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Leitneria Floridana, Chapm. VII

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Jonathan Damery, *Editor*
Andy Winther, *Designer*

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Front and back cover: William Purdom collected seed for this peachleaf crabapple (*Malus* × *robusta* var. *persicifolia,* 10011*B) on the road between Beijing and Wutaishan in 1909. Taxonomist Alfred Rehder named the variety after observing the tree in cultivation at the Arnold Arboretum. Photo by Jonathan Damery.

Inside front cover: In the *Silva of North America,* Charles Sprague Sargent described suckering colonies of corkwood (*Leitneria floridana*) "sometimes occupying muddy sloughs of considerable extent to the exclusion of other woody plants." The accompanying illustration was prepared by Charles Edward Faxon. Illustration from Arnold Arboretum Archives.

Inside back cover: Corkwood (*Leitneria floridana*) is dioecious, meaning single plants produce either male or female flowers, not both. This plant (part of a mixed accession, 244-97*MASS) shows female flowers. Photo by Danny Schissler.

PUBLICATION NOTE: Volume 78 will comprise six issues published on the current quarterly schedule. Volume 79 will begin with the first issue published in 2022 and will include four issues.

BROWN, E. AND MAYNARD, B. 2021. FIELD BOTANY IN THE TIME OF COVID-19. *ARNOLDIA,* 78(4): 2–6

Field Botany in the Time of COVID-19

Emma Brown and Brian Maynard

The students in our University of Rhode Island field botany class exclaimed with surprise as they tried to balance atop lopsided hummocks of tussock sedge (*Carex stricta*). The mounds arose between expanses of boot-sucking sphagnum moss. Red cranberries (*Vaccinium macrocarpon*) dotted the shimmering surface around them. This was the first time most of the students had seen cranberries in the wild—a powerful learning moment. Memories of the sour explosion of the cranberries would become associated with the comradery of learning how to differentiate this flowing fen from a typical bog—or how to identify the three-way sedge (*Dulichium arundinaceum*) on the fen's edge and the delicate beaked sedge (*Rhynchospora capitellata*) breezily waving in the center of the scene. Six months later, in March 2020, the pandemic had hit. As university classes pivoted online, we, as instructors, were forced to figure out how the unique shared experiences of the previous fall's classes, held in the field, could be translated meaningfully into a remote format for the upcoming summer and fall offerings.

Field Botany and Taxonomy has been taught at the University of Rhode Island since the late 1940s. Professor Elmer Palmatier, a local botanical legend, established the class and was known to say: "There should be no monotony when studying your botany." His legacy—students quickly learning hundreds of wild plants—has been maintained by a lineage of memorable naturalists. Today, it continues in summer and fall classes led by Professor Brian Maynard, botanist Robin Baranowski, and their teaching assistants. The summer is an intense marathon to identify every plant found between late May and the end of June—over 300 plants in a typical term. The sessions are composed of fast-paced, four-hour meetings, held four days a week. In the more traditional fourteen-week fall semester, the class heads out together twice a week to explore natural habitats around Rhode Island and identify about 250 plant taxa using sight, scent, texture, and even taste. Students collect and bind samples in herbarium presses for both courses and are constantly quizzed on plant names in the field. The courses cover both native and naturalized plants, with detailed units on grasses and mosses. The fall session becomes a race against time, given the threat of frost, and attention turns to autumn colors and winter twig characteristics.

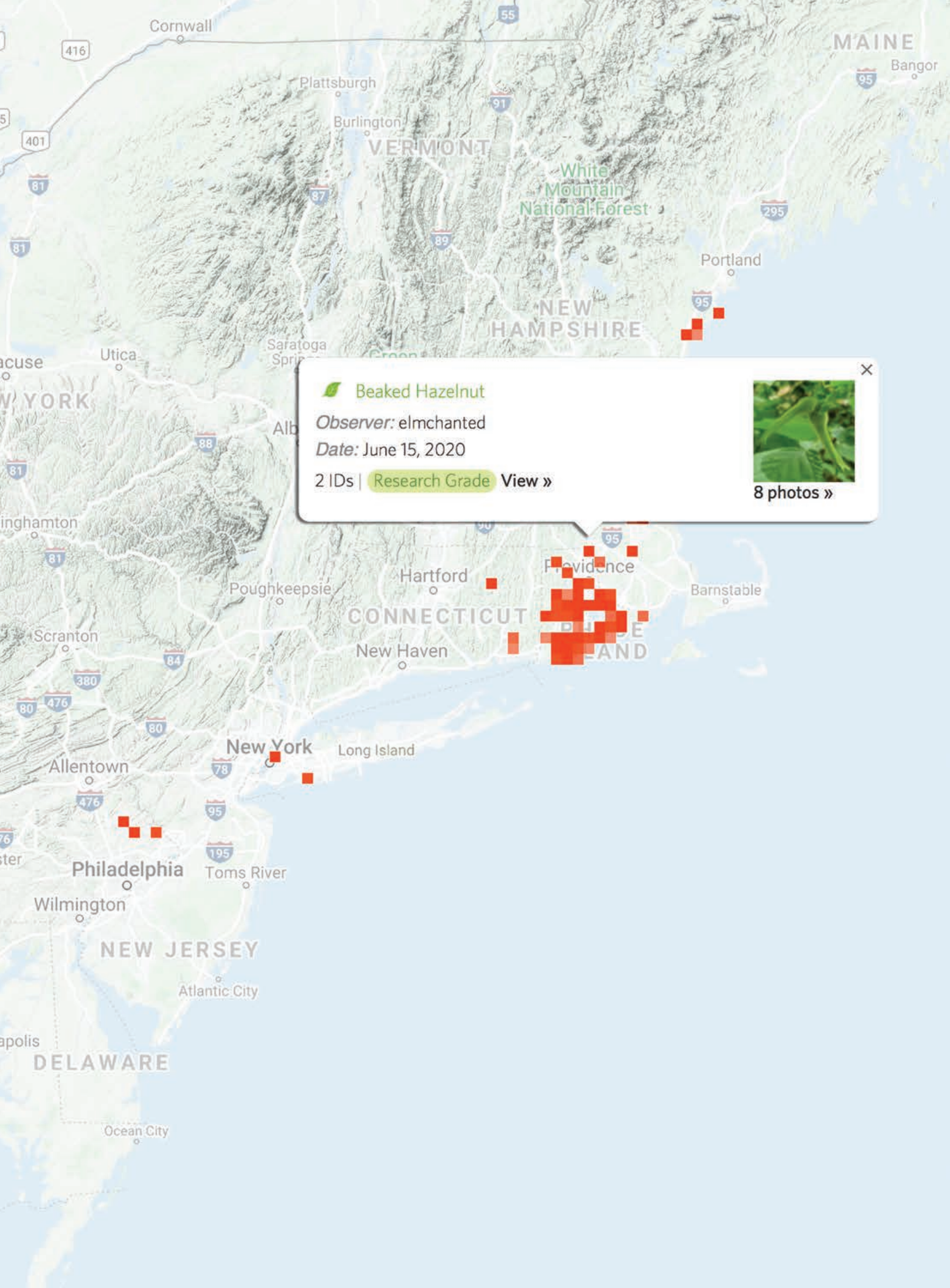
The coronavirus pandemic forced virtually all college courses online, many for the first time. Higher education as we knew it would change dramatically. While adequate tools for online education have been around for nearly two decades, most professors and students of the natural sciences had little experience with online learning, as it had never been necessary before. Now we had just a few weeks to move our courses entirely online before students returned from an extended spring break. Our most significant concern—other than fears about keeping ourselves and our students safe from COVID-19—was that we would not be able to provide our students with the quintessential field botany course experience.

After much deliberation, we settled on a progressive learning structure that involved "flipping" the course. Instead of loading students up with plants to memorize through the usual sage-on-the-stage approach, we would hold the students responsible for finding and identifying plants on their own. While the traditional field course had emphasized learning a shared list of plants, this version would prioritize the development of skills that students could employ to identify any plant they encountered.

Using an online learning platform called Brightspace, we created a series of modular lessons about the major groups of plants: wildflowers, trees and shrubs, ferns, and grasses. Each module included daily activities to train students on identifying the plants that they

When Field Botany and Taxonomy at the University of Rhode Island went remote during the pandemic, the authors found that online tools like iNaturalist supported independent and flexible learning. This iNaturalist map from the summer term shows the wide distribution of class observations.

MAP COURTESY INATURALIST; PLANT PHOTO BY SARAH MCDONOUGH



Beaked Hazelnut

Observer: elmchanted

Date: June 15, 2020

2 IDs | Research Grade **View »**

8 photos »

found on their own. We centered these activities around multimedia tutorials on how to navigate four different field manuals (one for each major plant group) and two of the online keying systems found on the Native Plant Trust's GoBotany website. This was the first time we had used online keys for the class. The students would identify plants using the field manual or online keying system taught each week and then document their observations with photographs and notes using iNaturalist, a citizen-scientist app and website. These digital herbarium vouchers, as we call them, were formatted according to a template we developed and took the place of the herbarium collection the students would have created for the in-person class. The new keying and vouchering skills of our students culminated in a capstone project. Each student designed a vegetation survey in a nearby natural area safely accessible during the pandemic. Students used iNaturalist to record the plants found along a transect line, pacing step-by-step and pausing at regular intervals to document the plant species encountered. The integration of iNaturalist into the class and requiring a vegetation survey were other firsts for the course.

The summer session began in late May 2020 with eighteen students enrolled. Instruction was entirely asynchronous, meaning students could watch presentations and complete assignments on their own schedule. Students communicated with us by email, text, phone, and video calls. Challenges included making sure students had the necessary technology and access to natural spaces. We also needed to ensure that students understood the language of botany and, perhaps most importantly, that they could distinguish between native or naturalized plants and those in managed landscapes (which might not be found in their field guides).

Fortunately, most students had smartphones that automatically tagged the photos uploaded to iNaturalist with GPS data. After keying and identifying a plant, the student would create a voucher with three clear images taken in the field and a description of the plant's shape, foliage characteristics, and other identification features. We guided students through the process of taking clear images. As a set, the photos should zoom to capture the entire plant silhouette, the branch arrangement, and finally up-close details of foliage, twigs, and flowers. Vouchers also included the steps used to identify the plant in the specified field guide, a link for that plant to the Consortium of Northeast Herbaria (a digital collection of herbarium sheets from dozens of herbaria), and an image of the plant on a plain white background with a digital herbarium label. The students posted the photos and notes to the class iNaturalist page, where the instructors, teaching assistants, and other iNaturalist users confirmed or challenged their identification.

As new observations popped up on the iNaturalist map for the class, the difference from the in-person course was apparent. Instead of everyone learning the same plant in the same location, all in Rhode Island, we now racked up twenty-three unique records of sensitive fern (*Onoclea sensibilis*) from southern Maine to Philadelphia. One student reported plants sighted in a Maine salt marsh. Another documented vegetation in Manhattan parks.

Each week, the students expanded one voucher into a presentation and posted it to a discussion blog. The presentations included a range map and notes on plant family characteristics, habitat, ecological relationships, and historical human uses. Blog conversations around these presentations became surprisingly animated: students enjoyed finding similarities in their plant-hunting adventures and learning new facts about plants they had also discovered, as well as about plants they had never seen before. Our learners went above and beyond our expectations by sharing photographs of the habitats and wildlife surrounding their botanical entries. Pictures of herons flew back and forth in the discussion posts, along with wild tales of adventurous plant-hunting escapades. Even a cinnamon-colored housecat participated in the fun as a model to show the size of cinnamon fern (*Osmundastrum cinnamomeum*) fronds against a large enough white surface for the digital herbarium voucher.

These blog entries fostered engagement and interactions that we had thought were only possible in person, when we could walk back to the vans after foraging cranberries, with fen water sloshing in our boots and conversations gushing. As it turned out, the blogs still allowed

SCIENTIFIC NAME: *Vinca minor*
COMMON NAME: periwinkle
LOCATION/HABITAT: South Kingstown, RI
DATE: May 10, 2020
COLLECTOR: Robin Baranowski

ROBIN BARANOWSKI

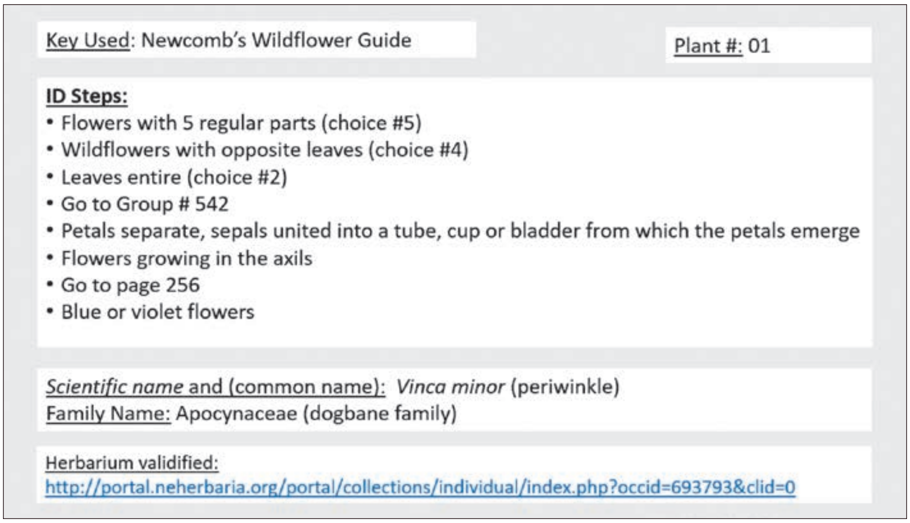
Students created "digital herbarium vouchers" for the class. Each voucher included at least three photographs of the plant in the field and one photograph showing the plant against a white background.

the students to share their experiences with excitement and passion. In the last week of the class, the vegetation survey capstone tested the students' plant identification skills. After proposing a study area (which ranged from vacant lots to pristine forests), each student walked their transect and identified every plant species they found, posted their findings on iNaturalist, and produced a final report that they shared with the class.

As the course unfolded, we found that the switch to the online format had created new learning opportunities. Students continued hands-on learning with greater independence. Resources designed for the course could be reused by students time and again, and we improved accessibility by captioning videos and narrating PowerPoints. Several students completed classwork from out of state, adding to the diversity of plants that the class found. The asynchronous schedule allowed students with personal or work obligations to participate fully. While our students all reflected that the course was time-intensive, they enjoyed the motivation to spend more time outdoors each week.

After our success with eighteen summer students, we took stock of what worked best and ramped up for a fall course of fifty students. We ended up using many of the same tools developed for the summer class, but the material was now spread out over ten weeks and focused on the vegetation we would encounter in New England in late summer and fall. An added challenge of the pandemic was that students were scattered far and wide—from Maine to Philadelphia—and could be forced into lock-down or quarantine at any time. For quarantined students, we prepared contingency samples, which included collections of photos and descriptions of habitat and plant characteristics that we observed in the field. While many fall students still attended remotely, we were finally permitted to meet in person, in small recitation groups, if students could get to campus. Twice a week, we helped up to five in-person students at a time with their keying and plant vouchers.

We were initially concerned that students would learn only a fraction of the usual number of plants, but these concerns were assuaged by the depth of knowledge the students acquired



Key Used: Newcomb's Wildflower Guide

Plant #: 01

ID Steps:

- Flowers with 5 regular parts (choice #5)
- Wildflowers with opposite leaves (choice #4)
- Leaves entire (choice #2)
- Go to Group # 542
- Petals separate, sepals united into a tube, cup or bladder from which the petals emerge
- Flowers growing in the axils
- Go to page 256
- Blue or violet flowers

Scientific name and (common name): *Vinca minor* (periwinkle)
Family Name: Apocynaceae (dogbane family)

Herbarium validified:
http://portal.neherbaria.org/portal/collections/individual/index.php?occid=693793&clid=0

ROBIN BARANOWSKI

Students also submitted detailed notes with each digital herbaruim voucher. This section describes the steps taken to identify periwinkle (*Vinca minor*) using *Newcomb's Wildflower Guide* and also includes a link to a digitized specimen of this species at an herbarium.

for each plant and the confidence they gained in keying on their own. Across the summer and fall classes, our students posted nearly three thousand individual observations to iNaturalist—about 360 unique species in each class. This number far surpassed the 300 or so plants taught in the past. Moreover, our students can now apply their plant identification skills anywhere in the world. We foresee that these tech-savvy citizen scientists will continue to use iNaturalist, including for BioBlitzes, which are intense twenty-four-hour events in which groups find and identify as many species of life as possible in a specific area.

