International Oaks

The Journal of the International Oak Society

…the new classification of oaks, truffles,
treehouses, oaks of Lebanon and Iran,
desperately seeking Q. tardifolia*,*
the IOS 25th anniversary…

Issue No. 29 / 2018 / ISSN 1941-2061

This issue is dedicated to
Michel Timacheff
whose memory will live on in his beautiful
photographs and in the hearts of the many in
this Society who were his friends.

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Photos. Cover: John Harris (*Quercus robur*). Page 7: Béatrice Chassé Page 9: Cécile Souquet-Basiege.

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FOREWORD

Turn to Oaks in a Time of Uncertainty

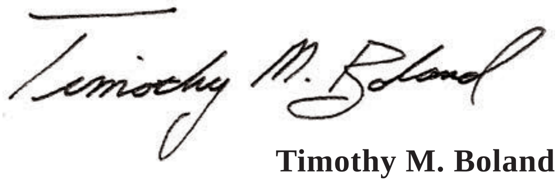
Reading the news on a daily basis it's safe to say the geopolitical world has changed so dramatically that many of us live in a state of quiet desperation as to what comes next. To counteract this feeling of anxiety, not surprisingly, I turn to trees. This has been a lifelong place of comfort for me that started in my teenage years and led to my academic pursuits to become a horticulturist, botanist, curator, and eventually an arboretum director. Not surprisingly, it also led me to the International Oak Society. Currently, I live on the oak-dominated island of Martha's Vineyard with six species of *Quercus* and associated hybrids. My winter days start with sitting quietly and watching the sunrise behind the silhouettes of black oaks. Onward, my mornings have a ritualistic procession: loading our woodstove with oak logs, and driving a short distance to work on oak-canopied roads.

In my day-to-day work as the Director of the Polly Hill Arboretum, I often have little contact with actual trees. That may seem surprising but finances, personnel matters, building maintenance, board work, insurance rates, and more eat away at the enjoyment of my chosen vocation and avocation: trees. Each year I try to carve out more time to focus on plants, and those plants, more often than not, are oak trees!

I was recently asked to give an inspirational talk – a Sunday morning sermon – about trees at a local church. I fretted over this commitment for weeks. I'm not a religious person as such, yet when in wild, beautiful, serene, biodiverse places, I catch the fever. And though I may not practice a traditional faith, I do have faith in trees. My address went well as I rattled off statistics about the world's largest and oldest trees, and summoned every exemplary tree factoid that I could muster in hopes the congregation would stay with me. Of course, as a card-carrying member of the IOS, I included the symbolism, culturalism, and the long association of humans with oaks. I also shared that oak ecosystems in many parts of the world are critical biological infrastructure, hosting an amazing assortment of co-dependent lifeforms (microbial, fungal, and macroinvertebrates). It was a sermon disguised as an Arbor Day speech on steroids! Unplanned, I went off topic and brought forth the real and troubling relationship we have with nature, a separation that places man in "dominion" over the earth's resources. I challenged the attendees to become better stewards of the earth, and suggested a good place to start … trees!

As IOS members, when we consider the world of oaks, we find them inspirational and endlessly challenging. Our emotions place us in awe of their grandeur and resiliency. We are young once again and energized when holding for the first time the acorns of *Quercus ithaburensis*! We are humbled by the centuries-old English oaks in Sherwood Forest, and troubled about red-listed oaks that need empathy and righteous action to shield them from extinction. Our rational intelligence delves into the incredible advances we are making as investigative oak scientists. Imagine unravelling the Oak Tree of Life? The pages within this edition of *International Oaks* reveal new discoveries driven by intelligent inquiry and the scientific method. I know I speak for all of us when I say it's an honor to work with such a magnificent genus.

The other half of the oak equation is what we do as citizens of the world to spread the gospel of oaks? That's where you come in as a member of the IOS. It's never too late to engage both the young and old in oak conversations. Yes, some may run in the other direction, but many will be inspired by your earnest (and somewhat peculiar?) devotion to oak trees. 2018 promises to be interesting to say the least! I hope to see many of you at the 9th International Oak Society Conference in California in October. If ever there was a self-help group meeting for a genus, this is the one. Here we can find comfort in all things *Quercus*. In the meantime, stay curious, and turn to trees. That's how you arrived here in the first place!



Timothy M. Boland

INTRODUCTION

Marvellous Miscellany

Tasked with writing an introduction to *International Oaks*, one instinctively looks for links or common themes between articles in order to slot their summaries together and give the introduction a logical backbone, but this year's splendidly diverse offerings seem to defy such an approach – often their only link seems to be our dear friend Oak himself. Defeated, I commence instead with the items in order of appearance.

For the East Asian warm-climate Ring-cup Oaks, *Cyclobalanopsis* continues even today to be considered as a genus separate to *Quercus* in some parts of the world. Conversely, in the West it has long been treated as a subgenus. However, the phylogenetic pot has been boiling rapidly of late as molecular research deepens its reach: our Editor thus summarizes a radically new proposed classification system for oaks in which *Cyclobalanopsis* finds itself merely as one of three sections (along with *Cerris* and *Ilex*) in a subgenus *Cerris*, with all other oaks being contained in subgenus *Quercus*. But wait, isn't that pot still boiling….?

Allen Coombes has been turning over stones, and entertains us in his "Nomenclatural Notes" with what he has found underneath: *Quercus candicans* is not an oak! To find out what it is, read within. Meanwhile, as they are wont to do, Mexico and Central America have produced more oak species, one described in detail here by Susana Valencia-A, and a further two summarized by Béatrice Chassé and Allen Coombes, who go on to cover additional new species from Vietnam and even from staid old Europe.

Next we cater for the inner man in an article with a truly international flavor. Bogdan Caceu was born in Romania, but has gravitated to Oregon's Willamette Valley by way of Paris, New York and San Francisco, along the way becoming inoculated, or perhaps infected, with a passion for truffles. Here he tells us about his truffle-growing project; in addition one of his French mentors, Joël Gravier, reveals a more science-based approach to truffle production than the semi-mythic folklore of yore.

Inebriation Saves Veteran Ash Tree! To find out more read the article by Thomas Allocca, and you will at the same time learn more of the beauty and romance of treehouses.

Amid the turmoil of the Middle East, it is good to know that in Lebanon, a landscape much altered by man since earliest times, moves are afoot to identify conservation imperatives for seven oak taxa there (Stephan et al.). And speaking of ancient times, our gnarled oaks hold diaries in their tree rings whose secrets they are willing to divulge to those who understand the language of dendrochronology (Loader et al.).

Two highly contrasting conurbations are researching ways to ensure a future for their green areas in which oaks are important components. Joeri Sergej Strijk describes the diversity found on the sub-tropical islands of Hong Kong, including a creditable fourteen species of oak, one only recently recorded in the territory; whilst Chicago seeks a pragmatic approach to the conservation of iconic native oak ecosystems (Custic et al.). Meanwhile, a workshop of the Oaks of the Americas Conservation Network (OACN) in Puebla, Mexico, signals a welcome and timely continent-wide interest in investigating and preserving the explosion of oaks found in Mexico (pp. 91-98).

No issue of *International Oaks* would be complete without an update on new and recently published oak cultivars, here provided as usual by Eike Jablonski and Ryan Russell. Next, Texas comes in for some rewarding attention, with Emily Griswold and others seeking to collect for ex-situ conservation efforts, and the indefatigable Béatrice Chassé on the road again (and it's a long road from east to west and back!) also in search of oaks and acorns. Béatrice and Charles Snyers give detail on the two 25th birthday celebrations held for the Society in 2017, the first at Dusan Plaček's arboretum in the Czech Republic, the second at Guy Sternberg's Starhill Forest Arboretum in Illinois. Participants at the former will have met the energetic and effervescent Josef Souček, who on pages 151-160 describes an oak-hunting expedition he made to Iran. Roderick Cameron continues his Central American excursions with a visit to Costa Rica (pp. 181-193), and finally you are exhorted to attend the 9th International Oak Society Conference to be held at the UC Davis Arboretum ad Public Garden in California in October – with a wide-ranging array of associated tours in addition, I can't wait!

Shaun Haddock

Updated Classification of Oaks: a Summary

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ABSTRACT

The recently published updated infrageneric classification of the genus *Quercus* (Denk et al. 2017) based on molecular phylogeny and pollen ornamentation confirms that the traditional subgeneric division between, on the one hand, *Cyclobalanopsis* (the East Asian subtropical and tropical oaks), and, on the other, *Quercus* (all other oaks) is artificial. This present paper gives an overview of past classification systems, the basis upon which current oak phylogeny has been constructed, and of the perspectives for future research as regards the morphological circumscription of infrasectional groups.

Keywords: oak phylogeny, *Quercus* phylogeny, history of oak classification systems, palynology

Introduction

A classification system is supposed to tell us not only in what "file" to put something, but more significantly what the relationships between all the "files" that we put them in are. "Ay, there's the rub." (*Hamlet*, Act III, Scene I.). Those of us who spend time ripping our hair out trying to attribute this or that oak tree to a particular species of the genus *Quercus* have perhaps not reflected enough on the fact that the same painful (though rewarding) experience has awaited (and most probably awaits) those who have tried (or will try) to establish a classification for this genus.

The history of attempts at organizing this genus is at once homage to those who have tried and (for the post-Darwin ones) a reflection of how challenging it is to understand the processes of evolution. The publication of the *Origin of Species* changed the perspective of taxonomy: if it is true that species are not static entities but the product of evolution then this must be reflected in systems of classification. From "artificial" classification systems that found order in the natural world based on similarity between one or two morphological characters (for example, Aristotle's – and many, but not all, after him – grouping of birds and bats) to the "natural" systems initiated by Michael Adanson that were to become the rule and that were based on paying minute attention to a complex of morphological characters, the most recent classification systems are grounded in the evolutionary relationships revealed through molecular-phylogenetic analyses and corroborating morphological characters.

The recently published updated infrageneric classification of the genus *Quercus* (Denk et al. 2017)[1] based on molecular phylogeny and pollen ornamentation confirms that the traditional subgeneric division between, on the one hand, *Cyclobalanopsis* (the East Asian subtropical and tropical oaks), and, on the other, *Quercus* (all other oaks) is artificial – in other words, that it does not reflect the evolutionary relationships that exist within the genus. This new classification system divides the genus into two subgenera and eight sections: *Cyclobalanopsis*, *Cerris* and *Ilex* in the subgenus *Cerris*; *Quercus*, *Virentes*, *Ponticae*, *Protobalanus*, and *Lobatae* in the subgenus *Quercus*. Previous phylogenetic classification systems resolved two subgenera into, variously, four to nine sections. None included the subgeneric break between *Cerris* and *Quercus* sensu stricto, and none recognized *Ponticae* as a section. The new classification thus reflects substantial rearrangement of our understanding of the genus.

A short history of infrageneric classification

From Loudon (1830) to Nixon (1993) attempts at classification have been based solely on morphology; and because different authors selected different morphological characters as most significant, these classification systems differed to varying degrees. In addition, in order to appriciate the difficulties involved in classifying this genus one must take into account the fact that as a result of convergent evolution, many morphological traits in oaks are homoplastic (i.e., they do not have the same origin), a common phenomenon within the genus, and generally within the family Fagaceae.

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1. An electronic appendix can be retrieved at https://doi.org/10.6084/m9.figshare.5547622.v1 and includes the following valuable information (which may be subject to future updates): (i) an overview of earlier systematic schemes for oaks (genera, subgenera, sections) in comparison to the new classification; (ii) diagnostic morphological traits reported by earlier taxonomists extracted from the original literature; (iii) a comprehensive list of formerly and currently accepted species of oaks, compiled from the cited oak monographs and complemented by further data sources.

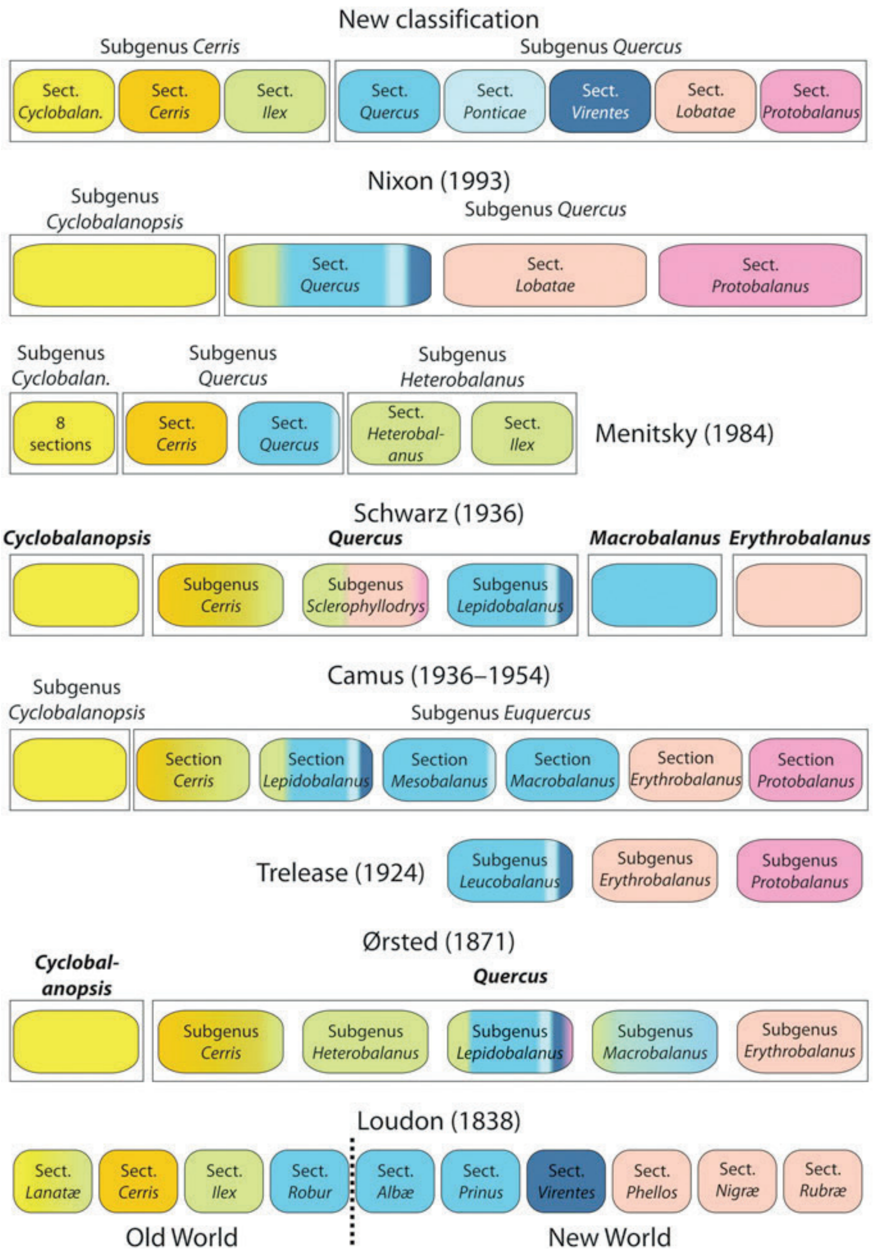

Figure 1/ Color coding denotes the actual systematic affiliation of species included in each taxon. Of the "Old World" or "mid-latitude" clade: section *Cyclobalanopsis* (yellow), *section Cerris* (orange), and section *Ilex* (green); and of the "New World" or "high-latitude" clade: section *Quercus* (blue), sections *Virentes* (dark blue) and *Ponticae* (light blue), section *Protobalanus* (pink), and section *Lobatae* (light pink). Color gradients reflect the proportion of species with different systematic affiliation included in each taxon. Note: Menitsky (1984) and Trelease (1924) only treated the Eurasian and American oaks, respectively, and provided classifications in (nearly) full agreement with current phylogenies (Reproduced from Denk et al. 2017).

We owe the first infrageneric classification of the genus *Quercus* to John Claudius Loudon (1838, 1839), who had 150 taxa to think about. He erected his classification based on reproductive and leaf characters. Remarkably, his subdivision of the European oaks into sections *Cerris*, *Ilex*, and *Robur* was maintained (with various modifications) in nearly all of the later classification systems. Even more interesting perhaps is that these sections correspond to clades in the most recent molecular-phylogenetic trees.

About three decades later Anders Sandøe Ørsted (1871), working with 184 species, recognised the Cycle-cup Oaks of subtropical and tropical Asia as a separate genus, *Cyclobalanopsis* – a distinction still used today in the Flora of China (2016). Camus (1936-1938) and Nixon (1993) both adopted the distinction but divided the genus into two subgenera, *Quercus* and *Cyclobalanopsis*.

Roughly fifty years later, William Trelease (1924) focusing on the American oaks organized them into three subgenera or sections based on style morphology, the position of abortive ovules, and cupule morphology: styles spatulate-elongated and abortive ovules apical in section *Erythrobalanus*, while *Protobalanus* and *Leucobalanus*, that share the same style morphology (short, broad and spreading) and abortive ovule position (deeply lateral or basal), are distinguished from one another by the presence (*Protobalanus*) or absence (*Leucobalanus*) of tomentum on the inner surface of the cupule. These three sections, like Loudon's three for the European oaks, appear in all later classification systems, with the significant difference that his *Leucobalanus* would change names (to become section *Quercus*) and come to include all of the White Oaks (for Trelease *Leucobalanus* included the American and the North European White Oaks).

Aimée Antoinette Camus (1936-1938, 1938-1939, 1952-1954), like Otto K.A. Schwarz (1937), agreed with Trelease's system for the American oaks, but disagreed with him as regards the relationship between them and the Eurasian oaks. Contrary to Mme Camus, Schwarz followed Ørsted, grouping the North American and Eurasian White Oaks in the same section. His system is based on four genera, *Cyclobalanopsis* and *Erythrobalanus* together in the tribe Cyclobalanopsidae, and *Macrobalanus* and *Quercus* in the tribe Querceae. Interestingly, his subgenus *Sclerophyllodrys* (in the genus *Quercus*) regroups many sclerophyllous oaks from Eurasia with Trelease's *Protobalanus*, some Asian White Oaks and some of the oaks from Trelease's *Erythrobalanus*. Mme Camus divided the genus into two subgenera, *Cyclobalanopsis* and *Quercus*, thereby reducing Ørsted's subgenera into sections. For Madame Camus, the position of the arbortive ovules was stable within species, but could also be used to characterize groups of species. These classification systems became the two competing models throughout much of the 20th century, and partly still today.

Yuri L. Menitsky's 1984 monograph of Asian oaks (translated to English in 2005) is the only morphology-based classification that correctly identified the natural groups of Eurasian oaks. Like Trelease's sections for the American oaks, Menitsky's have been confirmed with palynological and molecular data as natural groups. Using his own voluminous personal collections of herbarium material he attempted to analyse species variability with multidimensional statistical analysis. In a sense, instead of trying to determine which morphological traits are the most stable, he tried to get a grasp on what the variation meant.

Finally, the most widely used system today is based on Nixon (1993) who adopted Camus' general concept, though merging into one section (*Quercus*) her sections *Cerris* (*Cerris* and *Ilex* oaks) and *Euquercus* (remaining *Ilex* oaks and the White Oaks). In

Nixon's system, the genus is divided into two subgenera, *Cyclobalanopsis* and *Quercus*, and this latter subdivided into three sections, two of which are natural, *Protobalanus* and *Erythrobalanus*, and the third that is artificial and includes all of the White Oaks, along with the *Cerris* and *Ilex* oaks. This concept is based primarily on the position of aborted ovules which has been shown in subsequent work to be the result of different developmental processes and less stable than originally presumed (Borgardt and Pigg 1990; Borgardt and Nixon 2003; Deng et al. 2008).

