

Saratoga Horticultural Research Endowment Grant Final Report
Introduction and Testing of Texas Trees in Sacramento Valley Landscapes

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Investigators

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INTRODUCTION

With support from the Saratoga Horticultural Research Endowment, we launched the first year of a multi-year project to introduce and test new landscape trees from arid zones in west and central Texas in Sacramento Valley landscapes. With climate change, California's interior cities are projected to become significantly hotter, which will reduce the palette of urban trees available to shade streets and sequester carbon. There is a pressing need to expand the palette of climate-ready trees available for California's urban landscapes in the Central Valley, which are predicted to shift to more desert-like climate conditions by the end of the 21st century. Many native plants of the Chihuahuan Desert region and Hill Country of Texas are well-adapted to extreme heat, drought, and alkaline soils. Trees from this region already comprise some of the recommended low-water species for desert climates in California. The first year of our project focused on gathering information about the performance of trees from west and central Texas in interior California landscapes and acquiring and propagating plants from a target list of 37 taxa for future field testing in the Sacramento Valley climate.

MATERIALS AND METHODS

Expert Survey

At the outset of the project we identified 37 target Texas taxa that represented the most promising candidates for propagating and trialing based on information from Michael Powell's *Native Plants in Landscaping* and the Lady Bird Johnson Wildflower Center's Native Plant Database. We generated an online survey to gather feedback from California and Texas tree experts about the landscape performance of our 37 taxa and received ten responses (see Figures 1 and 2). Following up on the survey, we consulted with several experts in person while traveling in Texas, and their feedback has guided the addition of new taxa to our list. A few Texas horticulturists also provided propagation advice that supplemented information that we gathered from Jill Nokes' *How to Grow Native Plants of Texas and the Southwest* and the Lady Bird Johnson Wildflower Center Native Plant Database.

Experts consulted via survey or interview for this project include:

California

Jim Downer

Advisor

UC Cooperative Extension Ventura County

Donald R. Hodel

Environmental Horticulture Advisor Emeritus

UC Cooperative Extension Los Angeles County

Greg McPherson

Emeritus Scientist

USFS Pacific Southwest Research Station

David Muffly

Consulting Arborist

Oaktopia

Warren Roberts

Superintendent Emeritus

UC Davis Arboretum and Public Garden

Stewart Winchester

Horticulture Instructor

Merritt College

Texas

Adam Black

Director of Horticulture

Peckerwood Garden

Seth Hamby

Head Gardener

Chihuahuan Desert Nature Center

Dan Hosage

Owner

Madrone Nursery

Andrew McNeil-Marshall

Arborist

Lady Bird Johnson Wildflower Center

Michael Merritt

Regional Urban Forestry Coordinator

Texas A&M Forest Service

Michael Powell

Professor Emeritus and Herbarium Director

Sul Ross State University

David Richardson

Arborist

University of Texas Southwest Medical Center

Phillip Schulze

Site Manager

Lady Bird Johnson Wildflower Center

Plant Acquisition

Introducing new plants to cultivation in California was a major focus of this project. Because the targeted trees are not readily available in the California horticultural trade, traveling to Texas to collect propagation material directly from the source was a key element of the project. Due to phytosanitary concerns, we chose not to bring any rooted plants or soil back to California. Instead, we focused our efforts on seed collection.

Each seed collection was accessioned in the UC Davis Arboretum and Public Garden's plant records database with detailed information on the collecting locality (including geographic coordinates), surrounding habitat if applicable, and the condition of the parent plant (see Figure 3). Whenever possible, care was taken to collect seeds from individual plants that exhibited superior health and a form that would be favorable in an urban landscape setting.

The majority of seed acquisition for the project occurred on a collecting trip to Texas that was timed for mid-September to maximize the availability of ripe seeds. Emily Griswold, Abbey Hart, and student intern Ellen Sanders-Raigosa traveled to Texas from September 12 to 19, 2019 to learn more about our study trees and collect propagation material. Adam Black, Director of Horticulture for Peckerwood Garden was our local guide and collecting partner, and he arranged access to several private properties with landowner permission to collect. Most seeds were collected directly from wild populations.

Collections from cultivated plants at the Lady Bird Johnson Wildflower Center and the Chihuahuan Desert Research Institute supplemented this material. Based on feedback from Texas horticulturists, we expanded our palette to include 12 additional species.

We were unable to collect some taxa on our target list while we were in Texas. Some species were not accessible to us on our itinerary and others lacked sufficient ripe seed for us to collect for our project. For seven of the target species that have ranges extending into Arizona, we were able to opportunistically collect seeds for those taxa while performing field work for another project in that state. Three species with late ripening seeds were collected in November by Lady Bird Johnson Wildflower Center arborist Andrew McNeil-Marshall and mailed to us. Seeds for two taxa were also collected from cultivated plants in the UC Davis Arboretum.

See Figure 3 for a full list of plant acquisitions and their sources, collection locality, specimen and ecological details. This list does not include plants that were already in propagation before the project began.

Propagation

Performing rigorous propagation trials for each tree species was beyond the scope of this grant project. However, we kept detailed propagation records to allow us to track and share the results of our efforts. Nursery student employee Ellen Sanders-Raigosa took the lead on cleaning seeds, researching recommended propagation protocols, and implementing and recording propagation efforts. For taxa where conflicting or no protocol information was found, we did preliminary trials of various propagation treatments.

Each propagation attempt was recorded with a unique propagation number along with details including: the plant accession number, date, seed pretreatments, pot/flat type, and growing environment (heated greenhouse, mist, cold). Records were updated when seedlings were ready to be up-potted to track germination rates and propagation success.

Depending on size and quantity, seeds were sown communally in flats or individually in plug trays or cone-tainers. Species with seeds that are attractive to rodents (acorns, walnuts, and pecans) were grown in protective wire mesh cages. We built a second cage structure to accommodate our expanding inventory (see Photo 6). As seedlings have developed, they have been shifted up to 4" wide and 8" deep air pruning pots (Pioneer Pot™) to encourage the development of a fibrous root system. Faster-growing seedlings are currently being up-potted to several types of 3-gallon and 5-gallon pots to be ready for planting out in winter 2020-21 for field trials. We are trialing air pruning RootMaker® 3-gallon (RootTrappers and Injection-molded) pots to continue the development of fibrous, non-circling root systems as well as conventional 3-gallon and 5-gallon tree pots to compare and trial. Supplemental liquid fertilizer has been provided as needed to address the high levels of boron and sodium in our irrigation water supply.

See Figure 4 for the detailed results of all propagation efforts. See Figure 5 for a current nursery inventory and summary of propagation results for each taxon.

RESULTS

Please see the following figures and photos at the end of this report for our project results:

Figure 1. Expert Survey Results Ranked by Performance Rating

Figure 2. Horticultural Performance Chart

Figure 3. Plant Acquisitions and Source Information

Figure 4. Detailed Results from all Propagation Attempts

Figure 5. Taxon Propagation Results and Inventory Summary

Figure 6. Sample Interpretive Sign

Project Photographs

DISCUSSION

Our collection and propagation efforts have been even more successful than we anticipated. Through collection trips to Texas and Arizona and contributions from partner institutions, we were able to collect 75 unique accession items of 44 taxa. This included twelve taxa not originally in our proposal. Propagation of these items has been highly successful resulting in more than 1,100 tree seedlings of 41 taxa (including four taxa that were already in production before the project began). The COVID-19 shelter-in-place orders posed a significant challenge to our operations this spring, but maintaining and continuing the research became the primary priority of Abbey Hart's essential duties, and we were able to avoid plant losses.

The majority of the species we collected show promising results in this first phase of trialing their horticultural performance in a nursery container environment. Future research is needed where we had inconsistent or no propagation success with the following taxa: *Morus microphylla*, *Fraxinus albicans*, *Prunus serotina* var. *virens*, *Tilia americana* var. *caroliniana*, *Pinus remota*, *Pinus cembroides*, *Styphnolobium affine*, *Diospyros texensis*. Our research will continue with the support of the Saratoga Horticultural Endowment grant through 2020-21 by beginning field trials of approximately 10 taxa. We will also expand our nursery capacity to accommodate the growing inventory of over 1,000 trees for this project in preparation for the next series of field trials in 2021 and beyond.

The success of this project is in great part thanks to the collaboration and assistance of the 14 experts highlighted in the Methods section. We have gained valuable insight through the survey we developed and disseminated, the in-person meetings in Texas and in ongoing consultations with regional experts. This collaboration helped guide the species we chose to trial, their collection localities and propagation methods.

In order to build on and further disseminate this knowledge, we aim to share our findings with horticultural professionals and students as well as the public as this project continues. Abbey Hart wrote an article for the fall 2019 issue of *The UC Davis Arboretum and Public Garden Review* describing the research project and its goals. This publication was distributed to the 1750 members of the Friends of the UC Davis Arboretum and Public Garden and is also accessible to the public as a blog post on our website which receives approximately 500,000 visits per year. With funding from Saratoga Hort for the

2020-21 year, we plan to further improve access to our work by building a user-friendly web resource for sharing research information and results.

Public engagement and student learning and career development training through the Learning by Leading™ internship program have been instrumental to the success of this project and will continue in the coming year. In our first year, Nursery interns and Museum Education interns have played important roles in implementing and sharing stories about this research. The Museum Education interns interviewed Nursery interns and staff to create a series of temporary interpretive signs about the project for installation in Shields Oak Grove (see Figure 6 for an example). Our oak collection includes examples of several Texas species that are part of this project which are highlighted by the signs.