In explaining to our students how to learn their plants, we always stress that the best way to learn is to teach. The act of teaching others is a higher-level step in the learning process. The same students who initially had shied at the prospect of the online format shared plans to use their new knowledge for future careers and reported passing along what they had learned to friends and family. A select few students admitted to not liking plants before this class but noted that they learned to appreciate and even love the plants they encountered. Even as we return to in-person instruction this summer, we will use many of the tools we developed in 2020. We have committed to teaching a blended (online and in-person) field botany course to thirty-six students this fall. Moving forward, we expect to keep several of the teaching strategies that encourage independence and foster flexibility: keying modules, digital plant vouchers, a vegetation survey capstone experience, and the integration of iNaturalist and GoBotany. We are growing with the plants we teach. While the format may be different, the class is definitely a new sport off an old tree that we will continue to cultivate.

For more information

Visit our class iNaturalist sites at https://www.inaturalist.org/projects/uri-bio-323-summer-2020 and https://www.inaturalist.org/projects/uri-bio-323-fall-2020.

GoBotany—the Native Plant Trust's online tool for plant identification—can be accessed at https://gobotany.nativeplanttrust.org/. This provided a valuable complement to the four field manuals that we also taught: *Newcomb's Wildflower Guide* by Lawrence Newcomb and Gordon Morrison, *A Field Guide to Trees and Shrubs* by George Petrides and Roger Tory Peterson, *Northeast Ferns* by Steve Chadde, and *Grasses, Sedges, and Rushes* by Lauren Brown and Ted Elliman.

Acknowledgment

Thanks to iNatauralist for permission to republish the map in this article. iNaturalist is a joint initiative of the California Academy of Sciences and the National Geographic Society.

Emma Brown is completing her master of science degree at the University of Rhode Island and writing a thesis analyzing the experience of taking field-based courses online during the pandemic. This summer, she will return to her native Delaware, where she practices horticulture and compiles the Delaware Native Plant Society newsletter.

Brian Maynard is a professor in the Department of Plant Sciences and Entomology at the University of Rhode Island. He teaches courses in plant propagation and production, landscape management, arboriculture, and field botany. Brian received the Gold Medal Award from the Massachusetts Horticulture Society in 2009 and the Award of Merit from the International Plant Propagator's Society in 2016.

ILES, J. 2021. THE CONFERENCE MUST GO ON. *ARNOLDIA*, 78(4): 7–9

The Conference Must Go On

Jeff Iles

Like a shimmering mirage on some lonely two-lane blacktop, the end of our global pandemic remained out of reach during the last academic year. No backyard barbeque with humans from another pod. No hockey games or theatre. No going anywhere sans facial covering. In my circle of fellow plant nerds, in-person trade shows and educational conferences topped the list of favorite social events that vanished. Remember those days? Striding up to the registration desk, receiving your official conference name badge, pawing through a complimentary tote bag filled with an eclectic assortment of swag, and then rushing off to the opening plenary session and, without giving it a second thought, sitting next to, or even shaking hands with, your randomly chosen seatmate.

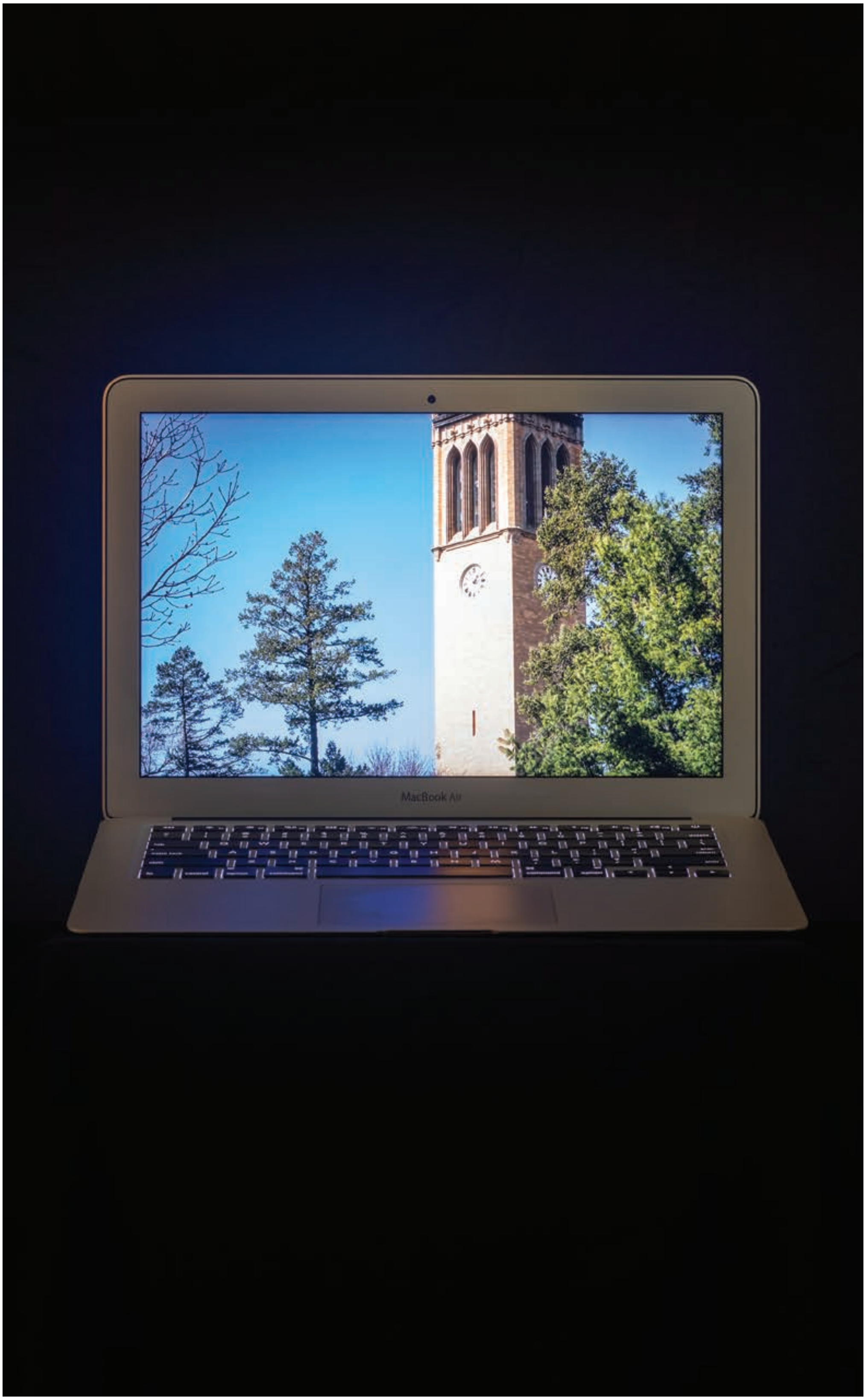
As 2020 dragged on and the 2021 conference season loomed on the horizon, it became abundantly clear to conference planners that in-person, traditional educational events were not a possibility, at least not for events scheduled for prime conference season between January and March. But the show must go on, right?

This was my challenge as I contemplated strategies for keeping the flame alive for an educational conference I've managed since 1995: the annual Iowa State University Shade Tree Short Course, held on the university campus in Ames, Iowa. The event, which was heralding its sixty-fifth year in 2021, was the brainchild of Harold "Sande" McNabb, a forest pathologist at Iowa State. As the story goes, Dutch elm disease and its assault on our American elm (*Ulmus americana*) provided the impetus for the first gathering, which occurred at the McNabb residence. Now, many years later, the short course has become the can't-miss event for arborists and allied industry professionals in Iowa and surrounding states, drawing well over six hundred participants annually and featuring notable presenters like the late Alex Shigo, who encouraged us to "touch trees" and learn about their biology, care, and responses to wounding via compartmentalization. The themes, points of emphasis, and methods of instruction (hands-on workshops are always popular) vary from year to year. So, too, does the number of presenters (approximately thirty). But we never stray too far from discussing the benefits and maintenance requirements of these large, life-breathing, woody friends.

Not to overstate the importance of this conference or my hand in bringing it to fruition, but there can be no denying that the Shade Tree Short Course has earned its reputation as a trusted platform for arboricultural and horticultural education in Iowa and the upper Midwest. As the new year dawned, I felt an almost parental responsibility for the conference—in part to continue McNabb's steadfast tradition, but also, even more importantly, to continue serving our loyal audience, some having attended since the late 1970s. Of course, our short course was not alone in facing this dilemma. Seemingly every educational conference around the country (even the world) was simultaneously confronted with the same set of circumstances and arrived at the same conclusion: "If we're gonna do this, we're gonna have to go online."

The world of video conferencing is a frightening place—or at least it was for me. My fear was born out of the personal experience of witnessing even the simplest of virtual meetings with a handful of participants devolve into real-time lessons in frustration and futility. Who hasn't experienced the same? Poor or indecipherable audio. Low bandwidth prompting the meeting host to switch faces and voices into muted squares with names. Video conference platforms requiring tedious and sometimes confusing downloads—and yet another password. If the downloads had required social security numbers and bank account information, I wouldn't have been surprised. Of course, I'm exaggerating for effect, but for those who grew up using technological advances such as the telephone, fax machine, electric typewriter, and those cute little personal computers (a.k.a., word processing machines) from the mid-1980s,

JEFF ISLES



The Iowa State University Shade Tree Short Course is an annual conference that draws well over six hundred participants. In 2021, the event went online.

receiving a link that, if it worked, would transform desktop computers into portals to another realm could be a bridge too far. But what other choice did I have?

Enter my grand plan. Historically, the Shade Tree Short Course takes place over two full days, but I knew that convincing an audience accustomed to working outdoors to stare at a computer screen for two solid days was going to be a nonstarter and, by extension, could have a dampening effect on attendance. Instead, I reasoned smaller chunks of virtual interaction and educational content would be far more palatable. Therefore, with wise counsel and advice from a university conference coordinator, we devised a week-long event at the end of February. Presentations would begin at eight in the morning and wrap up most days by eleven.

Next, we needed to determine a fair registration fee for a virtual conference. Because I no longer had to worry about transporting and feeding my presenters, nor feeding participants, and because the number of educational sessions was reduced from previous years, I knew the registration fee used in 2020 ($170 early and $220 late) had to be reduced. With the intent of covering my remaining expenses (conference management fee and speaker honoraria), we decided on $40 for early registration and $55 for those coming late to the party. We also offered a reduced fee for university staff and students. But had I gone too far? In my attempt to provide an affordable product that would maintain registration numbers at least at a break-even point, had I committed the unforgivable sin of devaluing my own conference?

As it turns out, full value for conference attendees was never in doubt thanks to the impressive lineup of speakers who, to a person, agreed at once to participate. And, to their credit, many graciously reduced or declined to accept their standard speaker fee, an acknowledgment perhaps of the reduced time commitment for a virtual conference. As the first day of the Shade Tree Short Course approached, however, one problem continued to silently orbit my conference, and its threat was potentially devastating: we needed to find the right video-conferencing platform. My unease was validated during a preconference practice session when our chosen video-conferencing platform performed in a less-than-satisfactory way. Most of my presenters were unfamiliar with the platform and found it user-unfriendly. When the same old audio problems surfaced, I knew it was time for plan B.

Much to my relief, equipped with an alternate and reliable virtual conferencing platform and even a dose of unseasonably good late-winter weather (a nice touch even though we didn't need it), everything went swimmingly. No, we weren't able to offer the traditional scope of topics and workshops (over forty-five concurrent sessions spread over two days), but the aforementioned cadre of top-quality speakers made up for any deficiency in quantity. In the end, we attracted an audience of over 370 participants, including many longtime attendees and a few who'd never attended the short course before. In fact, many first-timers remarked that they attended in 2021 only because the program was offered online. And therein lies my next problem. Now that we've explored the realm of virtual education and witnessed its many benefits (the chat room was incredibly popular), many attendees would like our short course to preserve and integrate aspects of virtual programming in all future conferences. Ideally, a hybrid version could allow attendees to select from in-person sessions that would either be livestreamed or recorded for viewing later. In the end, cost and practicality will dictate the feasibility of such a hybrid model. Honestly, my preference would be for a return to our tried-and-tested in-person roots; however, I also must allow for and accept that, in so many ways, the world has changed.

This not-so-sudden immersion into the world of virtual conferencing has transformed the thinking of this reluctant conference chair. I now possess a new set of skills and have thoughtfully reconsidered what an educational conference should be. Just the same, while I can freely agree that learning doesn't necessarily require in-person, face-to-face interaction, virtual conferencing will always fall short as a replacement for engaging conversation around the coffee dispenser, in the buffet line, or gathered inside the pub at day's end.

Jeff Iles is professor and chair of the Department of Horticulture at Iowa State University, in Ames, Iowa.

DOUGLAS, P. AND SJÖMAN, H. 2021. INTO THE VALLEY OF *PARROTIA*. *ARNOLDIA*, 78(4): 10–15

Into the Valley of *Parrotia*

Phillip Douglas and Henrik Sjöman

The triumph and anguish of plant collectors can often be summed up with a single word: timing. No matter how well an expedition has been planned, collectors often confront either empty capsules or immature fruits. At other times, however, the fates align. In September of 2017, we embarked with colleagues on a collecting expedition to Azerbaijan, searching for multiple species poorly represented in botanical collections. The Persian ironwood (*Parrotia persica*) was our primary target, and for this species, our timing could hardly have been more auspicious.

The Persian ironwood is an ornamental workhorse in the witch-hazel family (Hamamelidaceae) and is one of two species in its genus. Documented collections of *Parrotia persica* in public gardens tend to be from nurseries, and plants of known wild provenance are mostly sourced from populations in Iran. Although descriptions of the species' range tend to focus on the Alborz Mountains in northern Iran, plants do not typically recognize geopolitical boundaries, and thriving populations of *Parrotia* also exist in areas of the Hyrcanian forest and the Talysh Mountains of southern Azerbaijan. The flora in these biomes is considered a relict of a forest type that was much more widespread before glaciation events in the Quaternary, starting around two and a half million years ago. The Talysh region, in particular, includes more than ninety endemic species.[1] Herbarium vouchers for *Parrotia* indicate a disjunct population in the country of Georgia, but it is widely believed these specimens were planted.

In mid-September, our team departed the Azeri capital city of Baku and drove southward along the coast towards Lankaran. The trip had been organized by the Plant Collecting Collaborative, an organization consisting of eighteen botanical institutions, and our collaborators on the trip included Peter Zale from Longwood Gardens, Matt Lobdell from the Morton Arboretum, and Vince Marrocco from the Morris Arboretum. Vast agricultural fields dominate this landscape along the Caspian Sea, irrigated with the waters of the Kura River, which flows throughout the Caucasus region. Cotton, tea, grapes, and various citrus trees are the primary crops. Along the drive, we saw roadside plantings of *Quercus castaneifolia,* the chestnut-leaved oak, which was another one of our species of interest. These plantings were the first we saw of the species in the country. After a long and bumpy drive, we were met in Lankaran by Hajiaga Safarov, deputy director of science at Hirkan National Park. Hajiaga committed his career to exploring southern Azerbaijan, documenting the flora and fauna. He graciously agreed to guide us over the next three days and assured us that he knew of several populations of *Parrotia persica* in the area.