A major obstacle in understanding the relationships within the genus *Quercus* has come from mixing, as it were, the Old World Oaks with the New World Oaks. Only Trelease who limited himself to the American oaks and Menitsky who did the same with the Asian ones, constructed groups that have largely stood the test of phylogeny precisely because they were not mixing morphologically similar but entirely unrelated species. Even their groupings, however, reflect mixtures of clades that were not predicted based on morphology alone.

Molecules and morphology: finding the fit

The first phylogenetic studies of oaks in the 1990s were based on sequences of the nuclear ITS[2] region and plastid[3] RFLP[4] data (Manos et al. 1999, 2001). Challenging all traditional views, the Intermediate and White Oaks grouped with the Red Oaks forming the "New World Clade" leaving the *Cerris* and *Ilex* oaks to form an "Old World Clade", that would later include also the *Cyclobalanopsis* (Manos et al. 2008). However, while the Red and Cycle-cup Oaks showed as distinct clades, this was not the case for the *Cerris* and White Oaks. Additionally the two well-resolved clades lacked unifying morphological traits.

These earlier molecular studies demonstrated that it was essential to sample large numbers of nuclear gene regions to accurately reconstruct oak evolutionary history (Hipp 2015; Pham et al. 2017), and researchers in the last decade have relied exclusively on nuclear-encoded regions to recover the oak phylogeny (Oh and Manos 2008; Denk and Grimm 2010; Hubert et al. 2014; Hipp et al. 2015; Deng et al. 2018). These studies in aggregate support the recognition of two reciprocally monophyletic groups of oaks, divided into two subgenera with eight phylogenetic lineages (sections). As mentioned above, the sections established by Trelease in 1924 and Menitsky in 1984 are reflected in this new classification system. The main morphological character that distinguishes these phylogenetic lineages is pollen morphology, which is perhaps less susceptible to convergence in the clade and, as a side-benefit, is well conserved in the fossil record. The study of pollen morphology has shown, for example, that nearly all of the species in section *Ilex* share distinctive microrugulate pollen ornamentation (Denk and Tekleva 2014).

As shown in Figure 2, most morphological traits are shared by more than one section (even between non-sister-lineages), a result of convergent evolution (a phenomenon illustrated throughout the entire family Fagaceae with, for example, concentric cupula rings). These morphological traits cannot therefore be relied on when attempting to understand evolutionary relationships. Conversely, although today's molecular data tell

2. Internal Transcribed Spacer (ITS) is a region of non-coding, or spacer, DNA found between repeated copies of ribosomal RNA genes.
3. Plastids are major organelles found in plant and algae cells that manufacture and store important chemical compounds, and contain RNA (3-4%) and DNA (0.5%).
4. Restriction Fragment Length Polymorphism (RFLP) is a piece of DNA that has been cut by a restriction enzyme and that is different in length for each genetically related group. It is used to trace family relationships.

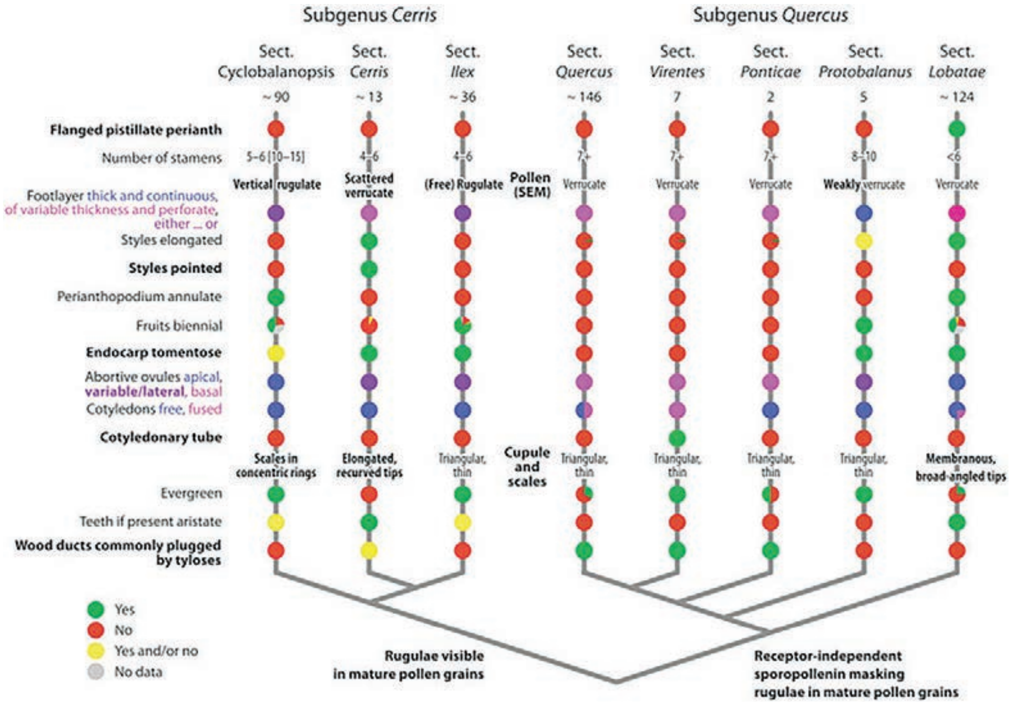

Figure 2/ Revised infrageneric classification of oaks showing the phylogenetic relationships between the groups. Most of the diagnostic characters are shared by more than one section, including non-sister lineages. Nonetheless each section can be diagnosed by unique, unambiguous character suites (reproduced from Denk et al. 2017).

us that *Q. alnifolia*, *Q. aucheri*, *Q. coccifera* and *Q. ilex* belong to the same section, various traditional classification systems placed them in different sections/subsections because of quite remarkable morphological differences (indumentum, leaf margin, and cup scales).

Resolving this incongruence between traditional and DNA-based classification systems represents the major challenge for understanding the genus *Quercus* at infrasectional level. It has been shown that pollen ornamentation in sections *Quercus* and *Lobatae* is conservative to the point that morphologically and ecologically different species have nearly indistinguishable pollen ornamentation (Solomon 1983; Denk and Tekleva 2014). It is therefore difficult to infer geographic or taxonomic patterns within sections using this morphological character.

Future avenues of investigation

With the recognition that the position of aborted ovules is less stable than previously thought, investigation of the developmental pathways of seed ontogeny and their distribution is one route that lies ahead for the morphological circumscription of infrasectional groups. Additionally, those morphological characters that have largely been examined on the basis of herbarium specimens, such as the maturation time of fruit, need to be reinvestigated in the field. Attention to the largely unstudied fossil record in East Asia and the Far East should also contribute to better understanding the evolutionary history of the genus *Quercus* as well as the classification and evolution of the Eurasian taxa (Deng et al. 2018), while close interpretation of biogeography and ecology seems likely to provide a refined classification of the American oaks (Hipp et al. 2018).

	New classification		Previous, generally accepted classification	
Species	**Subgenus**	**Section**	**Subgenus**	**Section**
Q. acuta	*Cerris*	*Cyclobalanopsis*	*Cyclobalanopsis*	-----------
Q. acutissima	*Cerris*	*Cerris*	*Quercus*	*Quercus*
Q. alnifolia	*Cerris*	*Ilex*	*Quercus*	*Quercus*
Q. baloot	*Cerris*	*Ilex*	*Quercus*	*Quercus*
Q. baronii	*Cerris*	*Ilex*	*Quercus*	*Quercus*
Q. brandegeei	*Quercus*	*Virentes*	*Quercus*	*Quercus*
Q. chrysolepis	*Quercus*	*Protobalanus*	*Quercus*	*Protobalanus*
Q. fusiformis	*Quercus*	*Virentes*	*Quercus*	*Quercus*
Q. geminata	*Quercus*	*Virentes*	*Quercus*	*Quercus*
Q. humboldtii	*Quercus*	*Lobatae*	*Quercus*	*Lobatae*
Q. macrocalyx	*Cerris*	*Cyclobalanopsis*	*Cyclobalanopsis*	-----------
Q. oleoides	*Quercus*	*Virentes*	*Quercus*	*Quercus*
Q. pontica	*Quercus*	*Ponticae*	*Quercus*	*Quercus*
Q. robur	*Quercus*	*Quercus*	*Quercus*	*Quercus*
Q. rysophylla	*Quercus*	*Lobatae*	*Quercus*	*Lobatae*
Q. suber	*Cerris*	*Cerris*	*Quercus*	*Quercus*

Table 1/ A comparison by species between the new infrageneric classification (Denk et al. 2017) and the previous, generally accepted classification (Nixon 1993).

Acknowledgements

I am grateful to Thomas Denk for authorizing the reproduction of Figures 1 and 2 from the original publication (Denk et al. 2017) and wish to thank Andrew Hipp for his invaluable comments.

Photographers. Title page: Béatrice Chassé (*Quercus rotundifolia*).

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Nomenclatural Notes

Holm oak is indeed *Quercus ilex* but *Q. candicans* is not an oak

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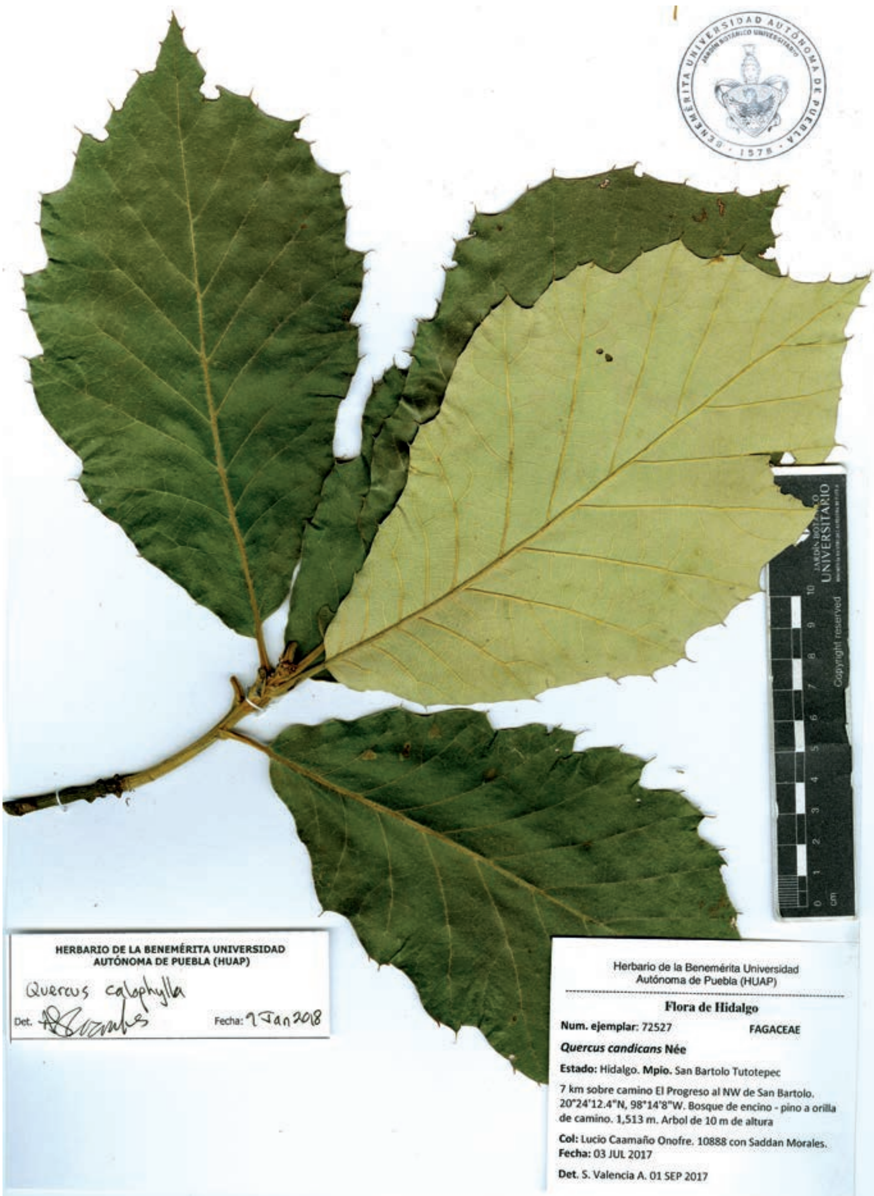

***Quercus calophylla*, previously known as *Q. candicans* (BUAP Herbario).**

Introduction

While most of us are familiar with the problems of assigning a name to any particular oak, or, come to that, any other plant, we do assume that a name can be relied upon as a firm foundation to anchor our plant to once it has been identified. What few may realise is that in some cases there is considerable confusion that can give even the most familiar names a very shaky basis.

There are strict rules on how plants are named (McNeill et al. 2012). One of these states that a holotype must be designated and deposited in a named herbarium. This is a single specimen chosen by the author of the name that forever fixes that name to the taxon it represents. Now, if a holotype is not designated, or if more than one specimen is cited, or if the name of the herbarium is not given, then the name can be regarded as invalid. As an example, when Susana Valencia and colleagues published the name *Quercus meavei* (Valencia-Avalos et al. 2016) they designated a holotype, a single specimen collected in Hidalgo, Mexico and deposited in the herbarium of the Faculty of Sciences, UNAM. They also cited isotypes, duplicates of the same collection sent to other herbaria, and paratypes, different collections that the authors regard as belonging to the same species. There is, therefore, no doubt about the correct application of this name.

The complications of lectotypification

Of course these rules have not always existed and in order to name a new species, the designation of a holotype has not always been necessary. Names published by Linnaeus have been a particular problem because he often cited several earlier names, specimens, illustrations and descriptions. One problem that arose recently was choosing a type for the well-known *Q. ilex*. Linnaeus published this name in *Species Plantarum* in 1753 together with *Q. suber*. He referred to his previous description of this species, in *Hortus Cliffortianus* (1737), where he did not use binomials, and where *Q. ilex* was listed as no. 2 under *Quercus*. In the same publication *Q. suber* was listed as no. 1. Specimens bearing these numbers are found in the Linnaean herbarium. The fact that Linnaeus listed other material under his *Q. ilex* meant that the name had to be lectotypified, that is, a type has to be chosen from the material cited to represent the species. Lectotypification is not a simple procedure as a type must be chosen that agrees with the author's original intentions (bearing in mind that if several specimens or descriptions are cited they could represent different species), and hopefully agreeing with current usage.

Quercus ilex proved to be a particular problem. Iamonico and Peruzzi (2013) lectotypified it by choosing one specimen from the available material. However, recent work (Vázquez and Coombes 2017) has shown that the specimens have been confused and the specimen annotated "1 Quercus suber" is clearly *Q. ilex* while that annotated "2 Quercus ilex" is *Q. suber*. Unfortunately the latter specimen was designated as lectotype for *Q. ilex*. From the descriptions of Linnaeus it is clear that he intended to apply these names in the way that we do today and a recent publication (Vázquez and Coombes 2017) proposes a new lectotype for *Q. ilex* that clearly belongs to what we all know as that species.

Photo 1/ Young shoots of *Quercus ilex* (L) and *Q. suber* (R) can appear very similar. Both collected from plants cultivated in the BUAP Botanic Garden, Puebla, Mexico, Jan 2018.

Candid confusion

A perhaps even stranger case has also presented itself recently when Susana Valencia sent me photographs she had taken in the Madrid herbarium of type material of *Q. candicans* collected by Luis Née in Guerrero, Mexico in 1791. Many of those who have visited the collection at Chevithorne may remember the two fine specimens of this tree that grew there until they were killed in a particularly cold winter. When I saw the photographs I was very surprised because this was obviously not an oak. The specimens only consisted of a few leaves but I was eventually able to identify it as *Roldana lineolata*, a type of shrubby *Senecio* (the genus in which it was first published) that I am familiar with here. The original description of Née (1801) clearly mentions a "medium sized tree" but he goes on to describe exactly the leaves of the *Roldana*. How could this happen I wondered, and how many people have seen these specimens and identified them as oaks? It is not even certain that the "medium-sized tree" that Née found was an oak, and there is nothing to indicate that it may have been the *Q. candicans* that we are familiar with.

Photo 2/ *Roldana candicans* (as *R. lineolata*) showing the oak-like leaves (HUAP).

Conclusion

The *Q. ilex* problem will have no effect on what we call our plants, although had it not been resolved it would have been possible to argue that what we know as *Q. ilex* needs a new name. However, the problem with *Q. candicans* unfortunately will. In a recent publication (Valencia-Avalos et al. 2018) we decided that the simplest way to solve the problem would be to change the names. As the type specimen of *Q. candicans* is actually *R. lineolata* (and the 'oak' was named first) the name for the *Roldana* becomes *R. candicans* (Née) Villaseñor, S. Valencia & Coombes, while what we have known incorrectly as *Q. candicans* for many years becomes *Q. calophylla* Schltdl. & Cham.,

Photo 3/ New growth on *Quercus calophylla* (Arboretum des Pouyouleix).

the next available name, and which appropriately means "the oak with beautiful leaves". Unfortunately this is not a species that is very widely grown - so, on the upside, not many labels will need to be changed! Surely the few who do grow it successfully will be happy to have it whatever it is called.

Quercus calophylla in cultivation

Arboretum de la Bergerette (France)
Arboretum de Chocha (France)
Arboretum des Pouyouleix (France)
Arboretum Wespelaar (Belgium)
Chevithorne Barton (United Kingdom)
Eastwood Hill (New Zealand)
Hackfalls Arboretum (New Zealand)
Heanley Farm (United Kingdom)
Jardín Botánico de Iturraran (Spain)
Peckerwood Gardens (United States)
Sir Harold Hillier Gardens (United Kingdom)
UC Davis Arboretum (United States)

Acknowledgements

I would like to thank Susana Valencia and Francisco Vázquez for reviewing this article.

Photographers. Title page, 1, 2: courtesy of the Herbario de la Bénémérita Universidad Autónoma de Puebla (HUAP). Photo 3: Béatrice Chassé.

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Quercus breedloveana Nixon & Barrie: a Recently Described Red Oak from Mexico

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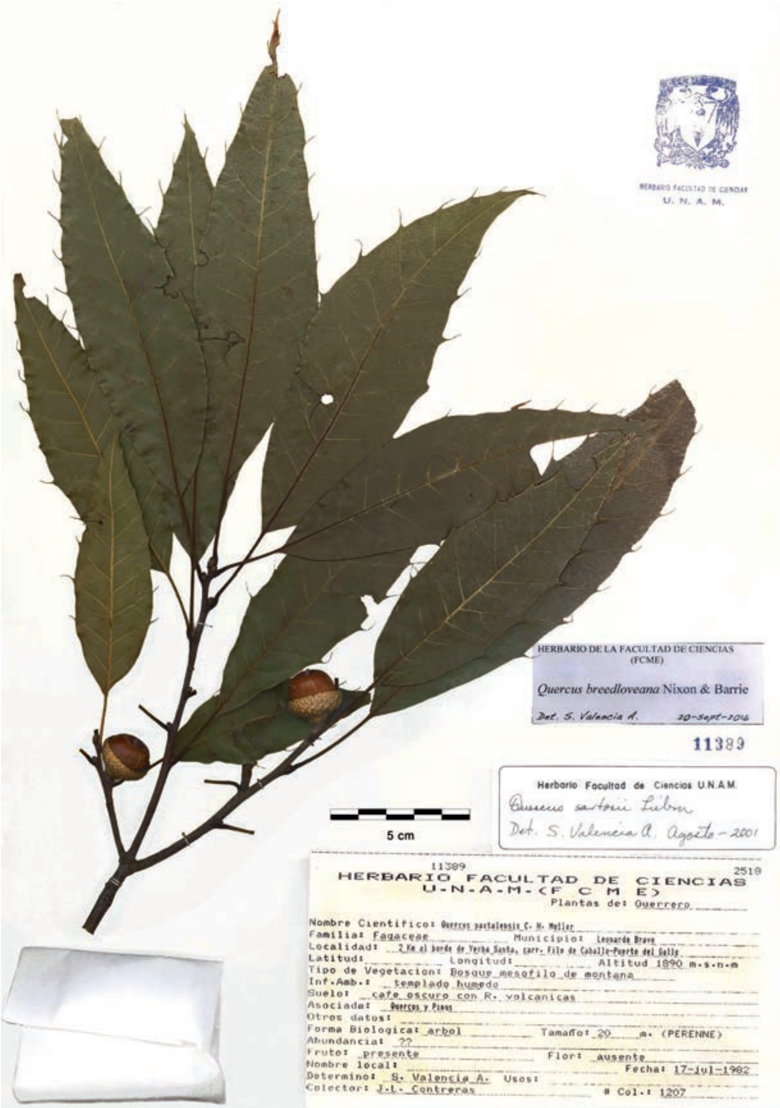

Isotype of *Quercus breedloveana* Nixon & Barrie (FCME).

