Building a Better OAK

There is no superior species of oak that can thrive in every climate found in urban areas. But a joint breeding program between Cornell University and the Landscape Plant Development Center has made it possible to create oak hybrids for streetscapes that are nearly perfect.

by Peter Podaras
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Planting trees in the urban landscape unquestionably improves the quality of life for all who live there. Reduction of noise, pollution and heat are just a few of the benefits to us, but wildlife also benefits.

Oaks are among the most beautiful and durable trees planted alongside our city and town streets, making them highly desirable. They can be found naturally all over the world, from temperate forests all the way into the tropics of Southeast Asia and South America. Such a broad geographic distribution is due in part to their ability to adapt to diverse soils and climates during the course of their natural history. As a result, there are many species with qualities that allow them to grow well in many climates and adverse soil conditions.

However, the urban environment is not natural: It is man-made, and often, the soil is not ideal in places where we would like to plant a tree. It can be altered to such a degree that it would be nearly impossible to find a tree naturally adapted to these soil conditions.

Soil compaction from heavy construction equipment and traffic makes it difficult for tree roots to find adequate nutrients, water and oxygen. Salt used to melt ice on the street can also leach into the soil, making it difficult to grow trees well. Similarly, material leached from concrete in sidewalks and buildings also winds up in the soil and raises pH to levels that make it hard for trees to absorb nutrients.

These trees must be able to survive in the particular climate they are planted in. It would make no sense to use trees from subtropical locations in cities that get very cold in the winter. While there are oaks that are able to grow well in one or more of the adverse conditions I described, there is no single species that can do it all.

Quercus minima (dwarf live oak) is an exciting species to work with because it stays small, tolerates salt and roots well from cuttings. It is found growing on sand dunes along the mid-Atlantic Coast. The reason it roots well is it adapts to being buried by shifting sand.

Clonal propagation. It should be noted that even if there was a perfect oak out there, it might still be very difficult to propagate. It has been well-established that traditional cutting propagation is usually not very effective. However, clones of superior cultivars are produced in this manner, making them plentiful and relatively inexpensive to use.

Using clonal propagation leaves growers with only two choices. The first choice is to grow seed from superior trees. However, this method can be just as variable as a litter of kittens from a stray cat, and a tree may take 30 or more years to produce nuts. Eventually, you might get some good trees, but you never can really be sure. The other alternative is to graft twigs of superior plants onto seedlings. Again, this is not an ideal solution. Although the top of the tree may look superior, its root system is still derived from seedlings and will remain this way for the entire life of the tree.

Additionally, many species of oak reject grafted parts even from their own species. But there are some species that root with great ease. Currently, there is no "super oak" that can be planted anywhere — in any soil or in any climate — with the ability to be clonally propagated efficiently and economically. But there is hope.

These acorns from crosses of *Quercus muehlenbergii* (chinkapin oak) and *Q. fusiformis* (Texas live oak) were collected in the fall, spent three weeks in a refrigerator and have germinated. They will be planted in tree tubes and put into a large, rodent-proof cooler.

PHOTOS COURTESY OF PETER PODARAS

Breeding oaks. Oaks have a tendency to hybridize freely, and in the wild, it seems the only limitation is the distance the wind is able to blow their pollen. Certainly, this has produced many natural North American hybrids, like *Quercus bicolor* (swamp white oak) × *Q. macrocarpa* (burr oak), that have great potential. Even more accidental crosses, such as *Q. bicolor* × *Q. robur* (English oak), have occurred in botanic gardens.

Imagine what could be accomplished if it was possible to deliberately bring species from different parts of the globe together so that distance or timing or flowering is not a limiting factor. In the joint breeding program between Cornell University, Ithaca, NY, and the Landscape Plant Development Center, Mound, MN, we have accomplished just that.

The project, which started in 2003, involves hybridizing (emasculation, pollen collection, storage and pollination, seed collection, propagation, planting and evaluation) plants and controlling the screening of potential parents and progeny for tolerances to environmental and biological stresses. Sharing of pollen and plant germplasm with others involved in the Landscape Plant Development Center at other geographic locations also is part of the program. By hybridizing species that as individuals possess desirable qualities, we have produced seedlings that could very well possess most, if not all, of the qualities of the perfect street tree.

Male catkins hanging off this *Quercus muehlenbergii* (chinkapin oak) will be removed prior to pollination.