This January we also selected and hired two additional student interns to assist with the project through summer of 2021. They have been assisting with propagation, plant care, and record-keeping in the nursery, and are in the midst of planning implementation of fall field trials. They are also helping develop the curriculum for a new Learning by Leading™ Urban Tree Stewardship student intern team focused on tree propagation, young tree care, and urban forestry that they will launch in winter 2021 with the goal of involving more interns in the project. The experience these students are gaining in horticultural research, as well as the unique opportunity for field-work experience that Ellen Sanders-Raigosa received, are critical to the development of the next generation of horticultural leaders.

WORKS CITED

Lady Bird Johnson Wildflower Center Native Plant Database. Accessed summer and fall 2019.
<https://www.wildflower.org/plants/>

Nokes, Jill. *How to Grow Native Plants of Texas and the Southwest*. University of Texas Press, 2001.

Powell, A. Michael, and Shirley A. Powell. *Native Plants in Landscaping: Trees, Shrubs, Cacti, and Grasses of the Texas Desert and Mountains*. Iron Mountain Press, 2005.

Figure 1. Expert Survey Results Ranked by Performance Rating

Tree Species	Average rating of horticultural performance		California respondents with species experience	Texas respondents with species experience
<i>Quercus laceyi</i> (Lacey oak)	4.00	excellent	40%	100%
<i>Quercus oblongifolia</i> (Mexican blue oak)	3.86	excellent	80%	60%
<i>Sophora affinis</i> (syn. <i>Styphnolobium affine</i>) (Texas sophora, Eve's necklace)	3.83	excellent	20%	100%
<i>Quercus arizonica</i> (Arizona white oak)	3.75	excellent	40%	40%
<i>Quercus muehlenbergii</i> (Chinquapin oak)	3.75	excellent	60%	100%
<i>Ungnadia speciosa</i> (Mexican buckeye)	3.75	excellent	60%	100%
<i>Quercus fusiformis</i> (Escarpment live oak)	3.67	excellent	80%	100%
<i>Sophora secundiflora</i> (syn. <i>Dermatophyllum secundiflorum</i>) (Texas mountain laurel)	3.67	excellent	80%	100%
<i>Fraxinus greggii</i> (Gregg's Ash)	3.57	good/excellent	40%	100%
<i>Quercus gravesii</i> (Chisos red oak)	3.57	good/excellent	60%	80%
<i>Cercis canadensis</i> var. <i>texensis</i> (Texas Redbud)	3.50	good/excellent	20%	100%
<i>Leucaena retusa</i> (Goldenball leadtree)	3.50	good/excellent	20%	100%
<i>Fraxinus albicans</i> (Texas ash)	3.40	good/excellent	0%	100%
<i>Juglans microcarpa</i> (Texas little walnut)	3.33	good	20%	100%
<i>Prunus mexicana</i> (Mexican plum)	3.33	good	80%	100%
<i>Prosopis glandulosa</i> (Honey mesquite)	3.30	good	100%	100%
<i>Cotinus obovatus</i> (American smoketree)	3.29	good	80%	60%
<i>Fraxinus cuspidata</i> (Fragrant ash)	3.25	good	0%	80%
<i>Cercis canadensis</i> var. <i>mexicana</i> (Mexican redbud)	3.22	good	80%	100%
<i>Diospyros texana</i> (Texas persimmon)	3.17	good	20%	100%
<i>Quercus grisea</i> (Gray oak)	3.13	good	60%	100%
<i>Bauhinia lunarioides</i> (Texasplume)	3.00	good	40%	100%
<i>Juniperus deppeana</i> (Alligator juniper)	3.00	good	80%	100%
<i>Morus microphylla</i> (Texas mulberry)	3.00	good	0%	60%
<i>Pinus edulis</i> (Colorado pinyon pine)	3.00	good	20%	40%
<i>Pinus ponderosa</i> var. <i>scopulorum</i> (Rocky Mountain yellow pine)	3.00	good	0%	40%
<i>Quercus graciliformis</i> (Graceful oak)	3.00	good	20%	100%
<i>Sapindus saponaria</i> var. <i>drummondii</i> (Western soapberry)	2.88	good	60%	100%
<i>Quercus emoryi</i> (Emory oak)	2.86	good	40%	100%
<i>Ulmus crassifolia</i> (Texas cedar elm)	2.83	good	20%	100%
<i>Pinus cembroides</i> (Mexican pinyon pine)	2.67	good	20%	40%
<i>Pinus remota</i> (Texas pinyon pine)	2.50	fair/good	0%	80%
<i>Pistacia texana</i> (syn. <i>Pistacia mexicana</i>) (American pistachio)	2.50	fair/good	0%	80%
<i>Quercus stellata</i> (Post oak)	2.17	fair	20%	100%
<i>Arbutus xalapensis</i> (Texas madrone)	2.00	fair	40%	100%
<i>Quercus marilandica</i> var. <i>ashei</i> (Blackjack oak)	2.00	fair	20%	100%
Average experience			39%	88%

The electronic survey was administered between July 31 and August 8 in 2019. Ten respondents included five California horticultural experts and five Texas horticultural experts.