Departing from our hotel the following morning, Hajiaga led our team southwest of the city to the rural farming village of Az Filial. As we gained elevation, the paved highway soon ended, and we continued driving on a hard-packed, single-lane road. Cresting the top of a small hill, we suddenly found ourselves in the middle of *Parrotia*-dominant forest. Scant herbaceous vegetation existed under the canopy of these magnificent trees, a result of intense grazing pressure from the surrounding farms. We parked under the shaded canopy of ironwoods and began to hear tapping on the car's roof, as though a light rain were passing over. The cloudless sky was not precipitating; the sound we heard was something much more miraculous.

Plants in the witch-hazel family exhibit a unique form of seed dispersal. As the capsules of *Parrotia persica* begin to dry, the exterior walls (technically the exocarp) shrink in size and begin to apply pressure to the seed, causing its forceful ejection. This method of seed dispersal—the so-called drying squeeze catapult[2]—was the source of the light raining sound. When we exited our vehicle, we witnessed small, black seeds bouncing off the roof

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The Persian ironwood (*Parrotia persica*) fills a valley near Lerik, Azerbaijan. When the authors first encountered this overlook in 2017, the diversity of fall color and form was unmistakable. This photo was taken on a return trip in 2019.

ALL PHOTOS BY PHILLIP DOUGLAS UNLESS NOTED

The first population of *Parrotia persica* that the authors visited in Azerbaijan revealed a typical, overgrazed understory. Yet the trees displayed variable and unique bark.

and hood. In a marvelous turn of fate, we had timed our trip to document and collect *Parrotia* at the most advantageous time. Witnessing the forceful ejection of these seeds only added to the intrigue of the species. All hands worked quickly to obtain fruits that had not yet dehisced. We gathered several hundred capsules from throughout the population.

Diversity in the Wild

The Hyrcanian forests extend from southern Azerbaijan into Iran, wrapping around the southern coast of the Caspian Sea. In Azerbaijan, *Parrotia* occurs at elevations between sea level and around 1,600 feet (500 meters). Strong cultural influences of forest grazing, active felling of trees for firewood, and coppicing for fencing materials and winter feed have transformed the landscape. Farmers also coppice trees to minimize the shading of valuable meadow environments that provide winter fodder for sheep, cattle, and goats. The extensive coppicing in this region has made it difficult to see the natural habitat and variability of *Parrotia.* Examining the approximately fifty trees within the small population that we first encountered, it quickly became clear that an impressive amount of genetic variability was present. Bark characteristics alone were distinctly different, with variation including creamy, dappled camouflage mottling and golden, iridescent, paper-thin flakes. It was far too early in autumn to see any fall color in this population, but we suspected that variation might exist for this trait as well. After making another collection from a heavily fruited Caucasian zelkova (*Zelkova carpinifolia*), we departed from the site and headed farther south towards the Hirkan National Park.

Driving along the Lerik–Lankaran highway, we saw the Talysh Mountains begin to slowly build elevation as the forested areas became more dispersed between meadows and xeric terrain. Hajiaga was leading us to a historic cemetery and mosque outside the village of Babagil. In addition to *Parrotia,* our group was targeting several other unique woody species: the chestnut-leaved oak and a subspecies of the common boxwood that is endemic to southern Azerbaijan, *Buxus sempervirens* subsp. *hyrcana.* We encountered both species outside of the cemetery and mosque. This site dates to the sixteenth century and contains many enormous planted specimens of Caucasian zelkova and chestnut-leaved oak. Across the road from the cemetery is a remnant piece of the

Hyrcanian forest. Here, we discovered large boxwood growing in the heavy shade of *Parrotia persica.* Just beyond the roadway, we encountered our first large specimens of the chestnut-leaved oak. They created a towering forest canopy over 65 feet (20 meters) tall, with trunk diameters reaching over 3 feet (1 meter). Unfortunately, these two species develop seed at the opposite ends of autumn; the boxwood had already dehisced, and the oaks were not yet ripe enough for collection. We were able to make a large collection of intact seed capsules from the *Parrotia* on the property. This collection, at 1,510 feet (460 meters), marked the highest elevation at which we found *Parrotia* growing, and it should make for an interesting evaluation for cold hardiness.

Departing westward, our group continued towards Lerik, a historic mountain town perched at 3,600 feet (1100 meters), overlooking the border with Iran. Gazing southward from the windows of our vehicles, we came across a magnificent sight: a sprawling forest of *Parrotia persica* filled the expansive valley beneath us. Towering velvet maple (*Acer velutinum*) dominated the upland areas, and enormous Caucasian alder (*Alnus subcordata*) were dotted along a slow-moving creek. Azerbaijan had been plagued in 2017 with a major drought, leaving the herbaceous layer completely dormant in autumn and adversely affecting the quality of autumn color. Despite this drought, the *Parrotia* in this valley showed deep hues of burgundy, red, orange, and yellow. Throughout this population, a diversity of form was also present. We noted many trees with dense conical crowns and a strong branching hierarchy. These structural characteristics would be well suited for trees selected for urban plantings. We were unable to access the forest because we had much more work ahead of us, but the memory of this valley remained with us after the trip.

A Return to the Valley

In late October 2019, the two of us traveled again to Azerbaijan to attempt collecting the chestnut-leaved oak from throughout its northern range. Similar to *Parrotia persica,* this species only occurs in the mountains of southern Azerbaijan and northern Iran. Its acorns don't fully ripen until late in the season, and we hoped to collect them before they fell to the ground, where insects and herbivores can render them useless. The drive south from Baku to Lankaran took half of the time during this trip, as construction of a multilane freeway had been completed, connecting Baku to Tehran, Iran. Our failure to collect acorns from this rare oak had haunted us for the past two years, and we were eager to determine if we had properly timed our trip.

The landscape throughout southern Azerbaijan looked vastly different compared to 2017. Precipitation had fallen evenly through the year, and the previously dormant herbaceous layer was putting on an amazing show. The meadows surrounding the Babagil cemetery and mosque were filled with flowering geophytes. Two species of crocus (*Crocus speciosus* and *C. caspius*) carpeted the landscape and appeared almost as a monoculture lawn in areas that were heavily grazed. Pink-flowered cyclamen (*Cyclamen coum*) dotted the shaded understory of the endemic boxwood. The flowering spectacle was a wonderful sign of good seed development, and we were able to make three separate collections of chestnut-leaved oak at elevations ranging from 1,540 to 2,900 feet (470 to 900 meters). After finishing our oak collecting early, we had time to indulge in the forests of *Parrotia persica.*

As we drove along the highway from Lerik, back to our accommodations outside of Lankaran, we made a familiar stop to gaze across the valley of *Parrotia* that we had discovered two years before. Our timing was once again rewarded with amazing views of the valley in full autumn colors. It is difficult to describe the array of colors. Individual trees within the canopy exhibited shades of deep burgundy, brick red, orange, and buttery yellow. We decided to use our remaining day of the trip to attempt to access and document this population. We collected GPS coordinates and headed back to our accommodations to plan the next day's work. After looking over various maps and satellite images, we were able to devise a way to drive as close as possible to the ridgeline across the valley, where several small houses stood. Our goal was to closely examine the trees in this population, taking photographs to document autumn color and differences in form. Trees

HENRIK SJÖMAN

The authors ventured into the valley of *Parrotia* in late October 2019. Fall color took on rich variation. Trees with dense, pyramidal habits (left) suggest exceptional potential for urban plantings. Phillip Douglas (bottom right) stands with a large *Parrotia* observed at another location earlier in the trip.

with exceptional qualities would be geotagged so that we could return to them for propagation material in the coming years.

The following morning, we departed the hotel and headed towards the valley, excited by the prospect of getting to walk beneath the canopy of the relict forest. The paved road quickly turned into a dirt path, and after crossing over a shallow creek, it became a deeply rutted, muddy quagmire. Our translator and driver, Ilgar Guliyev, guided us through the terrain with expert precision. We soon found ourselves parked outside of a small farmhouse, and Ilgar went in to inquire about accessing the valley below the property. After a short conversation with the owners, we were informed that the valley belonged to the state, and our collecting permits would allow us access to the site. Basing our navigation on several massive chestnut-leaved oaks and oriental beech (*Fagus orientalis*) along the top of the ridge and a group of towering Caucasian alder at the bottom, we began traversing towards several *Parrotia* we had photographed the day before. The first selection that we documented exhibited a uniform, brick-red autumn color throughout the canopy. We continued to traverse up and down the steep slopes of the hill, documenting selections with peachy-pink autumn color, dense and pyramidal habits, and even dappled burgundy and green foliage. The diversity of the species within this singular valley was amazing to see. We hope to return to the valley in late spring to obtain scion wood from these selections to begin growing and evaluating their performance in various climates and conditions.

From the Wild, Into Cultivation

The study and documentation of plants *in situ* is a valuable means of determining species that are well suited for urban horticulture and other specific uses. In Lankaran, we were also able to see how *Parrotia persica* has been used locally in extensive urban plantings. The species could be seen in park environments as well as in small curbside planter spaces. The hot, dry summers of Lankaran coupled with challenging site conditions of urban environments did not seem to affect this highly adaptable species. As a street tree, the species often becomes too wide, resulting in unflattering pruning efforts, but this issue could be solved with more intentional selection. As we had observed, an extensive variation in the size and expression of *Parrotia* occurs in the wild, suggesting the fantastic development potential of the species for public plantations in both Europe and North America.

In cultivation, *Parrotia* is mainly represented by seed-propagated material, which results in large variations, making it difficult to predict mature size and habit. Presently, cultivars of *Parrotia persica* available on the market include 'Vanessa', 'Ruby Vase', and 'Persian Spire', which all represent narrow-growing forms. Based on our field observations, the species has significantly more expressions that deserve to be evaluated in cultivation. We hope to develop new cultivars of this species that will have uniform size and fall color characteristics. The species' adaptability to periods of intense heat and dry soil conditions, coupled with its tolerance for high pH soils, makes it a perfect candidate for further development as an urban tree. Hopefully, we will once again be blessed with perfect timing to collect from these populations and continue working with this relict species.

Endnotes

[1] Safarov, H. M. 2009. Rare and endangered plant species in Hirkan National Park and its environs. In N. Zazanashvili and D. Mallon (Eds.). *Status and protection of globally threatened species in the Caucasus* (pp. 193–198). Tbilisi: CEPF, WWF.

[2] Poppinga, S., Böse, A. S., Seidel, R., Hesse, L., Leupold, J., Caliaro, S., and Speck, T. 2019. A seed flying like a bullet: Ballistic seed dispersal in Chinese witch-hazel (*Hamamelis mollis* Oliv., Hamamelidaceae). *Journal of the Royal Society Interface,* 16(157): 1–10. http://doi.org/10.1098/rsif.2019.0327

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Phillip Douglas is the director of plant collections for the Chicago Botanic Garden and also serves as the chair of the Plant Collecting Collaborative.

Henrik Sjöman is a senior researcher at the Swedish University of Agricultural Sciences and the scientific curator at the Gothenburg Botanical Garden.

ELKIN, R.S. 2021. AN IMPERMANENT INVENTORY: PLANT COLLECTIONS FOR A CHANGING CLIMATE. *ARNOLDIA,* 78(4): 16–23

An Impermanent Inventory: Plant Collections for a Changing Climate

Rosetta S. Elkin

> **"Permanence doesn't really interest me. My whole focus has been on the activity of my life. Out of the activity has come a mass of works, which are really just evidence that I'm still paying attention."**
>
> ***—Robert Rauschenberg***

Barrier islands are young landscapes. Although absolute dates are hard to pin down, the barrier islands that ring Florida's coast are only about five thousand years old and represent some of the most dynamic landscapes in the world. In the context of earthly timescales, the islands surfaced at the end of the Stone Age, around the same time that written language was developed in Ancient China and humans began to interact with yeast microorganisms for producing alcohol and bread. At the time, plant life was already well established for millions of years, taking root firmly and resolutely across landscapes that were only slightly more intact than not.

Today, Florida's coastline extends 1,350 miles, of which 700 miles are structured by barrier islands that are characterized by urbanization rather than earthly formation. Development is intended to prevent the young landscape from further formation, arresting worth in property value while securing costly infrastructure projects. Young soils are paved and only tend to host disturbance-adapted plants that creep in along built lines, chain-link fences, beachfront terraces, and in the obvious cracks between sidewalks. The most iconic plants are the mangrove species (*Rhizophora mangle, Laguncularia racemosa, Avicennia germinans*) that silhouette the shoreline, while florific beach sunflowers (*Helianthus debilis*), green-fruited pond apples (*Annona glabra*), and sea grapes (*Coccoloba uvifera*) with dense crowns are commonly found inland. In this setting, few remnants of the barrier island ecology remain amidst the rich imported flora of the mixed tropical and temperate zones.

If you consult a map of Florida on your handheld device, the string of thin barrier islands that contour the coast is barely legible. Zooming in yields more clarity between land and water. Each barrier island floats along the shore of the mainland, stitched together by a line of causeways and interstate roads that seem to pull the islands landward, or stop them from moving seaward. Now, zoom in on the west coast near Fort Myers. Here, the stitch is called the Sanibel Causeway, which starts at a small crossing known as Punta Rassa. The causeway is supported by a sandy spit that separates Pine Island Sound from the Gulf of Mexico. The route extends into Periwinkle Way and stretches the length of Sanibel until it turns into the next stitch line at Blind Pass, a managed inlet known for shelling and fishing. Blind Pass is the last stop before arriving on Captiva Island.

Consider the same map, and zoom in again on Captiva Island: the gray asphalt of parking lots and sidewalks, the vectorized streets and alleys, and the blank fills of the private space around each foundation. If you search for directions, the route leads you past green golf courses and beige beaches, while the rest of the landscape is defined by different shades of gray. There is no public information beyond the built form, and certainly no recognition of plant life.

The lack of public knowledge about plants always strikes me as unusual, although it comes up frequently in my work as a practicing landscape architect and as a professor and

Facing page: **Captiva Island, on the southwestern coast of Florida, is especially vulnerable to the effects of climate change, including sea-level rise. In 2017, the author was commissioned to develop a landscape-adaptation plan for the former home of Robert Rauschenberg on Captiva. A dynamic plant inventory would be essential.**

ALL IMAGES COURTESY OF THE AUTHOR


Manatee County
DeSoto County
Sarasota County
Peace Watershed
Charlotte County
Lee County
Site Location

researcher, studying the interactions between human and plant life. Within landscape architecture, the prominence of pathways and built structures seems to resonate with the public more than careful attention to particular plants. Presumably, this is one reason why landscape architecture is losing plant knowledge.[1] So when it comes to finding your way in a new landscape, it is no wonder that the only means of tracking distance and not getting lost are found in the gray surfaces that demarcate outward appearance and built materials. But, as streets are inundated, seawalls fail, and foundations erode, might the endurance of plant life be appreciated in new ways?

Designing a Plant Inventory

In 2017, I was commissioned to study the changing conditions at the home of Robert Rauschenberg on Captiva Island, in order to propose a landscape-based adaptation plan to the effects of a changing climate.[2] These effects include, but are not limited to, sea-level rise. Across Florida, the effects cascade: warmer waters increase the velocity of hurricanes, increased salination threatens drinking water supplies, the blooms of red tide devastate sea life, while blue-green algae amalgamate with heavy erosion to suppress tourism. The risks brought on by our warmer climate are not singular, which is why there is no simple solution.

