Oaks (Quercus spp.) have become a world-wide symbol of tree conservation. Of the approximately 450 described oak species, at least 175 are of conservation concern and many require further conservation assessments (Oldfield and Eastwood, 2007; Jerome et al., 2017). To aid in these efforts, public gardens around the world have invested significant energy to develop taxonomically and geographically exhaustive, genetically diverse oak collections with high conservation value. Aside from their importance as landscape and garden specimens, maintaining living collections of oaks in public gardens is particularly important because recalcitrant (desiccation intolerant) oak seeds cannot be stored long term in germplasm repositories, highlighting an increased need for *ex situ* conservation of individual trees and improvements in collection practices. Within the United States, the American Public Gardens Association (APGA) has recognized the efforts of 20 public gardens who have formed a Plant Collections Network Quercus multisite collection to tackle some of these efforts (APGA, 2017).

Benchmarking studies have become an important tool to help these and other gardens prioritize their conservation and collecting efforts by revealing the diversity of oaks in their collections relative to those in cultivation elsewhere. Gaps, or missing species, reveal areas for future development, and the identification of species (or clones) uniquely or poorly represented in cultivation can indicate those in need of further preservation and distribution. However, the power of benchmarking is predicated on the quality of records and the verification of species to accurate identity. In 2015, verification of tree plantings on perimeter areas of Longwood Gardens revealed a mysterious oak bearing an incorrect label. An exercise in curatorial sleuthing led me on a chase to discover the species’ identity to be *Quercus castaneifolia*, chestnut-leaf oak, and that the accession had a provenance linked to the wilds of northern Iran. In my further investigations, I learned more about its natural history and, eventually, saw it growing in its native habitat.

**Taxonomy and geography of chestnut-leaf oak**

*Quercus castaneifolia* was first described in 1831, and belongs to Section *Cerris* and Subsection *Cerris*, a placement within the genus that has remained stable since Camus’ 1936 monograph. However, the taxonomy within *Q. castaneifolia* has been debated, with at least eight intraspecific botanical taxa (varieties, subspecies, and formae) described based on differences in leaf, acorn, trichome, foliar epidermis, and pollen morphology (Panahi et al., 2011). Molecular analysis using Amplified Fragment Length Polymorphisms (AFLP) indicated that the differences at the molecular level were not enough to distinguish among the previously proposed intraspecific taxa, except for *Q. castaneifolia* subsp. *aitchisoniana*, and that molecular variation in some cases was indicative of introgression from other species (Azadbakht et al., 2015). Presently, the botanical community considers *Q. castaneifolia* to be a single polymorphic or highly variable species (Rix and Kirkham, 2009; The Plant List, 2017).

In addition to its distinct leaf characters, diagnostic morphological features of this species include its linear bud scales, and curiously elongated, but variably sized, ellipsoidal acorns—maturing in two years—that reach 2 to 4.5 cm (0.78 to 1.78 in) in length and have cupules or caps covered with prominent scales (see inside front cover). The branching habit of mature trees is variable, ranging from upright with a dominant central leader, to a spreading structure devoid of a strong central leader that
Quercus castaneifolia is aptly named, with leaves [7 to 20 cm (2.8 to 7.9 in) long and 3 to 6 cm (1.2 to 2.4 in) wide] resembling those of the sweet or Spanish chestnut (Castanea sativa). This herbarium voucher was collected from the specimen growing at Longwood Gardens.
results in a distinctly rounded canopy. In the wild trees can reach heights of 45 m (148 ft), but 10 to 25 m (33 to 82 ft) tall and wide seems more typical, particularly in cultivated trees. Fall color develops late in the season in hues of clear yellow and brown.