Figure 2. Horticultural Performance Chart

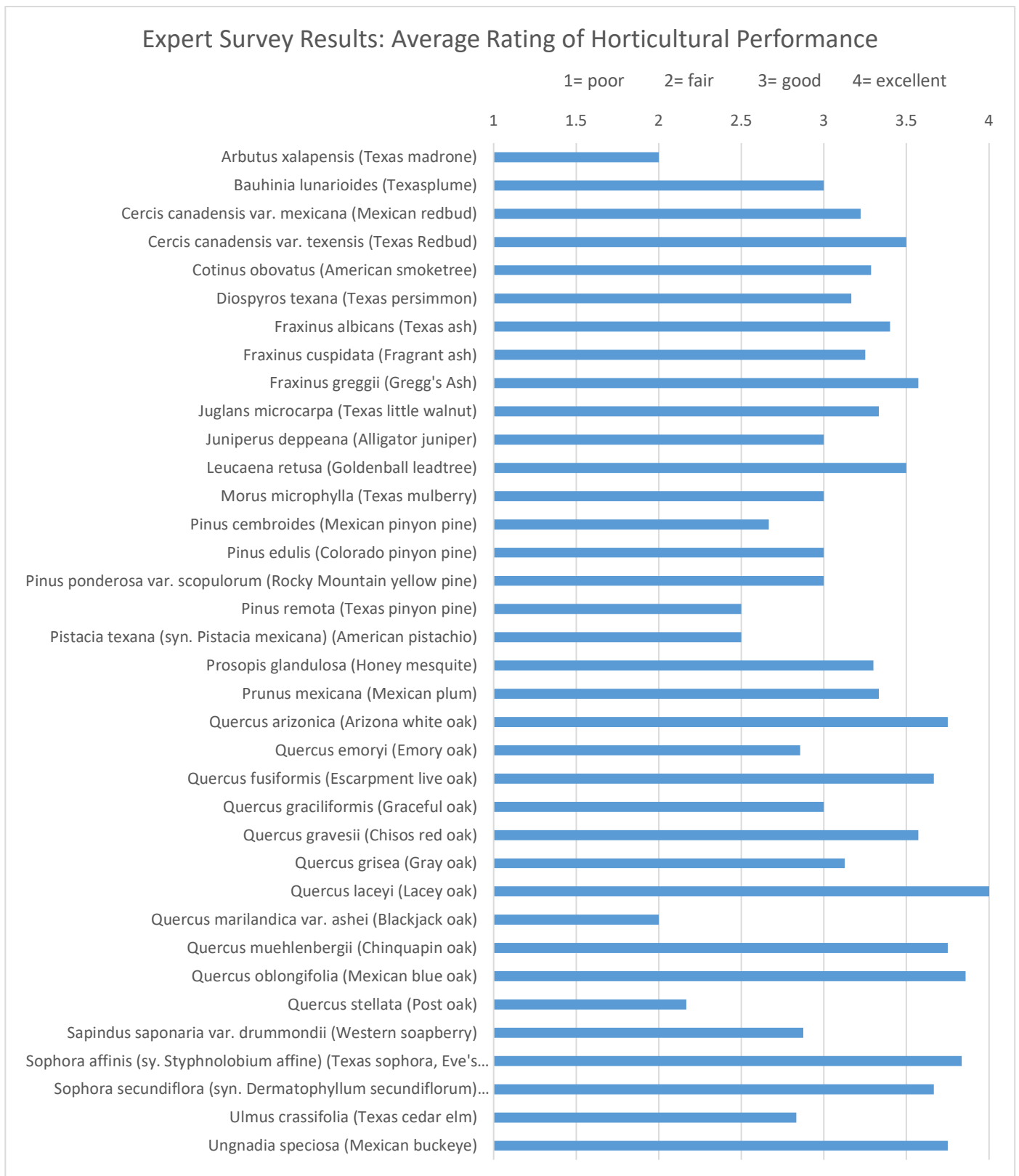


Figure 3. Plant Acquisitions and Source Information

Acc #	Scientific Name	Provenance	Received Date	Source State	Source County	Locality detail	Plant description	Associates
2019.873	<i>Acacia wrightii</i> *	Wild	9/20/2019	Texas	Uvalde County	growing in hedgerow between highway and railroad	Multistemmed large shrub/small tree, 15' tall, 20' wide, sinuous branching, spreading habit, small white flower spikes, 4" long reddish brown flattened fruits	<i>Prosopis glandulosa</i> , <i>Artemisia ludoviciana</i>
2019.822	<i>Acer grandidentatum</i> *	Wild	9/20/2019	Texas	Bandera County	growing on slope on upper terrace above creek on limestone soil	Single trunked deciduous tree, 35' tall, 40' wide, 24" dbh. Large tree leaning to south, leaves with minimal secondary lobing, gray bark, excellent health and heavily fruiting.	<i>Juniperus ashei</i> , <i>Aesculus pavia</i> var. <i>flavescens</i> , <i>Celtis</i> , <i>Diospyros texana</i> , <i>Juglans major</i> , <i>Quercus muehlenbergii</i> , <i>Quercus fusiformis</i>
2019.834	<i>Acer grandidentatum</i> *	Wild	9/20/2019	Texas	Bandera County	north-facing slope, rocky limestone soil, heavily wooded	Single trunked deciduous tree, 35' tall, 25' wide, 12" dbh, good health, gray bark with vertical fissures, medium green foliage	<i>Celtis</i> , <i>Juniperus ashei</i> , <i>Tilia americana</i> var. <i>caroliniana</i> , <i>Juglans major</i> , <i>Quercus buckleyi</i> , <i>Fraxinus albicans</i>
2019.821	<i>Arbutus xalapensis</i>	Wild	9/20/2019	Texas	Bandera County	north side of road	Multitrunked evergreen tree, 20' tall, 30' wide, 3 main trunks, largest trunk 20" diameter	<i>Juniperus ashei</i> , <i>Quercus fusiformis</i> , <i>Rhus aromatica</i> , <i>Prunus serotina</i> var. <i>eximia</i> , <i>Mahonia trifoliata</i> , <i>Garrya</i> , <i>Matelea reticulata</i> , <i>Zanthoxylum</i>
2019.872	<i>Arbutus xalapensis</i>	Wild	9/20/2019	Texas	Real County	dense woodland	Single trunked evergreen tree, 15' tall, 12' wide, 8" diameter trunk, smooth pale bark, rounded crown, berries ripening from green to orange	<i>Garrya lindheimeri</i> , <i>Juniperus ashei</i> , <i>Quercus fusiformis</i> , <i>Vitis</i>
2019.1227	<i>Arbutus xalapensis</i>	Garden	12/11/2019	Texas	Travis County	LBJ Wildflower Center		
2019.1228	<i>Arbutus xalapensis</i>	Wild	12/11/2019	Texas	Hays County			
2019.907	<i>Bauhinia lunarioides</i>	Garden	9/20/2019	Texas	Jeff Davis County	Chihuahuan Desert Research Institute Botanical Garden		
2019.914	<i>Carya illinoensis</i> *	Wild	9/20/2019	Texas	Gillespie County	growing at top of rocky limestone roadcut in oak savanna	Multitrunked deciduous tree, 18' tall, 20' wide, trunks 4" to 6" dbh, yellow-green foliage and oval green fruits	<i>Quercus fusiformis</i> , <i>Saponaria drummondii</i> , <i>Lonicera albiflora</i>

Acc #	Scientific Name	Provenance	Received Date	Source State	Source County	Locality detail	Plant description	Associates
2019.825	<i>Celtis aff. laevigata</i> *	Wild	9/20/2019	Texas	Bandera County	growing on slope on upper terrace above creek on limestone soil	Single trunked deciduous tree, 35' tall, 35' wide, 22" dbh, gray bark with clusters of rough plates, fairly good health with dieback at top of canopy, 1/4" orange-brown fruits.	<i>Acer grandidentatum</i> , <i>Juniperus ashei</i> , <i>Aesculus pavia</i> var. <i>flavescens</i> , <i>Diospyros texana</i> , <i>Juglans major</i> , <i>Quercus muehlenbergii</i> , <i>Quercus fusiformis</i>
2019.837	<i>Celtis lindheimeri</i> *	Wild	9/20/2019	Texas	Uvalde County	at edge of ranch road near goat pasture, shallow slope on north side of hill	Single trunked deciduous tree, 30' tall, 30' wide, 15" dbh, rough light gray bark with vertical ridges, covered with lichens and ball moss, olive-brown berries, ovate to lanceolate leaves medium green, slightly paler on abaxial surface with light pubescence	<i>Ulmus crassifolia</i> , <i>Monarda citriodora</i> , <i>Diospyros texana</i> , <i>Juniperus ashei</i>
2019.863	<i>Cercis canadensis</i> var. <i>texensis</i>	Wild	9/20/2019	Texas	Uvalde County	growing on rocky limestone slope in thicket	Multistemmed deciduous shrub, 12' tall, leaves curled upward, slightly undulate leaf margin	<i>Rhus virens</i> , <i>Juniperus ashei</i> , <i>Leucaena retusa</i> , <i>Yucca</i> , <i>Quercus fusiformis</i> , <i>Mahonia trifoliata</i>
2019.864	<i>Cercis canadensis</i> var. <i>texensis</i>	Wild	9/20/2019	Texas	Real County	growing in open woodland	Multiple deciduous shrubs, 10' tall	<i>Quercus marilandica</i> var. <i>ashei</i> , <i>Dermatophyllum secundiflorum</i> , <i>Styphnolobium affine</i> , <i>Diospyros texana</i>
2019.912	<i>Cercis canadensis</i> var. <i>texensis</i>	Wild	9/20/2019	Texas	Kimble County	row of seedlings along fenceline	Multitrunked deciduous shrubs, 10' tall, older plants with 2" to 3" diameter stems, smooth gray bark, glossy yellow-green foliage, abaxially glabrous, leaves up to 4" long, many mahogany-brown seed pods, most seeds aborted	<i>Quercus fusiformis</i> , <i>Yucca constricta</i> , <i>Juniperus ashei</i>
2019.972	<i>Cercis canadensis</i> var. <i>texensis</i> 'Alba'	Garden	10/3/2019	California	Yolo County	UC Davis Arboretum and Public Garden		
2019.649	<i>Cupressus arizonica</i> *	Wild	8/12/2019	Arizona	Coconino County	East facing slope above creek		<i>Juniperus</i> , <i>Platanus wrightii</i> , <i>Rubus</i> , <i>Cercocarpus</i> .
2019.840	<i>Dermatophyllum secundiflorum</i>	Wild	9/20/2019	Texas	Uvalde County	along rough ranch road, growing on gradual west-facing slope, open woodland	Multitrunked evergreen tree, 20' tall, 20' wide, trunks 8" to 10" dbh, dark brown bark somewhat stringy with vertical fissures, glossy green foliage, most seed pods soft and 1 year old	<i>Quercus fusiformis</i> , <i>Juniperus ashei</i> , <i>Mahonia trifoliata</i> , <i>Diospyros texana</i> , <i>Quercus buckleyi</i>

Acc #	Scientific Name	Provenance	Received Date	Source State	Source County	Locality detail	Plant description	Associates
2019.884	<i>Dermatophyllum secundiflorum</i>	Wild	9/20/2019	Texas	Jeff Davis County	growing in open shrubland between two boulders near fence	Evergreen shrub, 9' tall, 8' wide, low branching and 6' diameter at base of trunk, upright branching, rounded crown, medium green leaves with light pubescence adaxially and pale green with heavy pubescence abaxially, papery thin fruit wall, likely last year's fruit. This plant was spotted by Adam Black as a "silver leaf form" in fall of 2018. The distinctive color was no longer strongly apparent.	Atriplex canescens, Aloysia gratissima, Bouteloua curtipendula, Acacia greggii
2019.820	<i>Diospyros texana</i>	Wild	9/20/2019	Texas	Travis County	Oak savanna with dry grass understory. Growing under oak canopy		Quercus fusiformis
2019.882	<i>Diospyros texana</i>	Wild	9/20/2019	Texas	Brewster County	dense woodland in drainage area	Multistemmed evergreen tree, 12' tall, many stems	Mahonia trifoliata, Quercus mohriana, Pinus remota, Prosopis glandulosa
2019.919	<i>Fraxinus albicans</i>	Wild	9/20/2019	Texas	Travis County	growing in thickly wooded area behind guard rail along road edge above Collier Hollow	Multitrunked deciduous tree, 18' tall, trunks 2" to 4" diameter, pale gray bark, medium green foliage, paler abaxially	Rhus virens, Juniperus ashei, Celtis, Eysenhardtia
2019.908	<i>Fraxinus cuspidata</i>	Garden	9/20/2019	Texas	Jeff Davis County	Chihuahuan Desert Research Institute Botanical Garden		
2019.877	<i>Fraxinus greggii</i>	Wild	9/20/2019	Texas	Brewster County	growing in canyon along dry creek drainage	Multistemmed evergreen shrubs, 10' to 12' tall, many stems ranging from 1" to 2" diameter, glossy green pinnately compound leaves, gray bark	Eysenhardtia, Lycium, Leucaena retusa, Diospyros texana, Juniperus pinchottii, Quercus mohriana
2019.652	<i>Juglans major</i>	Wild	8/12/2019	Arizona	Gila County	Granite boulder strewn canyon bottom		Rhus aromatica, Chilopsis, Pinus monophylla, Fraxinus lowellii, Quercus turbinella.
2019.818	<i>Juglans major</i>	Wild	9/11/2019	Texas	Kerr County	Top of drainage above creek with limestone bed		Quercus buckleyi, Quercus fusiformis, Juniperus ashei, Rhamnus, Celtis, Smilax, Vitis.