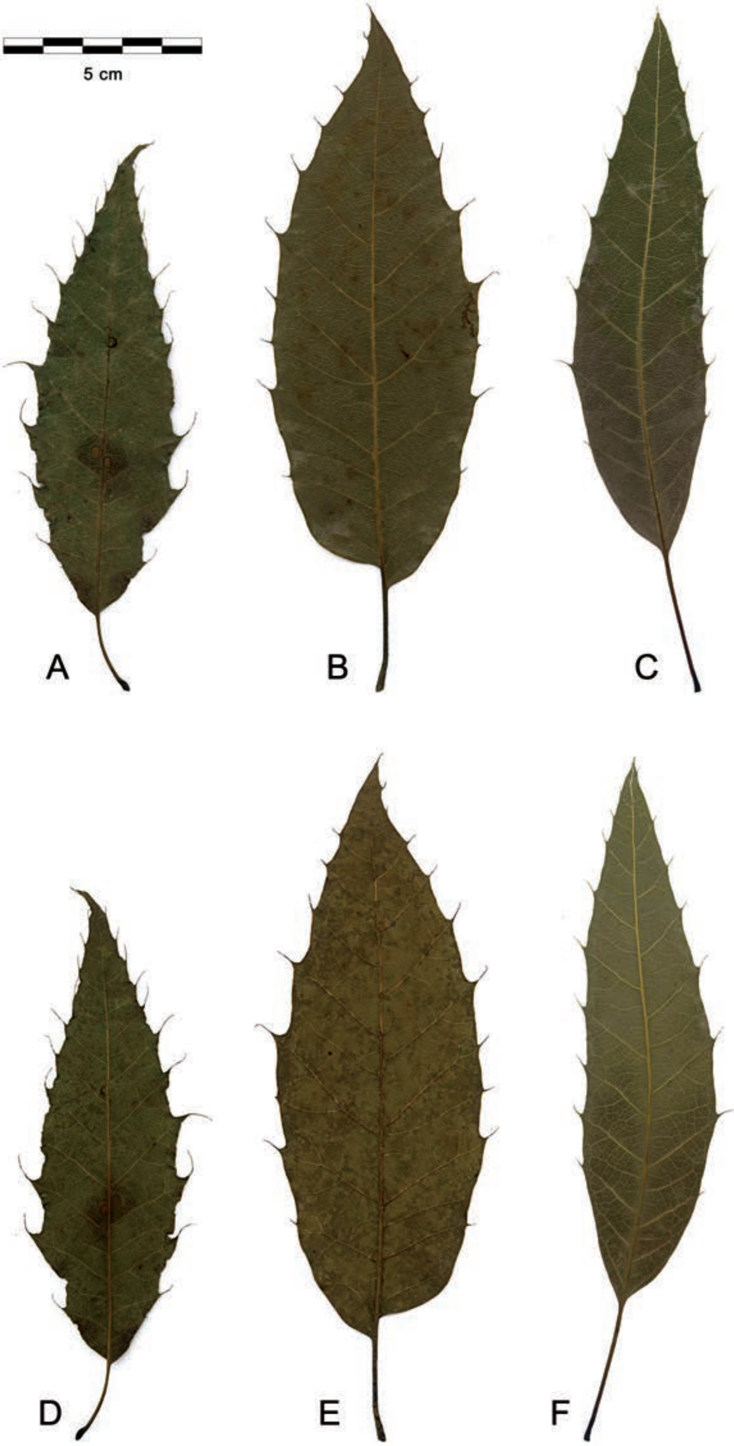

Photo 1/ *Quercus breedloveana* (A) adaxial surface; (D) abaxial surface. *Q. sartorii* (B) adaxial surface; (E) abaxial surface. *Q. paxtalensis* (C) adaxial surface; (F) abaxial surface.

Introduction

In November 2017 a new species of Red Oak *Quercus* (section *Lobatae*) from southwest and southern Mexico was described by Nixon & Barrie.[1] The new species was named in honor of the late Dennis Breedlove who studied the genus *Quercus* in México, and collected extensively a lot of botanical specimens during many years in Chiapas. Specimens of *Q. breedloveana* were collected in the states of Guerrero and Chiapas, but in Guerrero state it was wrongly identified as *Q. sartorii* Liebm. The specimen chosen as the holotype is in the CAS herbarium, but there is one isotype in the Herbario de la Facultad de Ciencias de la UNAM (FCME) (shown on the title page of this article).

Description

Quercus breedloveana is a medium-sized tree reaching about 20 m tall. Twigs glabrous, terete, with evident lenticels; buds globose to ovoid, brown or brown-greenish, glabrous and shiny. Leaf blades 11.5-24.5(27) × 2.4-5.7 cm, coriaceous or subcoriaceus, lanceolate-elliptic or narrowly elliptic; with (6)11-14 straight secondary veins on each side of the midvein, at an angle close to 55º, continuing into the aristate teeth, there are intersecundary veins which ramify before the margin. Margin slightly crisped with 9-12(26) short aristate teeth on each slide of the blade; adaxial blade surface glabrous and somewhat shiny, abaxial blade surface less shiny that the adaxial surface. The fruits ripen from July to August, they are annual, with turbinate cupules from 13.5-21 mm diam. × 9-12 mm long, broadly ovoid or depressed-globose, 12.8-17 mm × 11-15 mm glabrous or scarcely canescent.

Quercus breedloveana is known only from Mexico, there are scarce collections, but they are in excellent condition. It is distributed in the Sierra Madre del Sur in Guerrero and Chiapas, in cloud forest and tropical semi-deciduous forest at altitudes of between 1,100-1,800 (2,200) m.

Quercus breedloveana can be confused mainly with *Q. sartorii* and *Q. paxtalensis*, although it can also be confused with *Q. xalapensis* and *Q. skinneri*, because of its similar aristate-dentate blade margin and glabrous or glabrate leaves which all these species have. The last two species differ from *Q. breedloveana* in having fruits that ripen in two years and hemispheric cupules. Distinguishing *Q. breedloveana* from *Q. sartorii* and *Q. paxtalensis*, both with fruits that ripen in one year, is more difficult, so a comparative table is presented on page 28.

1. Nixon, K.C., and F.R. Barrie. 2017. Three Previously Undescribed Species of *Quercus* (Fagaceae) from Mesoamerica and the Designation of a Lectotype for *Q. acutifolia*. *NOVON* 25: 444-450. DOI: 10.3417/D-16-00014

	Q. breedloveana	*Q. sartorii*	*Q. paxtalensis*
Shape of the blade	Lanceolate-elliptic or narrowly elliptic 3-4 times longer than wide	Elliptic, ovate or lanceolate 2.2-2.5 times longer than wide	Lanceolate or narrowly-elliptic, sometimes oblong 2.7-3.7 times longer than wide
Secondary veins on each side of the midvein	(6) 11-14	7-12	10-13
Blade base	Symmetric, acute	Asymmetric or symmetric, rounded or truncate, rarely cuneate	Asymmetric or symmetric, rounded to truncate or acute
Petioles, mm	6-39	11-25	20-45
Shape and size of the cupule, mm	Turbinate (13.5)17-21 diam. × (9)10-12 tall	Hemispheric or slightly obconic 8.6 diam. × 6-10 tall	Turbinate 12.5-18 diam. × 10-13.5 tall
Shape and size of the acorns, mm	Broadly ovoid or depressed-globose, 12.8-17 long × 11-15 diameter	Ovoid 11.5-13 long × 7.8-10 diameter	Ovoid 18-20 long × 12-14 diameter

Table 1. Comparison of main characters between *Quercus breedloveana, Q. sartorii* and *Q. paxtalensis.*

Acknowledgements

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New Species from Around the World

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Quercus protoroburoides

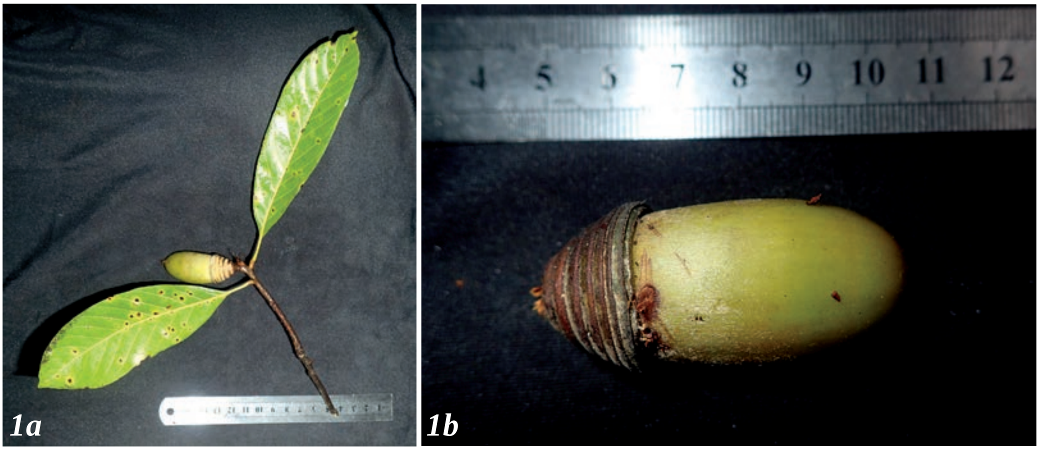
From Mesoamerica

Quercus sarahmariae Nixon & Barrie, is named in honor of Sarah Maria Nixon, daughter of the senior author (Nixon and Barrie 2017). The holotype is from a collection in Costa Rica in the foothills of the Cordillera de Talamanca in 1983 that was deposited as an undetermined species in the Missouri Botanic Garden Herbarium. According to the authors, "*Quercus sarahmariae* is a narrow endemic that has been variously identified under different names. In herbaria, material of this species has most often been identified as *Q. rapurahuensis* Pittier ex Seemen and, more recently, as *Q. benthamii* A. DC. It differs from both in the occasional teeth in the distal quarter of the leaf (*Q. benthamii* does not have teeth, although some specimens misidentified as *Q. benthamii* with teeth appear to be of hybrid origin), from the former in its larger leaves with typically more secondary veins, and from the latter in those characters as well as the distinctive flat-cupped and extremely large acorns. The large leaves with occasional distal teeth and very large acorns with flat, saucer-shaped cups distinguish it from all other species in the region and elsewhere." The species is found in wet, premontane or cloud forests at between 700 and 1,900 m.

Quercus melissae Nixon & Barrie is named in honor of Melissa Barrie Lehmann, daughter of the junior author (Nixon and Barrie 2017). The holotype is from a collection in 1958 in Chiapas (Mexico) that was deposited in the Chicago Natural History Museum as *Quercus segoviensis* Liebm. According to the authors, although herbarium specimens of *Q. melissae* have been consistently identified as *Q. segoviensis*, the two species differ, in leaf morphology, peduncle length, and cotyledons. "The fused cotyledons and general leaf morphology suggest that *Q. melissae* is related to the group of mostly Mexican white oaks centered around the species *Q. glaucoides* M. Martens & Galeotti. Indeed, vegetatively *Q. melissae* resembles *Q. tuberculata* Liebm., a species of northern and western Mexico, more than it does *Q. segoviensis*, differing in the persistent sparse pubescence of the lower leaf surface and the heavily pubescent peduncles and acorn cups. *Quercus liebmannii* Oerst. ex Trel., an oak from Oaxaca that might be confused with this species, has free cotyledons... *Quercus liebmannii* also has more regular, mostly parallel veins and a very dense, close tomentum covering the abaxial leaf surface, in contrast to the irregularly toothed leaves with looser, sparse pubescence on the abaxial leaf surface in *Q. melissae*."

From Asia

Quercus xuanlienensis Binh, Ngoc & Bon, has been described (Binh et al. 2018a) from the Xuan Lien Nature Reserve (Thuong Xuan District, Thanh Hoa Province, North Vietnam) from which derives the species epithet. Although only one individual has been found, phylogenetic analysis appears to support the conclusion that this is indeed a new species. Morphologically it is most similar to *Q. edithiae* Skan, with 8–11 pairs of secondary veins, bowl-shaped cupules, and ellipsoid to cylindrical-ellipsoid and basally convex nuts, it differs in having serrulate leaf margins only at apical 1/5–1/7, almost entire margins of bracts on cupule and much longer nuts. The species is also similar to *Q. fleuryi* Hickel & A. Camus with leaves glabrous on both surfaces and with the margin serrulate only apically but differs in having ellipsoid buds, shorter petioles, cupules enclosing 1/5 of the nut, and much longer nuts. Fruiting specimens were collected in March.



Photos 1/(a-b) ***Quercus xuanlienensis***

The taxonomy of *Quercus langbianensis* Hickel & A. Camus and its relatives in Vietnam and Cambodia has been revised based on evidence from field observations, morphological comparison of herbarium specimens, and molecular analyses using both classic and next generation DNA markers (Binh et al. 2018b). The results of this work have led the authors to recognize a ten-species complex, three of which are new, and briefly described here.

Quercus baolamensis Binh & Ngoc is named after the type locality, Bao Lam District. It is most similar to *Q. langbianensis* sensu stricto but differs in the leaf margin that is regularly distinctly serrate in the upper 1/2 (vs. serrate in the upper 1/3) and shorter petioles (0.4-1 cm vs. 1-1.8 cm long). Only one individual was found at 1,000 m along the edge of an evergreen forest. Fruiting specimens were collected in June.

Photo 2/ ***Quercus baolamensis***

Quercus bidoupensis Binh & Ngoc named after the type locality, Bidoup-Nui Ba National Park in Lam Dong Province. This species is similar to *Q. langbianensis* sensu stricto in leaf shape, the number of secondary veins and the basal scar of the nut which is convex but differs in having oblong to ellipsoid buds (vs. globose to broadly ovoid), undulate and distinctly serrate leaf margin along the upper half (vs. regularly distinctly serrate in the upper 1/3), obconical cupules (vs. cup shaped), cupule bracts arranged in 5-6 rings (vs. 6-9 rings) and the ovoid nut (vs. obovoid to ellipsoid). At present, this species is only known from the type locality, in evergreen forest dominated by Fagaceae. Phenology is unknown, acorns were collected from the ground in February.

Photo 3/ *Quercus bidoupensis*

Quercus honbaensis Binh, Tagane & Yahara is named after the type locality, Mt. Hon Ba in the Hon Ba Nature Reserve (Khanh Hoa Province). This species has been distinguished from *Q. langbianensis* sensu stricto in having shorter petioles (0.8-1 cm vs 1-1.8 cm long), more secondary veins ((10-)14-16 pairs vs 10-12 pairs) and obconical cupules (vs. cup-shaped). The species is known only from the type locality where several individuals were found in evergreen forest from 225-617 m. Fruiting specimens were collected in February.

Photos 4/(a-b) ***Quercus honbaensis***

From Europe

The name ***Quercus protoroburoides*** has somewhat of a convoluted history. In 1969 Boris Buzov and Zhelez Dontchev published the name *Quercus macranthera* subsp. *balcanica* J. Dontchev & B. Bousov to designate an oak found in the Rila Mountains

(Bulgaria). This name was not published according to the *International Code of Botanical Nomenclature*. In 1981, the same authors, considering taxonomic affiliation and morphological characters, increased its rank to species and gave it the name *Q. protoroburoides* Donchev & Bouzov – again, however, not published in accordance with the rules. A recent study has been undertaken (Tashev and Tsavkov 2017) to validate the name and to provide additional data regarding morphology and taxonomic affinity. The species epithet expresses the authors' opinion that this taxon is ancestral to section *Quercus* oaks. This taxon is morphologically close to *Q. hartwissiana* Steven, but with longer petioles, shorter fruit stalks, variable trichomes, and a thicker leaf cuticle. The distribution of the two species in Bulgaria does not overlap.

Photo 5/ *Quercus protoroburoides*

Photographers. Title page: Alexander Tashev (*Quercus protoroburoides*). Photos 1-4: Hoang Thi Binh, Photo 5: Alexander Tashev.

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La Creole Orchards: a Truffle (Ad)Venture

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ABSTRACT

Although truffle culture is historically associated with France, successful attempts at growing this highly valued mushroom have been made in different parts of the world including, amongst others, Australia, New Zealand and several areas in the United States. This paper tells the story of a truffle-growing adventure in Oregon, born from a personal link to oak forests in Romania and carried by a more scientific approach to the question as developed by a group of truffle growers in Europe, spearheaded by Joël Gravier.

Keywords: *Tuber melanosporum, T. uncinatum, T. macrosporum,* truffle culture

Introduction

My oak-centric project in the Willamette Valley in Oregon was initially just a vague idea. Its kernel was a feeling I had about the relationship between nature and history. Most immediate in my mind was the role of nature in our moment in history, defined by the environmental imperatives and choices of our day. Present also was the bond between nature and the deep history of my European culture, with its love for the forest that was almost entirely decimated on the old continent many, many generations ago, but a love that endures to this day. Finally, very present in my mind was the role played by nature – by trees in particular, and by oaks more specifically – in my very personal history.

I am Romanian by birth and was brought up in the western part of the country, very close to the quasi-virgin oak forest of Runcu-Groşi[1] in Arad County.[2] As a child, the symbol of the oak was extremely powerful: I clearly remember it as the representation of utmost strength and longevity. The oak leaf was emblazoned on the shirts of the national rugby team that epitomized my idea of beauty and strength.

After many years spent in Paris, in New York City, and in San Francisco, I settled in the verdant Willamette Valley. Within a short time, I noticed that our valley was dominated by magnificent specimens of the native *Quercus garryana*. My relationship with oaks had effectively circled around to a place populated with beautiful oaks. All put together, this led me to think about undertaking a project that would involve oaks.

Getting started

That kernel germinated over the course of a couple of years and numerous personal communications with foresters, horticulturists, farmers, and investors. Eventually, I decided to focus on establishing a truffle orchard, in an attempt to cultivate three *Tuber* species – *T. melanosporum*, *T. uncinatum* and *T. macrosporum* – using several species of oak – *Q. pubescens*, *Q. ilex*, *Q. cerris* and *Q. robur*. The project has also involved *Carpinus betulus*, *Corylus avellana*, *C. colurna* and *Fagus sylvatica*. I should point out here that I hedged my bets by also planting a few acres with cold-hardy cultivars of *Olea europaea*. It turns out that harvesting olives is much easier than trying to harvest truffles![3]

I approached the truffle orchard project in a disciplined and studious manner. I read voraciously: every book and peer-reviewed article I could get (primarily in French, though I did find some limited material in English as well). And I started to contact the authors of the research, as well as truffle growers that I identified from personal communications with researchers and others.

