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A Legacy of Elm Improvement at Morton Arboretum

Kim Shearer

The Morton Arboretum, 4100 Illinois Route 53, Lisle, Illinois 60532 U.S.A.

kshearer@mortonarb.org

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INTRODUCTION

The Morton Arboretum

In 1922, after some consultation with Director of Arnold Arboretum Charles Sprague Sargent, Joy Morton founded the Arboretum on a 400-acre private estate in the country side of Lisle, Illinois just west of Chicago. Morton was best known for his founding of the Morton Salt Company but wanted to leave behind a lasting legacy that would have a positive impact.

Morton was the son of J. Sterling Morton, originator of Arbor Day and Secretary of Agriculture under President Cleveland, and Caroline Joy French, an avid gardener. Their family motto "Plant Trees" proved to be a driving force for Morton as he approached retirement. By the time Morton passed in 1934, the Arboretum had already grown to 735 acres and included an herbarium, library, collection of living plants, nurseries, and a staff to manage it all.

Today, nearly 100 years later, the Morton Arboretum is a well-visited 1700-acre tree museum and lab with a mission focused on collecting trees and shrubs from around the world, displaying them in naturally beautiful landscapes, promoting the planting of trees, and making the world a greener, healthier and more beautiful place.

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ELMS AND DUTCH ELM DISEASE IN THE CHICAGO REGION

Elms (*Ulmus* L.) are a widely distributed genus of trees with approximately 35 species found across the temperate and subtropical regions of the northern hemisphere and a species reported in the southern hemisphere on the Indonesian island of Sumatra (Fu et al., 2004; Melville and Heybroek, 1971; Press et al., 2000; Sherman-Broyles, 1997; Todzia and Panero, 1998). There are 10 species of elm native to North America (Sherman-Broylese, 1997), but historically the most widely planted elm in the United States was *Ulmus americana* L.

In the early 1930s, Dutch elm disease (DED) was introduced to the United States by a shipment of logs imported from Europe (Marcotrigiano, 2017). The disease, *Ophiostoma ulmi* , is a fungus vectored by the European bark beetle which burrows into the host tree and creates galleries in the vascular tissues where the fungus is deposited and spreads. As American elms were widely planted as street and park trees all across the country as well as being native to floodplains, the disease spread rapidly and wiped out much of the urban and suburban tree canopy. Beginning as early as the mid-1930s, newspapers such as the Chicago Tribune began raising the alarm on the widespread loss of trees in the east as the disease proceeded to spread to the Midwest (Chicago Tribune, 1934). By 1970, the Chicago region was reported to have lost more than 50 thousand trees. At the time, there were 750 thousand to one million American elms planted in the region, and municipal foresters expected an additional loss of 50 thousand trees by 1972 (King, 1971).

GEORGE WARE, THE THORNHILL ELM, AND BUILDING GERMPLASM

As DED was ravaging the trees of American neighborhoods, parks, and forests, the Morton Arboretum was focused on elevating research at the institution and hired Dr. Marion Trufant Hall, a well-rounded and experienced scientist, as director in 1966. Dr. Hall, charged with the task of increasing the research capacity of the Arboretum slowly and steadily, reached out to his good friend and former classmate Dr. George Ware. In 1968, Dr. Hall hired Dr. Ware to be the Ecologist and Dendrologist (Doty, 1987).

Four years into Dr. Ware's tenure at the Arboretum and after some time observing the impact of DED on the landscape, he noticed a particular tree that was thriving with lush, healthy foliage and an arching canopy reminiscent of the beloved American elm. This tree would come to be referred to as the "Thornhill Elm" (Morton Acc. No. 2352-24*1), and would be the inspiration for initiating the Elm Improvement Program at the Arboretum. During the initial phase of acquiring plant material for establishing live collections at the Arboretum, a packet of seed labeled *Ulmus crassifolia* was sent to the Morton Arboretum from Arnold Arboretum (Jamaica Plains, Massachusetts) in 1924. Said seed was propagated, and trees were planted out on the grounds. Eventually, it would be identified as a hybrid of *U. japonica* × *U. wilsoniana* (synonym, *U. davidiana* var. *japonica*).

What Dr. Ware recognized in this tree was the potential for developing elms with DED resistance perhaps due to the coevolution of the Asian elm species with the pathogen. By 1980, Ware had begun the propagation and evaluation of this tree and was in search of more germplasm to build a breeding program. In the Journal of Arboriculture, Ware would publish two articles in 1980, both with a focus on describing the qualities necessary for trees to survive in urban environments and the potential of broadly distributed Asian elm species not yet introduced to the American nursery industry (Ware, 1980a; Ware, 1980b). As outlined by Ware, these traits were

tolerance of extreme temperatures, drought and flood, high winds, blizzard, and "hostile" soils. These "hostile" soils that Ware referred to are high in pH, have poor aeration, and hardly any organic matter present. And while it is noted that these are common conditions of landscapes in the Midwestern and Great Plains landscapes, it was equally noted that these are the very conditions trees face in developed landscapes irrespective of the "native" region.