Acc #	Scientific Name	Provenance	Received Date	Source State	Source County	Locality detail	Plant description	Associates
2019.885	<i>Juglans microcarpa</i>	Wild	9/20/2019	Texas	Jeff Davis County	steep slope along Limpia Creek Canyon	Multitrunked deciduous tree, 15' tall, 30' wide, trunks 8" to 10" diameter, light gray bark peeling with vertical fissures, medium yellow-green foliage, ripe 1" diameter fruits, spreading form, vigorous and in good health	Chilopsis linearis, Celtis reticulata, Bouteloua curtipendula, Rhus aromatica, Prunus serotina var. virens, Mahonia trifoliata
2019.857	<i>Leucaena retusa</i>	Wild	9/20/2019	Texas	Uvalde County	growing in dense thicket of thornscrub approximately 50 yards from the Frio River channel	Multitrunked tree, 12' tall, large curled seed pods, few leaves at the top of canopy, two individuals but otherwise uncommon	Acacia, Condalia, Rhus virens
2019.862	<i>Leucaena retusa</i>	Wild	9/20/2019	Texas	Uvalde County	growing on rocky limestone slope	Single trunked deciduous tree, 12' tall, 12' wide, 4" dbh, locally common along road edge	Rhus virens, Juniperus ashei, Cercis canadensis var. texensis, Yucca, Quercus fusiformis, Mahonia trifoliata
2019.894	<i>Leucaena retusa</i>	Wild	9/20/2019	Texas	Jeff Davis County	rocky slope, igneous soil, open oak-pinyon-juniper woodland	Single trunked deciduous tree, 15' tall, 20' wide, 8" dia trunk, broad spreading form, lush green canopy, pods green ripening to caramel brown, gray-tan bark with small peeling patches, brittle branches	Quercus grisea, Dasyllirion leiophyllum, Pinus cembroides
2019.847	<i>Morus microphylla</i>	Wild	9/20/2019	Texas	Uvalde County	in dense woodland on rocky southwest-facing slope, limestone	Multistemmed deciduous shrub, 15' tall, 4 main trunks, 4" to 6" diameter, many small basal sprouts, solitary plant	Juniperus ashei, Diospyros texana, Quercus laceyi, Vitis, Forestiera reticulata, Mahonia trifoliata
2019.893	<i>Pinus cembroides</i>	Wild	9/20/2019	Texas	Jeff Davis County	top of road cut above highway	Single trunked evergreen tree, 30' tall, 30' wide, 24" dbh, deeply fissured and blocky gray bark, broadly conical crown, excellent health and strong branch structure	Quercus emoryi, Cyllindropuntia imbricata, Rhus aromatica, Piptochaetium fimbriatum
2019.896	<i>Pinus cembroides</i>	Wild	9/20/2019	Texas	Jeff Davis County	rocky north-facing slope, igneous soil, oak-pinyon-juniper woodland	Single trunked evergreen tree, 25' tall, 25' wide, 12" dbh, rough dark gray bark, 1.5" needles 3 per fascicle, heavily coning with copper-colored cones, upright and spreading form with outer branches pendulous	Quercus grisea, Juniperus deppeana, Quercus emoryi

Acc #	Scientific Name	Provenance	Received Date	Source State	Source County	Locality detail	Plant description	Associates
2019.898	<i>Pinus ponderosa</i> var. <i>scopulorum</i>	Wild	9/20/2019	Texas	Jeff Davis County	flat terrace, open woodland	Single trunked evergreen tree, 40' tall, 30' wide, tall and narrow conical form, 9" long light green needles 3 per fascicle, green cones	Piptochaetium fimbriatum, Artemisia ludoviciana, Stipa tenuissima, Quercus emoryi, Pinus cembroides, Juniperus deppeana, Quercus grisea
2019.869	<i>Pinus remota</i>	Wild	9/20/2019	Texas	Real County	thick woodland	Evergreen trees of varying heights up to 30' tall, small cones open and shedding seed, trees with conical form when young and rounded canopy in age	Juniperus ashei, Quercus fusiformis
2019.871	<i>Pinus remota</i>	Wild	9/20/2019	Texas	Real County	rocky limestone soil	Evergreen trees, 12' tall, rounded crowns	Dermatophyllum secundiflorum, Opuntia, Forestiera reticulata, Diospyros texana, Mahonia trifoliata, Rhus lanceolata, Quercus vaseyana, Dalea frutescens
2019.874	<i>Pistacia texana</i>	Garden	9/20/2019	Texas	Val Verde County	growing in cultivated native plant demonstration garden in turf of small draw near the stone bridge	Multistemmed evergreen trees, 20' tall, 30' wide, trunks ranging from 6" to 12" dbh, female trees covered with 1/4" red berries aging to dark purple	
2019.859	<i>Prosopis glandulosa</i>	Wild	9/20/2019	Texas	Uvalde County	growing along edge of Kneuper Ranch road in thicket at edge of pasture	Many multitrunked trees and shrubs ranging from 15' to 20' tall and spreading	Acacia farnesiana, Celtis, Diospyros texana
2019.819	<i>Prunus mexicana</i>	Wild	9/20/2019	Texas	Travis County	oak savanna with dry grass understory, growing under oak canopy		
2019.833	<i>Prunus serotina</i> var. <i>eximia</i> *	Wild	9/20/2019	Texas	Bandera County	growing on bank above Duncan Creek	Single trunked deciduous tree, 35' tall, 30' wide, 20" dbh, upright form with top dying back, gray-brown bark with rough texture broken into plates, heavily fruiting with 1/2" black drupes, green lanceolate leaves with serrated margin	Juniperus ashei, Quercus buckleyi, Quercus laceyi, Fraxinus albicans, Juglans major

Acc #	Scientific Name	Provenance	Received Date	Source State	Source County	Locality detail	Plant description	Associates
2019.891	<i>Prunus serotina</i> var. <i>virens</i> *	Wild	9/20/2019	Texas	Jeff Davis County	fence line tree in open grassland	Multitrunked deciduous tree, 25' tall, 20' wide, one primary trunk 10" dbh, 5+ secondary trunks, young bark gray with horizontal lenticel striations, older bark peeling to rough tan-gray with bird-drilled holes, upright branching, open grown tree with canopy all the way to the ground, clean dark green glossy leaves, reddish brown twigs, tree in excellent health.	Bouteloua gracilis, Bouteloua curtipendula, Ratibida, Gaura
2019.1092	<i>Quercus arizonica</i>	Wild	10/24/2019	Arizona	Cochise County	oak woodland/grassland transition zone, dry sandy loam soil, growing in partial shade.		Quercus emoryi, Bouteloua gracilis, Bouteloua curtipendula, Juniperus deppeana, Yucca schottii, Agave palmeri.
2019.658	<i>Quercus emoryi</i>	Wild	8/12/2019	Arizona	Cochise County	Granitic soil		Quercus arizonica, Erythrina flabelliformis.
2019.838	<i>Quercus fusiformis</i>	Wild	9/20/2019	Texas	Uvalde County	along rough ranch road, growing on gradual west-facing slope, open woodland	Multitrunked evergreen tree, 40' tall, 40' wide, 3 trunks ranging from 12" t 20" dbh, rough gray-brown bark with vertical ridges, olive-shaped fruit	Dermatophyllum secundiflorum, Juniperus ashei, Mahonia trifoliata, Diospyros texana, Quercus fusiformis
2019.848	<i>Quercus fusiformis</i>	Wild	9/20/2019	Texas	Uvalde County	along road in loamy soil on flat plain, lone tree in meadow surrounded by thornscrub, limestone substrate	Single trunked evergreen tree, 25' tall, 30' wide, 24" diameter trunk, rough gray-brown bark, obovate leaves with entire margins, dark glossy green adaxially, pale gray-green abaxially, elongated acorns	Acacia farnesiana, Diospyros texana, Condalia ilicioides, Acacia berlandieri, Jatropha dioica, Platyopuntia
2019.895	<i>Quercus gravesii</i>	Wild	9/20/2019	Texas	Jeff Davis County	rocky north-facing slope, igneous soil, oak-pinyon-juniper woodland	Single trunked deciduous tree, 12' tall, 12' wide, 8" diameter trunk, tree leaning over road, lobed foliage 6" long and 3" wide, acorns green	Quercus grisea, Pinus cembroides, Juniperus deppeana, Quercus emoryi
2019.1093	<i>Quercus gravesii</i>	Garden	10/24/2019	California	Yolo County	UC Davis Arboretum and Public Garden		