Rauschenberg cared deeply for Captiva both in terms of creative inspiration and also because it appealed to his ideas of impermanence, so elegantly stated in an interview about his art process: "Permanence doesn't really interest me." When we were guided through our first site visit, intricacies of the built landscape were prioritized, including workshops for printmaking and dance studios, a beach house, the main studio, and the historic Fish House—a building perched in the bay.[3] Yet, the grounds are most remarkable because they encompass twenty acres of uninterrupted barrier island, a landscape that bridges the bay and the beach sides. Most properties either enjoy views of the beach or the bay, but rarely both. The Rauschenberg campus is verdant and alive with a continuous canopy that distinguishes it from the rest of the island because Rauschenberg valued the dynamic landscape and never sought to arrest and define it. The grounds—now used to host an internationally recognized artist residency program—are so culturally rich and ecologically lively that there was no lack of inspiration, and I was eager to get started.

At its widest, Captiva is two thousand feet wide; at its narrowest, only about four hundred feet. The Rauschenberg campus sits along the widest portion. Despite its verdant ecology, a standard map registers gray tones, presumably because private land is not rendered beyond building footprints. As the project began, I sought more detail from standard site plans and surveys, the basis of architectural traditions, anticipating more specificity because Rauschenberg himself was so committed to his plants. In particular, he was committed to maintaining an area that he called the jungle, a ramble of sprouting spontaneous plants that makes up almost half the site.[4] Rather, we were handed a site plan that outlined the property lines and included the building footprints, connected by a path system. The rest of the site was white. A site plan without any indication of plants is not only blank; it creates the impression of a landscape devoid of life. As a result, our first act of design was to put the plants back on the map.

Creating a plant inventory for a landscape architectural project is not a normative or established convention. But a plant inventory is a curatorial tradition that supports research within the living collections of arboreta and botanic gardens. An inventory charts long-term change and unlocks the puzzles of horticulture, so it is surprising that inventories are not more of a standard in professional practice. The objective of a plant inventory is to document and describe the current status of a collection. Over time, the inventory can be compared to past iterations, revealing landscape changes.[5] In turn, this secures a plan for future plantings. A plant inventory must be updated in order to remain dynamic, which requires ongoing interaction in the field. This is especially true because plants move, die back, transform, and sometimes shift from their original locations.

Initial site plans and surveys for the Rauschenberg campus emphasized the built infrastructure. Notably, the plants were unrepresented, even in the densely vegetated area known as the jungle.

Typically, an inventory is established at the same time as a garden and creates a baseline to determine future accessions and deaccessions. For instance, the first accession records at the Arnold Arboretum date to 1872, the year the institution was founded, although it took about a decade for the initial card-file system to be refined. In an account from 1881, Charles Sprague Sargent outlines the importance of the inventory but admits that accurate records are often abandoned because they are "too expensive for practical working."[6] He references the future value of recording each plant despite the challenge, suggesting that the effort must bear the test of time. At the Rauschenberg campus, our team believed that the strain of changing climates made the connection to time even more powerful. Establishing a curatorial tradition within an undocumented collection posed two important challenges to the inventory from the start: first, to establish what constituted a "tree" among a host of woody plants, and second, to assess a largely spontaneous collection. Both challenges forced us to make value judgments based on what to count, and thus what to omit, a puzzle that raised more questions than we could answer alone.

The Inventory Process

The Sanibel-Captiva Conservation Foundation (SCCF) was founded in 1974 by a group of Islanders committed to the preservation of the island ecosystem. At the time, SCCF successfully opposed development in Sanibel by incorporating as a city, enabling votes on dredge-and-fill policy, uprooted mangroves, seawall construction, and overscaled condominiums.[7] The same constituency hired the firm of Ian McHarg, the renowned landscape architect who wrote *Design with Nature,* an

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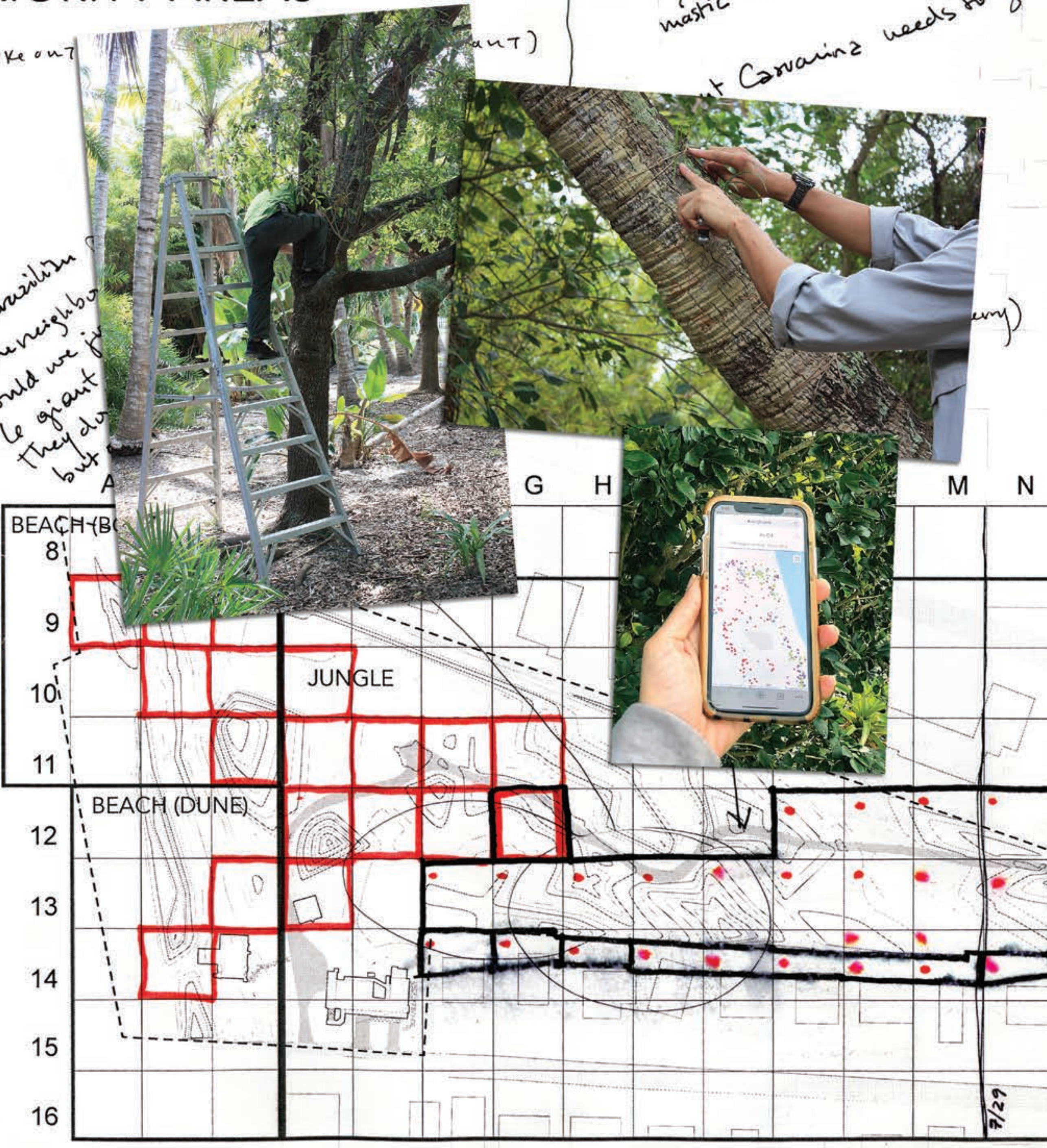

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influential ecological treatise.[8] Captiva did not follow suit and has experienced the consequences of haphazard planning ever since. This is one of the main reasons that the Rauschenberg campus is so uniquely important: it is an anomaly in the landscape that might help inform Captiva's future.

Our team, based in Massachusetts, worked with local horticulturist Jenny Evans from SCCF to initiate the process of developing a baseline for the plant inventory. Without a baseline, neither preservation nor conservation exists. It creates a reference for measuring and assessing disturbance. Although Jenny and her team had little experience establishing a plant inventory, she saw value in the challenge due to the extremities of change expressed by plant loss throughout the hurricane season. The baseline would help us chart the rapidity of change in both the loss of material in hurricane season and, hopefully, the regrowth of disturbance-adapted species. Collectively, we were motivated to tackle the questions raised about the process of gathering and digitizing the data because we saw the importance of creating publicly accessible plant knowledge.

Our inventory would prioritize woody plants, but as we worked through our initial questions, we found that trying to define a "tree" at Captiva proved conceptually hazardous in itself.[9] Many woody plants do not behave as trees with a single trunk, but clump or spread. To capture this distinction, we created two categories of data: rather than discriminating between trees and shrubs, we suggested *points* and *areas.* Points recorded the center of woody plants with single trunks. Areas recorded the total diameter of the woody plant—the perimeter of all trunks and shoots. Each point was recorded in a discrete location using latitude and longitude, while areas were recorded by walking the perimeter of the plant and recording the path.[10] The system of areas was especially useful for taking stock of the mangrove fringe on the bay side, yet flexible enough to allow us to indicate where specific points were noticeable as major trunks within the tangle. The points within the mangrove area are only one example of how the standards of defining a tree helped us standardize a method across a site full of exceptions.

As trees were defined and included in the inventory, a workflow developed between the on-site project team and the data input team. First, the site was divided into 75-by-75-foot quadrants in order to work systematically across the landscape. The quadrants did not have to be delineated in physical space: they were charted by datasets of a handheld GPS device. The on-site team then recorded woody plants using the system of points and areas, and the data from each quadrant was shared with our team sitting at our studio in Massachusetts. This workflow enabled the field team to move from one quadrant to the next and continue to amass data.[11] Our team uploaded their new field data to a global information system (GIS) and aligned this work with site surveys used in the original design documents.[12] We checked the data, cleaned duplicates or errors, and assigned a unique catalog code in GIS, which was exported with labels and integrated into the site survey.

The process raised questions about what type of data was most useful to contain on the map label and how the information could be read by those both familiar with and unfamiliar with plants. Therefore, we decided on two distinct categories: standard and custom. Standard data included common, Latin, and family names, along with trunk diameter (at breast height) in centimeters, height taken in meters, geospatial location (latitude, longitude), location on site (quadrant), and the year recorded. To include canopy cover in the standard category, Jenny came up with a novel expression—a range from one to five—that corresponded to how much of the sky could be seen when standing at the trunk. If 80 to 100 percent of the sky was obscured, she would give the canopy a five; 60 to 80 percent obscured would be a four, and so on. This might not seem relevant in the context of temperate trees, but in a tropical site that is largely overgrown by densely sprouting palms, the canopy can still lack density, which affects overall shade and comfort despite height and maturity. We also assigned a Florida Exotic Pest

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To develop the plant inventory at the Rauschenberg campus, a field team collected GPS points, measurements, and detailed observations for all woody plants growing on the twenty-acre property. The complete inventory can now be accessed on a handheld device.

Plant Council category to each plant. Finally, we created a unique identifying code for each woody plant in the inventory.

The custom category necessitated the most creative collaboration as we imagined what future residents and stewards might wish to know about the plants of the present. The first section within the custom category includes descriptions of environmental influences (damaged or broken limbs, leaning habit, and so forth), notes about neighboring plants in relation to the spread (consider for instance *Ficus aurea,* the strangler fig, which envelops a host tree), and surveyor comments. The collaboration with SCCF was crucial to the comments section and includes remarks about character or significance that were personal, such as "never seen it grow this way" or "covered in lianas," a crucial input to research in heavily urbanized landscapes that resist standards. The subsection also provides space for more nuanced assessments of the Florida Exotic Pest Plant Council criteria, with notes such as "typically invasive, but not aggressive on this property" that overcome the binaries of what typically counts and what doesn't count in a living collection.

In the Context of Change

Landscape design often implies stability and predictability. Yet, the dynamics of the landscape are changing, which invites practices to change in turn. This need is especially pronounced on the Florida coast. As we looked for models for our project, we consulted with curatorial staff at public gardens and found a range of concerns. At the Arnold Arboretum, for instance, staff pay especially close attention to evidence of infestations, as some of the most devastating losses to the living collection are brought on by foreign pathogens.[13] While the rise of foreign pathogens is certainly not bound to the Northeast, Florida must first contend with the intensely localized effects of increased storm damage brought on by rising seas.

A more apt comparison might be made to the inventory at Montgomery Botanical Center in Coral Gables, Florida, a historic collection specialized in the conservation of palms, cycads, and conifers from across the world. The garden is a coastal site vulnerable to episodes of increased storms and the very real effects of about one-third of an inch (nine millimeters) of rise in sea level per year.[14] Thus, Montgomery is grappling with a concern common to all coastal living collections in a time of rapid climate change: How far into the future should we plan? While this is an enduring question in relation to living collections, it finds amplified resonance considering that Montgomery calculates an increased inundation of forty-three acres, or 36 percent of the entire garden.[15] While this number is staggering, the plant inventory confirms that only 8 percent of the collection will be lost in this scenario. Although the figure does not include storm damage, salt intrusion, and other vulnerabilities, it does significantly change the answer to the question: planning can no longer occur in one-hundred-year increments.

The status of any living collection is dependent on maintaining an inventory, which raises questions as to why plant inventories are not more commonly practiced beyond the world of public gardens. In the context of barrier islands, like Captiva, change is noticeable seasonally as hurricanes sweep across the surface of the land while fluctuating sea levels remake the coastline. But, of course, landscapes everywhere are increasingly in states of flux. The knowledge of how to create and maintain an inventory is critical to engendering a unique collaboration between plant and human life within our everyday landscapes. A plant inventory is a record of human and biotic adaptation, a neutral middle ground that accumulates experience and data. It helps visually connect the public to the effects of accelerated climate change, and in a practical sense, it inspires care and helps humans take notice of the plants in their environment.

After the success of developing the plant inventory at the Rauschenberg campus, our team's ensuing idea is to adapt the same open-source technology into a handheld, user-friendly platform that could form the basis of a public inventory for landscapes anywhere, populating our blank site plans and challenging generic street views. We imagine citizen scientists learning to create a site history, as plants under their stewardship become a baseline for future generations. Plant inventories are crucial to increasing an awareness of change, especially in the face of both chronic and episodic stresses of the twenty-first century. Perhaps we can shape an understanding of change by visualizing and valuing impermanence.

Endnotes

[1] A number of authors, myself included, write about the loss of plant knowledge in design. See, for instance: Raxworthy, J. and Harrisson, F. 2018. *Overgrown.* Cambridge: MIT Press.

[2] Practice Landscape includes Emily Hicks and Joanna Lombard, and we were commissioned by the Robert Rauschenberg Foundation to work as part of a team in collaboration with WXY architects and eDD engineers.

[3] Rauschenberg bought the Fish House from Jay Norwood "Ding" Darling, chief of the US Fish and Wildlife Service (formerly the Biological Survey). Ding Darling is best known for ushering in the Federal Duck Stamp Program to expand the federal purchase of wildlife habitat. See, for instance: Ding Darling Wildlife Society. n.d. *Our namesake.* https://dingdarlingsociety.org/articles/our-namesake

[4] The cultural history of the plantings is culled from various oral accounts and conversations, especially with Matt Hall, the site manager who worked closely with Rauschenberg on Captiva, until Rauschenberg's passing in 2008.

[5] The Arnold Arboretum plant inventory claims that to meet objectives "the Arboretum fields expert curatorial staff able to conduct inventories as well as troubleshoot an array of taxonomic, cartographic, and horticultural puzzles." See: Arnold Arboretum of Harvard University. 2011. *Plant inventory operations manual* (2nd ed.). http://arboretum.harvard.edu/wp-content/uploads/2020/07/plant_inventory_operations_manual.pdf

[6] Sargent, C. S. 1882. In Harvard University, *Annual reports of the president and treasurer of Harvard College, 1881–82* (pp. 122–123). Cambridge, MA: University Press.

[7] SCCF's mandate continues to advocate through education and outreach, supported by an intellectual generosity and a spirit of collaboration. For a short history of SCCF in the context of early development see: Davis, J. E. 2017. The Gulf: The making of an American sea (pp. 406–410). New York: Liveright Publishing Corporation.

