said to be atypical for oak — neither lobed nor toothed, but oblong, dark green, leathery, and lustrous. The autumn foliage is not ornamental, drying tan in late autumn and usually persisting through the winter, falling gradually in late winter.

This native species is cold hardy throughout much of the central Midwestern and eastern states. It matures to a medium size. It is readily reestablished following transplanting, establishing well in various soil types. It has been reported to exhibit tolerance to urban conditions, such as can be found along a major thoroughfare on the campus of Iowa State University, Ames.

All eight replications of *Q. imbricaria* became heavily infested with horned oak gall during years in the Secret Arboretum Shade Tree Evaluation Plot. No treatment was made to prevent galls, and no galls were removed from infested trees. The galls seemed to continually build up over a 20-year period.

### ***Quercus palustris* — Pin Oak**

Many trees do not survive on wet sites or in soils with poor internal drainage. *Q. palustris* is one species able to survive such conditions and even make good growth. The species grows naturally on wet sites, often spoken of as Pin Oak Flats, where the surface water may lay from a few days to a month or more. Such periodic flooding is quite normal for natural stands. Some of these areas are so wet that they are locally called Crawdad Lands as they are identified by the presence of mounds of soil and holes made by crayfish.

Pin oak also grows naturally on deep rich soils of bottom lands and around borders of ponds and swamps where it often grows in company with American sweetgum, *Liquidambar styraciflua*; blackgum, *Nyssa sylvatica*; and red maple, *A. rubrum*. In fact, it grows so often in association with American sweetgum that a forest type or association has been described as Pin Oak-Sweetgum, found in the Ohio River Valley and its tributaries.

Pin oak will also grow on drier upland areas as it is adaptable to a wide range of growing conditions. It grows naturally all over Ohio and is one native species which has been used quite extensively as a shade and street tree. The lustrous, deep green summer foliage turns a yellow or slight bronzing before drying a tan, with some foliage remaining into winter.

A readily known issue about pin oak is that foliar yellowing is an indication of its striking intolerance to neutral or calcareous soils, developing interveinal chlorosis because of insufficient iron availability to the root system in such soils. I would say that successfully correcting iron chlorosis in trees planted on calcareous soils is a band-aid approach, with repeated applications needed over years. Plant the right tree according to the existing soil conditions.

The form of pin oak is distinct, with drooping, horizontal, and ascending branches depicting its broadly pyramidal outline. Descending lower branches are best removed to the trunk to accommodate pedestrian and vehicular traffic. In large lawn areas where there is plenty of room for a tree to grow, lower branches can remain drooping to the ground and provide an excellent landscape effect.

It has been reported over and over that it is one of the easiest oaks to transplant, and I would venture to say that more pin oaks have been transplanted in created landscape situations than any other oak. It has a spreading fibrous root system that is much shallower than most oaks. It does not have as well-developed a taproot as the white oak, especially when growing on wet sites. A shallow spreading root system is characteristic of many trees growing in wet locations.

A most beautiful pin oak selection at OSU Wooster is *Q. palustris* 'Sovereign,'

set out in 1972. Sovereign pin oak has a more horizontal and ascending branching habit than the species, making it useful in accommodating pedestrian and vehicular traffic passing near the tree. It has been observed that most species plantings have grown faster than the selection Sovereign.

### *Quercus phellos* — Willow Oak

*Q. phellos* leaves are quite different than most oaks. The attractive, bright green leaves are unusually slender — almost willow-like — and add a finer texture to the landscape than do most other oaks. The foliage is exceptional throughout the growing season. Autumn foliage is less striking and unreliably colorful — dull yellow to reddish and persisting well into winter.

From all comparisons of oaks for the Midwest that I have made, willow oak has the smallest acorn — 1/2" in diameter — obviously no ornamental value or litter problem. The overall tree form of willow oak is similar to the pin oak.

In Ohio, willow oak is reported growing locally in Jackson and Scioto Counties, but the native range is southward into Kentucky and Tennessee. The species is native on the eastern seaboard and Gulf States and hardy westward to St. Louis. It is found not only in lowlands and along borders of rivers and swamps but also on rich, sandy uplands. It is indigenous to areas receiving moderate rainfall, so it is not suitable to dry planting sites.

*Q. phellos* has a moderate growth rate and is reportedly readily transplantable. I have been significantly impressed with sizable specimens located in various locations in northeastern Ohio. I am going to pursue further seed propagation of genetic material as described earlier.

## *Quercus rubra* — Northern Red Oak

*Q. rubra* has been praised as the most adaptable oak species in city plantings involving a relatively narrow tree lawn. According to Arboretum records of the late John Ford, red oak had been the fastest-growing oak in the Arboretum. One of the most northern grown of the American oaks, it is scattered throughout the hardwood forests of eastern North America from Nova Scotia to Minnesota south to Arkansas, in the East following the Appalachian Mountains and Piedmont into Georgia and then to central Alabama.