In addition to providing a list and description of Asian elm species to consider incorporating into elm breeding programs (Table 1), Dr. Ware would call for the enrichment of North American public garden collections.

Table 1. A list and description of elms suggested as potential urban trees by Ware Journal of Arboriculture and Landscape Plant News (1980a, 1980b, 1996b). Distribution and description adapted from Ware papers.

Species	**Geographic distribution**	**Ware description**	**Selections available in U.S.A. nursery trade?**
Ulmus davidiana Planch. (syn. includes *U. japonica, U. wilsoniana, U. propinqua*)	China, Manchuria, Japan, Korea, Mongolia, Siberia	Variation in habit; tolerant of hostile conditions	Yes; many introductions made in the past couple decades
U. glaucescens Franch.	Kansu Province (China), Northern China	Small tree; small leaves, fine texture; yellow to orange fall color; tolerant of urban conditions based on distribution	No
U. laciniata Göpp.	Humid areas of Manchuria, northern China, Korea, Siberia, and Japan	Small to medium tree; potential drought hardiness; lobed leaves; *Zelkova*-like branching	No
U. macrocarpa Hance	China, Mongolia, Korea, and Siberia	Strong wood; shrub to medium sized tree; adapted to humid/arid regions; tolerant of "hostile" conditions	No
U. parvifolia Jacq.	China, Korea, Japan	Tolerant of drought, pollution, poor soils; attractive lace bark; glossy leaves	Yes; many introductions made in the past couple decades

This was due to the limited provenance representation available at the time. As Ware highlighted, Asian elms were broadly distributed across the Asia and Eastern Europe, yet taxa were only represented by a handful of accessions representing a limited number of populations. This ultimately would result in a completion of five plant exploration expeditions in China and three in what was then considered the Soviet Union; and many collaborative efforts with fellow tree researchers around the world including foresters in China who would send wild collected seed to Ware that would be included in the breeding program. Today, in large part due to Ware's efforts, the Elm Collections of Morton Arboretum include 355 individual trees representing 25 species, 17 unnamed hybrids, 38 cultivars, and a grex making it one of the most comprehensive elm collections in the world.

The Elm Improvement Program

As Ware was building a rich breeding germplasm collection, he began evaluating seedlings in the Morton Research Field (now named Ware Field). With the assistance of his technician Mike Spravka and then propagator Kris Bachtell, Ware began selecting seedlings and having them cloned for the development of an elm breeding isolation block. Selection criteria that Ware developed included DED and elm yellows tolerance, pest resistance, cold hardiness, vigor, and red foliage. In a group of Asian elm seedlings, Ware noted the red pigmentation of emerging leaves. This new trait inspired a breeding objective for improved fall color in elms that generally displayed a range of yellow fall color. In addition to selecting chance seedlings from wild collected germplasm, Ware made controlled crosses to develop new breeding parents and identify potential selections for the nursery industry.

By 1995, Ware would finally send scion material to cooperating nurseries for propagation and field production evaluations. These nurseries included wholesale liner producer J. Frank Schmidt & Son working in collaboration with Keith Warren, and Microplant Nurseries, Inc., working in collaboration with Gayle Suttle. At the time, there were no Asian elms available through the nursery industry. In the time since, the Morton Arboretum has introduced five elm cultivars through the Chicagoland Grows® plant introduction program, all developed through chance seedling selection and controlled crosses conducted by Ware himself (Table 2), and today propagated via microcuttings, softwood cuttings, and grafting.

Elms Today

All across the country, Asian elms are planted in the developed landscapes of cities and suburbs. These include more than 13 cultivars of elms in what is known as the *U. davidiana* complex (*U. japonica, U. wilsoniana, U. propinqua*) (Dirr and Warren, 2019) in addition to at least 13 cultivars of the lacebark elm (*U. parvifolia*). The original "Thornhill Elm" once distributed to the Morton Arboretum by the Arnold Arboretum now is present in the landscape of the city of Boston, coming full circle in its journey through tree cultivation. In the years of 2017-2018 alone, there were approximately 97 thousand liners of Morton introductions sold in the wholesale market.

Table 2. A list and description of elm cultivars developed at Morton Arboretum by the Elm Improvement Program led by Dr. George Ware. Note that *Ulmus japonica, U. wilsoniana* are taxonomic taxa that make up the *U. davidiana* species complex, but they are listed here as the original species for the sake of simplicity. Information found in this table is adapted from Chicagoland Grows® Plant Release Bulletin #44.