The myth – like many, based largely in truth – that the truffle community is very closed and discreet might be the rule, but I have found that there were many exceptions. My project owes a lot to people who openly shared their best ideas with me. In the United States, there was Tom Michaels, a true pioneer and perhaps the only truly successful (commercial) truffle grower in North America. First and foremost, my project was made possible by extensive advice from my French connection: scientists Pierre Sourzat and Gérard Chevalier, nurseryman Damien Berlureau (Agri-Truffe), and truffle growers

1. Since 1982, the Runcu-Groşi Natural Reserve (262 ha).
2. For a detailed account of Romania's oak forests, see Radu and Coandă 2013.
3. Since 2016, Bogdan Caceu serves as Executive Director of Olive Growers of Oregon (OGO), the nonprofit growers' association. He also serves on the Advisory Council to Oregon State University's olive research project.

like the genial Joël Gravier (Vaucluse), Patrick Déquéant (Côte d'Or), Bernard Vonflie (Alsace), Alain Adamec and Luc Bailly (Haute-Marne), Pierre Alis and Bernard Rosa (Lot-et-Garonne), and others.

Initial plantings

The project consisted of planting several hundred oaks inoculated with *Tuber* species on a parcel of land in the foothills west of the Willamette River, that I purchased in 2008. Finding this piece of land took a steady effort of one to two hours each day for just about one year. Within that time span, I identified a couple dozen potential properties. Through the use of modern technology tools such as Google Earth, county GIS records, the Oregon state database of water-well logs, and the absolutely excellent Soil Survey database from the USDA-NRCS, I was able to do the bulk of the initial due diligence remotely. Only two properties passed this initial screening. Site visits, personal communications with neighbors, and specific soil samples that were sent to a specialized laboratory for analysis, predicated my decision to acquire the property that has become La Creole Orchards.

The hillside upon which the truffle (and olive) orchard was to be developed had been a plum orchard from the 1930s until the 1970s, left fallow for over 30 years. It had grown into a jungle of mainly two invasive species: *Cytisus scoparius* and *Rubus armeniacus*. There was one block of approximately 12 ha of solid brambles. The old saying "horse high, bull strong, pig tight" perfectly describes the mass of vegetation that thickly covered the entire hillside. It took some effort to clear all of that and in the process save several

Photo 1/ The truffle orchard: in the foreground *Quercus ilex*, with *Q. pubescens* and *Q. cerris* in the background.

hundred native *Q. garryana* as well as hundreds of remnants from the old plum orchard.

While the oaks inoculated with *Tuber* species for truffle production were planted in an area that had no native oaks anywhere close by, the olive orchard was planted among some of the old plums and smaller, scrawny native *Q. garryana*: we set the rows for the olive orchard where we wanted them and when we came upon a preexisting tree, we simply skipped one spot and continued the row of olives on the other side, thus preserving a park-like atmosphere and using the presence of the larger trees to moderate the microclimate for the young olives.

Importing the inoculated oaks from France, with a federal import permit from USDA and rigorous checks from APHIS upon arrival at Seattle-Tacoma International Airport, was an interesting process. There were some radical decisions that had to be made: APHIS inspectors found a pest in one of the boxes in one shipment of oaks, and we had to decide whether to have the trees fumigated, returned to the sender, or destroyed. Because we had the same species of oak in several boxes, treatment could not be done only on the box in which the pest had been found but had to include all the boxes in that shipment. A word of advice: if you import trees, plan ahead and be ready to have to make a same-day decision you might not like.

The permit also stipulated that for two years the trees would be inspected in situ by an official from the Oregon Department of Agriculture; my trees passed these inspections with flying colors. The trees were planted in several phases, between winter 2009-2010 and winter 2011-2012.

Photo 2/ Acorns on *Quercus ilex*…but no truffles yet! Attentive readers will notice the very atypical acorn caps. These plants were raised from seed collected from *Q. ilex* growing near Corning, CA.

A small number of trees (25 *Corylus avellana* inoculated with *T. macrosporum*) were also generously donated by a local nursery and were planted along with the oaks, in one small separate block.

Irrigation was a challenge because this property and most of the hill formations on the west side of the Willamette Valley are plagued by low-yielding wells. The solution was to install solar-PV-powered pumps (from Grundfos, a Denmark-based company) in the two deep wells, to continuously pump small amounts of water into a 130 cubic meter above-ground storage tank. In order to reduce or virtually eliminate evaporation and the formation of algae in the stored water, an innovative floating cover was installed inside the water-storage tank. The cover, designed by Hexa-Cover, another Denmark-based company, is made of Frisbee-size plastic pieces that float on the surface of the water; their specially-designed edges lock together to form a perfect cover that blocks sunlight. Delivery of water to the trees is via very low-flow drip irrigation or low-flow micro jets.

La trufficulture raisonnée

A number of key cultural practices have been undertaken each year:

(i) cultivation/hoeing around each tree at a specific angle and depth, in order to promote rejuvenation of fine roots (the preferred real estate for the *Tuber* fungus), to lead the truffles to grow a few cm deeper, and to help maintain moisture in the soil (by breaking capillarity);

(ii) addition of *Tuber* species spores, in order to add to the store of spores in the vicinity of the roots of the host tree;

(iii) addition of calcium (in the form of lime/calcium carbonate), in order to maintain proper calcium and pH levels in the soil;

(iv) pruning (in particular *Q. robur* that so loves to grow) in order to reduce vigor (that is boosted by the fertility of Oregon soils and by the use of irrigation), to increase budding, and to stimulate root growth, that results in additional fresh real estate for the *Tuber* fungus to expand.

The combination of irrigation and of the cultural practices listed above forms the core of a program that a group of French truffle growers has been calling *trufficulture*

Photo 4/ Row of *Quercus cerris* inoculated with *Tuber uncinatum* (Pépinières Tenoux) planted in November 2011, in between rows of *Q. pubescens* also inoculated with *T. uncinatum* (Agritruffe) planted in March 2010.

raisonnée, which can be translated as reasoned/logical trufficulture but is better rendered as data-driven trufficulture. The term was coined by Joël Gravier, a very successful and thoughtful grower in the south of France (see interview with Mr. Gravier, pp. 42-43, this volume). Based on careful observation of several distinct parcels planted with inoculated oaks at his farm, Joël refined a process that is more rigorously data-based/driven than any I have come across in personal communications with close to one hundred truffle growers worldwide.

Photo 3/ Very robust growth on *Quercus ilex* (center) and *Q. robur* (left), both inoculated by the author. With deep fertile soils (40% clay but well drained) occasional irrigation, and pruning, both species tend to show growth of over 1-1.2 m each year.

To be continued…

Although the production of extra virgin olive oil from my olive trees has been quite successful, I cannot yet say if my truffle orchard will be. The inoculated oaks are now within the range of age to start production. Several truffle-hunting dogs have come, sniffed, and gone. No truffle yet.

I should like to point out that there are a handful of truffle orchards in Oregon that have produced *T. melanosporum*, though in very small quantities, which at least proves that it can be done here (as it has been done in the Tennessee/North Carolina area, in Idaho, Northern California, British Columbia, Australia and New Zealand). The areas that can produce one of the most desired *Tuber* species might be wider than previously thought. The actual harvest appears to be a bigger obstacle than growing truffles. Access to a good truffle-hunting dog and the ability to survey an orchard on a regular basis over a period of three to four months during the long maturation season being the key issues.

My venture has nevertheless been more an adventure than a shrewd moneymaking investment. What could be more beautiful and inspiring than working with oaks, in the fresh, clean air of the hills of the Willamette Valley, with panoramic views, the American goldfinch (*Spinus tristis*) roller-coasting above as it bounds up and down in flight, constantly calling out its joy (one presumes), and with the feeling that these oaks, regardless of whether they will ever produce a single truffle, might still be on these hills hundreds of years from now?

Photo 5/ No truffle yet, but the "scorched zone" indicative of the mycelium development is visible at the base of the tree (*Quercus pubescens*).

Photo 6/ La Creole Orchards

Another Way For *la Trufficulture*

Interview with Joël Gravier (*joel-gravier@club-internet.fr*)

IO: You have spent a great deal of time trying to pierce the mysteries of successful truffle growing – what was your motivation?

Joël Gravier: In the 19th century in the Vaucluse region in France the sale of wild-collected truffles was an important commercial activity. Up until the 1970s the market was dominated by wild-collected truffles, whereas today they have been nearly entirely replaced by those produced on irrigated truffle farms. For almost a century and a half now truffle farms have been planted in the region. Historically, because of the random character of success most attempts have been made on poor soils, or on that part of the farmland not suitable for more profitable crops. The history of truffle culture is complex and confusing, with the corpus of existing information being infused with secrecy and dominated by the conviction that the "ancestral" way of doing things produced excellent results. In my opinion this is not true if only because a serious read through what has been left by our predecessors, reveals a mass of incredibly contradictory information.

IO: Who were some of the early pioneers in truffle growing?

JG: In the first quarter of the 19th century, around 1815, Mr. Joseph Talon, farmer and truffle hunter, was the first. His initial success (first harvest: 1825) and ensuing reputation, led him to produce and sell "truffle trees". Around 1835, a few other truffle hunters followed in his footsteps, initially obtaining plants from him. Those who did succeed in producing (first harvests: 1845/50) also became nurserymen and most of them also became truffle brokers. Herein lies the root of one of the obstacles to objective evaluation of these early producers: the figures that we have are based on commercial transactions with no distinction between wild-sourced or farm-produced. Additionally, the only available figures were (and still are) provided by the brokers…in other words by the same individuals that were collecting the wild ones, growing the cultivated ones, and selling the plants reputed to be good producers. It is therefore impossible to correlate production levels with a particular methodology. In 1847, Mr. Rousseau, a successful businessman from Carpentras, became interested in truffle culture and began by purchasing plants from Mr. Talon and introducing irrigation. This innovation apparently reduced the number of years needed before the trees started producing while resolving dependency on rainfall. But the success was short-lived: like all truffle plantations, Mr. Rousseau's trees produced truffles for a couple of decades and then stopped.

IO: And in your family…?

JG: My great-grandfather was part of the third wave of French "truffle adventurers" in the beginning of the 20th century. It is thanks to the observations he recorded that I was able to reconstruct what his annual production was. His harvests were erratic, seemingly linked to rainfall. On average there was a "good" year every 3-4 years. These "good" years were always preceded by a year of drought with no truffles at all. The truffle plantation on the whole was productive for about 30 years, during which time there were 7-10 "good" years, and after which other mushrooms appeared that eventually replaced the *Tuber* species. In the 1970s and 1980s new trees were planted by my grandfather and shortly thereafter by my father.

IO: And these were the new mycorrhized seedlings?

JG: Yes, it was a time when many farmers were trying their luck with the first mycorrhized seedlings. So, there was renewed enthusiasm, and new seedlings but…no truffles. What was the problem? Why did this not function? Climate change? Were mycorrhized seedlings a pipe dream? Some, like Mr. Rousseau in the 1850s, tried irrigation in the 1980s – but this did not guarantee success either.

IO: When did you become actively involved in growing truffles?

JG: I became seriously involved with truffles in 1996. It had been a year of abundant rainfall but, though my grandfather's plantation was 22 years old, it had never produced one single truffle. Nevertheless, because of all of the rain that we had had, I went to visit the farm and to my joyous surprise…truffles galore! Even the trees that my father had planted that were much younger were producing their fair share. The following year was very dry with not one truffle to be seen, so I decided to install an irrigation system because it seemed to me that the year before was proof that the problem was not with the trees. My efforts were not in vain: the following year, the truffle plantations yielded 70 kilos per hectare but after four years, production collapsed: one after another all of our plantations stopped producing. It was obvious to me that something was going on that needed to be understood – and that could be understood if we stopped relying on rumor and legend. So I contacted other truffle growers and some were willing to develop an informal network to exchange information.

IO: Specifically, what aspects did you start investigating?

JG: What we knew empirically was that irrigation promoted truffle production – but apparently it had negative effects on long-term production. Why? What was immediately obvious was that a 25-year-old irrigated truffle farm had trees the same size as a 100-year-old non-irrigated truffle farm. Studying the roots revealed that the zone linked to truffle production was far from the trunk, that new root development was sluggish, and that the mycorrhizal associations were not maintained. In one of our younger plantations I therefore attempted in the first years of the 21st century to contain the vigorous growth by pruning both the branches and the roots. Pruning the branches during the productive life of the trees stimulates leaf, bud, and root formation, while promoting a more compact shape and denser root system. The roots are pruned by working all around the tree a short distance from the trunk to a depth of 15 cm with a sharp spade, and a few meters from the trunk to a much greater depth with a subsoiler. If fibrous-root development happens too slowly, the mycorrhizae do not flourish, indeed may not survive. These techniques promote the development of fine roots closest to the tree, the most propitious area for mycorrhizae development.

IO: What results did you observe from the implementation of these techniques?

JG: It turned out to be a good course of action! There were no negative effects on trees that were already productive and it stimulated production in trees that were not. We decided that our general methodology for all of the trees would be based on irrigation, pruning, and a pinch of ground truffle (for the spores). An interesting result has been the reduction of time between planting and production, in some cases as little as three years, with maximum production potential attained at a younger age (80% of the trees reached their maximum production potential in their seventh year). Did we at last have a way to control what had been up until this point a process with random results? Though the answer to that question is still not a definitive “yes”, two truffle growers with whom I collaborated, also started using these techniques: Jérôme Gallis, who today is the largest truffle producer in France, and Emidio Angellozzi, an Italian colleague, the largest producer in the world.

IO: What lies ahead for the truffle world?

JG: Scientific research continues to advance, and scientific interest in our results to increase. For example, the sequencing of the truffle genome paved the way to understanding that adding spores promoted fertilization rather than mycorrhizal development. In 2007, thanks to the creation of the grossestruffes.com website and forum, exchanging information has been facilitated. Today, other growers have adhered to our methods – and all boast the same good results. In reality, and this is exactly where the difficulty lies, there is no miracle recipe for truffle growing that can be used at every site. Nothing is simple or straightforward, but it seems to me that today there is a dynamic evolution in the truffle-growing world as we have come to realize that the “legendary” information passed down from generation to generation since the mid 19th century is not very useful. The past 50 years have shown us that cultural practices based on this yields at best erratic results whilst today we have the knowledge and the means to pave “another way” for the production of truffles, resolutely determined not to be slaves to chance!

Photographers. Title page: Pierre Sourzat (*Tuber melanosporum*). Photos 1-6: Bogdan Caceu.

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Living in the Magic of Trees

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ABSTRACT

What is a treehouse?

Not surprisingly, in this age of extreme ecological concern and ever-increasing interest in the natural world from many quarters, a number of architects have, over the past two decades, reflected on the arboreal world to develop an innovative answer to that question. Arboreal architecture is thus not just about "building in trees" but rather, as this paper shows, a philosophy that has inspired the use of architectural knowledge to enhance the beauty of trees and to develop a novel way of interacting with them. Beyond simply providing an extravagant solution to private homes, arboreal architecture has a role to play in developing positive interactions with trees and forests.

Keywords: *Quercus alba*, arboreal architecture, White Oak Treehouses

Whisky-flavored beginnings

In the summer of 2002 I built my first tree terrace in a 300-year-old *Fraxinus excelsior* (common ash) in Ballinderry (Ireland), near lake Derg, on a property owned by my friend Paddy Fogarty, better known in the village as “Whisky Man” for reasons I’m sure I need not explain. A tree terrace is an open treehouse that doesn’t require a building permit because it is not a closed living volume. It consists of a simple “floor”, with or without a balustrade or a roof. Walls can be a part of the terrace, but only on three sides or less. One night, Paddy was seriously inebriated and I took the occasion to ask for his permission to use a tree in his wonderful woodland to build a tree terrace.

Surely I could be accused of taking advantage of the situation knowing full well that in the above-mentioned state he was strictly a “yes” man. So be it! I got his permission and the very next day I started building the terrace using materials from a nearby building site that I was working on for the architect Antony John Murphy. We were building a private residential house with timber floors and roof, and a round Finnish-like wooden sauna and I was allowed to take away all of the unneeded timber to build my terrace.

It took about two weeks to build the terrace and every night thereafter for the next two months I was in that tree, perched four meters above the ground in my arboreal front-row seat from where I admired the splendor of the natural world and the changing of the guard between the sun and the moon, in the company of a couple of giant crows, who, seemingly not frightened by me in the least, kept me company as if I were one of them. Together we listened to the wind coming through the branches like ancient Gaelic whispers of long-lost stories.

As the days went on, Paddy and I were increasingly convinced that this tree terrace was not simply an architectural experiment but rather something new in arboreal architecture. A couple of days before my departure from Ireland, Paddy declared, “Thomas, my intention was to cut down that ash to sell the timber. You saved it because I was drunk,” he said smiling, “but really I am happy I was drunk because now that tree has a unique story to tell, more valuable than anything I could have earned from selling the timber. Your terrace has exalted its natural beauty over its economic value and I will keep it alive.”

A treehouse vs. a house in a tree

From that first experience shared with my friend I realized that there is an enormous difference between a house in a tree and a treehouse. A treehouse is a house with the added value of an arboreal story. Every tree has a different story to tell, a different *genius loci*, and this can only be expressed through architecture that takes into account the tree’s symbolic and emotive dimensions. It is in this sense that I define arboreal architecture as better “tree-centric architecture” the goal of which is to underline the beauty of trees and their environment rather than to promote an aesthetic philosophy or to glorify specialized building skills.

Three years later I started to design and to build my first treehouses, through a collaborative effort between John Harris’ Treehouse Company and my first experimental design company, Wooden Architecture (since 2017, White Oak Treehouses). Right from

Photo 1/ Perched in amongst *Carpinus betulus*, this treehouse was built in 2005 by John Harris and Thomas Allocca, using *Pinus sylvestris* and *Thuja plicata*.

the start we were fortunate to have clients[1] with sufficient means to seriously invest in their treehouse dreams and this in turn has allowed me to experiment enormously, increasing my knowledge exponentially, helping me to redefine what is commonly referred to as a treehouse. What I was trying to achieve each time was a resolution of the client's needs and desires with the objective of keeping the tree alive and happy without creating any negative side effects that could result from having human beings living in,

1. For example, Prince Alexander and Princess Astrid of Liechtenstein, Prince Sigieri Diaz Della Vittoria Pallavicini, and Umberta Beretta.

Photos 2/(a-b) The warm and cozy atmosphere in this elegant treehouse built by John Harris.

and passing through, the tree all the time, possibly interfering with its biological cycles. Since every tree is different, so every project was a challenge from both a philosophical and an architectural point of view.

What makes a treehouse a really well integrated project? By making it disappear or covering it with mirrors? Is it "ecological" just because wooden elements and low-cost energy systems are used? Is it non-invasive for the tree just because as few stems and branches as possible are cut? Is it impressive only if it is constructed ten meters or more above the ground? The answer to all of these questions is an emphatic "no"! A well-integrated project, in other words a real treehouse, must be defined by the "dialogue" it establishes between the tree's style and shape and the characteristics of the building materials that are used. It must combine aesthetic and technical proposals that will enhance the tree's beauty and it must make the inhabitants feel that the house owns them rather than the other way around. The perfect treehouse is one that obscures the frontier between inside and outside.

Even if not all trees meet the technical requirements needed to support the weight and other physical constraints of a treehouse, all trees can be part of a treehouse project because they all have a story to tell. For example, a treehouse does not necessarily need to be supported by trees: it can be built on pillars integrating it with the surrounding trees if this type of architecture provides a more harmonious solution to the specific woodland configuration where the house is to be built.

Choice of timber

Photo 3/ With 200 m² of indoor space, this amazing construction, built by John Harris, is a "tree-housed" shopping center with a variety of stores.