At the Cornell University F.R. Newman Arboretum, we are very fortunate to have such an extensive selection of species and hybrids of oak at our disposal. One of the best species used in our work is *Q. bicolor*, which is extremely well-adapted to the most heavily compacted soils. This is due to its natural ability to grow in waterlogged

This is an example of one species, *Quercus bicolor* (swamp white oak), that is very tolerant of heavy, compacted soils crossed with another species, *Q. muehlenbergii* (chinkapin oak), that tolerates high pH and salt.

Peter Podaras pollinates an oak flower of *Quercus macrocarpa* (burr oak) × *Q. gambelii* (Gambel oak). The leaf morphology shows the influence of *Q. lyrata* (overcup oak).

soils that are very low in oxygen, and it also makes this species preadapted to growing in compacted city soils. But unfortunately, *Q. bicolor* doesn't like road salt or all the lime from concrete that makes soil pH high in the city. Hybrids of *Q. macrocarpa* not only have hybrid vigor, but also possess the ability of the burr oak to tolerate road salt and high pH.

Many of the oak hybrids produced so far are similar. The general formula is to cross oaks that tolerate compacted soils with oaks that tolerate high pH and salt. But interestingly, some of the species that tolerate salt and high pH also possess the ability to root well from cuttings, so it might be possible to eventually have superior trees that could be propagated clonally with relative ease.

A typical breeding season starts with a lot of planning during the winter months, followed by contacting people in different parts of the country who have access to the species of oak desired as pollen parents. We contact people in warmer climates whose trees are further along than ours so that we have plenty of time to process, label, categorize and store the pollen they send. It can be kept viable for up to three years in an ordinary freezer if dried right. Sometimes, we will even travel as far south as Florida and collect pollen from established botanical collections or from the wild. This still gives us enough time to drive back to Ithaca and process the pollen.

Oak trees typically make both male and female flowers on the same tree. Female flowers are ready before the male flowers, but they are barely visible compared to the long, draping catkins of the male flowers. As long as the male flowers are not shedding their pollen, there is time to pollinate. Pollen is heaped over the tiny female flowers, and then a tag with a number is applied to the branch.

The acorns of white oak only take one season to mature and are collected from August to September. Sometimes, hardwire cloth is cut and bent around the acorns and stapled in place to keep thieving squirrels away. Seed are planted right away and then stored in the cooler. Roots emerge, but shoots won't be seen until after at least 90 days of cold. Sometimes, hybrids can be detected right away in the first year, but it can also take up to two years to compare leaves to the parents to be sure you have something intermediate.

Although the trees from our breeding program are still young, many hybrids are already showing superior qualities when compared to seedlings of the parental species being grown at the same time under the same conditions. We are learning a lot from trying so many different cross combinations, but at this point, it can only be considered anecdotal until formal scientific evaluation is conducted. Yet, it is hard to ignore some already striking features in our hybrid populations.

Hybrid vigor is probably the first thing we notice because we need to repot or cut back certain populations much more than others. Another thing that is hard to ignore is the lack of chlorosis in certain populations. Due to the hardness of the water used to water plants, the pH of the growing media tends to rise over the course of the growing season. Near the end of the summer, it is obvious which species and hybrids are the greenest when they are organized in groups at one location. It is especially gratifying to see blocks of seedlings where *Q. bicolor* has been used as the mother with deep green leaves, while plain *Q. bicolor* seedlings used as controls are very chlorotic.

The next step in this research is to make sufficient copies of our hybrids because we usually end up with only a handful of plants after making thousands of crosses.

Seed taken out of a cooler were moved to a greenhouse. Care must still be taken to keep rodents away.

Superior clones of oak need to be grown on their own roots in order to observe the full benefit of their complex genetic background. As mentioned earlier, it can defeat the purpose of breeding a superior oak if it is grafted onto inferior seedlings.

If grafted, the full benefit of a superior genetic background stops at the graft union because what is on the top of a grafted tree is limited by the genetics of the rootstock used. Fortunately, concurrent research conducted by Cornell University professor Dr. Nina Bassuk in stool bed propagation of oaks has clearly demonstrated that production of large numbers of clonal plants grown on their own roots is possible. By using these protocols in the next phase of this work, we can create and use significantly large quantities of clonal plants in large-scale evaluation of hybrid growth, tolerance to environmental stress and adverse urban soil conditions.

The potential to create custom-tailored oak trees for our cities is a very real possibility. All the best qualities of a superior oak tree are already out there, but they're just not in one tree. It just takes some creative thinking, hard work, collaboration and research to make it a reality.

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