[8] McHarg, I. L. 1969. *Design with nature.* Garden City, NY: Published for the American Museum of Natural History [by] the Natural History Press.

[9] We initially turned to a definition of trees provided by the Arnold Arboretum's Peter Del Tredici: "A tree can be defined as a plant that, when undisturbed, develops a single, erect woody trunk. A shrub, on the other hand, is a woody plant that, when undisturbed, branches spontaneously at or below ground level to produce multiple stems. In general, a tree will develop secondary trunks in response to injury to its primary trunk or root system, to displacement of its primary stem out of the normal vertical orientation, or to a dramatic change in surrounding environmental conditions." Despite the usefulness of this definition, in practice, we found the distinction was difficult to apply at Captiva. Del Tredici, P. 2001. Sprouting in temperate trees: A morphological and ecological review. *The Botanical View* 67: 121–140.

[10] Data was collected using a handheld Trimble, a GNSS-based data collector that is integrated with ArcMap GIS and is the standard in forestry surveys. This system allows for ease of data entry and storage that works well with our needs for both quantitative and qualitative data. Model: Trimble Geo 7X.

[11] The field team received the initial GIS data for each quadrant as a CSV and shapefile.

[12] This data alignment involves changing the coordinate system to a *projected coordinate system.*

[13] Emerald ash borer (*Agrilus planipennis*) and hemlock wooly adelgid (*Adelges tsugae*) are of particular concern in eastern Massachusetts. Among numerous scientific studies on monitoring, see, for instance: Knight, K. S., Flash, B. P., Kappler, R. H., Throckmorton, J. A., Grafton, B., and Flower, C. E. 2014. Monitoring ash (*Fraxinus* spp.) decline and emerald ash borer (*Agrilus planipennis*) symptoms in infested areas. *General Technical Report NRS-139.* Newtown Square, PA: United States Department of Agriculture, Forest Service, Northern Research Station.

[14] Wdowinski, S., Bray, R., Kirtman, B. P., and Wu, Z. 2016. Increasing flooding hazard in coastal communities due to rising sea level: Case study of Miami Beach, Florida. *Ocean & Coastal Management,* 126: 1–8.

[15] According to a one-hundred-year projection: Griffith, M. P., Barber, G., Tucker Lima, J., Barros, M., Calonje, C., Noblick, L. R., Calonje, M., Magellan, T., Dosmann, M., Thibault, T., and Gerlowski, N. Plant collection "half-life:" Can botanic gardens weather the climate? *Curator: The Museum Journal,* 60(4): 395–410.

Rosetta S. Elkin is an associate professor at McGill University, an associate of the Arnold Arboretum at Harvard University, and the founder and principal of Practice Landscape. Rosetta's work considers living environments with a particular focus on plant life and climate change. She teaches planting design, fieldwork, and seminars that advance a theory of plant life between ecology and horticulture.

GORDON, F. 2021. WILLIAM PURDOM: THE FORGOTTEN ARNOLD PLANT HUNTER. *ARNOLDIA,* 78(4): 24–37

William Purdom: The Forgotten Arnold Plant Hunter

Francois Gordon

It was early March 1912, on the banks of the Yellow River, 450 miles south of Beijing. An Arnold Arboretum plant collector and his three-man escort had ridden more than five hundred miles east from Minxian, in Gansu Province, through a region devastated by the Xinhai Revolution. The revolution had toppled the last Qing emperor and replaced the centuries-old imperial system of government with a republic, which was struggling to establish its authority against a plethora of regional warlords. The roads were alive with bandits, and food and shelter hard to find, but the collector's journey to date had been uneventful. He and his escort were drawing near their destination, the railhead to Beijing in Honan (now Luoyang), the provincial capital of Henan Province. Suddenly, they were ambushed by a group of mounted men, who fired as they charged, killing two horses in the first moments of the attack.

It's unlikely that the bandits knew what the travelers' saddlebags and packhorses' loads comprised, still less that they coveted the herbarium specimens and the seeds and tubers laboriously collected in Gansu and Tibet over the previous year. But a foreigner was sure to be carrying silver specie to pay his way on the road, and the surviving horses would fetch a good price.

The botanist, however, had other ideas. He drew a lever-action rifle from the scabbard beside his saddle and, as he would later write, "made a stand," shooting three of the attackers and several of their horses. His escort joined in, driving off the bandits, and the party galloped to the small city of Shenchow, from where they eventually continued their journey to Beijing, which passed without further incident.[1]

The plant collector was William Purdom, at the conclusion of a three-year expedition on behalf of the Arnold Arboretum and the British firm of James Veitch & Sons to northern and northwestern China and the Tibetan region of Amdo. In the course of his expedition, he sent to Boston 550 packages of seeds and well over one thousand herbarium specimens.[2]

* * *

Purdom, born in 1880, was a head gardener's son from the Lake District in northern England. He served an apprenticeship with his father before working for two distinguished London nurseries, then joining the Royal Botanic Gardens, Kew, as a student gardener. The Kew course of training for botanists and horticulturalists was internationally renowned and correspondingly demanding to join and to pursue. Purdom had done well and had proved a particularly skilled propagator, especially of woody plants. But Kew's director, Sir William Thiselton-Dyer, did not appreciate Purdom's activism as the secretary of the Kew Employees Union, and in 1905, Purdom was dismissed for "agitation." Purdom promptly petitioned the Board of Agriculture, Kew's parent ministry, which agreed that he was perfectly entitled to join a trade union and ordered his immediate reinstatement. Thiselton-Dyer, unable to bear this humiliating public reversal, resigned. The new director, Colonel David Prain, then had to contend with the only strike there has ever been at Kew, efficiently organized by Purdom. All in all, it's perhaps not surprising that when, in 1908, Charles Sprague Sargent enquired whether Kew could recommend someone to undertake a three-year expedition to China, Prain enthusiastically recommended Purdom as the very man for the job![3]

Sargent had come to Britain in August 1908 to engage a plant collector to travel to northwestern China to collect plants and seeds for the Arnold Arboretum. Ernest Wilson, whom Sargent had sent to China in 1907, had made it clear that he would not extend his two-year contract.[4] In 1906, Sargent had also agreed

William Purdom spent three years collecting in northern China and Tibet on behalf of the Arnold Arboretum and the British nursery James Veitch & Sons. Here, Purdom passes through a gate in the Great Wall, in Shanxi Province, in the spring of 1910.

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ARNOLD ARBORETUM ARCHIVES

Frank Meyer photographed larches (*Larix gmelinii* var. *principis-rupprechtii*) near Wutaishan, in Shanxi Province, in February 1908. Charles Sprague Sargent, suspecting these and other conifers in the region to be unique, wanted Purdom to revisit the site.

with the United States Department of Agriculture that Wilson would work in partnership with Frank Meyer, the department's collector in China. Meyer, whose main interest was in plants of agricultural value, would also collect ornamentals in northern China, and Wilson would collect useful plants for the department in the southern zone. But Sargent was bitterly disappointed by how few ornamental specimens Meyer sent from Shanxi Province and was furious when these specimens were discovered to include several previously unknown species of larch (*Larix*), spruce (*Picea*), and pine (*Pinus*) from which Meyer, who had not recognized them as novelties, had not collected seed.[5] Wilson, by contrast, was spectacularly successful, sending back thousands of herbarium specimens and large quantities of plant material, in the process enhancing the reputation of the Arboretum.

Sargent, a man of strong opinions and personal self-confidence verging on arrogance, refused to accept Meyer's explanation that the north of China was "an utterly barren region"[6] when it came to new ornamental woody plants and wanted to send a collector there to prove the contrary. Sargent also wanted this collector to harvest the botanical riches he was convinced were to be found in the high mountains of Shaanxi and Gansu Provinces in northwestern China. Sargent believed that, because the plants from that region endure harsh winters in their home range, they would be better able to stand the New England and north European winters than those from farther south. (The logic is seductive, and such plants will indeed withstand bitterly cold winters, but they are very vulnerable to late spring frosts, having evolved in a climate where spring is a brief prelude to a hot summer, a short transition from extreme cold to baking heat.)

Sargent asked Isaac Bayley Balfour, the regius keeper of the Royal Botanic Garden, Edinburgh, for advice in identifying a collector, and Balfour recommended George Forrest,[7] who had, in the spring of 1907, returned from a very successful three-year plant-hunting expedition in Yunnan Province and whom Balfour knew wanted to return to China.[8] Sargent suggested to his old friend Harry Veitch, whose family firm, James Veitch & Son, dominated the British horticultural trade, that they jointly engage Forrest and share the harvest he would send back from China.

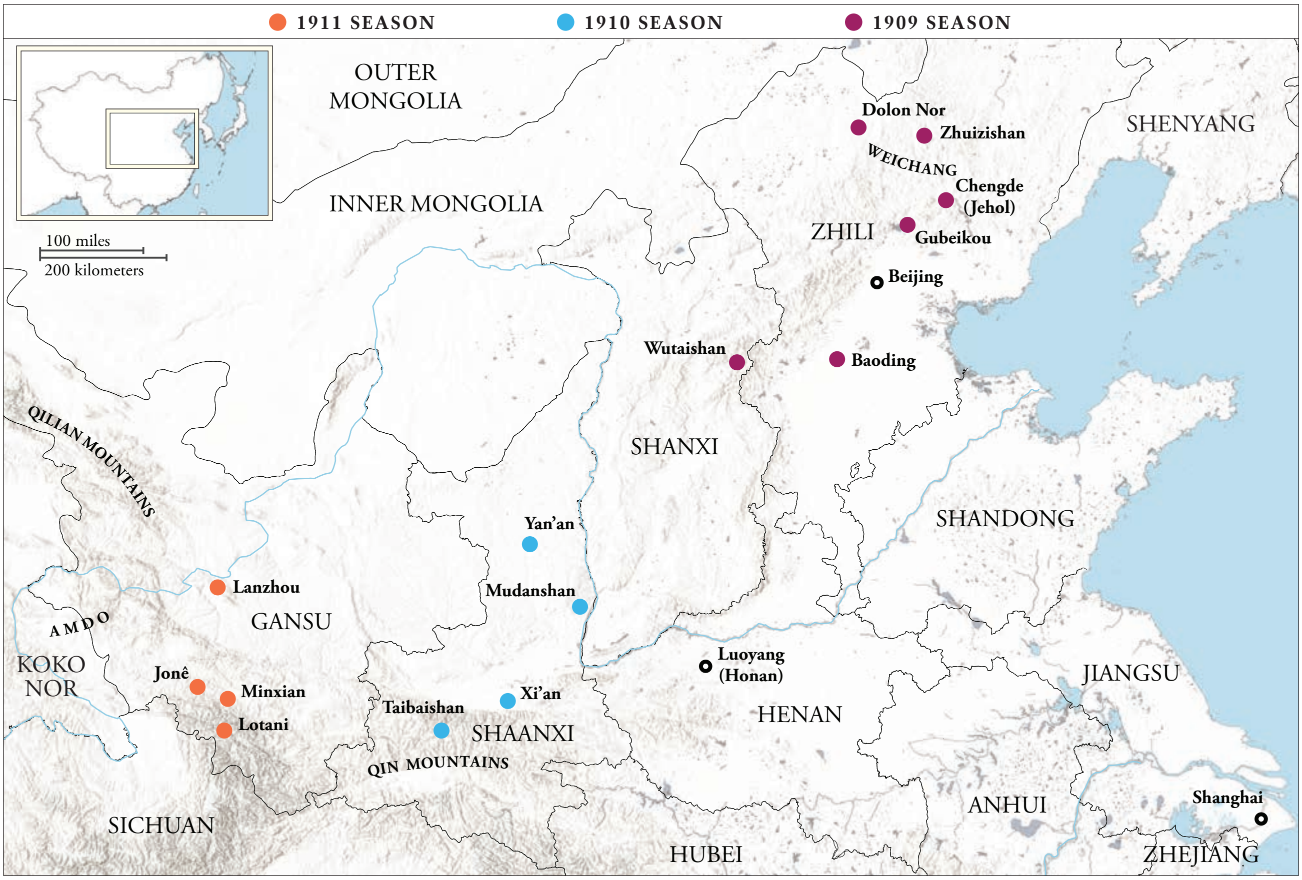
Harry Veitch was agreeable, but although Forrest came to London in September to meet Sargent and Veitch, he refused their offer. Forrest was not impressed with the salary offered by Sargent and was reluctant to collect outside Yunnan, where he believed, quite correctly, that much more remained to be discovered. Nor would he agree to travel to China in early 1909 because he wanted to be at home for the birth of his first child in April. Sargent had to return to Boston in October, leaving Veitch to find a collector.

After two months during which Veitch failed to propose a candidate, Sargent wrote to him in early December reminding him of their agreement to send a collector in early 1909. After consulting Prain and the director of the Kew Arboretum, William Bean, Veitch offered Purdom the post at a salary of two hundred pounds a year plus expenses of four hundred pounds a year. Purdom asked for time to think about it before agreeing on January 7, 1909. Truth to tell, Purdom had little alternative but to accept Sargent and Veitch's offer; his contract at Kew had expired, and he knew that his well-publicized (in Britain) record as a trade union activist—about which both Prain and Veitch appear to have maintained a discreet silence vis-à-vis Sargent—meant that most potential employers saw him as a troublemaker, a label which would have made it very difficult for him to find employment in Britain.

* * *

The first few weeks of 1909 passed in a blur, as Harry Veitch organized detailed briefings for Purdom on China. Purdom's instructors included Sir Robert Hart, recently retired after forty-eight years in China as inspector general of China's Imperial Maritime Customs Service, and Augustine Henry, the distinguished dendrologist who had spent nineteen years in China working for the Customs Service. The Kew-based photographer E. J. Wallis gave Purdom lessons in using a sophisticated glass-plate camera.[9] Purdom sailed on the *Oceanic* from Southampton to New York on February 3 and reached Boston four days later. Sargent immediately formed a favorable impression of Purdom,[10] and he spent Purdom's second day in Boston writing an eight-page memorandum of guidance about where, when, and what to collect in China.

Sargent told Purdom that, on arrival in China, he should seek out Ernest Wilson in either Shanghai or Yichang (in western Hubei Province)[11] before proceeding to Beijing. From there, he was to continue 120 miles north to Chengde (then often known as Jehol) and still farther north to the old imperial hunting ground at Weichang. In a characteristic display of wishful thinking, Sargent asserted that since Weichang "has never been covered by a botanist, it is not impossible that you will find many interesting and possibly entirely new plants." Purdom was to leave Weichang in August so as to be in the Wutai mountain range, 180 miles southwest of Beijing in Shanxi Province, in mid-September, in time for the seed-drop of the conifers: obviously, Sargent especially desired seed from the new spruce, larch, and pine of which Meyer had sent herbarium specimens. Once the seeds had been collected, which Sargent thought "ought not to take very long," he hoped that Purdom would return, via Beijing, to Weichang—a round



ARNOLD ARBORETUM AND GIS COMMUNITY

Purdom spent his first collecting season, in 1909, north and west of Beijing. His second year centered on Shaanxi Province. In the third year, he collected in Gansu Province and the Tibetan region of Amdo.

trip of around six hundred miles—to gather seeds and herbarium specimens there.

The year 1910 was to be spent in Shaanxi Province, where Purdom was to seek "the wild tree peony" (*Paeonia suffruticosa*) before exploring the mountain range near Xi'an, the ancient former capital. This region is around five hundred miles southwest of Beijing. Finally, the third and last year, 1911, was to be spent in Gansu Province, in the high mountains on the border with Tibet, over one thousand miles from Beijing.

All this was spelled out by Sargent with admirable clarity, and he was equally clear about the principal object of the expedition, which was "to investigate botanically unexplored territory [and] to increase the knowledge of the woody and other plants of the [Chinese] Empire." In pursuit of this last goal, Sargent expected Purdom to dry six sets of herbarium specimens for all woody plants, including specimens of the same species that might occur in different regions so as to show the extent of any variation. He also wanted Purdom to photograph "as many trees as possible," including their flowers and bark, and "if time permits [...] views of villages and other striking and interesting objects, as the world knows little of the appearance of those parts of China you are about to visit."