Oak timber is the best because of the quality and thickness of the heartwood, a major consideration for the long-term solidity of the structure (tree species with thicker sapwood tend to reject screws, for example). My architectural firm, specialized in treehouses as well as in interior and furniture design, is named White Oak in homage to *Quercus alba*, a tree that I adore both for the aesthetics of its square geometry and for the extraordinary quality of its timber. Its slow growth rate (as evidenced by the close rings) and high carbon content (about 35%) explain the hardness and resistance to wear through time even in conditions of high humidity. Indeed, *Q. alba* has long-been used in boatbuilding and tight cooperage applications. The grain is generally rather straight, with a medium to coarse, uneven texture; the heartwood is of variable color, from light to dark brown while the sapwood is lighter colored. *Quercus alba* is truly one of the best hardwood tree species for a wide range of architectural and design applications, while *Larix sibirica* is the best softwood, and *Phyllostachys bambusoides* the best bamboo.

Of oak and bamboo

In 2010 I started collecting timber bamboo species to experiment their potential cultivation in Italy and to develop architectural and design applications. The collection is called the Madake[2] Bamboo Collection and comprises to date about forty species. The Madake Italian Network project, begun in 2012 is a private network of timber bamboo plantations (*P. bambusoides*) and experimental fields for the development of sustainable building activities in Italy. Since 2017 the Madake Network has signed several contracts

2. *Madake* is the common name in Chinese for *Phyllostachys bambusoides*.

Photo 4/ A treehouse designed by Thomas Allocca that is to be built amongst oak trees in Italy. *Larix sibirica* and *Thuja plicata* are to be used for the construction, and *Quercus alba* for the indoor and outdoor furnishings. The treehouse and accompanying terraces comprise roughly 40 m^2.

for the development of different architectural projects.

Before my interest in bamboo, I had occasion to offer oak seedlings to my treehouse clients or, generally, to clients with large gardens, or if I knew they had land, or friends that had land, available for planting them. With the birth of the White Oak firm, I decided to enrich the Madake Bamboo Collection with a *Q. alba* nursery in order to produce seedlings to promote the development of oak plantations for timber. To initiate this project I contacted James Hitz (currently Treasurer of the International Oak Society and owner of Hitz Horticulture in Kouts, Indiana) to see if he could help me in my first step: collecting *Q. alba* acorns to sow. Exceeding all my expectations, I received on 22 September 2017 an extraordinary gift of 1,240 acorns collected by Jim in Indiana.

These acorns were sown in a substrate composed only of finely chopped oak chips I have produced, with the help of Pasquale Ristallo, from oaks growing in the Cilento region of Italy. At the time of writing this article, 700 acorns had germinated and after only 2 months the seedlings have shown remarkable root development. I have no doubts that my nursery will continue to produce new, high-quality *Q. alba* seedlings from acorns I hope to receive in the future.

I have also designed a four-hectare botanic garden that I have named The White Square and that will feature a one-hectare *Q. alba*/bamboo labyrinth and, of course, include treehouses. The White Square Botanic Garden, and appropriate site (not necessarily in Italy) still needs investors but I am confident they can be found, in Italy or elsewhere.

Hopefully, my project will also be useful to the IOS and contribute to its extraordinary efforts in promoting oak culture around the world.

Conclusion

Expensive or economical, perched one or ten meters above the ground, the magic of a tree house comes from the poetry it embodies – and this can not be achieved with blatantly arrogant architecture that is in competition with the tree. It means integrating our needs harmoniously, rather than viewing trees and or forests as just the “material” means to accomplish a particular building project. It is in this context that arboreal architecture represents more than an extravagant alternative to private homes. There is great potential to develop this idea to change the way tourists experience trees and woodlands – perhaps even how we build our cities.

Photographers. Title page: Thomas Allocca (wood shingles). Photos 1, 4: Thomas Allocca. Photos 2, 3: John Harris.

Niche Characterization of Oaks in Lebanon

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ABSTRACT

Lebanon is considered a biodiversity hotspot of the East Mediterranean Basin and a habitat for seven oak taxa. Many of these taxa occur in Lebanon on the edge of their distribution range, sometimes as isolated trees. These fragmented populations are the result of anthropogenic activities that have modified the landscape. Based on current niche occupancy, this work aims to model the potential niches of these seven taxa (and of their eventual hybrids identified in Lebanon) to determine which of them have restricted ranges in order to better evaluate their vulnerability to climate change and to help us set priorities for the conservation of species with restricted ranges and limited areas of occupancy.

Keywords: ***Quercus*, East Mediterranean biodiversity, oak species distribution**

Introduction

Oaks constitute a major group of trees, 30 of which are found in the Euro-Mediterranean region (Govaerts and Frodin 1998; Denk and Grimm 2010; Simeone et al. 2013). Lebanon is considered a biodiversity hotspot of the East Mediterranean Basin and a habitat for 7 oak taxa (Tohme and Tohme 2014). The high polymorphism and the occurrence of hybridization, has resulted in a series of taxonomic and nomenclatural revisions. The 7 taxa identified in previous works conducted in Lebanon (Mouterde 1966; Tohme and Tohme 2014; Stephan and Teeny 2017) are listed below with some common synonyms.

***Quercus calliprinos* Webb** is an evergreen oak, sometimes considered a synonym of *Q. coccifera* L. or a distinct subspecies of the latter, *Q. coccifera* subsp. *calliprinos* (Webb) Holmboe, distributed in Cyprus, Anatolia, and the Levant (Menitsky 2005). In Lebanon it has a wide distribution range, from sea level up to 1,800 m altitude on both western and eastern slopes of Mount Lebanon and the southern part of the Anti-Lebanon Mountains (Abi Saleh et al. 1976).

***Quercus cedrorum* Kotschy**, sometimes regarded as a synonym of *Q. petraea* subsp. *pinnatiloba* (K.Koch) Menitsky, is endemic to the Asian part of Turkey (Anatolia) and the Near East (Hedge and Yaltirik 1994; Menitsky 2005). In Lebanon, it is very localized and found exclusively within the area of occupancy of *Cedrus libani* A. Rich. (to which its epithet is attributed).

***Quercus cerris* L.** is widely distributed in southern Europe, Turkey, Syria and Lebanon (Govaerts and Frodin 1998; Menitsky 2005). In Lebanon, It is found in middle altitudes on the western slopes of Mount Lebanon.

***Quercus infectoria* subsp. *veneris* (A. Kern.) Meikle**, sometimes regarded as a synonym of *Q. boissieri* Reut., is present in the Near East, Cyprus, Caucasus, Iran and Turkey (Govaerts and Frodin 1998; Menitsky 2005). This oak has a wide bioclimatic range and can be found in pure stands or mixed with other oak species with which it hybridizes (Hedge and Yaltirik 1994; Menitsky 2005). In Lebanon it is mostly common at middle altitudes on both western and eastern slopes of Mount Lebanon, as well as the southern part of the Anti-Lebanon Mountains.

Quercus ithaburensis* Decne. subsp. *ithaburensis is found in Turkey, Syria, Lebanon, Jordan, Palestine and Israel (Mouterde 1966; Menitsky 2005). In Lebanon it is found in the Akkar region in the north, in open forests or as isolated trees.

***Quercus look* Kotschy** is endemic to Lebanon and Syria (Roskov et al. 2015). It is found as isolated trees or in degraded woodlands above 1,400 m in the southern parts of Mount Lebanon and on Mount Hermon.

***Quercus kotschyana* O. Schwarz** is the accepted name for the taxon referred to by Mouterde (1966), as *Quercus pinnatifida* Gmel. (Stephan and Teeny 2017). It is endemic to Lebanon and thrives in high altitudes (between 1,600 and 2,000 m) on the western slopes of northern Mount Lebanon.

Many of these taxa occur in Lebanon on the edge of their distribution range (sensu Gaston 1991), sometimes as isolated trees. These fragmented populations are the result of anthropogenic activities that have modified the landscape (Jomaa et al. 2009) leaving only remnants of past forests.

Abi Saleh (1982) described the altitudinal zonation of vegetation in Lebanon, dividing it into 5 levels: Thermo, Meso, Supra, Montane and Oro Mediterranean for the Mediterranean bioclimatic zones on the western slopes of Mount Lebanon and

Mount Hermon; 4 of those levels (Meso to Oro) describe the altitudinal zonation in the Mediterranean steppe further inland. Each level roughly comprises an altitudinal range of 500 m, culminating in the Oro Mediterranean, above 2,000 m.

Based on current niche occupancy, this work aims to model the potential niches of the previously mentioned 7 taxa (and of their eventual hybrids identified in Lebanon) to determine which of them have restricted ranges in order to better evaluate their vulnerability to climate change.

Materials and Methods

Through the area of occupancy of each taxon, 91 points were selected and distributed as follows: 23 for *Q. calliprinos*, 23 for *Q. infectoria*, 15 for *Q. cerris*, 10 for *Q. kotschyana*, 7 for *Q. look*, 4 for *Q. ithaburensis*, 4 for *Q. cedrorum*, 2 for *Q. cedrorum* × *infectoria*, 2 for *Q. infectoria* × *cerris* and 1 for *Q. infectoria* × *brantii* (Figure 1). For widely distributed species (*Q. calliprinos* and *Q. infectoria*) we selected populations representative of the diversity of bioclimatic conditions and vegetation levels in the species area of occupancy. For the remaining taxa, almost all populations were geo-referenced.

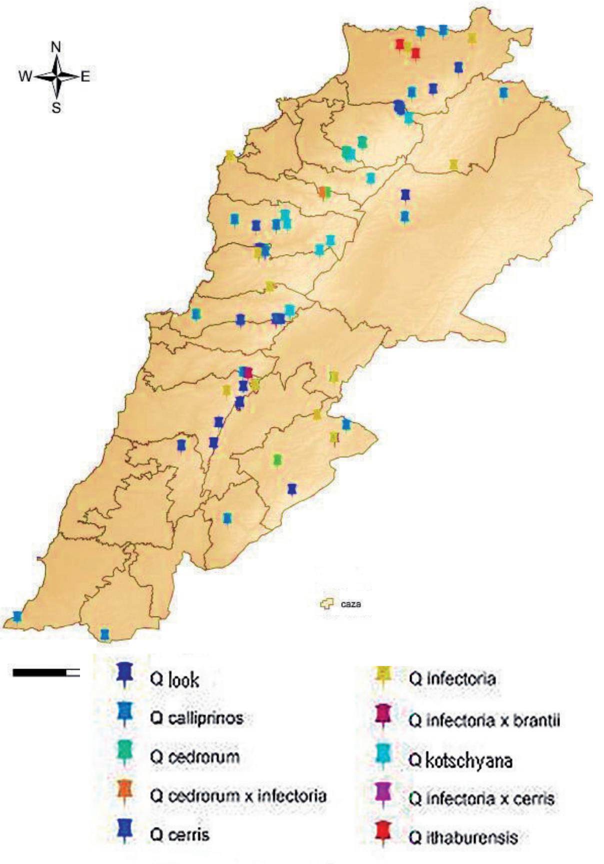

Figure 1/ Distribution of the sampled sites with oak species in Lebanon.

At each site, geographic, orographic and bioclimatic parameters were recorded on site or generated through GIS tools by geo-referencing the sites and overlaying them on the required maps (Table 1). Since Lebanon is under the Mediterranean climate zone sensu Köppen where a Csa/Csb climate rules (Peel et al. 2007), the difference between plant species' requirements of humidity and temperature is best expressed with the Emberger Quotient (Emberger 1955, 1971), calculated as follows:

$$Q = \frac{2000 \times P}{M^2 - m^2}$$

Where *P* is the mean annual precipitation (mm), *M* is the maximal temperature average of the hottest month, and *m* is the minimal temperature average of the coldest month (˚K). In this study we converted *Q* into (˚C) by adding 546.24 (Daget et al. 1988).

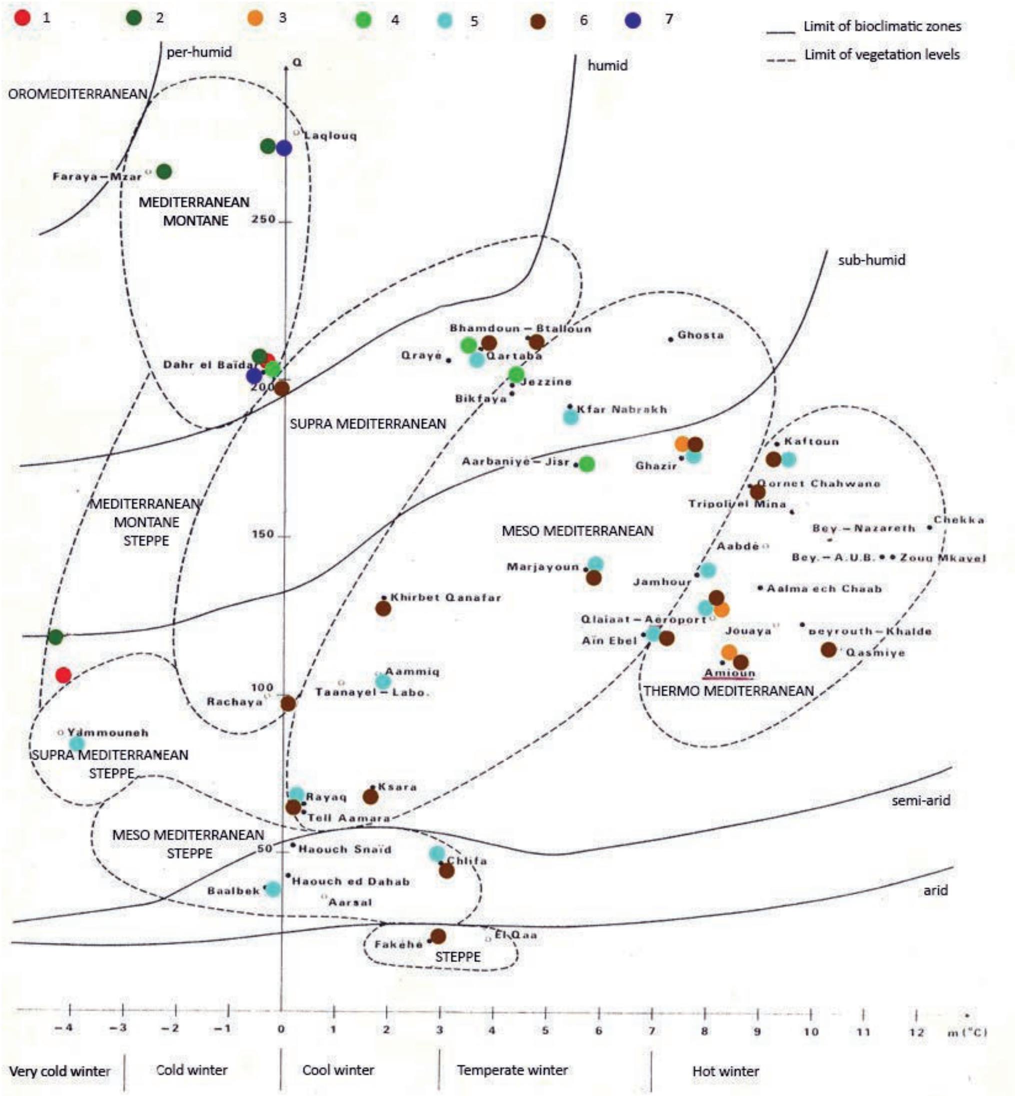

Figure 2/ Distribution of oak sampling points according to the climagram of Emberger (*Quercus look*: 1; *Quercus kotschyana*: 2; *Quercus ithaburensis*: 3; *Quercus cerris*: 4; *Quercus infectoria*: 5; *Quercus calliprinos*: 6; *Quercus cedrorum*: 7).

Climatic data was retrieved from the *Atlas climatique du Liban* (Ministry of Public Works 1966) with 20 years of data for temperature (*M* and *m*) and precipitation (*P*), from the closest weather station at similar elevation as per Touchan et al. (2016). Estimating annual rainfall was done by geo-referencing each site on the precipitation map of Lebanon. Sites were located between 2 isohyets, and therefore 2 values covering the precipitation range within a site were obtained: *P1* and *P2* for the lowest and highest values respectively. Consequently, 2 values for *Q* were calculated for each site: *Q1* and *Q2*. In addition, we used Emberger's climagram to plot oak species distribution by combining the Emberger Quotient (*Q*) and the winter variant (*m*) (Barbero et al. 1992; Abi Saleh et al. 1996; Dufour-Dror and Ertas 2004) based on the data retrieved from the represented weather stations (Figure 2).

In order to understand the major factors affecting the distribution of oak species in Lebanon, a Discriminant Factor Analysis (DFA) was conducted to extract those environmental variables that maximize the variance among the studied species. Seven acknowledged taxa, plus hybrids found in more than one location were analyzed using a multi-variant approach for multiple species.

A correlation matrix was computed from the original dataset. The robustness of the assessed distances among species was further tested by the Fisher coefficients and their relative p-values. Finally, the coefficients of the canonical discriminant functions, the eigenvalues of each environmental variable, the barycenters scores and the a priori/a posteriori classification with the probability of affinity were calculated, using SPSS 17.0 and XLSTAT 5.03 add-in for Microsoft Excel.

Parameter	Description	Source
A	Aspect (degrees)	Field measurement
DtS	Distance to sea (m)	GIS
M	Maximal temperature average of the warmest month (˚C)	GIS/weather station
m	Minimal temperature average of the coldest month (˚C)	GIS/weather station
MR	Mother rock type	GIS/geological map
MY	Maximal temperature average of 3 years	Weather station
my	Minimal temperature average of 3 years	Weather station
P	Precipitation value (mm)	closest weather station
P1	Precipitation value of the lowest isohyet (mm)	GIS/precipitation map
P2	Precipitation value of the highest isohyet (mm)	GIS/precipitation map
Q	Emberger quotient value	closest weather station
Q1	Emberger quotient value	based on P1 (Q min)
Q2	Emberger quotient value	based on P2 (Q max)
S	Slope (%)	Field measurement
SD	Soil depth (in classes of 10cm)	Field measurement
Tar	Temperature Annual Range	This work
X	Longitude (decimal degrees)	Field measurement
Y	Latitude (decimal degrees)	Field measurement
Z	Altitude (m)	Field measurement

Table 1. Parameters used, description and data source.

Results

The variance within the sampled species, thus within their niches, was retrieved from DFA by using a dimensional reduction of the original dataset; the first two linear uncorrelated variables (namely, F1 and F2) explains 63.9% of the cumulative difference between species (Figure 3). Table 2 shows that the major factors (F1 axis) affecting species distributions are climatic parameters related to minimum winter temperature or winter variant (*m*, *my*), maximum temperature of the hottest month (*M*), minimum and maximum precipitation isohyets (*P1*, *P2*) as well as elevation (which strongly affects both temperature and precipitation). Local environmental factors (rainfall and soil type, for example) contribute to a lesser extent (F2 axis).