Chestnut-leaf oak is a member of the Hyrcanian Forest (from “Hyrcania”, the Greek form of an old Persian word describing the region of Gorgan or Asterabad, Iran), a relict forest widespread during the Tertiary Period (65 to 15 million years ago) and now occurring only on the mountain ranges that surround the southern Caspian Sea. The forest is a well-defined glacial refugium rich in endemic species, including this oak (Milne and Abbott, 2002). Throughout its range, it grows from sea level to 2400 m (7875 ft) in elevation, and is reported to grow on the northern aspects of mountain slopes. [My personal observations, however, indicate a more general distribution, at least in Azerbaijan.] In the Talysh Mountains of southeastern Azerbaijan and northwestern Iran, it is a component of the Quercus-Buxus Forest that once dominated the Caspian Coastal Plain, and the Quercus-Carpinus Forest in the lowlands to 1200 m (3937 ft). The latter forest type transitions to the Quercus-Zelkova Forest in the drier climate of Iran’s Alborz Mountains (Panahi et al., 2011). In some of these areas, Quercus castaneifolia can form pure stands, although it becomes a member of Fagus orientalis (oriental beech)-dominated forest above 1200 m (3937 ft). It is a minor forest component in the eastern portion of its range, in areas dominated by Platycladus orientalis (Oriental arborvitae) (Menitsky, 2005). One study indicated that Q. castaneifolia comprises 6.5% of the total Hyrcanian Forest, belying the fact that it is among the most commonly encountered species in the region (Panahi et al., 2011). It has yet to be analyzed for Red Listing to determine its conservation status (Oldfield and Eastwood, 2017).

The Specimen at Longwood Gardens

In the 1950s Longwood Gardens became part of a large-scale project called the Michaux Quercetum. This project began as a partnership between the Morris Arboretum of the University of Pennsylvania and the Northeastern Forest Experiment Station of the USDA, and was financed in part by the Michaux Fund of the American Philosophical Society. The primary purpose of the study was to develop a large-scale provenance test of US native oak species with the goal of selecting genetically superior trees for breeding and forestry purposes. Another part of the project was defined loosely as “preliminary tests of exotic oak species from all temperate oak-inhabited parts of the northern hemisphere” (Schramm and Schreiner, 1954). Little information exists on the full extent of exotic species of oaks trialed in the various Querceta, but in 1968, several exotic oaks were planted adjacent to the original Michaux Quercetum here in Longwood Gardens.

Among these were oak seedlings bearing USDA Plant Introduction [PI] numbers 228074 and 228075, both originally collected in 1955 as acorns by USDA Agricultural Explorer Howard Scott (H. S.) Gentry in northeastern Iran. The Plant Introduction Inventory (USDA, 1964), records Gentry’s description for the collections, each listed as yet-to-be-identified Quercus sp. For PI 228074: “Col. Nol. 15709. Twenty-five miles south of Kalow, Caspian slope of Alborz. Sept. 12, 1955. Elevation 6,000 feet. Second
growth from cut trees.” And, for PI 228075: “Col. No. 15799. Fifty-four miles east of Gorgan. Sept. 15, 1955. Spreading tree to 30 feet high.” These were grown at the US Plant Introduction Garden (USPIG) in Glenn Dale, Maryland, and in September 1957 Longwood Gardens received three seedlings of PI 228074 and two of 228075, which were planted in the research nursery and later near the Michaux Quercetum.

The Michaux Quercetum and adjacent oak plantings received little attention for the next five decades, providing a true test of a tree’s ability to survive with relative neglect. During the summer of 2015, the plant records office was inventorying trees in this part of Longwood Gardens and ‘rediscovered’ an unidentified oak tree. It was then brought to my attention and I began the detective work. An old planting map indicated the tree was Longwood Gardens accession 1957-2444*A, and the original packing slip from the USPIG linked that accession to one of Gentry’s collections: PI 228075 (accession 1957-2443 was assigned to PI 228074). It appears as if one seedling of each collection perished in the first few years. In 1971, an inventory of the Quercetum indicated that the two remaining seedlings of PI 228074 had perished due to sun scald, but no update was given for PI 228075. Using Gentry’s original collection notes of the tree’s nativity, I used the distinct shape of the tree’s leaves, acorns, and linear bud scales to confirm the identify as *Q. castaneifolia*. Further research indicated that it is the only remaining tree in cultivation from Gentry’s collection, and is thus unique among cultivated accessions of this species in public gardens worldwide.