Large deep-green lustrous leaves turn a bright red in autumn, but the quality of coloration varies within the species. Northern red oak has been used as an lawn tree. It should be planted where it has ample growing space. Open-grown trees have short boles and can develop massive crowns nearly as wide as the tree is tall, while forest-grown trees have a tall straight trunk and a more restricted crown.

As reported in the Ohio State University Street Tree Evaluation Project (STEP), trees planted out in an open lawn area in 1942 on Oakley Avenue in Wooster, Ohio, are in excellent condition today and have a broad pyramidal habit, providing excellent shade. The trees have grown magnificently and average measurements are recorded as follows: 1967 — 12.3" caliper, 32.8' height, and 28' spread; 1970 — 14.7" caliper, 38.6' height, and 33.4' spread; 1997 — 35.2" caliper, 82.6' height, and 59.6' spread.

For landscape plantings of red oak, heights of 25' to 30' can be reasonably expected in 10 years, 30' to 60' in 40 years, and 60' to 90' in 60 years.

## *Quercus shumardii* — Shumard Oak

*Q. rubra* and a close relative, *Q. shumardii*, remain popular and serviceable shade and street trees and transplant readily. As reported in the Ohio State Street Tree Evaluation Project (STEP), trees were planted in a 6' tree lawn in 1949 on West 107 Street in Cleveland, Ohio. In 1967 measurements were reported as 12" caliper, 34' height, and 24.8' spread; 1970 — 15.4" caliper, 39' height, and 33.6' spread; and in 1997 — 30.6" caliper, 62' height, and 59.8' spread with 100% of the planting surviving and creating a wonderful canopy effect.

This report is significant considering that a six-foot planting area can accommodate a tree with a mature height of 20' to 35', but in 1997 these trees were found to be 60' in height and the trunks and root collars took up the entire six-foot tree lawn and the trees appeared to be thriving, a good indication that Shumard oak could be a serviceable street tree.

Shumard oak usually goes unrecognized by many people who simply call it red oak, as it resembles this tree in overall appearance. Shumard oak has been planted in the Arboretum and on the campus of the Ohio Agricultural Research and Development Center in Wooster since 1915 when five trees were set out. In 1975, the largest in this group was 36" DBH and 65' in height. Since this initial planting, 53 trees were outplanted in 17 different locations.

One of the fastest-growing individual Shumard oaks at Wooster is a Texas variety, *Q. shumardii* var. *texana*, planted in 1950. The tree measured 21" in diameter and 50' in height after 25 growing seasons. This tree measured 40.6" DBH in summer 2000, and in summer 2004, it measured 43" DBH, 75' in height, and 68' in width.

The tree is in average condition, growing in a turf area which is managed with fertilization. From 1979 to 1998, this tree had supplementary summer irrigation through a turf sprinkler system. This type of maintenance affects the growth of oaks which, in general, grow best under moist, fertile growing conditions.

### ***Quercus coccinea* — Scarlet Oak**

One other oak species that I should describe and emphasize for its potential as a landscape tree is *Q. coccinea*. This North American species ranges from northern Georgia to southern Maine and westward to the Mississippi. In Ohio, the scarlet oak is fairly localized to the southeastern region of the state where it occurs abundantly on dry, rocky and sandy soils. The species real beauty occurs in autumn when the foliage reliably turns a maroon to vivid scarlet in coloration.

If I had two oaks to choose as the finest of oaks to try out in the residential landscape they would be *Q. coccinea* and *Q. phellos*. Both species are urban-tolerant, but the scarlet oak is more difficult to transplant unless grown in nursery production.

### **Conclusion**

Considerable biomass has been produced in the genus *Quercus*. As with many plants, there are site-specific requirements in the growth of oaks. Some are within a broad spectrum of tolerance of soil and environmental conditions for plant growth. Truly mighty are the oaks and: *Parvis e glandibus quercus*. Mighty oaks from little acorns grow!

### **Acknowledgments**

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Acknowledgment is made to researchers in forestry who greatly contributed to tree research work in Secrest Arboretum from 1908 to 1984 — Edmund Secrest, Ollie Diller, and John Ford. Additional acknowledgment is given to Secrest Arboretum staff technicians led by Jim Karcher, who worked with John Ford for many years in taking tree measurements, and more recently Jim working with staff technician, Roger Hamilton. Both provided the measurement work for this report.

A complete acknowledgment of people involved in my work with oaks would be most difficult, since a great number of colleagues, teachers, and green industry people have had input, but I am indebted to each of the previously mentioned people in particular. Each of these people was dedicated in their research work at Secrest, and they brought that work to a point in time where I could learn from it and pick up on their work.

I also acknowledge the authors of the resources listed here for the knowledge and ideas gained by reading their writings as well as through personal conversations in several instances.

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