Parameter	F1	F2
Z	**0.6683**	-0.2617
S	0.1344	0.0495
DtS	0.0320	-0.0416
X	0.0307	0.2891
Y	0.0770	0.3197
my	**-0.4502**	-0.0194
My	-0.3240	0.0477
P1	**0.4472**	-0.1056
Q min	0.2499	-0.1308
P2	**0.4596**	-0.1026
Q max	0.2320	-0.1264
P	0.0289	**-0.4023**
M	**-0.6999**	-0.0699
m	**-0.7319**	0.0674
Tar	0.1071	-0.1209
Q	-0.0255	-0.3143
SD (0-10)	-0.1423	-0.0895
SD (10-20)	-0.0943	-0.1274
SD (20-30)	0.3091	-0.1470
SD (25-35)	0.3147	0.0433
SD (30-40)	-0.2640	**0.4270**
A (North)	0.0653	0.0023
A (North East)	-0.1033	-0.0077
A (East)	-0.1034	-0.1019
A (South East)	-0.0199	-0.0105
A (South)	-0.0408	0.3588
A (South West)	0.1250	0.0843
A (West)	0.1588	-0.1006
A (North West)	-0.0575	-0.2116
MR (calcareous red)	0.0429	-0.1892
MR (calcareous red-dolomite)	0.1219	-0.0917
MR (volcanic)	-0.3442	**0.4673**
MR (mixed calcareous red and sandy)	-0.0880	-0.0298
MR (calcareous white)	-0.0545	-0.0676
MR (mixed calcareous red and white)	0.0452	-0.1471
MR (sandy)	0.1266	-0.0904
MR (mixed calcareous and volcanic)	-0.1964	**0.4677**
MR (moraine)	0.2499	0.1096

Table 2/ Eigenvalues of the correlation matrix for the original set of variables on the two main components, F1 and F2, of the Determinant Factor Analysis. Classes of categorical and nominal variables have been shown separately in this table. Symbols for the parameters are described in Table 1. Bold values indicate the parameters that mostly maximize the variance explained by F1 or F2.

By comparing Figure 3 with Figures 4 and 5, species can be distributed according to the winter variant (*m, my*), the major climatic parameter. *Quercus kotschyana, Q. infectoria* × *cedrorum, Q. cedrorum*, and to a lesser extent, *Q. look*, are negatively related to this parameter. *Quercus calliprinos* and *Q. ithaburensis* are the most positively affected

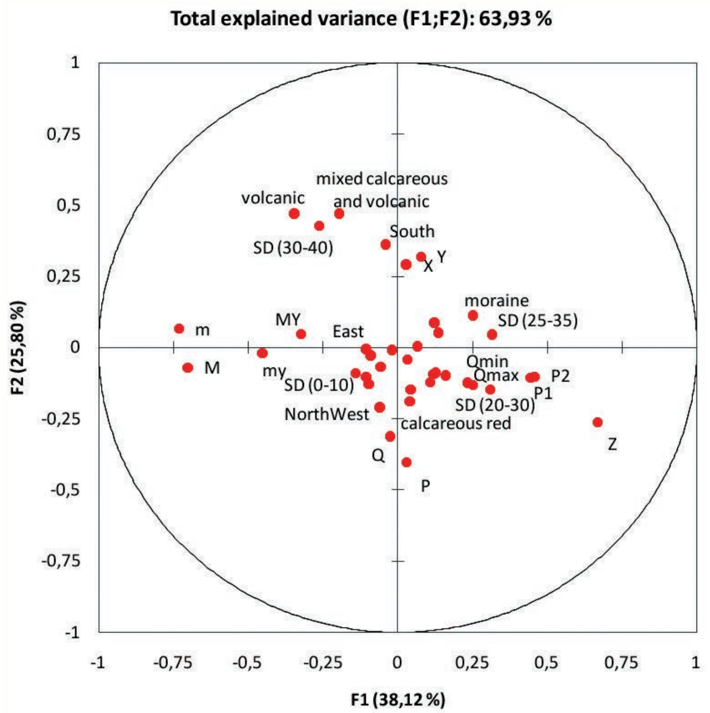

Figure 3/ Eigenvalues of the biogeographic parameters plotted on the DFA graph. For clarity of the plot, not all the parameters are labeled.

by high temperatures, whereas *Q. kotschyana* and *Q. cedrorum* are negatively affected by this parameter. Precipitation parameters (*P1*, *P2*) constitute the third major climatic factor affecting species distribution according to a bioclimatic range.

Elevation is the major parameter affecting oak species distribution in Lebanon. An altitudinal gradient could be drawn with *Q. ithaburensis* at the lowest altitudes, followed, in order of increasing altitude, by *Q. calliprinos*, *Q. infectoria*, *Q. cerris*, *Q. look*, *Q. cedrorum* and *Q. kotschyana* (Figures 4 and 5). Deep soils (SD 30-40) and soils developed on volcanic mother rocks (MR volcanic and mixed calcareous with volcanic) are secondary contributors (F2 axis) to oak species distribution in Lebanon (Table 2 and Figure 3). The distribution of *Q. ithaburensis* is strongly related to mature volcanic soil types (depth between 30 and 40 cm) and in this strongly differs from the other species (Figures 3 and 4).

However, using descriptive statistics species' biogeographic amplitude for the sampled populations (Table 4) can be characterized. Species located at the lowest and highest elevations (respectively *Q. ithaburensis*, *Q. look*, *Q. cedrorum*, and *Q. kotschyana*) have the most restricted altitudinal range, whereas those at middle altitudes have a wider range (*Q. calliprinos*, *Q. cerris*, and *Q. infectoria*).

A similar observation is worth mentioning regarding distance to the sea (*DtS*) where *Q. cedrorum*, *Q. cerris*, *Q. ithaburensis* and *Q. kotschyana* that are closer to the sea have more restricted ranges than *Q. calliprinos*, *Q. infectoria* and *Q. look* that reach distant locations inland (Table 4).

Figure 5 shows the relative differences in distribution area for each species (black circles) centered on the barycenters, i.e., a dispersion index of sites per species around its theoretical center. The larger the circle, the wider the distribution range of the taxa.

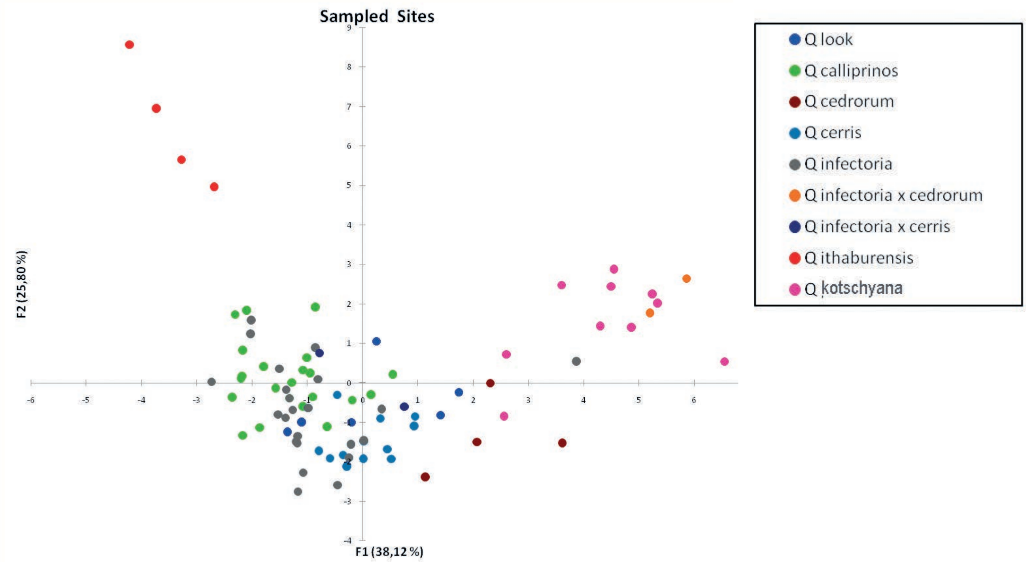

Figure 4/ Factor scores of the sample sites plotted on the two main functions of DFA.

Table 3 explains the degree of similarity in the environmental factors affecting species distribution. The greater the distance (p-values) between environmental factors affecting species distribution, the higher the probability that their niches are separated.

The current niches of *Q. ithaburensis* and *Q. kotschyana* are strongly distinguished from the other taxa. The current niche of *Q. calliprinos* is also significantly distant from some species, but not from *Q. look*, *Q. cerris* × *infectoria*,[1] and *Q. infectoria*. The current niche of *Q. infectoria* is close and/or overlaps with *Q. calliprinos*, *Q. cedrorum and Q. cerris*. It is also evident that *Q. cerris*, *Q. cedrorum* and *Q. look* have no significant difference between their respective current niches (Table 4 and Figure 5).

Discussion

This investigation has shown that climate is the major driving factor affecting oak species distribution in Lebanon, with temperature (minimum and maximum) and precipitation range being the most significant. Elevation is an important biogeographical factor, because of its effect on both temperature and precipitation, and contributes to amplifying the differences between potential niches of the different species, leading to a possible altitudinal zonation of the vegetation (Abi Saleh 1982; Quezel and Barbero 1985).

Climate is known as the major factor affecting the geographical distribution of plant species in general (Cox and Moore 1999; Lugo et al. 2015). Extreme climatic events such as drought combined with a long history of human activities in the Mediterranean region (forest fire, grazing, cutting and habitat fragmentation) have contributed to increased pressure on natural ecosystems (Jomaa et al. 2009; Touchan et al. 2014). As a result, orographic factors (slope, aspect) and soil characteristics affect species distribution only at local level, and do not constitute major driving forces in the distribution of species (Dufour-Dror and Ertas 2004).

1. The validity of this taxon, an intersectional hybrid, mentioned in Menitsky (2005) and Mouterde (1966), is under study by Dr. J. Stephan.

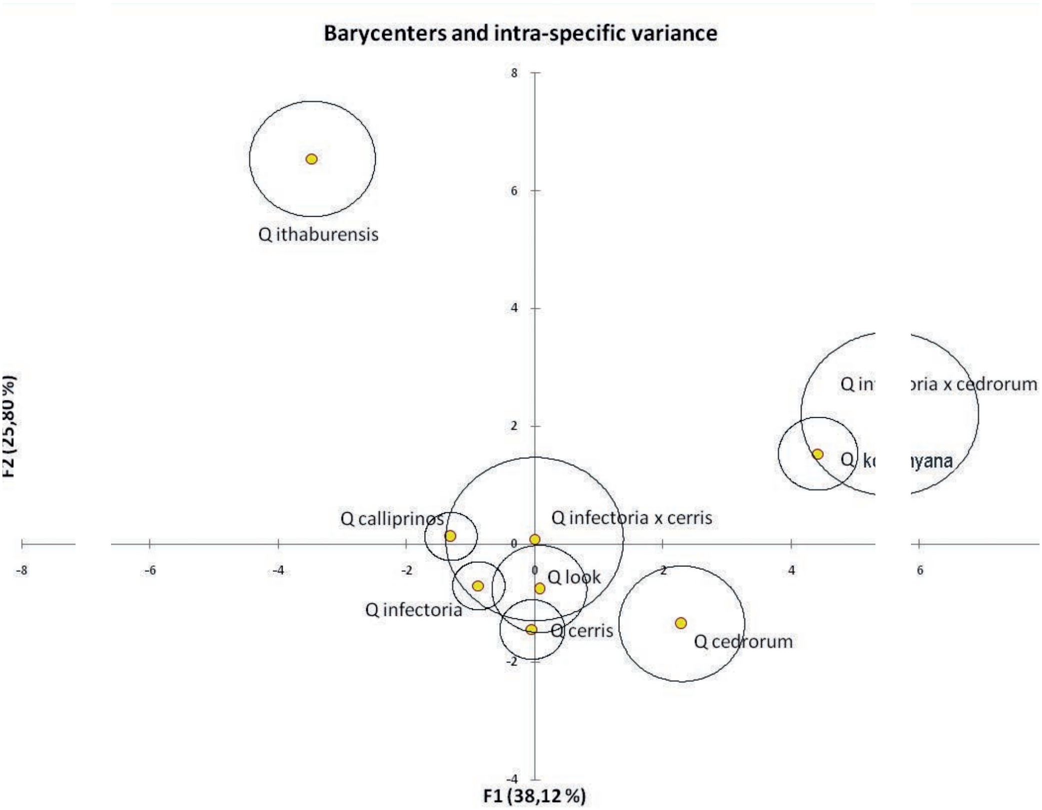

Figure 5/ Coordinates of the barycenters of the study oaks (yellow dots) and relative dispersion of the populations around each barycenter (black circles).

Quercus	*look*	*calliprinos*	*cedrorum*	*cerris*	*infectoria*	*infectoria* × *cedrorum*	*infectoria* × *cerris*	*ithaburensis*	*kotschyana*
look	--	0.2643	0.1038	0.1728	**0.0451**	**0.0427**	0.9850	**< 0,0001**	**0.0005**
calliprinos	1.2144	--	**0.0113**	**0.0139**	0.3718	**0.0073**	0.9849	**< 0,0001**	**< 0,0001**
cedrorum	1.4814	2.0421	--	0.0789	0.0131	0.5870	0.5303	**< 0,0001**	**0.0059**
cerris	1.3406	1.9923	1.5542	--	0.4561	**0.0111**	0.9890	**< 0,0001**	**< 0,0001**
infectoria	1.6983	1.1033	2.0071	1.0298	--	**0.0056**	0.9838	**< 0,0001**	**< 0,0001**
infectoria* × *cedrorum	1.7121	2.1508	0.9267	2.0463	2.2177	--	0.3176	**0.0007**	0.6182
infectoria* × *cerris	0.4872	0.4875	0.9704	0.4678	0.4923	1.1561	--	0.0709	0.5044
ithaburensis	3.5394	3.2604	3.8212	4.2466	3.8635	2.7448	1.5822	--	**< 0,0001**
kotschyana	2.7989	4.7442	2.2033	3.5895	4.3043	0.9030	0.9908	4.7691	--

Table 3/ Fischer's distance matrix with p-values for the oak species investigated in this study. Bold values show significant distances among species at α < 0.05 level.

Parameter	*Quercus look*	*Quercus calliprinos*	*Quercus cedrorum*	*Quercus cerris*	*Quercus infectoria*	*Quercus infectoria × cedrorum*	*Quercus cerris× infectoria*	*Quercus ithaburensis*	*Quercus kotschyana*
Z	1654 (1516-1808)	943 (74-1745)	1654 (1450-1766)	1280 (664-1634)	1099 (177-1811)	1756	1452	325 (182-592)	1755 (1591-1902)
S	36.6 (20-60)	27.3 (5-60)	30.5 (10-60)	33.2 (0-90)	20.7 (5-45)	31.0	12.5	31.2 (5-65)	32.8 (20-60)
DtS (km)	32.8 (23.0-50.0)	21.4 (1-51)	20.4 (17-23.5)	17.2 (9.2-27)	24.0 (1-49.5)	23.5	16.0	18.3 (12-29)	22.5 (17.2-28.3)
X	35.8103 (35.64-36.13)	35.8391 (25.14-36.4)	35.9421 (35.8-36.1)	35.9259 (35.6-36.3)	35.8686 (35.3-36.3)	35.9267	35.7861	36.1932 (36.1-36.3)	35.9481 (35.82-36.1)
Y	33.6829 (33.44-34.20)	33.9662 (33.06-34.6)	34.2513 (34.1-34.3)	34.1788 (33.5-34.5)	33.9576 (33.1-34.6)	34.2083	33.9662	34.5956 (34.5-34.6)	34.1564 (33.9-34.38)
my	7.2 (5.1-10.1)	9.2 (4.2-15.8)	6.9 (4.6-10)	7.7 (4.6-10.5)	8.8 (4.2-15.9)	5.4	6.5	9.6 (8-10.4)	5.1 (1.9-11.5)
MY	26.9 (25.6-28.6)	26.4 (23.6-29.4)	24.8 (23.6-26)	25.5 (23.5-27.7)	26.3 (23.6-29.5)	25.2	26.4	26.6 (25.7-27.2)	25.3 (23.4-28.1)
P1	1028 (600-1200)	943 (300-1400)	1200 (1100-1400)	1107 (800-1400)	961 (300-1400)	1200	1300	800 (800-800)	1240 (900-1400)
Q min	179.9 (111-215)	192.8 (50-287)	235.2 (202-301)	216.5 (168-286)	190.7 (60-287)	210.1	231.9	161.9 (155-170)	220.9 (144-342)
P2	1128 (700-1300)	1030 (400-1400)	1275 (1200-1400)	1207 (900-1400)	1022 (400-1400)	1300	1350	900 (900-900)	1310 (1000-1400)
Q max	197.4 (129-233)	210.8 (67-315)	249.3 (221-301)	236.0 (186-301)	203.3 (80-315)	227.6	239.7	182.1 (175-191)	233.4 (160-368)
P	1203 (979-1371)	1032 (191-1491)	1396 (1371-1471)	1438 (1295-1471)	1058 (412-1471)	899	1421	877 (782-1099)	993 (899-1371)
M	28.2 (23.4-34.6)	29.3 (23.4-34.2)	24.5 (23.4-28)	27.6 (23.4-31.1)	29.8 (22.8-36.1)	22.8	25.7	30.5 (29-32.3)	22.9 (22.8-23.4)
m	-2.0 (-0.4-4.20)	4.6 (-0.4-10.5)	0.6 (-0.4-3.7)	3.3 (-0.4-5.5)	3.3 (-4.2-10.3)	-4.0	1.6	8.0 (7.7-8.3)	-3.3 (-4.0--0.4)
Tar	30.2 (23.8-38.8)	24.8 (19.5-32.5)	23.9 (23.8-24.3)	24.3 (23.5-25.6)	26.4 (20.2-38.8)	26.8	24.0	22.5 (21.3-24)	26.2 (23.8-26.8)
Q	153.2 (88-202)	149.3 (22-214)	204.3 (202-210)	205.5 (174-209)	147.1 (39-214	118.8	206.1	134.6 (111-177)	135.5 (119-202)

Table 4/ Descriptive statistics of the biogeographic range of oak species investigated. For continuous variables, minimum and maximum values are given in brackets, except for those species represented by only two sites. For categorical and nominal variables, the frequency number per class (in percentage) is reported.

Parameter	***Quercus look***	***Quercus calliprinos***	***Quercus cedrorum***	***Quercus cerris***	***Quercus infectoria***	***Quercus infectoria × cedrorum***	***Quercus cerris× infectoria***	***Quercus ithaburensis***	***Quercus kotschyana***
SD 0-10	43%	30%	25%	0%	9%	0%	0%	0%	0%
SD 10-20	43%	57%	25%	27%	30%	0%	50%	0%	30%
SD 20-30	14%	9%	25%	60%	35%	50%	50%	0%	60%
SD 25-35	0%	4%	0%	13%	26%	0%	0%	100%	10%
SD 30-40	0%	0%	25%	0%	0%	50%	0%	0%	0%
A-NE	14%	9%	0%	20%	22%	0%	0%	25%	10%
A-E	14%	9%	0%	7%	9%	0%	0%	0%	0%
A-NW	14%	9%	0%	33%	26%	0%	0%	0%	10%
A-W	43%	17%	75%	7%	9%	50%	0%	0%	10%
A-S	14%	30%	0%	0%	4%	50%	50%	50%	20%
A-SE	0%	9%	0%	0%	13%	0%	0%	0%	10%
A-N	0%	13%	25%	33%	17%	0%	50%	25%	30%
A-SW	0%	4%	0%	0%	0%	0%	0%	0%	10%
MR-calcareous red	71%	53%	50%	40%	48%	100%	0%	0%	30%
MR-calcareous red dolomite	29%	22%	25%	26%	22%	0%	100%	0%	40%
MR-volcanic	0%	17%	0%	0%	9%	0%	0%	75%	0%
MR-mixed calcareous red and sandy	0%	4%	0%	0%	4%	0%	0%	0%	0%
MR-calcareous white	0%	4%	0%	7%	0%	0%	0%	0%	0%
MR-mixed calcareous red and white	0%	0%	25%	7%	4%	0%	0%	0%	0%
MR-sandy	0%	0%	0%	20%	13%	0%	0%	0%	20%
MR-mixed calcareous and volcanic	0%	0%	0%	0%	0%	0%	0%	25%	0%
MR-moraine	0%	0%	0%	0%	0%	0%	0%	0%	10%

The higher the precipitation, the higher the diversity of observed oak taxa in Lebanon. Although the Emberger Quotient is not found to be a major climatic parameter shaping the distribution of oak taxa, it remains a necessary parameter along with the winter variant to display on a climagram the bioclimatic range of plants according to bioclimatic zones and vegetation levels. By pointing out *Q* and winter variant (*m*) values of each point of distribution of oak species on the climagram of Emberger as illustrated in Figure 2, we confirm our results in relation to precipitation and temperature parameters:

Quercus calliprinos has a very large distribution range: this species grows everywhere except in bioclimatic zones with a cold and very cold winter variant.