Because of its unique lineage, and the rarity of wild-collected *Q. castaneifolia* in the US (see below), I collected acorns in 2016. Oaks are
The Kew specimen (accession 1969-15985) is one of the largest trees at Kew, and is the largest chestnut-leaf oak in the British Isles. In 2016 it was approximately 35 m (115 ft) tall, 30 m (98 ft) wide, and had a DBH of 2.52 m (8.26 ft) at 1.5 m (4.9 ft).
anemophilous (wind-pollinated) species that generally rely on fertilization from genetically different individuals of the same species for successful seed development. But there is some evidence that oaks have the ability for self-pollination on a limited basis (Yacine and Bouras, 1997). Of the 24 seeds collected, 12 germinated and the resultant seedlings so far appear to be true-to-type, despite extensive nearby plantings of US native and exotic species including Quercus macranthera (Caucasian oak), which is reported to hybridize with Q. castaneifolia. Despite promising initial results, verification to identity will have to wait until the seedlings mature. If anything, they can serve as understock to graft scions from the original tree, which would preserve the exact genetic lineage.

**Chestnut-leaf Oak in Cultivation**

The Botanic Gardens Conservation International (BGCI) PlantSearch website indicated that 68 public gardens worldwide (mostly in Europe) grow this species. For comparison, 148 gardens list the commonly grown Quercus cerris (Turkey oak), while 54 gardens list the less common Quercus libani (Lebanon oak). Perhaps the best-known specimen in cultivation is the tree growing behind the Water Lily house at Kew Gardens, London. Widely accepted as the first introduction of the species to cultivation in western Europe, the accession was received as seed in 1843 and was reputedly planted in 1846 by William Hooker himself (Rix and Kirkham, 2009). This imposing specimen is one of the most recognized trees in the collection at Kew and was one of few to survive the great storm of 1987 without damage.

Records of this species in cultivation in the United States are few. Some of the largest are two 1938 trees (239-38*A and D) at the Arnold Arboretum of Harvard University, which came from the Mount Mashuk Forest Garden Experimental Station in Pyatigorsk, Russia (Northern Caucasus), which is outside of the species natural range. The larger of the two (239-38*D) stands 22.33 m (73.3 ft) tall, has a spread of 18.3 m (60 ft), and a DBH of 98.6 cm (38.8 in). A query of the most current inventory (2014) of the members of the Plant Collections Network multisite Quercus group indicated 19 living accessions of Quercus castaneifolia in nine gardens. Of these, 16 are of garden or nursery origin, two are from wild collections, and one is actually a hybrid: Q. castaneifolia × Q. cerris. Interestingly, the two wild plants are 1994 accessions growing at the UC Davis Arboretum and originally came from Dr. Ahmad Mossadegh, Professor of Silviculture at the University of Tehran. He collected seeds from the Loveh Region, near Gorgan, Iran at an elevation of 830 m (2723 ft). This source locality, similar to that of the Longwood specimen, indicates that all of the known wild-sourced material in cultivation in the US comes from a similar place in the eastern extent of the species range. In addition to growing in the institutions mentioned above, chestnut-leaf oak is also at the Bartlett Tree Research Arboretum (Charlotte, NC), Denver Botanic Garden, Cornell Botanic Gardens (Ithaca, NY), and Morton Arboretum (Lisle, IL). Its ability to grow in such diverse places suggests a tolerance to extremes of heat and cold (USDA Hardiness Zones 5 to 9), as well as drought and a range of soil types. It is worth experimenting growing the tree in colder and drier regions where the palette of available landscape trees is limited.