These goals were not quite the same as those articulated by Harry Veitch, who had told Purdom "the object of your mission [is] to collect seeds and plants of trees and shrubs, also any plants likely to have a commercial value, such as lilies," but there was sufficient overlap that Purdom felt he could satisfy both his sponsors.

Purdom must also have welcomed Sargent's brief acknowledgment that it might be impracticable to complete the ambitious itinerary he had sketched out in three collecting seasons and that Purdom might need, in the light of local advice or experience, to change it.

Sargent had his legal adviser draw up a contract, which he and Purdom signed. This stipulated that "all seeds of herbaceous, alpines and bulbous plants and all bulbs and other roots except those of woody plants" collected by Purdom would be the property of the firm of James Veitch & Sons and would be sent directly to them from China. Collections of woody plants would be divided equally between Veitch and the Arnold Arboretum. Photographs and herbarium specimens would belong to the Arboretum. The Arboretum would pay his salary and expenses in January and July, after which Veitch would reimburse one-half of the total sum involved.

Purdom spent a fortnight in Boston, mostly being taught how to prepare herbarium specimens. This involves pressing specimens of plants in blotting paper (also known as drying paper), including, as appropriate, the leaves, stems, flowers, fruit, and seeds. It is a long and laborious process, not least because of the need to change the absorbent paper every couple of days until the plants are thoroughly dried out. These specimens are subsequently mounted on cardstock with a note of the name of the plant, if known, the date and site of collection, and any details recorded by the collector that may be lost as a result of pressing and drying, such as color or scent.

After his training in Boston, Purdom traveled by train to Vancouver, from where he sailed for China on the *Empress of Japan*. He arrived in Shanghai on March 16, 1909.

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Ernest Wilson had repeatedly made it clear that he would hold Sargent to their two-year contract and was not interested in extending it. Nonetheless, when Sargent wrote to him that he and Harry Veitch had engaged Purdom and hoped that Wilson would brief him before returning to London, Wilson expressed disappointment at being "passed over." But he promised that he would do anything he could to help "your new man,"[12] and his briefing of Purdom in Shanghai seems to have been reasonably cordial.

What is, however, clear from Purdom's full account of his briefing from Wilson[13] is that Wilson did not suggest to Purdom that it would be to his advantage to engage any of the eight trained Chinese collectors who had supported Wilson over the last three years. Their contract with Wilson would end as soon as they had finished packing the harvest of the last season's collecting for shipment to Sargent. If Purdom had hired some or all of them, he would have benefitted from their experience and expertise in, for example, preparing herbarium specimens rather than having to train collectors himself, starting from scratch. The men themselves would surely have welcomed the continuation of their employment. Wilson's reticence is all the more noteworthy when one recalls that when Wilson started on his first collecting expedition to China in 1899, he was briefed by Augustine Henry (who was leaving the country) and immediately thereafter hired Henry's entire team, who had been trained over the previous decade.[14] But Purdom lacked the experience to suggest he might do the same thing, and Wilson, despite his promise to Sargent that he would do all he could to help Purdom, did not propose it.

One wonders whether Wilson kept silent because he anticipated that he might return to China within the three-year period for which Purdom was contracted to collect for Sargent and Veitch. In fact, in June 1910, Wilson did return and promptly reconstituted his team of helpers. Obviously, this would have been impossible if the men had been in the field with Purdom. A less charitable alternative explanation is that Wilson was not especially keen to provide Purdom with assistants who might help Purdom challenge Wilson's burgeoning reputation as the greatest of the Western plant hunters active in China.[15] Certainly, in later years, Wilson quite deliberately burnished his reputation, including by rewriting some of the history of his first two expeditions.[16]

Immediately on his arrival in Beijing, Purdom applied himself to learning Mandarin Chinese, a language that he mastered remark-

ALL PHOTOS ARNOLD ARBORETUM ARCHIVES

Clockwise from top: **In the spring of 1909, Purdom traveled north of Beijing and crossed the Great Wall at the gateway town of Gubeikou. He continued northward by river and spent the summer in the imperial hunting grounds of Weichang. Although the region was predominately treeless, Purdom documented pines (*Pinus tabuliformis*) among the scattered forests. That fall, he returned to Beijing and headed west to Wutaishan, where he photographed a collection of Khingan fir (*Abies nephrolepis*) near his tent. The year 1910 was spent primarily in Shaanxi Province. He sent the Arnold Arboretum few photographs that year, but one showed the landscape of Mudanshan, where there was no sign of the wild tree peony.**

ALL PHOTOS ARNOLD ARBORETUM ARCHIVES

Clockwise from top: **In 1911, Purdom collected primarily in Gansu Province and Amdo, an adjacent region of Tibet, where he photographed a temple perched above the Tao River at Jonê. Purdom took a considerable number of portraits of families and individuals in the region. He also documented the dramatic mountains near Jonê, which he labeled as the Peling Mountains. Before returning to England, Purdom collected seedlings of the Chinese horsechestnut (*Aesculus chinensis*) at a temple in Beijing's Western Hills.**

ably quickly. Unusually for a Westerner in China at this time, Purdom consistently treated local administrators and farmers in the areas where he collected as his social equals, among whom he sought to make friends. Partly as a result, he was allowed into areas of China foreign travelers were actively discouraged from visiting, not least for their own safety.

Purdom spent the 1909 collecting season in northern China and Mongolia, including in Wutaishan. Sargent had specifically tasked Purdom with collecting seeds from spruce and larches found there, which were not in cultivation in the West, but the wet summer of 1909 meant that the trees did not set seed. Although Purdom sent cuttings and seedlings, Sargent complained that they had been poorly packed and that, as a result, many of them had died on the six-week journey to Boston.[17] He was only partly mollified by seeds that were germinating in the Arboretum's greenhouses. In fact, Purdom had dispatched thirty parcels of seeds and bulbs from more than three hundred unique collections to Boston and London that year. These included rhododendrons and primulas, a fine blue anemone, several peonies, and three species of clematis, one of which, the downy clematis (*Clematis macropetala*), has particularly graceful deep blue bell-shaped flowers. It first flowered in Veitch's Coombe Wood nursery in 1912 and remains very popular today. For Sargent, there were several poplars (*Populus*), elms (*Ulmus*), larch, and herbarium specimens of a new form of bird cherry (later named *Prunus padus* var. *pubescens* forma *purdomii*), which is a small tree with copious white racemes, bright red berries, and fine foliage.

In April 1910, after overwintering in Beijing, Purdom traveled to western China. Sargent had asked him to investigate Moutan-shan (or Mudanshan, which translates to "peony mountain") near the ancient city of Xi'an, where he hoped Purdom would find the original wild peony. When Purdom arrived, however, he found that the plants had long ago been harvested for traditional medicines and the mountain was stripped bare. Purdom took several photos of the mountain to leave Sargent in no possible doubt that there were no peonies (and few other plants) there. Purdom had better luck near Yan'an, where he found a wild population of the tree peony. He ultimately collected over five hundred seeds of this dark red peony, which was raised in both Boston and Coombe Wood. (Sargent would later write of this as a "first-rate achievement."[18]) On Taibaishan, in southern Shaanxi, he found a fine rhododendron with dark pink buds shading into white flowers, subsequently named *Rhododendron purdomii.* He also found another wild population of the tree peony, but with no seed.

The next year, Purdom continued westward to Gansu Province and the Amdo region of Tibet. He found, in a monastery garden, a lovely winter-flowering viburnum (*Viburnum farreri,* then known as *V. fragrans*). He sent seeds to Veitch, who grew them on and subsequently sold his stock to Gerald Loder, the owner of Wakehurst Place in Sussex, where, in 1920, they flowered for the first time in Britain. Purdom also sent seed of an edible honeysuckle, *Lonicera caerula,* whose curious cylindrical fruit is today sold in the West as "honeyberry." He ended the season in Minxian, in Gansu Province, where he had no choice but to wait for order to be restored following the anarchic violence that followed the Xinhai Revolution in October. Fortunately, Purdom had more or less completed the season's collecting, which included several fine primulas and asters, and in December, he was able to persuade the Minxian authorities to provide (for a fee) an armed escort to enable him to return, via Honan, to Beijing.

When Purdom told the political staff at the British Legation about the attempted ambush near Shenchow, they were horrified to hear that he had killed three of the attackers, whom they strongly suspected (or they may have had confidential information confirming it as a fact) had been off-duty government soldiers.[19] They urged Purdom not to repeat the story to anyone else lest he (and, by association, Britain) should be seen as taking up arms against the Chinese government. This advice suited Purdom, a very private man who throughout his life avoided personal publicity. Furthermore, Purdom was angling for a job with the Chinese Republican


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Purdom and two assistants make their camp on or near Mudanshan, in May 1910. His herbarium presses are arranged in the foreground, with his lever-action rifle resting against the central press.

government and may well have believed that to publicize the shooting wouldn't help his prospects. He did give Sargent and Harry Veitch very brief accounts of the incident,[20] but it was not reported in either the Chinese or English press, nor did he ever allude to it in later life.

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Both sponsors of the expedition were disappointed by Purdom's harvest. Harry Veitch recognized that "if the plants were not there, then he [Purdom] could not send them," but Sargent was reluctant to accept that while his decision to send Purdom to the botanical terra incognita of northwestern China had been a perfectly reasonable throw of the dice, the gamble had failed. That would have meant recognizing that Sargent had got it wrong, and he chose instead to blame Purdom for not trying hard enough.[21]

Sargent also rebuffed Purdom's request to return home from Beijing via San Francisco and New York in order to enable him to visit Boston to explain why the results of the expedition had not matched Sargent's over-ambitious hopes.[22] And the statistics that Sargent reported in his 1910–11 *Annual Report to the President of Harvard University* tended (at least) to leave readers with the impression that Purdom's harvest over the 1910 season had been less than one-quarter of Wilson's, whereas, in fact, he had sent the Arboretum and Veitch germplasm from almost exactly half the number of different plants collected by Wilson in the same season.[23]

Sargent's harsh judgment of Purdom's competence as a collector may well have been influenced by his comparing Purdom's collections with those of Ernest Wilson, sent from Sichuan Province. Such a comparison would prima facie not be to Purdom's advantage: the two men were not competing on a level playing field. The climate of Sichuan is subtropical, shading into tropical, and the annual monsoon delivers plentiful rainfall. Gansu, Shanxi, and Shaanxi Provinces, where Sargent had dispatched Purdom, share a temperate climate, with bitterly cold winters and little rainfall. Unsurprisingly, the flora of Gansu and its immediate neighbors is much sparser than the vegetation of Sichuan where Wilson principally collected.

The Hengduan Mountains in western Sichuan illustrate the extreme biodiversity of the region where Wilson was collecting. The mountains are far enough south that during the last ice age they escaped being scraped bare by glaciers. The substantial variation in altitude created a range of habitats, from river valleys to alpine meadows and peaks, and a huge range of plants flourished there while those further north were wiped out by the ice. In consequence, the Hengduan massif is a biodiversity hotspot, a veritable plantsman's paradise in which it is estimated there are over 8,500 species of plants, 15 percent of them endemic (found only in that confined geographical area). They include over one in four of the world's species of rhododendrons (224 species), primulas (113 species), and mountain ash (*Sorbus,* 36 species)—the list goes on and on.[24] In contrast, plant biodiversity where Purdom was collecting was much lower. In the Qilian Mountains of Gansu, researchers have tabulated around 1,044 species of plants, and in southeastern Gansu, the number is around 2,458 species.[25]

Neither Wilson nor Purdom ever claimed to have done more than explore part of the provinces in which they hunted for plants, but the bottom line is that Wilson was collecting in a region where there was approximately three and a half to eight times the number of plant species than in the area to which Purdom had been sent by Sargent and Veitch. This made it almost inevitable that Wilson would send back to Boston specimens and seeds of more species than Purdom. In 1910 and early 1911, the only season for which it is possible to make a direct comparison, Purdom sent back to Harry Veitch germplasm associated with 374 unique collections numbers, while Wilson sent back 744 collections, 271 of them collected by his assistants after he had broken his leg.[26]

Sargent's negativity towards Purdom may also have been influenced by his feeling a measure of responsibility towards Wilson in respect of the avalanche that had nearly caused him to lose a leg and that left him with a severe limp.[27] Wilson hadn't really wanted to go on the expedition, but Sargent had effectively forced him to, and it seems quite possible that he subconsciously vented a feeling of guilt about what had befallen Wilson on Purdom.

Furthermore, the extent to which Wilson's work in China captured the imagination of the United States media and public meant that Wilson found a ready market for the articles and books that Sargent encouraged him to write about his expeditions. Wilson stressed his links with the Arboretum in the publications, and his star status, in turn, added luster to the fundraising efforts in which Sargent was constantly engaged to support the Arboretum and its activities. In short, it suited both men very well for Wilson to be front and center of the public stage, and there is nothing to suggest that either of them was concerned that the accomplishments of other collectors, including Meyer and Purdom, were overshadowed as a result.

The final blow to any hopes Purdom entertained that this expedition might allow him to forge a reputation among the horticultural cognoscenti that would help him to secure a good job in Britain or the United States fell on his return to England. Harry Veitch had decided to close the firm, which had dominated the English nursery trade for decades, and sell the stock at auction, causing Purdom's collections to be dispersed and brought to market without his name being associated with them (*Viburnum farreri,* mentioned above, is a particularly egregious example).

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Purdom (left) returned to China in 1914 and spent two years collecting with the British botanist Reginald Farrer. Purdom used a clockwork self-timer to photograph himself with Farrer (right) and Zhang Bing Hua, the viceroy of Koko Nor (present-day Qinghai Province). This is the only known photograph of Purdom and Farrer together.

All things considered, if we factor in Purdom's fundamental modesty and aversion to publicity, it's easy to see why he never captured the public imagination in the way that, say, Wilson or Forrest did.

* * *

In 1912, Purdom began corresponding with officials in Beijing about a possible post in a yet-to-be-formed Chinese Forest Service, which would enable him to pursue an objective to which he was personally and strongly committed, namely the reforestation of China after decades of extensive and largely uncontrolled logging. There were long bureaucratic delays in setting up the service, and in 1913, when the alpine plant expert and plant hunter Reginald Farrer invited Purdom to join him on an expedition to northwestern China and Amdo, he accepted.[28] He and Farrer botanized successfully in 1914 and 1915, collecting *inter alios* some fine poppies, alpines, primulas, and an elegant butterflybush (*Buddleia alternifolia*). Although Farrer would go on to write two of the best travel books of the era about the expedition,[29] the devastating effect on European gardening and horticulture of the First World War and the complete collapse in demand for new plants brought an abrupt end to their plant hunting at the close of 1915.

In the spring of 1916, the Chinese government at last formally created a Chinese Forest Service, and Purdom was appointed as a senior forestry adviser to the Chinese government. Purdom must have been deeply happy at last to have achieved a senior management position in which he could make his mark. He began working with Han Ngen (Han An), the secretary of the Ministry of Agriculture, to train Chinese foresters, develop tree nurseries, and plant trees where they would do the most good. By 1919, after three years of backbreaking effort, over one thousand tree nurseries had been established in China, containing one hundred million young trees. In the same, year twenty to thirty million trees were planted on over one hundred thousand acres of otherwise unproductive land.[30] Many of these were timber trees new to China, mostly from North America, which Purdom knew would do well in different Chinese regions and climatic zones. He organized the importation of many millions of seeds and cuttings, making him the only Western plant hunter to have imported into China vastly more plant material than he ever collected there.

It appears that eventually Purdom and Sargent were reconciled: in 1920 and early 1921, Purdom is known to have sent plant material to the Arnold Arboretum. Frustratingly, however, there is no surviving correspondence from this time in the Arnold Arboretum files, and Sargent's personal papers are lost.