Quercus cedrorum is distributed in per-humid bioclimatic zones with cold and very cold winter variants (Mediterranean montane vegetation level).

Quercus cerris is essentially distributed in the Supra Mediterranean vegetation level, and also in Mediterranean Mountain and Meso Mediterranean levels, within the humid bioclimatic zone with cold, cool and temperate winter variants). *Quercus cerris* is comparable to *Q. cedrorum* in its humidity requirements (Ugurlu et al. 2012).

Quercus infectoria shows a wide distribution range and can be differentiated from *Q. calliprinos* by its lack of ability to thrive in arid zones and to tolerate bioclimatic zones with cold and very cold winters. Consequently, it is the only oak species that thrives at the Supra Mediterranean pre-steppe vegetation level in Lebanon.

Quercus ithaburensis is found exclusively at the Thermo Mediterranean and Meso Mediterranean vegetation levels (sub-humid zone with a hot winter variant) confirming the findings of previous investigations (Danin 2001; Dufour-Dror and Ertas 2004).

Quercus look is found at both the Mediterranean montane and Mediterranean montane pre-steppe vegetation levels.

Quercus kotschyana is found at the Mediterranean montane vegetation level (in per-humid, humid and sub-humid bioclimatic zones with cold and very cold winter variants). Although it is similar to *Quercus look*, this species has a wider distribution range because it is able to thrive in more humid conditions (as shown by its higher *Q* values. Based on humidity requirements, our results enable us to separate *Q. kotschyana* from *Q. cedrorum* in terms of bioclimatic conditions.

Lebanon is considered the western and northern limit of *Q. look*, and the southern limit of *Q. cedrorum,* and *Q. cerris*. Consequently, this isolation of oak species at edge conditions is explained by their restricted range of distribution; they thrive at higher altitudes, and at relatively short distances from the sea where both cool temperatures and relative humidity are ensured.

Niche overlapping

The restricted distribution ranges of these species, based on bioclimatic factors and marked by adaptive traits indicative of their low dispersal capacity, show that many current niches overlap (Gerber et al. 2014; Vessella et al. 2015). The area of occupancy of *Q. calliprinos* overlaps with that of *Q. cerris* for example; the significant distance between the actual niches of both species is due to the difference in the factors affecting their distribution (temperature, precipitation, soil characteristics, etc.). *Quercus look* does not intersect in its area of occupancy with *Q. calliprinos*, yet the major environmental factors affecting the distribution of both species are similar. *Quercus cedrorum* is geographically distant from *Q. look* although the environmental factors contributing to species distribution are similar for both species (elevation and minimum winter temperatures); other factors of lesser importance also contribute to their biogeographical separation (distance from the sea, Emberger Quotien, etc.). *Quercus ithaburensis* and *Q. kotschyana* can be discriminated from the lot as these species require specific environmental conditions.

Conclusion

This study enables us to set priorities for the conservation of species with restricted ranges and limited areas of occupancy and current niche (i.e., *Q. look*, *Q. cedrorum*, *Q. kotschyana* and *Quercus ithaburensis*), and contributes to further updating the IUCN Red List of Oaks (Oldfield and Eastwood 2007).

Future investigation should aim at better understanding the effect of bioclimatic gradients on the morphological and genetic variability of different oak species and hybrids, in an attempt to better understand their capacity to adapt to climate conditions, and to understand why hybrids would be stabilized in a distant niche from their parents. This work can be considered a solid baseline to build upon in order to assess the impact of climate change on the bioclimatic niches of oak species, under different scenarios, at both national and regional scale.

Photographers. Title page: Jean Stephan (*Quercus calliprinos*).

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Interrogating Ancient Oak Tree-Rings

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ABSTRACT

Oak trees are wonderful things; they help to sustain the planet by cleaning the atmosphere, storing carbon and cycling water; preserve biodiversity within their branches, roots and forests and throughout the Common Era they have made significant contributions to our built heritage, culture and societal wellbeing. In addition to these and myriad other roles, oaks have been used by academic researchers to date old buildings and artefacts, trace past climatic changes, the activity of our sun and tree response to the anthropogenic increase in atmospheric carbon dioxide concentration. In doing so these sentinel oaks allow scientists and policy makers to look towards the environmental challenges of the future within a longer-term perspective. This invited paper presents a non-specialist account of some of the ways in which oak trees have supported scientific research in the United Kingdom and presents results obtained through the UK Oak Project and allied group research. The paper provides an overview of dendrochronology and dendroclimatology, then explores the way in which the chemical analysis of oak tree-rings has helped us to date the past and taught us about past climates, our changing atmosphere and plant physiology.

Keywords: UK Oak Project, dendrochronology, dendroclimatology, paleoclimate, plant physiology, stable isotope

Introduction

Photos 1/(a-b) Sampling from living trees with an increment borer and attached extractor device.

Across the UK and Northwest Europe, as trees grow they typically form a single annual ring. This ring develops due to the regular annual cycle of spring/summer growth and winter dormancy. During growth, trees are influenced by climatic factors and by local disturbances (natural and anthropogenic) which imprint a signal in the physical properties of each annual ring, most notably the width of each growth ring (Fritts 1976). Trees growing together, experiencing the same environmental history, will preserve within their rings a common record of these changes such that it is possible to measure the width of these rings and, if the date of one of the series is known, one can match the pattern of ring width variability between the two series and in doing so precisely position the undated sequence in time. This method is termed dendrochronology and allows scientists to build precise calendrically-dated records extending back many centuries, and even millennia (Haneca et al. 2009; Čufar 2007). This is achieved by the careful sequential statistical matching of dated timbers from living trees with those sampled from wooden artefacts or structures such as panel paintings, old buildings and ships. Further back in time more primitive structures such as log boats and trackways can be used to extend the chronology and in a similar manner, sub-fossil trees recovered from river terraces, bogs or lakes can also be used to develop dated tree-ring series which span millennia.

Sampling is relatively straightforward: for living trees, and some dead material, an increment borer is used to remove a thin core of wood. This does not harm the tree if care is taken to sample responsibly and sterilize equipment between trees. Typically cores of 5 mm to 10 mm in diameter are collected. For historic buildings a power drill is normally required to collect cores, whilst for sub-fossil samples saws and borers are more routinely used. Dendrochronologists (practitioners of tree-ring dating) usually do not take only a single sample when they build a chronology. This is because co-extant trees of a common species share much in common in terms of growth response, but are also individuals (both genetically and in terms of micro-habitat) and so will vary in the magnitude and nature of their response to external stressors. If the intention is to obtain a representative record of tree growth it is therefore necessary to sample lots of trees. The

Photo 2/ Retrieving submerged sub-fossil timbers.

exact number and location of the trees required will depend upon the scientific question being addressed, but there are a number of statistical measures available to researchers which can be used to determine required sampling levels (e.g., Wigley et al. 1984a; McCarroll and Loader 2004).

Across the UK and Northwestern Europe the primary tree species studied by historical dendrochronologists are *Quercus robur* and *Q. petraea* (Haneca et al. 2009; Loader et al. 2008; Čufar 2007). Growth in this part of the world is characterized by a single ring formed each year. Each tree-ring comprises a band of early- or spring-wood vessels (formed in April/May) followed by late- or summer-wood formed from about May/June to late August/September. Anatomically these trees are termed ring porous, because the larger individual vessels (pores) are concentrated in the early-wood part of each annual ring rather than more diffusively. The deciduous habit of these oak species growing in a mid-latitude seasonal climate means that, in these regions, oak trees do not develop ambiguous ring patterns, such as double rings (two rings for a single year) or fail to form (miss) a ring for an individual year. Such problems do exist in other regions and for other species, especially where growth occurs close to ecological limits. Such growth anomalies can cause problems in establishing a precise chronology.

Archaeological dating (dendrochronology)

The last 40 years has seen dendrochronologists develop a substantial network of precisely-dated tree-ring chronologies extending back many centuries, with the longest covering millennia. These records are precisely and absolutely dated and are used as


Photo 3/ Coring historic timbers with a drill-mounted borer.

reference or master chronologies to date and provenance samples of previously unknown age. The dominant presence of oak in the UK historic buildings record means that, with these chronologies, we have a far better and more complete understanding of the temporal development of historic buildings across Britain and Ireland (Tyers 1998).

Occasionally, however, it may not prove possible to date individual tree-ring series using dendrochronology. This may be due to one of the following reasons: the ring sequence has been disturbed and is no longer representative of the regional signal (i.e., from woodland management, pollarding, coppicing, or natural factors such as fire, disease, wind etc.); the sequence is too short or the ring widths too invariant (complacent) to obtain a secure statistical match; the sample grew at a time not covered by the reference chronology or in a different climatic zone (import); the sample is of a different species from that of the reference chronology.

Fortunately the tree-rings do not simply contain a record of annual ring growth. From the chemistry of individual tree-rings it is possible to measure an annual signal preserved within the carbon, oxygen and hydrogen isotope ratios of the wood. These isotopic data can be used for dating in a similar manner to ring widths in dendrochronology (Loader et al. 2003; Roden 2008). A 1000-year master chronology has recently been developed and evaluated for the UK as part of the UK Oak Project (www.oak-research.co.uk). An important advantage of this approach is that not only can it date trees with complacent (invariant) ring series, but also potentially shorter series than those used in conventional dendrochronology (c. 50 years), and in certain cases it can even provide dating support for non-oak species (Loader et al., in prep.).

A further use of dendrochronology in science-based dating has been in the development and support of radiocarbon dating. Radiocarbon dating is a method commonly used in archaeology to date samples containing carbon (typically organic material) over a period of approximately the last 40-50,000 years. The technique is not as precise a dendrochronology and rather than matching two series, it is based upon the measurement of a radioactive form of carbon (^{14}C) preserved in the sample.

Radiocarbon is formed in the upper atmosphere where nitrogen is bombarded by neutrons from cosmic rays and then incorporated into the global carbon cycle. Changes in the amount of radiocarbon production along with climatic factors such as the large-scale sequestration of carbon by vegetation and the oceans, means that the amount of radiocarbon in the atmosphere and oceans changes over time. This would have an obvious impact upon the precision of the dating technique. The magnitude of this variability of radiocarbon in the environment was characterized by the radiocarbon dating of dendrochronologically-dated samples of *Q. robur*, *Q. petraea*, and other species; the result being a series of calibration curves which mainly reflect changes in solar activity over time and are used to establish chronology worldwide (e.g., Becker 1993; Reimer et al. 2013; Dee and Pope 2016).

Climate

Where the tree growth signal that enables dendrochronology is sufficiently strong and controlled by a single or limited number of identifiable environmental variables (e.g., temperature, rainfall, sunshine, etc.) it is possible to quantify this relationship and to model the extent to which climate controls growth. Statistical models linking growth and climate can be developed and applied to the ring width sequence to reconstruct the controlling climate variable back through time, beyond the period for which meteorological records exist. The value of this "palaeoclimatic" approach is that, while not a perfect record of temperature or precipitation, such reconstructions of past climatic changes provide a longer-term perspective on environmental change than can be obtained using the records of instrumental observations alone. In this manner it is possible to garner important information relating to pre-industrial baseline climate variability and the frequency and magnitude of extreme events such as heat waves and droughts. Such data are important in the detection and attribution of recently observed (natural and anthropogenic) climatic change.

Dendroclimatology works best where tree growth is strongly controlled by climate such as at the boreal, austral or altitudinal tree lines and extreme environments such as the dry (xeric) regions of Southwestern USA (e.g., Villalba et al. 1998; Esper et al. 2012; McCarroll et al. 2013; Helema et al. 2002; Woodhouse and Overpeck 1998). Unfortunately, the agreeable climate of much of Northwestern Europe means that oak tree growth is rarely dominantly controlled by a single climatic variable (Loader et al. 2008). This makes it difficult to develop a robust dendroclimatology for the UK based upon oak tree-ring width, because the amount of climate information preserved is relatively low and inconsistent. Attempts have been made to explore the oak tree-ring width signal for a range of meteorological variables including both temperature and precipitation, however for both indicators the amount of climatic information preserved and the stability of the climate/tree-ring relationships mean that they are poor arbiters of climate (Cooper et al. 2013; Wilson et al. 2013; García-Suárez et al. 2009; Briffa et al. 1986; Pilcher and Gray 1982; Hughes et al. 1978). Other emerging measures, such as the measurement of oak vessel area exhibit some climatic control, but it is likely that limits to physical growth in this region are too complex for high precision climate reconstruction (Sass-Klaasen et al. 2011). It is extremely important to understand how past climate change has affected these less extreme climatic regions because unlike the polar ice caps, deep ocean or boreal/altitudinal tree lines from where tree-ring and other palaeoclimate information can more confidently be obtained, it is in these lower latitude areas where the majority of people live.

To obtain robust palaeoclimate information from oaks in these regions we must turn again to the chemical record of stable isotopes preserved within the individual tree-rings. The reason that stable isotopes from oak tree-rings are effective as a dating tool is that they are driven by common environmental controls. Unlike tree-ring widths, the mechanistic controls over stable isotopes persist over a large environmental gradient, including the more benign climate of the United Kingdom and Ireland (Gessler et al. 2014; Loader et al. 2008; Roden et al. 2000; Farquhar et al. 1982). This means that it is possible to reconstruct past changes in these environmental controls, beyond the earliest meteorological climate records, using tree-ring stable isotopes as a proxy for climate.

The potential of tree-ring stable isotopes as a proxy for past climate in the UK has been recognized for many years (McCarroll and Loader 2004; Robertson et al. 1997, 2001; Loader and Switsur 1996; Switsur et al. 1995). However, until relatively recently the time and cost required to produce the long, well replicated chronologies required for climate work has limited the utility of isotopes in climate research. Recent advances in preparation and analytical techniques now mean that isotopic climate reconstructions are much easier to produce. Much of the developmental work building long, multi-centennial- to millennial-length isotopic chronologies focused on tree-line environments working with conifers (typically Scots pine, juniper and larch: Loader et al. 2013; Grießinger et al. 2011; Young et al. 2011; Gagen et al. 2011; Kress et al. 2010; Hilasvuori et al. 2009; Treydte et al. 2009, 2006). The interpretation of stable carbon isotopes as a proxy for past cloud cover and the implications that this has had for understanding past changes in cloud cover were important breakthroughs for climate and tree-ring science (Young et al. 2010).

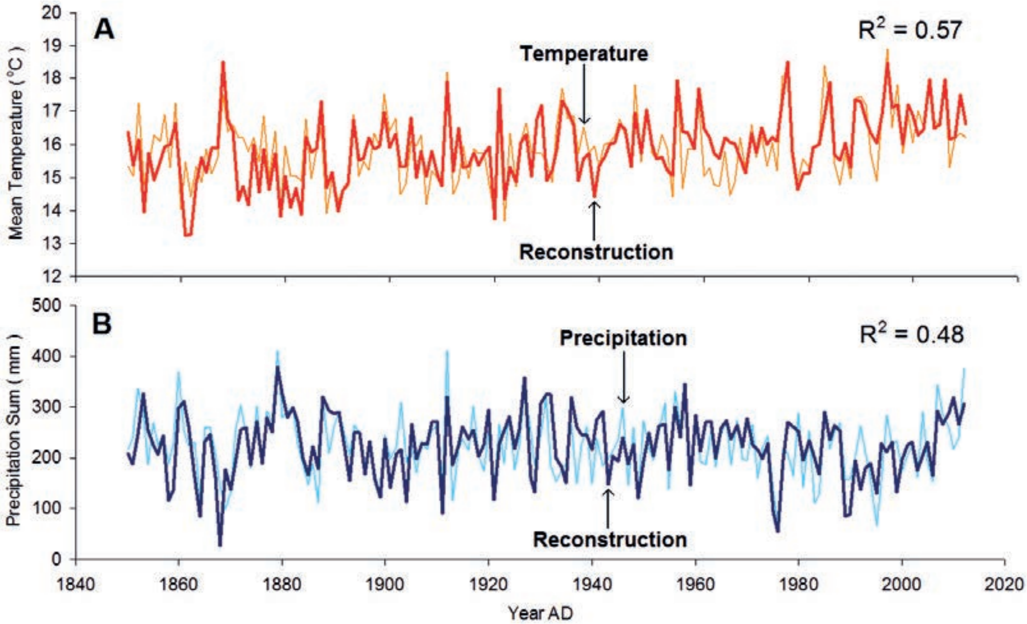

Figure 1/ The relationship between: summer Central England temperatures (A) and oak tree-ring stable carbon isotopes; and summer England and Wales precipitation (B) and oak tree-ring stable oxygen isotopes. In both cases isotopes have been scaled to summer climate, the squared correlation coefficient (R2) between the isotopes and climate is shown in both graphs (adapted from Young et al. 2015).

In recent years using tree-ring isotopes to understand past climate in more densely populated mid-latitude locations has become an important focus of tree-ring isotope science. A growing number of smaller-scale studies had been undertaken in Western Europe, which clearly demonstrated the potential for tree-ring isotopes to be used as faithful records of past temperature/sunshine (carbon) and precipitation (oxygen) (Vallack et al. 2016; Labuhn et al. 2013; Szymczak et al. 2012; Hafner et al. 2011; Seftigen et al. 2011; Rinne et al. 2013; Etien et al. 2008; Masson-Delmotte et al. 2005; Treydte et al. 2001; Saurer et al. 1997). Larger-scale studies have also clearly shown that extremely powerful and stable regional reconstructions of past climate are possible, which statistically match and even exceed the strength of climatic reconstructions developed for tree-line locations (Young et al. 2015, 2012; Saurer et al. 2008; Treydte et al. 2007).

Stable carbon isotopes in seasonal mesic climatic environments (such as the UK) are likely to be primarily controlled by the amount of photosynthetically active radiation that the tree receives during the growing season, which is closely related to sunshine and therefore cloudiness and temperature (Loader et al. 2013; Young et al. 2012). The oxygen isotope signal in annual tree-rings is primarily derived from the oxygen isotope ratio of the water which the tree draws through its root system during the growing season (Young et al. 2015; Treydte et al. 2014; Labuhn et al. 2015) (Figure 1).

In Western Europe the isotope ratio of growing season precipitation is strongly linked to atmospheric circulation, which in turn is strongly linked to summer rainfall. Wet summers are dominated by depressions and the precipitation will have low (more negative) oxygen isotope ratios; dry summers are dominated by anticyclones which bring dry continental air and what precipitation there is will have very positive oxygen isotope ratios. Within-tree processes also act upon the isotopic ratio of the water used by the tree and these tend to enhance the pattern of a more negative signal in wet summers and a more positive signal in dry summers (Figure 2).