Acc #	Scientific Name	Provenance	Received Date	Source State	Source County	Locality detail	Plant description	Associates
2019.900	<i>Quercus grisea</i>	Wild	9/20/2019	Texas	Jeff Davis County	flat terrace, open woodland	Single trunked evergreen tree, 25' tall, 40' wide, 36" diameter trunk at base, low branching, broad spreading tree with a low canopy, silver-blue velvety pubescent foliage	<i>Pinus ponderosa</i> var. <i>scopulorum</i> , <i>Piptochaetium fimbriatum</i> , <i>Artemisia ludoviciana</i> , <i>Stipa tenuissima</i> , <i>Quercus emoryi</i> , <i>Pinus cembroides</i> , <i>Juniperus deppeana</i>
2019.831	<i>Quercus laceyi</i>	Wild	9/20/2019	Texas	Bandera County	growing along edge of dry wash at ranch road crossing	Multitrunked deciduous tree, 25' tall, 3 trunks ranging from 8" to 12" dbh, spreading form, gray bark with vertical furrows	<i>Juniperus ashei</i> , <i>Dermatophyllum secundiflorum</i> , <i>Acer grandidentatum</i>
2019.832	<i>Quercus laceyi</i>	Wild	9/20/2019	Texas	Bandera County	growing along edge of dry wash at ranch road crossing	Multitrunked deciduous tree, 25' tall, 40' wide, 2 trunks, 8" and 12" dbh, gray bark with vertical furrows, leaves elliptic with minimal lobing, thick and leathery, blue green color, vigorous and healthy tree	<i>Juniperus ashei</i> , <i>Dermatophyllum secundiflorum</i> , <i>Acer grandidentatum</i>
2019.843	<i>Quercus laceyi</i>	Wild	9/20/2019	Texas	Uvalde County	headwaters of Little Blanco Creek, growing just adjacent to dry creek bed	Multitrunked deciduous tree, 35' tall, 40' wide, 3 trunks, each approx 15" dbh, upright spreading form, gray bark with vertical fissures, relatively large foliage up to 6" long in the shade	<i>Quercus buckleyi</i> , <i>Dermatophyllum secundiflorum</i> , <i>Aesculus pavia</i> var. <i>flavescens</i> , <i>Juglans major</i> , <i>Ungnadia speciosa</i> , <i>Prunus serotina</i>
2019.867	<i>Quercus laceyi</i> (<i>glaucoides</i> form)	Wild	9/20/2019	Texas	Real County	Rolling hills with oak savanna	Single trunked deciduous tree, 20' tall, 25' wide, 12" dbh; exceptionally thick, blue foliage; leaves elliptic with little or no lobing; few acorns still green, fully formed but not mature. Growing next to a <i>Quercus stellata</i> x <i>Quercus laceyi</i> hybrid. Progeny may exhibit hybrid characteristics.	<i>Quercus marilandica</i> var. <i>ashei</i> , <i>Quercus stellata</i> , <i>Asclepias texana</i> , <i>Stillingia texana</i>
2019.866	<i>Quercus marilandica</i> var. <i>ashei</i>	Wild	9/20/2019	Texas	Real County	growing in open woodland	Deciduous trees, several trees 30' tall and spreading, some show hybrid introgression with <i>Quercus buckleyi</i>	<i>Cercis canadensis</i> var. <i>texensis</i> , <i>Dermatophyllum secundiflorum</i> , <i>Styphnolobium affine</i> , <i>Diospyros texana</i>
2019.868	<i>Quercus marilandica</i> var. <i>ashei</i>	Wild	9/20/2019	Texas	Real County	Rolling hills with oak savanna	Multitrunked deciduous tree, 25' tall, 4 trunks, 10" to 12" dbh	<i>Quercus laceyi</i> , <i>Quercus stellata</i> , <i>Asclepias texana</i> , <i>Stillingia texana</i>

Acc #	Scientific Name	Provenance	Received Date	Source State	Source County	Locality detail	Plant description	Associates
2019.826	<i>Quercus muehlenbergii</i>	Wild	9/20/2019	Texas	Bandera County	growing in canyon along dry creek drainage	Single trunked evergreen tree, growing horizontally off cliff face, very vigorous and fecund, green acorns with distal pubescence, undulating leaf margin	Eysenhardtia, Lycium, Leucaena retusa, Diospyros texana, Juniperus pinchottii, Fraxinus greggii
2019.828	<i>Quercus muehlenbergii</i>	Wild	9/20/2019	Texas	Bandera County	on steep, rocky bank by Duncan Creek	Single trunked deciduous tree, 50' tall, 50' wide, 20" dbh, large arching branch over road, acorns still green	Quercus buckleyi, Tilia americana var. caroliniana, Fraxinus albicans, Celtis
2019.909	<i>Quercus muehlenbergii</i>	Garden	9/20/2019	Texas	Jeff Davis County	growing in visitor center landscape near parking lot	likely a cultivated source tree from the nursery trade	
2019.875	<i>Quercus mohriana</i> (x <i>grisea</i> ?)*	Wild	9/20/2019	Texas	Brewster County	growing along dry creek drainage near mouth of canyon	Single trunked tree, 25' tall, 20' wide, 30" diameter trunk at base, leaves lanceolate to elliptic 4 cm long x 1 cm wide, adaxially glossy glabrous medium green, abaxially light green and pubescent, acorn 1.5 cm, nut conical and still green covered 2/3 by pubescent pale tan cup, bark pale gray with deep vertical fissures. Lone tree growing in shrub-dominated landscape.	Eysenhardtia, Lycium, Leucaena retusa, Diospyros texana, Juniperus pinchottii
2019.906	<i>Quercus oblongifolia</i>	Garden	9/20/2019	Texas	Jeff Davis County	Chihuahuan Desert Research Institute Botanical Garden		
2019.1091	<i>Quercus oblongifolia</i>	Wild	10/24/2019	Arizona	Santa Cruz County	grassland/woodland transition zone, dry gravelly soil, growing in sun.		Quercus emoryi, Agave palmeri, Yucca baccata, Dasylirion wheeleri, Mimosa dysocarpa, Bouteloua curtipendula.
2019.1137	<i>Quercus oblongifolia</i>	Wild	1/27/1900	Arizona	Cochise County	Mesquite savanna		
2019.911	<i>Quercus stellata</i>	Wild	9/20/2019	Texas	Kimble County	oak savanna with dry grass understory	Single trunked deciduous tree, 30' tall, 40' wide, 20" dbh, rough vertically fissured gray bark, thick rough-textured leaves, dark green adaxially and pale green abaxially, most acorns underripe, tan acorn cups and yellowish green acorns up to 3/4" long and 1/2" wide, symmetrical domed canopy	Quercus fusiformis, Quercus marilandica var. ashei, Opuntia, Yucca

Acc #	Scientific Name	Provenance	Received Date	Source State	Source County	Locality detail	Plant description	Associates
2019.1226	<i>Quercus stellata</i>	Wild	12/11/2019	Texas	unknown	was sent to us from LBJ Wildflower Center		
2019.870	<i>Quercus vaseyana</i> *	Wild	9/20/2019	Texas	Real County	rocky, gradual slope in dense woodland	Single trunked evergreen tree, 12' tall, 8" wide, 4" dbh, pale tan shingled bark, rounded crown, glossy green foliage	Juniperus ashei, Celtis, Rhus virens, Dermatophyllum secundiflorum, Pinus remota
2019.659	<i>Sapindus drummondii</i>	Garden	8/12/2019	Arizona	Pima County	Arizona Sonora Desert Museum		
2019.860	<i>Sapindus drummondii</i>	Wild	9/20/2019	Texas	Uvalde County	growing in thicket along fenceline	Single and Multistemmed deciduous trees, 12' tall, growing closely together, some obvious young suckers, bright orange fruits	Prosopis glandulosa, Celtis, Centaurea americana
2019.888	<i>Sapindus drummondii</i>	Wild	9/20/2019	Texas	Jeff Davis County	fence line of trees in open grassland	Single trunked deciduous trees, 30' tall, 35' wide, 2 adjacent trees each 18" dbh, rough light gray bark peeling in thick plates in spiral pattern around trunk, wrinkled orange fruit, open canopy with snag, rounded crown with gnarled branching	Juglans microcarpa, Quercus emoryi, Celtis reticulata, Bouteloua spp.
2019.846	<i>Styphnolobium affine</i>	Wild	9/20/2019	Texas	Uvalde County	growing on flat terrace above dry creek bed at headwaters of Little Blanco Creek	Single trunked deciduous tree, 30' tall, 10' wide, 10" dbh, very narrow crown with vertical branching, foliage concentrated in top 25% of crown	Quercus buckleyi, Diospyros texana, Dermatophyllum secundiflorum, Juglans major, Ungnadia speciosa, Aesculus pavia var. flavesces
2019.865	<i>Styphnolobium affine</i>	Wild	9/20/2019	Texas	Real County	growing in open woodland	Multiple deciduous shrubs, 10' tall	Quercus marilandica var. ashei, Dermatophyllum secundiflorum, Cercis canadensis var. texensis, Diospyros texana
2019.915	<i>Styphnolobium affine</i>	Wild	9/20/2019	Texas	Gillespie County	suckering along fenceline within oak savanna	Multistemmed shrubs, 12' tall, stems 1" to 3" diameter, gray bark with linear striations, lacey open crown	Smilax, Quercus fusiformis, Quercus buckleyi, Quercus marilandica var. ashei, Celtis
2019.852	<i>Taxodium distichum</i> *	Wild	9/20/2019	Texas	Uvalde County	growing at edge of dry channel of Frio River, limestone	Single trunked deciduous tree, 35' tall, 50' wide, 40" dbh, broad spreading crown, good health, male and female cones present, stringy pale brown bark with deep vertical fissures	Celtis, Quercus fusiformis, Ulmus crassifolia, Condalia hookeri

Acc #	Scientific Name	Provenance	Received Date	Source State	Source County	Locality detail	Plant description	Associates
2019.853	<i>Taxodium distichum</i> *	Wild	9/20/2019	Texas	Uvalde County	growing at edge of dry channel of Frio River, limestone	Single trunked deciduous tree, 25' tall, 30' wide, 36" dbh, leaning tree, abundance of female cones in large clusters, uneven crown due to large broken branches	Celtis, Quercus fusiformis, Ulmus crassifolia, Condalia hookeri
2019.829	<i>Tilia americana</i> var. <i>caroliniana</i> *	Wild	9/20/2019	Texas	Bandera County	on steep, rocky bank by Duncan Creek	Multitrunked deciduous tree, 60' tall, 40' wide, 5 trunks ranging from 3" to 12" dbh, dark gray bark with vertical furrows, foliage yellowish green and glabrous with dull gloss, veins raised on abaxial side, tree in good health.	Quercus buckleyi, Quercus muehlenbergii, Fraxinus albicans, Celtis
2019.1229	<i>Ulmus crassifolia</i>	Wild	12/11/2019	Texas	Travis County			
2019.842	<i>Ungnadia speciosa</i>	Wild	9/20/2019	Texas	Uvalde County	headwaters of Little Blanco Creek, growing at edge of dry creek bed on west-facing rocky bank	Multistemmed deciduous shrub, 12' tall, 20' wide, stems 2" to 3" diameter, medium green foliage with yellow rachis	Juglans major, Dermatophyllum secundiflorum, Juniperus ashei, Quercus laceyi
2019.880	<i>Ungnadia speciosa</i>	Wild	9/20/2019	Texas	Brewster County	growing in canyon along dry creek drainage	Multistemmed deciduous shrub, 12' tall, 12' wide, stems 1.5" to 3" diameter, smooth gray bark, yellow-green foliage, vigorous	Penstemon baccharifolius, Leucaena retusa, Juniperus pinchottii