Quercus castaneifolia, recognized for its durability and ornamental qualities, has a number of selections. Aimée Camus, in her 1936 Les Chênes: Monographie du genre Quercus, was the first to mention four cultivars (then formae) of Q. castaneifolia: ‘Asplenifolia’, ‘Filicifolia’, ‘Aureovariegata’, and ‘Pyramidalis’. Although there were no descriptions provided, it is likely that the first two had fern-like, and the third had variegated leaves; the fourth likely had a narrow, yet not fastigiate, habit. No plants bearing these names have been found living in modern collections. Several other cultivars in Europe bear the place name where the original plant was selected. ‘Sopron’, ‘Zorgvlied’, and ‘Zuiderpark’ originated in European parks or cities, and have not been widely propagated or distributed. Though listed as a selection of chestnut-leaf oak, ‘Algerensis’ appears to be synonym for Quercus afares, the Algerian oak, a morphologically similar species from the coastal Atlas Mountains of Algeria and Tunisia.
Perhaps the most common cultivar is ‘Green Spire’ (note spelling, as numerous sources have it listed as ‘Greenspire’), selected and introduced by Hillier and Sons Nursery (Winchester, UK). It is described as “a broadly columnar form of compact habit, raised in our nurseries about 1948. A vigorous, tall tree. Probably Q. castaneifolia × Q. libani” (Hillier Nurseries, 1991). This selection has become available in the US and its putative hybrid origin requires verification. The species is known to hybridize with others (particularly within Section Cerris), and although hybrids are poorly represented in cultivation, could prove valuable for creating widely adaptable, drought-tolerant trees suitable for managed landscapes, notably urban forests. Oikos Tree Crops (Kalamazoo, MI) offers Q. castaneifolia ECOS Form, an open-pollinated strain sold as both seeds and seedlings from their original trees. According to their website description, the trees were originally obtained by growing acorns from gardens and arboreta, and may represent hybrids between Q. castaneifolia, Q. cerris, and Q. acutissima (sawtooth oak). They were reported to be the fastest growing oaks in their nursery, reaching nearly 2 m (6.6 ft) in height after two years from seed.

**Quercus castaneifolia in Azerbaijan**

From 9 to 22 September, 2017, the Plant Collections Collaborative (PCC, 14 US public gardens with similar interests in domestic and international plant exploration) organized and performed a plant collecting trip to the Republic of Azerbaijan. Participants included Phil Douglass (Chicago Botanic Garden), Matt Lobdell (Morton Arboretum), Vince Marrocco (Morris Arboretum of the University of Pennsylvania), and myself. Henrik Sjöman of the Gothenburg Botanical Garden (Sweden) joined us for the last week of the trip. Among the collection targets developed during trip planning was *Quercus castaneifolia*, no doubt inspired by my now familiarity with Longwood’s single specimen.

We were pleasantly surprised to find the species ubiquitous in the Lankaran Region of southern Azerbaijan, in the wild as well as a cultivated tree. It grew at sea level and was still abundant at 1500 m (4921 ft) in elevation, the highest point we reached between Lerik and Orand. We found it with other characteristic species of the Hrycanian Forest: *Acer velutinum* (velvet maple), *Buxus sempervirens* (common boxwood), *Carpinus betulus* (European hornbeam), *Parrotia persica* (Persian ironwood), and *Zelkova carpinifolia* (Caucasian zelkova). Trunks of old, open-grown trees were often massive and supported a distinctive branching structure with a tall, straight central leader and irregular branches that resulted in a loosely rounded crown. Unfortunately, none of the trees bore mature acorns, and our guide, Dr. Hacıaga Sofarov, Deputy-Director of Hrycan National Park in Lankaran, indicated that they would not be ready until late-October or early-November. This corresponds to the timing of seed maturation of the tree at Longwood, but differs from
Gentry’s field collection date of September 15, 1955, suggesting that acorns may mature earlier in the southeastern part of the species range.

Chestnut-leaf oak is perhaps the most widely cultivated tree in the Lankaran Region. We immediately encountered extensive plantings used as windbreaks amongst the vast agricultural expanses that dominate the Caspian Lowlands. Street trees were also common, which thrived despite compaction from surrounding sidewalks and streets, late-summer heat and drought, pollution from vehicle exhaust and general neglect. PCC members are again planning an autumn 2018 trip again to southern Azerbaijan to make collections of this and other important, under-represented species. Hopefully, our success in capturing the northwesternmost extent of its range will increase the presence of wild-origin *Quercus castaneifolia* at public gardens across the US.

**Conclusion**

Curatorial mysteries, like the story of Gentry’s unidentified oak, are found in public gardens throughout the world. When acknowledged and solved, they not only enrich the collections and institutions where they exist, but also the greater public garden, horticulture, and botanical communities. As is the case for *Quercus castaneifolia* at Longwood Gardens, unraveling this mystery helped us inform, revise, and add value to our plant collections, their data, and our broader collections development objectives. The project shed new light on an under-represented and under-collected species worthy of greater attention, and I hope this work serves to open new avenues of germplasm preservation, acquisition, and interpretation.

**References**


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