Cultivar and trade name	Parentage/origin	Traits	USDA Hardiness Zones	Dimensions (feet)
Ulmus 'Morton' Accolade™ elm	Chance seedling *U. japonica* × *U. wilsoniana*	Vase-shaped habit and vigorous grower; foliage fine-textured, dark green, and glossy with yellow fall color; DED and elm yellows resistance; resistant to elm leaf beetle	5 – 8	**20 year** 30 ft H, 15 ft W **Mature** 50 – 60 ft H 30 – 40 ft W
Ulmus 'Morton Plainsman' Vanguard™ elm	Chance seedling U. *japonica* × *U. pumila*	Relatively upright branching and rounded habit in youth; requires corrective pruning to avoid included bark; dark green foliage with yellow fall color; DED and elm yellows resistant; susceptible to elm leaf beetle, Japanese beetle, and leaf miner.	5 – 7	**Mature** 45 – 50 ft H 40 – 50 ft W
Ulmus 'Morton Glossy' Triumph™ elm	Controlled cross*U.* Accolade™ × *U.* Vanguard™	Grower favorite due to ease of training; lustrous dark green foliage with yellow fall color; upright oval form that ages to vase shape; strong branching; excellent DED resistance; moderate pest resistance	4 – 9	**Mature** 50 – 60 ft H 40 – 50 ft W
Ulmus 'Morton Stalwart' Commendation™ elm	Controlled cross *U.* Accolade™ × (*U. pumila* × *U. carpinifolia*)	Symmetrical arching branches, upright oval habit; large, dark green leaves with yellow fall color; rapid growth and broad adaptability; excellent DED resistance; moderate susceptibility to elm leaf beetle, Japanese beetle, and gypsy moth.	(4)5 – 9	**Mature** 50 – 60 ft H 40 – 50 ft W
Ulmus 'Morton Red Tip' Danada Charm™ elm	Chance seedling *U. japonica*	Rounded habit in youth maturing to large and elegant vase-shape; fast grower; glossy green foliage with red-pigmented new growth; yellow fall color; excellent resistance to DED and elm yellows; moderate susceptibility to Japanese beetle and elm leaf beetle.	(4)5 – 9	**Mature** 60 – 70 ft H 50 – 60 ft W

The Next Generation of Ware Elms

While Ware worked diligently to make the American landscape green again through the introduction of Asian elm selections, he also was sure to secure a future for the next generation of elms. In addition to generously distributing elm seedlings to public gardens, researchers, and breeders around the United States, and perhaps beyond, Ware planted a breeding population in a safe space where selected trees would have a chance to mature, flower, and cross pollinate. The composition of this breeding population includes the *U. davidiana* complex, *U. macrocarpa*, *U. minor*, *U. parvifolia*, *U. pumila*, and *U.* 'Sapporo Autumn Gold'.

In 2018, 3000 seeds were collected from three female parents (*U. davidiana* complex) selected for their form and clean foliage. Seeds were collected as they were just beginning to ripen and samaras were turning yellow. Only seeds showing full development of embryos through the samara were sown. Seeds were sown immediately in Ray Leach Cone-tainers™ and germinated summer 2018. During the fall of 2018, seedlings began to shut down and display fall color exhibiting primarily yellow fall color with a minority of seedlings exhibiting variations of red fall color. In 2019, 300 seedlings were selected and grown on in containerized production. Trees will be spring planted in 2020 and further evaluation of fall color will continue in the field.

The Lacebark Elm

While Ware generally focused on the development of elms in the *U. davidiana* complex, he did publish a note in Landscape Plant News (1996a) regarding the lacebark elm (*U. parvifolia*.) This note was written following a USDA-sponsored US-China Scientific and Technical Exchange Program that included Dr. Raymond Guries and Dr. Weidong Wu (UW-Madison), Dr. Mark Widrlechner (USDA-Ames), and Joan Smalley. The objectives of this journey were to photograph, seed-collect, and determine the natural range of *U. parvifolia*. While in a following note of the same publication (1996b) Ware notes that *U. parvifolia* would likely not be hardy in northern states, at the Morton Arboretum these trees were grown and evaluated. Today, there are 16 *U. parvifolia* and three unnamed hybrids of *U. parvifolia* in the Morton collections that have survived multiple polar vortex events.

The lacebark elm is broadly adapted tolerating heat and some cold, flooding and drought, hostile soils, and humid and arid conditions. It can be seen planted all over the southern United States from the east coast to the west coast. While it has not been planted as widely in the Midwest, it is already listed as a weed of concern in Wisconsin (Hoffman and Kearns, 1997). With this in mind, the new plant development program at Morton Arboretum has a lacebark elm breeding program focused on developing triploid selections with cold hardiness in the Midwest. We will focus on using cold hardy individuals present in the Arboretum collections and hybridizing with a tetraploid individual developed and shared by breeder Dr. Tom Ranney of the Mountain Crop Improvement Lab at North Carolina State University.

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