*Note: These taxa were not on our original target list

Figure 4. Detailed Results from all Propagation Attempts

Taxon	Accession #	Propagation #	Prop Start Date	Propagation Treatment Detail	Germination Rate	Notes
<i>Acacia wrightii</i>	2019.873	P001164	1/14/2020	hot water scarify, heated greenhouse sown	14% germination	
<i>Acer grandidentatum</i>	2019.822	P001043	11/1/2019	sown outside, cold temperatures	best germination	fresh seed
<i>Acer grandidentatum</i>	2018.1358	P000574	1/7/2019	warm soak 24 hours, cold stratification 180 days in moist perlite and peat in plastic bag in refrigerator	poor germination	
<i>Acer grandidentatum</i>	2019.834	P001044	11/1/2019	sown outside, cold temperatures	decent germination	fresh seed
<i>Arbutus xalapensis</i>	2019.872	P001042	10/30/2019	45 day cold stratification in moist peat in plastic bag in refrigerator	near 100% germination	fresh seed
<i>Arbutus xalapensis</i>	2019.1228	P001138	1/8/2020	40 day cold stratification in moist peat in plastic bag in refrigerator	33% germination	
<i>Arbutus xalapensis</i>	2019.1227	P001183	1/14/2020	60 day cold stratification in moist peat in plastic bag in refrigerator	35% germination	
<i>Bauhinia lunarioides</i>	2019.907	P001291	1/10/2020	24 hour hot water soak, heated greenhouse sown	52% germination	eratic germination over time, most recent one germinated 6 months after sowing
<i>Carya illinoensis</i>	2019.914	P001296	3/5/2020	90 day cold stratification, moist peat, perlite and vermiculite, in plastic bag in refrigerator	75% germination	
<i>Celtis aff. laevigata</i>	2019.825	P001133	1/7/2020	120 day cold stratification in moist peat in plastic bag in refrigerator	70% germination	
<i>Celtis lindheimeri</i>	2019.837	P001041	10/30/2019	42 day cold stratification in moist peat in plastic bag in refrigerator	97% germination	
<i>Cercis canadensis var. texensis</i>	2019.863	P001187	1/14/2020	30 minute 200°F water soak, heated greenhouse	87% germination	shriveled seed
<i>Cercis canadensis var. texensis</i>	2019.912	P001190	1/14/2020	30 minute 200°F water soak, heated greenhouse	36% germination	shriveled seed
<i>Cercis canadensis var. texensis</i> 'Alba'	2019.972	P001192	1/14/2020	30 minute 200°F water soak, heated greenhouse	8% germination	
<i>Cercis canadensis var. texensis</i> 'Alba'	2019.972	P001193	1/14/2020	30 minute 200°F water soak, heated greenhouse, 1 day aeration	13% germination	
<i>Cupressus arizonica</i>	2019.649	P000965	8/29/2019	no treatment	31% germination	
<i>Cupressus arizonica</i>	2019.649	P000976	10/3/2019	lightly covered	23% germination	
<i>Cupressus arizonica</i>	2019.649	P000967	8/29/2019	60 day cold stratification in moist sand in plastic bag in refrigerator	23% germination	
<i>Dermatophyllum secundiflorum</i>	2019.884	P001219	12/9/2019	24 hour hot water soak, lightly scarified with file	75% germination	
<i>Dermatophyllum secundiflorum</i>	2019.840	P001084	12/9/2019	scarified with knife	40% germination	
<i>Dermatophyllum secundiflorum</i>	2019.884	P001218	1/22/2020	24 hour hot water soak, heavily scarified with file	no germination	

Taxon	Accession #	Propagation #	Prop Start Date	Propagation Treatment Detail	Germination Rate	Notes
<i>Diospyros texana</i>	2019.882	P000985	10/9/2019	seeds planted 1/4' deep, greenhouse sown	almost no germination	slow and long germ period
<i>Diospyros texana</i>	2019.820	P000983	10/7/2019	surface sown in greenhouse	no germination	
<i>Diospyros texana</i>	2018.1381	P000560	12/19/2018	no treatment	70% germination	
<i>Fraxinus albicans</i>	2019.919	P001143	1/9/2020	winter sown outside, cold temperatures	no germination	
<i>Fraxinus cuspidata</i>	2019.908	P001146	1/9/2020	winter sown outside, cold temperatures	2% germination	
<i>Fraxinus cuspidata</i>	2019.908	P001271	2/25/2020	120 day cold stratification in moist moist peat in plastic bag in refrigerator	2% germination	
<i>Fraxinus greggii</i>	2019.877	P001145	1/9/2020	sown outside, cold temperatures	7.5% germination	
<i>Juglans major</i>	2019.652	P000966	8/28/2019	2 day bleach soak, 120 day cold stratification in moist perlite in plastic bag in refrigerator	61% germination	
<i>Juglans major</i>	2019.818	P001220	1/23/2020	2 day bleach soak, 120 day cold stratification in moist perlite in plastic bag in refrigerator	56% germination	
<i>Juglans microcarpa</i>	2019.885	P001194	1/15/2020	sown outside, cold temperatures	20% germination	
<i>Juglans microcarpa</i>	2019.885	P001195	1/15/2020	150 day cold stratification in moist perlite in plastic bag in refrigerator	45% germination	
<i>Juniperus deppeana</i>	2018.478	P000062	4/11/2018	48hr soak, then knife nick, 3 month cold strat	near 100% germination	
<i>Juniperus deppeana</i>	2018.478	P000065	4/11/2018	48hr soak, then nail clipper nick, 3 month cold strat	near 100% germination	
<i>Leucaena retusa</i>	2019.862	P001014	10/18/2019	sown in heated greenhouse	poor germination	seed had many insect exit holes
<i>Leucaena retusa</i>	2019.862	P001035	10/18/2019	sown in heated greenhouse, covered 1/2 soil	poor germination	seed had many insect exit holes
<i>Leucaena retusa</i>	2019.894	P001012	10/18/2019	sown in heated greenhouse	poor germination	seed had many insect exit holes
<i>Morus microphylla</i>	2019.654	P001140	1/9/2020	120 day cold stratification in moist moist peat in plastic bag in refrigerator	no germination	
<i>Pinus cembroides</i>	2019.893	P001025	10/23/2019	33 day cold stratification in moist peat in plastic bag in refrigerator	8% germination	
<i>Pinus cembroides</i>	2019.896	P001030	10/25/2019	31 day cold stratification in moist peat in plastic bag in refrigerator	10% germination	
<i>Pinus cembroides</i>	2019.896	P001031	10/25/2019	Fall sown outside	2% germination	
<i>Pinus ponderosa</i> var. <i>scopulorum</i>	2019.898					no viable seed
<i>Pinus remota</i>	2018.1375	P000360	9/20/2018	spring sown outside	poor germination	
<i>Pinus remota</i>	2018.1378	P000561	12/19/2018	6 week cold stratification in refrigerator	poor germination	
<i>Pistacia texana</i>	2019.874	P000994	10/14/2019	sown in heated greenhouse	10% germination	
<i>Pistacia texana</i>	2019.874	P001110	12/18/2019	sown in heated greenhouse	1% germination	
<i>Prosopis glandulosa</i>	2019.859	P001074	11/25/2019	1 minute hot water (200*) soak, sown in heated greenhouse	55% germination	

Taxon	Accession #	Propagation #	Prop Start Date	Propagation Treatment Detail	Germination Rate	Notes
<i>Prunus mexicana</i>	2019.819	P000991	10/14/2019	90 day warm stratification, 120 day cold stratification in moist sand in plastic bag	13% germination	
<i>Prunus serotina</i> var. <i>eximia</i>	2019.833	P001216	1/21/2020	3 month after-ripening period, 24 hour hot water soak, 5 day aeration, sown outside cold temperatures	40% germination	
<i>Prunus serotina</i> var. <i>virens</i>	2019.891	P001217	1/21/2020	3-month after ripening period, 24 hour hot water soak, 14 day warm stratification, then moved to hoop house, cold temperatures	no germination	
<i>Quercus arizonica</i>	2019.1092	P001037	9/12/2018	no treatment	no germination	
<i>Quercus emoryi</i>	2019.658	P000963	8/28/2019	no treatment	8% germination	
<i>Quercus fusiformis</i>	2019.838	P001033	10/25/2019	no treatment	37% germination	
<i>Quercus fusiformis</i>	2019.838	P001047	11/4/2019	no treatment	40% germination	
<i>Quercus fusiformis</i>	2019.848	P000993	10/14/2019	no treatment	33% germination	
<i>Quercus fusiformis</i>	2019.848	P001040	10/30/2019	no treatment	77% germination	
<i>Quercus fusiformis</i>	2019.848	P001048	11/4/2019	no treatment	69% germination	
<i>Quercus fusiformis</i>	2019.848	P001076	11/25/2019	no treatment	31% germination	
<i>Quercus gravesii</i>	2019.895					no viable seed
<i>Quercus gravesii</i>	2019.1093					no viable seed
<i>Quercus grisea</i>	2019.900	P000978	10/7/2019	no treatment	75% germination	
<i>Quercus laceyi</i>	2019.831	P001258	2/14/2020	no treatment	40% germination	
<i>Quercus laceyi</i>	2019.831	P001279	2/28/2020	no treatment	11% germination	
<i>Quercus laceyi</i>	2019.831	P001280	2/29/2020	no treatment	59% germination	
<i>Quercus laceyi</i>	2019.832	P001039	10/30/2019	no treatment	16% germination	
<i>Quercus laceyi</i>	2019.832	P001078	11/25/2019	no treatment	13% germination	
<i>Quercus laceyi</i>	2019.832	P001091	12/12/2019	no treatment	64% germination	
<i>Quercus laceyi</i>	2019.843	P000990	10/14/2019	no treatment	31% germination	
<i>Quercus laceyi</i>	2019.843	P001307	3/6/2020	no treatment	20% germination	
<i>Quercus marilandica</i> var. <i>ashei</i>	2019.866	P000987	10/9/2019	fall sown outside	5% germination	
<i>Quercus marilandica</i> var. <i>ashei</i>	2019.868	P001305	3/6/2020	90 day cold strat in perlite, peat, vermiculite in plastic bag in refrigerator	no germination	
<i>Quercus marilandica</i> var. <i>ashei</i>	2019.868	P001306	3/6/2020	spring sown outside	6% germination	
<i>Quercus mohriana</i>	2019.910	P000986	10/9/2019	no treatment	4% germination	
<i>Quercus mohriana</i> (x <i>grisea</i> ?)	2019.876	P000979	10/7/2019	no treatment	12% germination	
<i>Quercus mohriana</i> (x <i>grisea</i> ?)	2019.878	P000980	10/7/2019	no treatment	5% germination	
<i>Quercus muehlenbergia</i>	2019.909	P001303	3/5/2020	no treatment	16% germination	
<i>Quercus muehlenbergia</i>	2019.909	P001242	2/11/2020	no treatment	35% germination	