Purdom died suddenly in Beijing in November 1921 at the age of forty-one, due to an infection contracted following a minor surgery. He was buried in the English cemetery in Beijing, but fifty-four of his Chinese friends and colleagues clubbed together to commission a large and elegant memorial stele in the Forest Service plantation at Xinyang, which they renamed the Purdom Forest Park. Remarkably, the stele and the park were both left alone during the violently anti-foreigner Cultural Revolution of the 1960s and 1970s and they are both carefully preserved to this day. The epitaph is too long to quote in full, but a hundred years later the sorrow felt by Purdom's friends who subscribed to the stele is still very clear. Perhaps what would have most pleased Purdom is their description of him as "a true and loyal friend of the Chinese people who won the admiration and respect of his colleagues, worked tirelessly for the reforestation of China and who, had he lived, would certainly have trained the next generation of Chinese foresters."

Will Purdom was a fine and honorable man, who rose from a position of very limited personal agency and overcame formidable obstacles to leave the world a better place for his passage. Not only does he deserve to be remembered in his own right, but his life has a good deal to teach us about our place in this interconnected world. His concerns about protecting local ecosystems are a reminder that these ideas were current well over a hundred years ago. Finally, we should, in justice, remember him when we plant his introductions in our gardens: among them, "his" viburnum, butterflybush, or bird cherry.

Endnotes

[1] Purdom letter to Harry Veitch, 23 March 1912 (copied by Veitch to Charles S. Sargent, 10 April 1912), Arnold Arboretum Horticultural Library, Harvard University (AA archive).

[2] Anon. 1921. William Purdom. *Journal of the Arnold Arboretum,* 3(1): 55–56.

[3] David Prain letter to Harry Veitch, 31 December 1908, Royal Botanic Garden, Kew, archives.

[4] Ernest H. Wilson letters to Sargent, 21 November 1908 and 9 March 1909; also Sargent letter to Veitch, 26 April 1909, AA archive.

[5] Sargent letter to Wilson, 8 July 1908, AA archive. Sargent also expressed his disappointment to David Fairchild, Meyer's superior at the Department of Agriculture.

[6] Frank Meyer letter to Wilson, 7 May 1907, AA archive.

[7] Bayley Balfour letter to George Forrest, 26 August 1908, Royal Botanic Garden Edinburgh archive.

[8] George Forrest (1873–1932) made a total of seven expeditions to China, in the course of which he collected over thirty thousand different plants and herbarium specimens, nearly all of them from Yunnan Province in southwestern China.

[9] Purdom was an apt pupil, and the Arnold Arboretum archive has a large collection of his photographs, which are an important resource for our understanding of remote areas of China in the first decades of the last century.

[10] Sargent letter to Veitch, 16 February 1909; and to Prain, 25 February 1909, AA archive.

[11] Sargent letter to Purdom, 8 February 1909, AA archive.

[12] Wilson letter to Sargent, 9 March 1909, AA archive.

[13] Purdom letter to Sargent, 26 March 1909, AA archive.

[14] For a full account and a photo of the team, see: O'Brian, S. A. 2011. *In the footsteps of Augustine Henry* (p. 68 *et seq.*). Garden Art Press.

[15] Wilson's biographer, Roy W. Briggs, suggests that Wilson was concerned that his replacement by Purdom might be seen as an adverse reflection on the quality of his own work in China.

[16] See, for instance: Holway, T. History or romance? *Garden History,* 46(1): 3–27.

[17] Sargent letter to Purdom, 3 May 1910, AA archive.

[18] Sargent letter to Veitch, 13 June 1912, AA Archive.

[19] On March 10, 1912, the political department of the legation sent a telegram about the ambush to the Foreign Office in London, but unfortunately it has been "weeded" from the file in the Public Record Office. The legation also asked the representative of the London *Times* in Beijing, Ernest Morrison, not to report the incident, and Morrison complied.

[20] In addition to the letter that Purdom sent to Harry Veitch cited above, see: Thomas, W.B. 1913, July 10. Creator of 2,000 new plants. *Daily Mail,* p. 3.

[21] Frank N. Meyer letter to David Fairchild, 15 October 1912, USDA compilation of Fairchild correspondence held at the University of California, Davis, Vol. 3, pp. 1600–1601.

[22] Meyer letter to Fairchild, 21 December 1912, USDA compilation, Vol. 3, pp. 1619–1621.

[23] For my full accounting of this, see: Gordon, F. 2021 *Will Purdom: Agitator, plant-hunter, forester* (pp. 111–116). Royal Botanical Garden Edinburgh.

[24] See: Kelley, S. 2001. Plant hunting of the rooftop of the world. *Arnoldia,* 61(2): 2–13. These figures are likely to have changed slightly in the intervening twenty years as new species have been identified and others have been reclassified. By way of comparison, the British Isles presently (2021) have 1,443 species from 308 genera, only 1.2 percent of them endemic.

[25] Wang, J, Che, K., and Yan, W. 1996. Analysis of the biodiversity in Qilian Mountains. *Journal of Gansu Forestry Science and Technology;* also, Lu, W-Z. and Ren, J-W. 2005. Plant biodiversity and its conservation in Maijishan Scenic Regions of Gansu. *Journal of Northwestern Forestry University,* 20(4): 44–47.

[26] Plant collecting is emphatically not a "numbers game," and it would be foolish to use these figures to attempt to compare the relative efficiency of the two men. But Purdom clearly did a good job in a poor collecting area. Again, for my accounting of these numbers in the biography, see pp. 111–116.

[27] For a full account of the story surrounding Wilson's accident, see: Dosmann, M. 2020. A lily from the valley, *Arnoldia* 77(3): 14–25.

[28] Purdom letter to Reginald J. Farrer, 9 September 1913, Royal Botanic Garden Edinburgh archive.

[29] See Farrer's books *On the Eaves of the World* (1917) and *The Rainbow Bridge* (1921). Both books are dedicated to "Bill", i.e. Will Purdom.

[30] Reisner, J. H. 1921. Progress of forestry in China 1919-1920. *Journal of Forestry,* 19(4): 396.

The map in this article was inspired by the map on page 72 of *Will Purdom: Agitator, Plant-Hunter, Forester* and was created using Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, Garmin, GSA, Geoland, FEMA, Intermap and the GIS user community.

Purdom Plants at the Arnold Arboretum

As of this writing, visitors at the Arnold Arboretum can find twenty-five trees and shrubs that arrived directly from Purdom (as seed) or Veitch (as plants) from Purdom's first expedition to China. Another twenty-six plants represent other Purdom lineages, including *Forsythia* that originated from Purdom's collections with Reginald Farrer. To map them in the landscape, visit https://arboretum.harvard.edu/explorer/. Use the advanced search and input "Purdom" in the collector field.

Francois Gordon retired from the British Foreign Office in 2009 after thirty years mostly spent in Africa. Today, he lives and gardens with his wife Elaine in Kent. His first book, *Will Purdom: Agitator, Plant-Hunter, Forester,* was published by the Royal Botanical Garden Edinburgh in 2021. It can be purchased on Amazon.

SHEARER, K. 2021. GEORGE WARE AND THE THORNHILL ELM: A VISION OF TREES FOR THE FUTURE. *ARNOLDIA,* 78(4): 38–47

George Ware and the Thornhill Elm: A Vision of Trees for the Future

Kim Shearer

In 1987, a plant pathologist in Montana ended an incomplete experiment by cutting down fourteen young American elm trees (*Ulmus americana*). At the time, Dutch elm disease (*Ophiostoma ulmi,* DED) was taking hold in parts of Montana. The only management practices then available in Montana were tree removal or pesticide sprays to stop the movement of the vectors, elm bark beetles. The pathologist, Gary Strobel, had been hoping to develop an unconventional method of disease management—vaccinate the tree with a genetically engineered bacterium (*Pseudomonas syringae*) to fight the fungal disease.

In lab trials, Strobel and his colleague Donald Myers had demonstrated that *Pseudomonas syringae* produced natural antibiotics that suppressed the spread of DED through vascular tissue. Still, Strobel needed permission from the Environmental Protection Agency to proceed with a field experiment that involved a genetically engineered organism. The bureaucratic machinations promised to delay the field experiments for another year, so Strobel moved forward with his experiments and injected fourteen trees before receiving formal approval. This moment captured national headlines focusing attention on the debate over genetically engineered organisms and drawing unwelcome attention to Montana State University, where Strobel was a researcher. Rather than put his colleagues at risk of losing federal funding due to his decisions, Strobel volunteered to destroy his field experiment.

As an unanticipated result, however, the news also generated a newfound interest in tree breeding work occurring in a Chicago suburb. At the Morton Arboretum in Lisle, Illinois, George Ware had been busy developing DED-resistant elms the conventional way, through targeted breeding efforts using disease-resistant germplasm. In a 1987 *New York Times* article titled "Fighting Elm Disease the Natural Way," Ware is quoted as saying, "Dr. Strobel was trying to help one kind of elm quickly. We're looking more toward diversity over the long run." This quote highlights the nature of Ware's Elm Improvement Program and the efforts that he went through in developing the next DED-resistant elms.

* * *

George Ware arrived at the Morton Arboretum in 1968, a mere two years after Marion Trufant Hall was hired as director and charged to lead the arboretum in an initiative to expand our research capacity. Ware was enlisted as the research director and the in-house ecologist and dendrologist. In 1972, four years into his tenure, Ware began noticing a peculiar tree in the arboretum collections: a stately elm growing outside the former study of Joy Morton, the arboretum's namesake and founder.

At the time, much of the landscape in and around Chicago had been devastated by Dutch elm disease—as was the case across the United States. The graceful American elm had been widely planted in the Chicago area, along streets and in parks. The prevalence of this species, which was also a ubiquitous forest tree, would ultimately be its undoing, enabling the rapid spread of both the vector and the disease by air and by root-to-root transmission.

The first detection of Dutch elm disease in the United States was recorded in 1929 by Curtis May, a plant pathologist for the United States Department of Agriculture (USDA). May received samples collected in Ohio by plant pathologist Paul Tilford. The trees in Ohio were dying and a cause for concern. Later, in 1933, a USDA inspection would discover the source of the introduced disease: shipments of imported burl logs harboring the European elm bark bee-

***Facing page:* In 1972, George Ware observed an elm at the Morton Arboretum that displayed exceptional form and resistance to Dutch elm disease. The tree would become Ware's first commercial tree introduction: the Accolade elm (*Ulmus davidiana* 'Morton' Accolade™).**

PHOTO: STERLING MORTON LIBRARY

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Tree breeding is a slow, steady process, requiring years to grow and evaluate each generation of hybrids. Over the decades, Ware's Elm Improvement Program would produce some of the most popular disease-resistant elms for the North American landscape.

tle (*Scolytus scolytus*). The larvae of elm bark beetles, including our native species (*Hylurgopinus rufipes*), feed on the vascular tissue of infected trees, picking up spores with their bodies. When they mature and emerge from the tree, they can move to uninfected trees, introducing fungal spores.

Newspapers across the country began raising the alarm about the rapid loss of trees as the disease continued to spread in the East and Midwest. By 1970, the Chicago region was reported to have lost more than fifty thousand trees and was projected to lose another fifty thousand within two years. It was amidst this devastation, in 1972, that Ware noticed the tree growing outside of Joy Morton's study window at the Thornhill Estate. It was an elm (Morton accession 2352-24*1) with gracefully arching branches, healthy and green foliage, and no symptoms of the disease.

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The original elm, fondly referred to by Morton Arboretum staff as the Thornhill Elm, was accessioned into the collections in 1924, shortly after Joy Morton founded the arboretum on his estate in 1922. With guidance from Charles Sprague Sargent, the director of the Arnold Arboretum, Morton established a 735-acre arboretum that included an herbarium, library, and nurseries, along with staff to manage it all by the time of his death. The most integral component of the arboretum—the living collections—included many accessions of plants initially sourced from the Arnold. In the initial establishment of the Morton collections, Sargent provided access to seed, clonal propagation material, and plants.

One such packet of seed was labeled *Ulmus crassifolia* (the cedar elm), and records indicated that the seed had been wild-collected in Brownwood, Texas, by botanist Ernest Jesse Palmer. It was accessioned into the arboretum collections, and seeds were germinated and grown in the nursery. Eventually, a sapling was planted outside the bay window of Morton's study. As the years passed, the tree witnessed Morton's family and guests enjoying summer afternoons by the pool. The sloping vista beneath the elm was crowned by hawthorns for which the estate was named. There were staff picnics for Morton Salt

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

Ware recognized the value of Asian elm species as urban trees in North America. This list outlines species Ware recommended for evaluation and breeding in the *Journal of Arboriculture* and *Landscape Plant News.* Distribution and descriptions have been adapted from his papers.

Company and the Morton Arboretum in the coming decades. The tree overlooks the Morton family cemetery and bore witness to family funerals, but it also provided shade to guests at weddings and garden soirees. Eventually, when the crumbling mansion was demolished long after Morton had died, the tree stood guard over Morton's study, which was preserved as part of a new facility for educating the public about plants and the rest of the natural world.

In 1972, Ware looked at this tree and recognized that it was, in fact, not *Ulmus crassifolia.* The leaves were too large, the bark not quite right, and the form much too refined. As a dendrologist who had been a faculty member at Northwestern State College in Louisiana, Ware was familiar with *U. crassifolia,* which is native to that region. In fact, one of the first deposits Ware made into the arboretum collections in 1968 was a packet of cedar elm seed (Morton accession 385-68) that he had collected from the wild in Seguin, Texas. After further investigation (and even a visit to Arnold), Ware confirmed that the Thornhill Elm was *U. davidiana,* a species native to eastern Asia. Noting the native origin of the species and the lack of symptoms in the tree, Ware saw the possibility that the Dutch elm disease pathogen had Asiatic origins itself. Perhaps the presence of *Ophiostoma ulmi* in the natural habitat of *U. davidiana* had led to coevolution of the species such that the David elm had adapted a natural biochemical defense mechanism to combat the disease. In this tree, Ware saw great potential.

The Thornhill Elm inspired the development of the first breeding program at the Morton Arboretum, the Elm Improvement Program. As a trained ecologist and dendrologist, Ware understood the necessity for genetic diversity within a population. He was soon on the search for more parent material to include in his germplasm collection. By 1980, Ware had clones of the Thornhill Elm propagated and under evaluation. That same year, he published two articles in the *Journal of Arboriculture* focusing on the qualities necessary for trees to survive in human-built landscapes and the attributes of Asian elm species that made them ideal candidates for such an environment. These publications were an effort to raise awareness within a community of tree experts about the possibilities that were held within the genetic resources of Asian elms. While American elms were being felled across the eastern United States, Ware was proposing a new solution to a decades-old problem: Let's plant Asian elms, he suggested, given that these species are adapted to both the constructed environment and the devastating disease. Clones of the Thornhill Elm are now widely available in the commercial nursery trade under the name *Ulmus davidiana* 'Morton' Accolade™.

* * *

When developing any plant breeding program, a breeder must first start with objectives and further refine them by identifying specific desirable traits. Ware's primary objective was to develop elm trees with Dutch elm disease resistance. Second to that, he aimed to develop trees that were not preferred by the elm bark beetles or elm flea weevils (*Orchestes alni*). Beyond pest and disease resistance, Ware would focus on species adapted to environments of the extremes: temperature, drought, flood, high winds, blizzard, and "hostile" soils. He defined hostile soils as those with high pH, poor aeration, and minimal organic matter. He noted that these are all common conditions of the Midwest and Great Plains, and coincidentally, these are the same conditions faced by trees in developed landscapes regardless of the region. Ware went on to list and describe Asian elm species that should be considered for breeding programs.