Taxon	Accession #	Propagation #	Prop Start Date	Propagation Treatment Detail	Germination Rate	Notes
<i>Quercus oblongifolia</i>	2019.1091	P001038	10/30/2019	no treatment	3% germination	
<i>Quercus stellata</i>	2019.1226	P001111	12/18/2019	no treatment	100% germination	
<i>Quercus vaseyana</i>	2019.870	P001245	2/11/2020	no treatment	100% germination	
<i>Quercus vaseyana</i>	2019.870	P001286	3/3/2020	no treatment	73% germination	
<i>Sapindus drummondii</i>	2019.860	P001093	12/13/2019	48-hour hot water soak and 24 hour aeration, heated greenhouse sown		
<i>Sapindus drummondii</i>	2019.860	P001095	12/13/2019	48-hour hot water soak and 24 hour aeration, heated greenhouse sown	88% germination	
<i>Styphnolobium affine</i>	2019.846	P001067	11/22/2019	2 day warm water soak, heated greenhouse sown	18% germination	
<i>Styphnolobium affine</i>	2019.915	P001068	11/22/2019	3 day warm water soak, heated greenhouse sown	2% germination	shriveled seed
<i>Styphnolobium affine</i>	2019.865	P001131	1/7/2020	24 hour hot water soak, heated greenhouse sown	no germination	shriveled seed
<i>Taxodium distichum</i>	2019.852	P001130	1/7/2020	120 day cold stratification in moist peat in plastic bag in refrigerator	11% germination	
<i>Taxodium distichum</i>	2019.853	P001036	10/28/2019	hot water soak, 45 day cold stratification in moist peat in plastic bag in refrigerator	12% germination	
<i>Tilia americana</i> var. <i>caroliniana</i>	2019.829	P001295	3/5/2020	90 cold stratification in peat in plastic bag in refrigerator	no germination	
<i>Ulmus crassifolia</i>	2019.1229	P001137	1/8/2020	40 day cold stratification in moist peat in plastic bag in refrigerator	near 100% germination	
<i>Ulmus crassifolia</i>	2019.1229	P001107	12/13/2019	heated greenhouse sown	near 100% germination	
<i>Ungnadia speciosa</i>	2019.842	P001023	10/23/2019	heated greenhouse sown	100% germination	
<i>Ungnadia speciosa</i>	2019.880	P001011	10/18/2019	heated greenhouse sown	36% germination	
<i>Ungnadia speciosa</i>	2019.880	P001024	10/23/2019	heated greenhouse sown	69% germination	

Figure 5. Taxon Propagation Results and Inventory Summary

Taxon	Qty	Height	Propagation and growth summary
<i>Acacia wrightii</i>	26	1.5'	We had decent germination with hot water scarification and sowing in a warm greenhouse in January. Seedlings show moderately paced growth and should be ready to plant out in spring or fall of 2021.
<i>Acer grandidentatum</i>	51	6"-1'	We had great germination with fresh seed sown outside in a hoop house exposed to cold temperatures. We had very poor germination with 3 month old seed put through cold stratification in refrigerator. Seedlings are fast growing, but suffer from the high boron and sodium in our water. May be ready for winter 2020-21 planting.
<i>Arbutus xalapensis</i>	108	2"-1'	Preliminary research and consultation led us to worry about seedlings dampening off or lack of mycorrhizal partners in our soil. However, we experience near 100% germination with fresh seed put into 45 day cold stratification in moist peat in plastic bag in refrigerator. (The least successful germination we had was with older seed used.) Only very few seedlings suffered through transplant, or were lost to dampening off. They were sown in the heated greenhouse, and we were careful not to overwater. Seedlings are moderately fast growers and should be ready spring or fall 2021. They suffer leaf tip burn slightly under our poor water quality as well as from aphids this summer.
<i>Bauhinia lunarioides</i>	18	2"	We have had decent germination with a fresh seed given a 4 hour hot water soak, and then greenhouse sown. Germination is prolonged and erratic (52% germination so far) the latest germination was in July. Seedlings are slow growing and may be ready to plant out fall 2021.
<i>Carya illinoensis</i>	19	1'	We have had good germination with 90 day cold stratification in moist peat, perlite and vermiculite, in a plastic bag in refrigerator then sown in greenhouse.
<i>Celtis</i> aff. <i>laevigata</i>	69	1.5'	We got high germination with 120 day cold stratification in moist peat in plastic bag in refrigerator then greenhouse sown in spring. Seedlings are fast growing and should be ready for winter 2020-21 planting. Field trials will monitor for invasiveness potential.
<i>Celtis lindheimeri</i>	22	1'	We got near 100% germination with 42 day cold stratification in moist peat in plastic bag in refrigerator then greenhouse sown in December. Seedlings are fast growing and should be ready for winter 2020 planting. Field trials will monitor for invasiveness potential.
<i>Cercis canadensis</i> var. <i>texensis</i>	16	6"-1'	Viable seed was difficult to find on collecting trip. Much of the seed we found seemed to be poor quality, nonetheless we've had great germination with 30 minute 200°F water soak, greenhouse sown in January. Seedlings are growing moderately quickly and should be read to plant out in spring or fall 2021.
<i>Cercis canadensis</i> var. <i>texensis</i> 'Alba'	21	4"-1'	This seed was collected from a <i>Cercis canadensis</i> var. <i>texensis</i> 'Alba' specimen in the UCD Arboretum. We've had poor germination of this cultivar. It received the same 30 minute 200°F water soak, greenhouse sown in January, treatment as the wild collected straight species. The treatment with 1 day aeration after the soak performed slightly better. Seedlings are growing moderately quickly and should be ready to plant out in spring or fall 2021. We will monitor flower development.
<i>Cupressus arizonica</i>	59	2"-2'	We trialed sowing fresh seed immediately in greenhouse and fresh seed put into 90 day cold stratification in sand in the refrigerator. We got similarly mediocre germination with both treatments. Seedlings are fast-growing and many should be ready for winter 2020-21 planting.

Taxon	Qty	Height	Propagation and growth summary
<i>Dermatophyllum secundiflorum</i>	33	2"	We got good/the best germination with 24 hour hot water soak then a light scarification with file. We also got decent germination with no soak, only scarifying with knife. Too heavy of scarification led to zero germination. Further trials needed, perhaps with fresh seed. Seedlings are very slow growing, but several from 2018 collection trip may be ready to plant out winter 2020-21.
<i>Diospyros texana</i>	20	1" -1'	We had almost no germination with seed collected from two specimens on this trip. We trialed both in the greenhouse, with fresh seed surface sown or planted 1/4" deep. Seeds planted 1/4" deep were more successful. Germination period has been long with the latest seedling emerging in August. We had decent germination in 2018 with no treatment and 2 month old seed. Would need further trials to see if age of seed or variability in years or collection specimens determines germination. Seedlings are slow growing, but several from 2018 collection trip may be ready to plant out winter 2020-21.
<i>Fraxinus albicans</i>	0		We got no germination with seed sown in an open hoop house exposed to cold temperatures in and open flat in potting soil in January. Future trials should include cold stratification in refrigerator.
<i>Fraxinus cuspidata</i>	5	1'	We trialed sowing seeds in open flat in potting soil in hoop house exposed to cold temperatures and 120 day cold stratification in moist peat in plastic bag in refrigerator. Both were started in January and had equally poor germination. Seedlings are moderately fast growing and could be ready in spring or fall 2021. Future plantings would use fresher seed.
<i>Fraxinus greggii</i>	29	2"-1'	We got mediocre germination with seed sown in January in a hoop house exposed to cold temperatures in an open flat. Seedlings are moderately fast-growing, will be ready to plant spring or fall 2021. Future plantings would use fresher seed.
<i>Juglans major</i>	38	1.5'	We planted both fresh seed and 4 month old seed with both receiving a 2 day bleach soak then 120 day cold stratification in moist perlite in plastic bag in refrigerator. Both had equally good germination with the same treatment. Seedlings are fast-growing and should be ready to plant winter 2020-21.
<i>Juglans microcarpa</i>	13	8"	We trialed two treatments, both started in mid-January, with seed collected from 1 specimen. Half were put in 150 day cold stratification in moist perlite in plastic bag in refrigerator. The other half were sown outdoors. The refrigerated cold stratification had double the germination as the winter sowing. In future trials, outdoor sowing should be in fall. Seedlings are moderate growers and should be ready to plant in fall 2021.
<i>Juniperus deppeana</i>	30	6" - 1.5'	High rates of germination with 48 hour warm soak and nicking with knife or nail clippers then 3 month cold stratification in light soil in refrigerator. Seedlings are fast growing and should be ready to plant out in winter 2020-21.
<i>Leucaena retusa</i>	19	1-9"	Almost all of the seed collected from two individuals was damaged with insect exit wounds. All seed was sown fresh, immediately in the greenhouse and had poor germination. Seedlings are slow growing, may be ready in fall 2021.
<i>Morus microphylla</i>	0		We got no germination from seed collected from 1 specimen and put in 120 day cold stratification in moist peat in plastic bag in refrigerator started in January. Future trials would put seed immediately in cold stratification and trial scarification.
<i>Pinus cembroides</i>	6	6"	We got poor germination with 1 month cold stratification in moist peat in plastic bag in refrigerator. Seedlings are extremely slow growing. May be ready to plant out in 2022.
<i>Pinus ponderosa</i> var. <i>scopulorum</i>	0		No viable seed was found in cones collected.

Taxon	Qty	Height	Propagation and growth summary
<i>Pinus remota</i>	8	6"	We trialed fall sowing seed in hoop house exposed to cold temperatures, as well as 1 month cold refrigeration in plastic bag in moist peat then sowing in greenhouse. Neither treatment was successful. Both treatments began in October after cone was allowed to dehisce. With seed collected in 2018 we got poor to no germination with a 6 week cold stratification in refrigerator. We also trialed overnight soaking of seed previous to cold stratification which did not improve germination. Seedlings are very slow growing, may be ready to plant out in 2022.
<i>Pistacia texana</i>	10	1'	Freshest seed had best germination sown in October in the greenhouse. Future trials should include scarification and cold stratification. Seedlings are growing at a moderate pace and may be ready to plant out spring or fall 2021.
<i>Prosopis glandulosa</i>	30	1.5'-2.5'	We got decent germination with 1 minute hot water (200°F) soak and greenhouse sowing in November. Seeds germinated over the following 6 months. Seedlings are growing quickly, ready to plant out winter 2020-21.
<i>Prunus mexicana</i>	8	6"	We got poor germination with fresh seed put in 90 day warm stratification then 120 day cold stratification in moist sand in plastic bag in refrigerator. Future trials should have shorter cold stratification (this cold strat was extended beyond the recommended 90 days due to COVID-19 delays.) Seedlings are moderately slow growing; possibly read to plant out fall 2021.
<i>Prunus serotina</i> var. <i>eximia</i>	18	1'	We got decent germination with a 3 month after-ripening period, then a 24 hour hot water soak, 5 day aeration, then sown in January in unheated hoop house. Future trials should include warm stratification prior to cold. Seedlings are growing at a moderate pace and should be ready to plant out fall 2021.
<i>Prunus serotina</i> var. <i>virens</i>	0		We got no germination with 3 month after-ripening period, then 24 hour hot water soak, then 14 day warm stratification in greenhouse, then moved to unheated hoop house in February. Future trials should use refrigeration for more consistent cold temperatures.
<i>Quercus arizonica</i>	10		We got no germination with seed collected this trip and planted in October. Previous collections have had poor germination rates as well but will be ready to plant winter 2020-21.
<i>Quercus emoryi</i>	3	6"	We got poor germination with fresh seed fall sown. Seedlings suffer from poor water quality.
<i>Quercus fusiformis</i>	76	1'	We got good germination with seed sown in October. Seedlings are moderately fast growing, may be ready to plant out spring or fall 2021.
<i>Quercus gravesii</i>	3		Seed collected on this trip was non-viable. Seedlings from previous collection trip should be ready to plant out spring or fall 2021.
<i>Quercus grisea</i>	9	1"	We got good germination, with fresh seed sown in October. They are slow growing but seedlings from 2018 collection trip should be ready to plant out fall 2020.
<i>Quercus laceyi</i>	33	9"	We had good germination with seed sown outdoors October to December. Seedlings can suffer with our poor water quality but so far are growing moderately well with additional fertilization; could be ready to plant out spring or fall 2021.
<i>Quercus marilandica</i> var. <i>ashei</i>	7	9"	We had poor germination with fresh seed, fall sown outside. We got no germination with 90 day cold stratification in perlite, peat, vermiculite in plastic bag in refrigerator.
<i>Quercus mohriana</i>	23	4"	We got mediocre germination with fresh seed, fall sown outside. Seedlings are slow growing and may be ready to plant out in fall 2021.
<i>Quercus muehlenbergii</i>	12	9"	Best germination with seed sown outside in late winter. Seedlings are slow growing, may be ready to plant out fall 2021.

Taxon	Qty	Height	Propagation and growth summary
<i>Quercus oblongifolia</i>	3	4"	Poor germination with seed sown outside in October. Slow growing, maybe ready fall 2021.
<i>Quercus stellata</i>	20	9"	We had near 100% germination with seed sown outdoors in December. Seedlings can suffer with our poor water quality but so far are growing moderately well with additional fertilization; could be ready to plant out spring or fall 2021.
<i>Quercus vaseyana</i>	27	9"	We got excellent germination with late winter, sown outside. Seedlings are growing at a moderate pace and should be ready for planting spring or fall 2021.
<i>Sapindus drummondii</i>	65	1.5'	We got high rates of germination from 48-hour hot water soak and 24 hour aeration then greenhouse sowing in December. Seedlings are fast growing, should be ready to plant out spring or fall 2021.
<i>Styphnolobium affine</i>	4	9"	We were only able to find few and somewhat shriveled seeds on the collection trip. The best germination was with a 2 day warm water soak, then greenhouse sown in November. We got no germination with 3 month old seed 24 hour hot water soak, and greenhouse sown. Seedlings are growing slowly. Future trials should include scarification with knife.
<i>Taxodium distichum</i>	15	1'	We trialed 120 day cold stratification in moist peat in plastic bag in refrigerator as well as giving fresh seed a hot water soak and a 45 day cold stratification in moist peat in plastic bag in refrigerator. Both had similarly mediocre germination rates. The seedlings are fast-growing and should be ready to plant out winter 2020-21.
<i>Tilia americana</i> var. <i>caroliniana</i>	0		We got no germination with 90 day cold stratification in peat in plastic bag in refrigerator. According to Jill Nokes, there is no known consistently successful treatment. Future trials would include fall sowing outside.
<i>Ulmus crassifolia</i>	109	4"	We got near 100% germination with 40 day cold stratification in moist peat in plastic bag in refrigerator as well as with fresh seed greenhouse sown. Field trials will monitor for invasiveness potential. Seedlings are fast growing and could be ready to plant out in winter 2020-21.
<i>Ungnadia speciosa</i>	62	1'	All seed from three collection individuals were planted outside in October with no special treatment and with the same growing conditions. Germination rates varied from 36% to 100%, indicating mother plant may be important to success. Seedlings are moderately-slow growing, but many from 2018 collection trip are ready to plant out fall 2020.
Total count:	1157		

Figure 6. Sample Interpretive Sign

Standing Tall in the Face of the Unknown

UCDAVIS



**ARBORETUM AND
PUBLIC GARDEN**

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In order to prepare our campus for extreme heat and less predictable rainfall, the UC Davis Arboretum and Public Garden is developing the Living Landscape Adaptation Plan. In line with this plan, we aim to diversify the urban tree canopy. In Fall 2019, Arboretum and Public Garden staff and students traveled to west and central Texas to collect seeds which grow into trees that are compatible with our future climate.

This tree, the Texas live oak (*Quercus fusiformis*), is a resilient species to plant because it already lives in an environment with extreme temperature fluctuations.

The Introduction and Testing of Texas Trees in Sacramento Valley Landscapes project was made possible by the Saratoga Horticultural Research Endowment.

This sign was developed by students in the Museum Education *Learning by Leading*™ Internship.

Photo 1. Adam Black, Emily Griswold, Ellen Sanders-Raigosa consult with Philip Schulze and Andrew McNeil-Marshall at the Lady Bird Johnson Wildflower Center Arboretum in Austin.



Photo 2. Adam Black, Abbey Hart, and Ellen Sanders-Raigosa recording data and collecting seeds from *Quercus fusiformis* near the western edge of its range.



Photo 3. Adam Black, Ellen Sanders-Raigosa, and Emily Griswold hiking up ravine in the Davis Mountains in West Texas to find *Quercus gravesii* seed.



Photo 4. Ellen Sanders-Raigoa, Adam Black, Emily Griswold and Abbey Hart with all collected seed from West and Central Texas.



Photo 5. Ellen Sanders-Raigoa with seedlings in air-pruning pots in greenhouse, March 2020.



Photo 6. Learning by Leading Nursery interns, Riley Sholes and Ellen Sanders-Raigosa learned to build a cage to protect acorns from predation in fall of 2019.



Photo 7. Tree seedlings in hoop house, March 2020.



Photo 8. Tree seedlings, hoop house August 2020.



Photo 9. Tree seedlings, hoop house March 2020



Photo 10. Emily Griswold, tree seedlings, hoop house July 2020.