Meanwhile, Ware began the process of hybridizing elms that were available within the Morton collections. He collected branches covered in rounded floral buds and brought them into his lab. He placed the cut stems in vessels containing water and positioned them upon white sheets of paper spaced out along lab benches. As the forced stems began to flower, yellow piles of pollen would accumulate on the paper, signaling the pollen was ready to be collected and stored. Ware then used a ladder to take this pollen into the canopy of a female parent tree, where he secured a bag over a flowering stem. Making an opening in the bag, he dispersed pollen inside and mimicked the movement of the wind to ensure the pollen made contact with the receptive stigma. Once the bag was securely shut, he climbed down from his ladder and waited. This process led to the development of several new hybrid elms, including *Ulmus* 'Morton Glossy' Triumph™. This selection is one of the most popular of Ware's elm introductions due to its low maintenance requirements in both commercial nursery production and municipal tree management.

While a breeder can develop the best possible plant selection, the plants would not get very far out of the breeding program without help from the nursery industry. Ware was acutely aware of this. While his initial collaborations were with arborists, foresters, and botanists, he would go on to develop strong working relationships with the nursery industry, specifically Keith Warren, the former manager of new plant development for J. Frank Schmidt & Son, based in Boring, Oregon. The two first discussed the possibility of evaluating Ware's elm selections after a Metropolitan Tree Improvement Alliance conference, hosted at Thornhill in June of 1990. This meeting would lead to a collaboration between the Morton and J. Frank Schmidt that continues today, enabling hybrid elm selections to be propagated on greater scales and evaluated in field research.

The first grafting of Ware's elm hybrids at J. Frank Schmidt occurred in 1994—just twenty-two years after Ware recognized the tree's potential and seventy years after being received as seed labeled *Ulmus crassifolia.* The Oregon Department of Agriculture helped the collaborators set up a screened isolation and quarantine area at the commercial nursery, ensuring that DED would not be introduced into the Oregon landscape due to the nursery trade. By 1995, additional propagation material was distributed for in vitro propagation evaluation by Microplant Nurseries, a tissue culture lab based in Gervais, Oregon, managed by Gayle Suttle. At that time, there were not yet any cultivars of *U. davidiana* available through the commercial industry.

Ware also recognized that for elm breeding efforts to be effective, additional genetic material needed to be collected from the wild. When he began his research, he found that few elms of wild provenance were available in the collections of North American public gardens, potentially creating a genetic bottleneck for any North American elm breeding program. The total number of elm species is somewhere within the range of twenty to forty, depending on taxonomic classification, and the center for

Facing page: To develop new elm hybrids, including _Ulmus_ 'Morton Glossy' Triumph™, Ware carefully crossed select trees using pollination bags, secured high within the tree canopy.

PHOTO: JIM NACHEL, STERLING MORTON LIBRARY

Cultivar and trade name	Parentage/ origin	Traits	USDA Hardiness Zones	Dimensions (feet)
Ulmus 'Morton' Accolade™	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′ H, 15′ W Mature 50 – 60′ H 30 – 40′ W
Ulmus 'Morton Plainsman' Vanguard™	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 leafminer	5 – 7	Mature 45 – 50′ H 40 – 50′ W
Ulmus 'Morton Glossy' Triumph™	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′ H 40 – 50′ W
Ulmus 'Morton Stalwart' Commendation™	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′ H 40 – 50′ W
Ulmus 'Morton Red Tip' Danada Charm™	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′ H 50 – 60′ W

This table outlines five of Ware's most well-known elm cultivars. Note that *Ulmus japonica* and *U. wilsoniana* are taxonomic varieties 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 the Chicagoland Grows' *Plant Release Bulletin* (no. 44).

this diversity is unmistakably in eastern Asia. *The Flora of China* indicates that more than half of all elm species are native to the region. Ware and his colleagues ultimately visited China five times and the Soviet Union three times, developing relationships with forestry researchers willing to collect seeds in the wild and ship them to Ware. Today, the Morton's elm collection contains 329 accessioned individuals representing thirty-three species and thirty-four cultivars, a dramatic increase from 1968, when Ware arrived. At that time, the elm collection included fifty-one trees, which represented nine species and ten cultivars. Of the newer individuals accessioned into the Morton collections, eighty-one came directly as plants from Ware's breeding and research program.

Ware also actively distributed seed and plants throughout the United States. He coordinated a seedling distribution program through which he distributed one thousand seedlings to Midwestern nurseries, aiming to popularize the Asian elm species. Municipal foresters and park managers regularly arrived at the Morton Arboretum's service gate searching for elm seedlings he had promised. As the current manager of the program that Ware initiated, I still receive notes from recipients of such gifts who recount fond memories of Ware and his generosity. Today, the seedling trees that he distributed can be found from Oregon to New York and Illinois to Louisiana. Several of Ware's elms were even planted in the late 1980s on the course of the Winged Foot Golf Club, the prestigious host of multiple US Opens in Mamaroneck, New York. This planting was a direct result of a 1987 *New York Times* interview of Ware following the Strobel controversy.

By 1990, Ware had several elm selections in the pipeline and a greatly expanded collection of germplasm. He then began the process of developing a new breeding population. Working with large, wind-pollinated, late-winter-flowering trees presents unique challenges to a breeder. The flowers are insignificant and often located more than six feet above the ground. (I can attest to the complications of these factors as a breeder working with elms today.) To sim-

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Ware (center) embarked on plant-collecting expeditions to acquire new elm germplasm from populations in China and the Soviet Union. His collaborators on this 1990 expedition to Shaanxi Province, China, included (from left) Ross Clark, Peter van der Linden, Kris Bachtell, and William Hess.

plify the hybridization process, Ware developed an isolation block of sorts in a local cemetery. He knew the cemetery would not be paved and that the trees would be left alone until they declined from old age. While Ware retired in 1995, he continued to develop his vision of trees for the future as a research associate of Morton Arboretum until 2009.

The selection criteria that Ware developed for this population include tolerance to DED and elm yellows (a phytoplasma disease, *Candidatus Phytoplasma ulmi,* which causes leaves to suddenly wilt in late summer), pest resistance, cold hardiness, vigor, and red fall color. Red foliage is not commonly seen in elms. Typically, the fall color is a muddy yellow. Ware, however, had noticed an intriguing trait in a group of Asian elm seedlings: red pigmentation in emerging leaves. He understood that if the seedlings could produce red pigmentation (anthocyanins) in leaves during the spring, they should be able to use the same biochemical pathway to produce anthocyanins in the fall. This unexpected discovery led to red fall color becoming a new breeding objective.

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I was hired as the tree and shrub breeder for the Morton Arboretum in 2016. When I arrived here, I was certainly not an elm expert. I had spent my graduate school years working primarily with shrubs and herbaceous perennials. It took some time to unearth the details of the Elm Improvement Program, but today, I can say that we are continuing to make progress with Ware's legacy project. The program is now part of the Daniel P. Haerther New Plant Development Program, named in honor of a generous benefactor of the arboretum who was one of many that Ware inspired to appreciate the development of trees for the urban landscape. Ware consulted about elms on Haerther's estate, and in the process, the two would develop a relationship centered on a love of trees.

Currently, we have sixty-one seedling selections from the breeding population that Ware left behind for the next generation. These were all selected for fall colors ranging from oranges to reds and purples. The breeding population includes the *Ulmus davidiana* complex, a variable group that was historically treated as three

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A young Accolade elm represents the success of Ware's vision for tree breeding and introduction. This commercial introduction is now one of more than twenty-six cultivars of Asian elms available in North America.

separate species (*U. japonica, U. wilsoniana,* and *U. propinqua*). The population also includes three other Asian species (*U. macrocarpa, U. parvifolia, U. pumila*), an Asian hybrid (*U.* 'Sapporo Autumn Gold'), and the European field elm (*U. minor*). Our primary focus has been on the *U. davidiana* complex. We have selected a tree that will serve as the seed parent. It has an attractive form and relatively petite stature, along with somewhat glossy and predation-free foliage in the summer.

We also continue to expand the program, particularly with work on the lacebark elm (*Ulmus parvifolia*). In 1996, Ware published two short articles in *Landscape Plant News* regarding this Asian species. He had participated in a USDA-sponsored research exchange trip to China led by Eugene Smalley from the University of Wisconsin–Madison. Ware and four American colleagues joined Smalley in the field to collect seed and determine the natural range of *U. parvifolia.* They were also very much focused on building relationships with Chinese researchers. Ware considered this elm species to be an especially promising selection for built environments of the South due to its broad adaptability to heat, flooding and drought, hostile soils, and both humid and arid conditions. However, he also noted that it would not perform well in northern states due to limited cold hardiness.

Today, lacebark elms have demonstrated some hardiness with proper site selection. At the Morton Arboretum, seventeen individuals of this species (along with three cultivars and three unnamed hybrids) have survived multiple polar vortexes. I have also witnessed the lacebark elm growing and thriving from North Carolina to New York City and Las Vegas to New Orleans. This widespread adaptability, however, is accompanied by legitimate concerns about weediness. Even though the lacebark elm has not been widely planted in the Midwest, it is already listed as a weed of concern in Wisconsin. Colleagues at public gardens in other regions have expressed similar apprehensions about the species. This concern has led us to develop a new elm improvement project at the Morton Arboretum focused on developing selections with reduced fertility.

Breeders have long used methods of mutation breeding to develop seedless plants. The most commonly known examples include the seedless watermelon and banana. These were developed through a traditional breeding method referred to as interploidy hybridization. Ploidy is the number of complete sets of chromosomes found in the cells of an organism. Humans typically carry two sets of chromosomes (diploid)—

one set inherited from our mother, the other from our father. A plant, however, can carry many more sets of chromosomes within its cells. Having three sets of chromosomes (triploid) often causes issues in reproduction due to the odd number of chromosomes that cannot segregate evenly during meiosis. To develop a triploid, a breeder must hybridize a diploid and a tetraploid (four sets of chromosomes). Tetraploids can be developed through the application of chemical mutagens known as mitotic spindle fiber inhibitors. (One such chemical is colchicine, a toxic compound found in the autumn crocus, *Colchicum autumnale.*) We currently have several tetraploid lacebark elms, but now we must wait for them to mature. Once these trees have reached maturity, we will hybridize them with diploids in our collections that are reasonably cold hardy.

Meanwhile, from the *Ulmus crassifolia* seed that Ware deposited in the Morton Arboretum collections in 1968, we have selected a tree with a remarkably symmetrical and pyramidal form that has survived severe winters and flooding events unscathed. We are building numbers of rooted cuttings to grow in evaluation blocks, inoculate with DED, and distribute to partners for evaluation around the country. Additionally, both this species and the lacebark elm are fall-flowering species. Considering they are wind-pollinated and not self-compatible, we have begun collecting open-pollinated seed from our cedar elm selection and an adjacent lacebark elm, and we plan to evaluate the resulting seedlings. According to a paper published by USDA researcher Frank Santamour in 1973, not only are the two species compatible, but the lacebark elm confers increased DED resistance to its hybrid progeny.

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As Ware noted in his 1987 *New York Times* interview, the Morton Arboretum's effort to develop new trees for the American landscape has been focused on traditional breeding efforts. These slow and steady methods have required several decades, spanning multiple careers. Yet, the value in Ware's approach to breeding and outreach is evident in today's nursery catalogs and landscape. Once there were monocultures of American elm planted across the country in the built landscapes of cities and suburbs, but today the monocultures have been replaced with DED-resistant Asian elms. This diversity includes more than thirteen cultivars of elms from the *Ulmus davidiana* complex, in addition to at least thirteen cultivars of *U. parvifolia.* Many more selections of various species are still in the pipeline from academic and commercial breeding programs around the country.

Through tenacity and vision, George Ware managed to inspire the nursery industry to adopt a new crop and introduce an unfamiliar Asian elm species to the North American landscape. The work has resulted in further diversification of our tree palette. It all began with the original Thornhill Elm, distributed to the Morton Arboretum by the Arnold Arboretum almost a century ago. Now, this very selection graces the landscape of the city of Boston, having come full circle in its journey from seed to cultivated tree.

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Kim Shearer is the tree and shrub breeder at the Morton Arboretum, where she is also manager of the Daniel P. Haerther Charitable Trust New Plant Development Program and woody plant liaison for Chicagoland Grows.

ENZENBACHER, T. 2021. A TEMPERATE COUSIN: *LEITNERIA FLORIDANA. ARNOLDIA*, 78(4): 48–49

A Temperate Cousin: *Leitneria floridana*

Tiffany Enzenbacher

"Stop! We're here!" directed Kea Woodruff, who was navigating from the passenger seat of our rented vehicle. Woodruff was then the Arnold Arboretum's plant growth facilities manager. We were on day three of a 2018 plant-collecting expedition to Arkansas and Oklahoma—part of the Arboretum's Campaign for the Living Collections—and we were driving up Highway 62 in northeastern Arkansas, approaching the Missouri border. Months prior, we reached out for guidance on our Ozark-specific taxa list to the Arkansas National Heritage Commission. They provided an account of a particular population of corkwood (*Leitneria floridana*), a rare shrub sparsely endemic to the southeastern United States. We dropped a Google pin on the approximate location of their 2003 description and hoped that no habitat loss occurred between then and October 2018. I steered onto the shoulder, and we began scouring the nearby flora as traffic whizzed by.

After what seemed like only a moment, Woodruff pointed to a promising-looking stand. "Wait," she inquired, "isn't that it?" Corkwood is a striking plant, and we were able to confirm it in short order. It is monotypic (the only species in its genus) and is in a mostly tropical family, Simaroubaceae. The most well-known and recognizable temperate member is the tree of heaven (*Ailanthus altissima*), a noxious urban weed. The noninvasive, but just as conspicuous, corkwood typically grows five to ten feet tall—although it can reach up to twenty feet. It is adorned with elliptic olive-green leaves that are glossy, leathery, and crowded toward branch tips. The common name derives from the buoyancy of the wood. It is one of the lightest woods known and has been used to float fishing nets. The bark is a deep reddish-brown with lenticels. Corkwood is content to sucker and form thickets, particularly in its ideal environment: forested swamps and flooded soils.

The Arboretum's inaugural corkwood plants (accession 5336) arrived from botanist Benjamin Franklin Bush, who sent plants in 1894, just two years after he had first documented the species in southeastern Missouri. (The species had been named, in 1860, by Alvan Wentworth Chapman, based on populations in the estuary of Florida's Apalachicola River.) The plants prospered along Meadow Road, in a location affectionately known as "*Leitneria* swamp," where water accumulates and persists throughout most of the year. Eventually, this accession became indistinguishable from other corkwoods that were planted around 1970, and the mixed planting was given a new accession number (244-97). Plants from Taylor County, Florida, were later added to the location (accessions 29-96 and 30-96). The species is near threatened in the wild and remains in several Florida and Texas counties abutting the Gulf, and a few inland ones in Arkansas, Georgia, Mississippi, and Missouri.

Woodruff and I were determined not to let several feet of muck act as a deterrent. I repurposed two herbarium voucher bags as waders and bounded in. As we had anticipated, we found no fruit. The olive-sized brown drupes are borne in clusters of two to four near branch tips, below the foliage. Corkwood is dioecious, having separate male and female plants. Flowers are axillary catkins approximately one-and-a-half inches long. This colony could have been a single sex, or perhaps voracious critters beat us to the fruit. Plan B consisted of combing for small suckers. We dug three, which we bagged and labeled as puzzled drivers drove past.

From there, we continued to the nearest FedEx location, where we were grateful for the kindness of strangers. After we explained that we hailed from Boston and were in the midst of an expedition, the store clerks were keen to facilitate packaging in the tallest boxes they had available. The plants arrived the next day at the Dana Greenhouse, where they were potted and catalogued (accession 278-2018). In April 2020, the three individuals were planted in the seep on Bussey Hill—this time a location distinct from any others. I hope these plants will colonize the seep over the next decade, just as the original collection has done to the *Leitneria* swamp.

Tiffany Enzenbacher is the manager of plant production at the Arnold Arboretum.

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