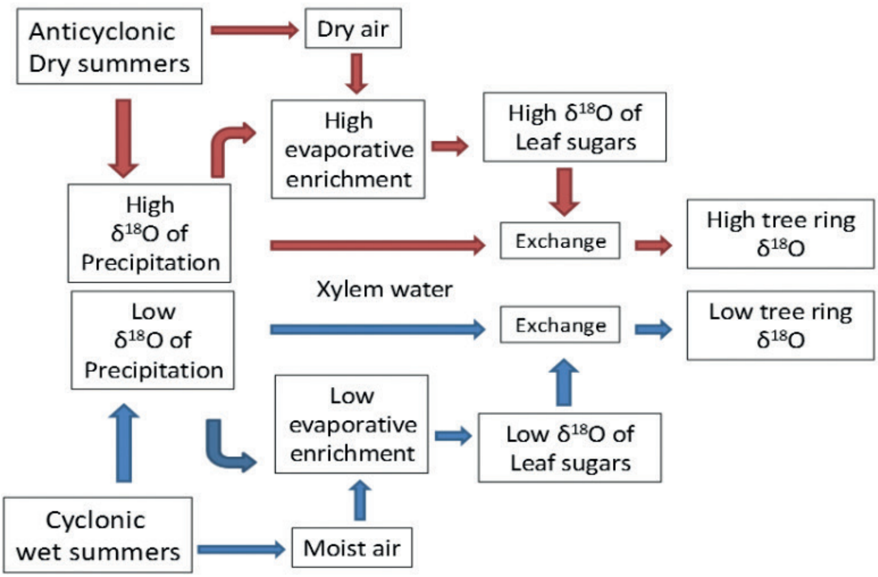

Figure 2/ Schematic diagram showing a conceptual model of the relationship between stable oxygen isotopes in oak tree-rings and summer precipitation with links to atmospheric circulation. The oxygen isotopic signature of precipitation is transferred to the wood via sugar production in the leaf (photosynthesis), where vapour pressure difference drives evaporative enrichment. The link to the oxygen isotope signature of the source water is further enhanced by post-photosynthetic exchange between the oxygen atoms of the plant sugars and unaltered xylem (source) water (from Young et al. 2015).

The climate signal derived from oak trees is extremely robust and unlike reconstructions of precipitation and temperature, from tree-rings widths in the mid-latitudes, they have a strong and stable relationship with measured climate. Another important feature of mid-latitude climate reconstructions is the length and quality of the climate records available to test and calibrate the past reconstructions of climate. In the case of precipitation the isotope series has been verified back to 1766 CE, against the full England and Wales precipitation record (Wigley et al. 1984b), the longest continuous record of precipitation amount in the world. Records of temperature are even longer, with the longest, the Central England temperature record, stretching continuously back to 1659 CE (Manley 1974).

Atmosphere

As trees grow, they sample carbon dioxide from the atmosphere. Since the onset of global industrialization the amount of carbon dioxide in the atmosphere has been increasing as a consequence of land-use change, combustion of fossil fuels and industrial processes (e.g., cement manufacture). Since the dominant source of this CO_2 is old and largely plant-derived, the carbon dioxide released during combustion is depleted in the ^{13}C and ^{14}C isotopes relative to the atmosphere. As a result of this it is possible, by measuring the change in tree-ring carbon isotopes, to trace isotopic change in atmospheric CO_2 and other pollutants through time. The results of such analyses provide clear evidence for the impact of humans on their environment and is seen in both ^{13}C and ^{14}C worldwide (Waters et al. 2018; Reimer et al. 2013; Rinne et al. 2010; Freyer 1979). The common decreasing trend in atmospheric ^{13}C, which must be removed mathematically prior to any palaeoclimate research, has been proposed by some researchers as a marker for the Anthropocene epoch – a new geological classification reflecting the profound influence of humanity upon the Earth System and geological record. A further record of environmental change is observed if the radiocarbon content of tree-rings is measured over the period from c.1950 to the present. Immediately prior to the global treaties banning nuclear weapons testing in 1963 there was a marked increase in these and this is reflected in a "bomb spike" in the amount of radioactive carbon (^{14}C) found in the atmosphere. The peak is diminishing exponentially, but remains in the environmental record and is useful in radiocarbon dating (Reimer et al. 2013).

Physiology

A further application which has arisen from the study of stable isotopes in tree-rings is their ability to monitor and record changes in the storage and use of stored photosynthates by trees from year to year. In *Q. robur* and *Q. petraea* early wood is largely formed prior to bud burst and so the photosynthates used in the growth of this part of the tree-ring are dominated by carbohydrates fixed during earlier growing seasons (Bréda and Granier 1996). Several studies have now measured the stable carbon isotopes in early- and late-wood and have reported a lag between years suggesting that the carbon used to make the early wood of one year was predominantly fixed during the previous year's growing season. Early studies (Switsur et al. 1995; Hill et al. 1996) identified this in a relatively small number of tree-rings from a single tree. McCarroll et al. (2017) explored this further using a pool of a number of trees growing at the same location and linked the degree of carry-over to the climate of the previous growing season. Other studies argue an alternative, more complicated model (Kimak and Leuenberger 2015; Helle and Schleser 2004). Work is ongoing to investigate these mechanisms further, and it appears that the measurement of stable isotopes in the early- and late-wood of oak tree-rings can provide useful information relating carbon use and storage which in turn may also be related to tree health or decline.

Further research by Switsur et al. (1995) and Hill et al. (1995), studied the behavior of the oxygen isotopes between different ring components. They found that, unlike carbon, oxygen did not exhibit the same carry-over between the latewood of one growing season and the early wood of the next. Hill et al. (1995) were able to propose a mechanism for this which invoked the re-exchange of photosynthate oxygen with xylem water during cellulose synthesis via the futile cycling of triose phosphate which was further investigated by Anderson et al. (2002) and forms part of our current understanding of stable oxygen isotope fractionation during tree-ring formation (McCarroll and Loader 2004).

Through the mechanistic understanding of how trees assimilate carbon dioxide and water to make their rings, it is possible to explore how this relationship has changed as humans have modified the atmosphere and increased CO_2 concentrations, from c. 280 ppm to 400 ppm, since the onset of large-scale industrialization (*c.* 1850 CE). Measurement of the intrinsic water-use efficiency (iWUE) of oaks (a measure of the amount of water used per unit carbon fixed) can be tracked through time and compared directly to changing atmospheric CO_2 concentration (McCarroll et al. 2009; Seibt et al. 2008; Waterhouse et al. 2004; Feng 1999; Marshall and Monserud 1996). An increase in water-use efficiency can change the amount of water cycled by a tree and the degree to which a tree is resilient to climatic stressors such as drought, however the signal is also influenced by climate and nutrient variability. Saurer et al. (2014) and Frank et al. (2015) conducted a European synthesis and simulation of the change and impact of recent observed changes in iWUE across a range of species including oaks. Given the socio-economic and ecosystem services importance of *Q. robur* and *Q. petraea* across Europe there is an increasing need to understand the likely future direction and consequences of these changes. Large-scale networks and mature ecosystem studies such as the Free Air CO_2 Enrichment experiment (Mill Haft, Staffordshire, UK) provide a potentially very powerful way to take this important work into the future.

Conclusion and future scope

One of the advantages of working with the tree-ring archive is its ability to provide precise chronology and the confidence afforded to researchers through the replication of results using many independent trees. This allows absolute dating and since this is precise to a single year it allows scientists to identify extreme climatic events and to track their changing frequency through time. Conventional ring-width reconstructions of climate for Britain and Ireland are not capable of capturing strong palaeoclimate signals due to the complex nature of the factors controlling growth, however the signals preserved within the carbon and oxygen isotope ratios of tree-ring cellulose demonstrate their ability to provide reliable palaeoclimate information throughout the Common Era.

Significant potential also exists for linking tree-ring series together to form networks of stable isotope series which will provide large-scale palaeoclimatic and physiological information relating to tree response to climate and CO_2, as well as a test set for an emerging generation of climate models capable of tracking isotopes within the Earth System.

At a more local spatial scale, new advances in chronology afforded through stable isotopes are already providing practitioners of dendrochronology and heritage managers with new information on previously undateable structures and new tools with which to refine the uncertainties of radiocarbon dating (Catling 2018).

At the individual level, the measurement of stable isotopes in tree-rings has provided insight into the response of trees to increasing atmospheric carbon dioxide levels, which are likely to prove very useful in tracking the nature of this response through time and determining climatic resilience of oaks in a high CO_2 world. These data will also provide a useful baseline for future CO_2 enrichment experiments and response scenarios for the forestry and arboricultural sectors.

Oak tree-ring research in the UK has a rich and diverse scientific history. This invited paper presents only a brief overview of the field by highlighting some of the recent work conducted by the UK Oak Project Team (https://www.oak-research.co.uk/). This overview of stable isotope analysis of tree-rings, with a broad focus on the research activities of a single group, can therefore only capture a small part of this vibrant and exciting field of research.

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The Oaks of Hong Kong: Evolutionary and Morphological Diversity on a Continental Margin

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ABSTRACT

Hong Kong represents an intriguing example of how topography, climate and evolutionary time can combine to create a highly diverse array of environmental conditions on a small geographic scale. Located on the edge of continental Asia, it consists of pieces of mainland, islands and peninsula that were once home to warm forests with elephants, tigers and rhinoceros. Today it holds one of Asia's megacities with a population of 7.4 million people, yet more than half of its surface area has been designated as protected green zones. These country parks, watershed reservoirs and protected upland areas hold the last populations of Hong Kong's oak species (in addition to 24 other Fagaceae), as well as a rich and varied flora and fauna. Here I provide a brief overview of the history of Hong Kong's forests, its oaks and the efforts currently underway to secure their survival. Finally, I present a newly recorded oak species for Hong Kong, bringing the total number of species found to 14.

Keywords: *Quercus*, Fagaceae, Hong Kong, China, mountains, microhabitat, population reduction, conservation, urbanization

Introduction

China ranks second in number of recognized species in the genus *Quercus*: 104 according to Wu and Raven (1999). This is far below Mexico with around 160 species (Trehane 2007) and contrasts with Indochina: Cambodia, Laos and Vietnam with between 55 and 60 species (Strijk 2016; Forthcoming a); Thailand with approximately 30 (Phengklai 2008); and Indonesia with an estimated 15 (Soepadmo and Steenis 1972).

In subtropical and tropical Asia, the distribution of *Quercus* species is tightly correlated with higher elevation and cooler climate. Some *Quercus* species are restricted to lowland tropical rainforest environments (e.g., *Q. kerangasensis* Soepadmo at < 100 m in Borneo and *Q. merrillii* Seemen at 100-500 m in Borneo and the Philippines) but the vast majority are either reported with wide elevational ranges (i.e., 650-1,700 m) or are firmly recognized to occur only in higher elevation zones (1,000 m and higher). Ecosystem preferences in widespread, speciose groups like *Quercus* become more apparent in regions where geography imposes spatial constraints on plant lineages and communities.

In areas where lowland conditions are rare, such as in the extensive isthmus of Kra region of Thailand, the distribution patterns of eight species of *Quercus* show spot occurrences for six species only in the highest habitat available (Phengklai 2008). Conversely, in areas where only lowland habitat is available, like on the island of Singapore (max. elevation: Bukit Timah, 163m), only one species has been recorded, *Q. argentata* Korth., a widely distributed species growing from sea level to 2,700 m (Chong et al. 2009). An additional twenty species of Fagaceae in two other genera (*Lithocarpus* and *Castanopsis*) are native to Singapore (Strijk 2016, Forthcoming b). Natural limitations in distribution can have important implications for speciation, genetic diversity and species survival of past and future populations. This is particularly poignant for extant populations of *Quercus* (and other Fagaceae) existing in increasingly urbanized settings, such as Singapore and Hong Kong.

Past and present forest habitat

Hong Kong is relatively small (roughly 1,100 km^2), but its varied topography, volcanic foundations and resulting geological substrates are highly complex (Corlett 1992). The subtropical climate, with mild, temperate winters (but with occasional frost at higher elevation) and hot, humid summers with tropical cyclones, creates a wide range of habitat types throughout the territory (Shum 2015; Environmental Resources Management 2008). The total number of plant species found surpasses that found in the British Isles, but over a period of many centuries, nearly all of Hong Kong's old-growth forests have been lost to lumber harvesting, tea plantations and lime-production that have taken much of the native flora and fauna (Hau et al. 2005). This has left Hong Kong, much of which is covered by steep mountain ranges unsuitable for urban development, barren and covered in treeless grasslands. Consequently, most of the lowlands and lower strata are now converted into dense urban sprawl that has little left in terms of native species.

As of 2017, only about 25% of the total land area has been developed, with the remainder of Hong Kong left in relatively undeveloped state, designated as protected areas in various categories (e.g., more than 45% as country parks). Just above the most densely populated areas of Hong Kong, forest vegetation still persists and is poised to make a comeback. The reasons for this are both historical and ecological.

Species	First publication	Vernacular name[1]	Cons. status[2]	Regional distribution[3]	Hong Kong distribution
Q. acuta Thunb.	A.Murray, Syst. Veg. ed. 14: 858 (1784).	Japanese evergreen oak	Introduced	China (Guangdong), Taiwan, S. Korea (incl. Jeju-do), C. & S. Japan	Hong Kong Bot. Gard., Hong Kong Island (other sites unclear)
Q. acutissima Carruth.	J. Proc. Linn. Soc., Bot. 6: 33 (1861)	Sawtooth oak	Native LC	Himalaya to China, Korea, C. & S. Japan	New Territories
Q. bambusifolia Hance	Bot. Voy. Herald: 415 (1857).	Bamboo-leaved oak	Native	China (Guangdong, Guangxi) to N. Vietnam	Mt. Gough, Mt. Nicholson, Tai Tam, Wan Chai gap
Q. bella Chun & Tsiang	J. Arnold Arbor. 28: 326 (1947).	-	Native	China (Guangdong, Guangxi), Hainan	Tai Po, Yin Ngam
Q. blakei Skan	Hooker's Icon. Pl. 27: t. 2662 (1899)	Blake's oak	Native	Assam to China (Guangdong, Guangxi)	Ta Tit Yan, Tai Po, She Shan Tsuen
Q. championii Benth.	Hooker's J. Bot. Kew Gard. Misc. 6: 113 (1854)	Champion's oak	Native	SE. China, Taiwan, Hainan	Victoria Peak, Mt. Nicholson, Mt. Cameron, Ma On Shan, Tai Mo Shan, Lantau Island
Q. chungii F.P.Metcalf	Lingnan Sci. J. 10: 481 (1931)	Chung's oak	Native	SE. China	Castle Pk., So Kwun Wat
Q. edithiae Skan	Hooker's Icon. Pl. 27: t. 2661 (1900)	Thick-leaved oak	Native, NT	China (Guangxi, Guangdong, Hainan) to Vietnam	Mt. Kellet, Sai Kung, Tai Wai, Ta Tit Yan
Q. fabri Hance	J. Linn. Soc., Bot. 10: 202 (1869)	White oak	Native	E. & SE. China, Hainan, Korea	Fanling
Q. glauca Thunb.	A.Murray, Syst. Veg. ed. 14: 858 (1784)	Blue japanese oak	Native, LC	Himalaya to Japan	Shek O, Cape d'Aguilar, Pok Fu Lam, Ma On Shan
Q. hui Chun	J. Arnold Arbor. 9: 126 (1928)	Hu's oak	Native	SE. China to Hainan	Pat Sin Leng
Q. litseoides Dunn	J. Bot. 47: 377 (1909)	Litsea oak	Native, DD	China (Guangdong, Guangxi)	Lantau Island
Q. myrsinifolia Blume	Mus. Bot. 1: 305 (1851)	Small-leaved oak	Native	C. & S. Japan, Korea (Jin-do), C. & S. China to Indo-China	Common throughout Hong Kong
Q. variabilis Blume	Mus. Bot. 1: 297 (1851)	Chinese cork oak	Newly reported here, LC	C. & S. Japan, Korea, Taiwan, C., E. & S. China, Tibet, Vietnam	So Kwun Wat

Table 1/ The 14 oaks of Hong Kong. (References: 1. Agriculture, Fisheries and Conservation Department 2012; 2. Oldfield and Eastwood 2007; 3. World Checklist of Selected Plant Families. Retrieved February 9, 2018).

Reforestation of Hong Kong's barren hills has always been an aim of successive administrative bodies, but its drivers have evolved over time. In the 19th century, health and aesthetics were the prime reasons, while in the 20th century soil erosion and water supply

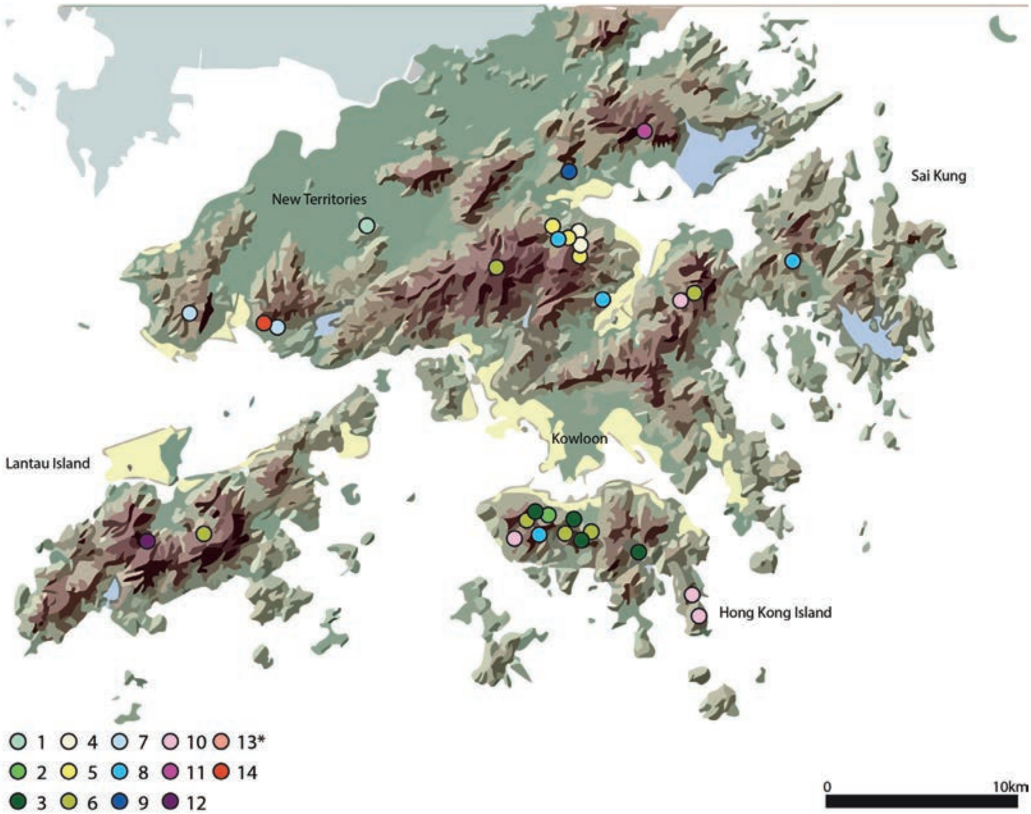

Figure 1/ Map of Hong Kong showing elevation gradients and relative distribution of oak species from known locations. 1: *Q. acutissima*; 2. *Q. acuta*; 3. *Q. bambusifolia*; 4. *Q. bella*; 5. *Q. blakei*; 6: *Q. championii*; 7. *Q. chungii*; 8. *Q. edithiae*; 9. *Q. fabri*; 10. *Q. glauca*; 11. *Q. hui*; 12. *Q. litseoides*; 13. *Q. myrsinifolia* (distribution not indicated on map as it is common throughout Hong Kong); 14. *Q. variabilis*. (Map modified from www.hkss.cedd.gov.hk).

needed to be brought under control as Hong Kong experienced a population boom and intense urbanization (Corlett 1999). Nowadays, efforts have coalesced into incorporating ecological restoration as an integral part of urban slope and water management systems. Although there is some debate on how the potential natural vegetation (PNV) of Hong Kong should be classified, the most recent views suggest that the lowlands (below 500 m) should be considered as largely tropical while the vegetation above 500 m should be considered as subtropical (Dudgeon and Corlett 2004).

Seasonal variation in precipitation in Hong Kong can be extreme (ranging from monthly averages of 24 mm in January to over 400 mm in June). Precipitation is also dependent on spatial variation: high mountains such as Tai Mo Shan (957 m) can receive up to 3,000 mm annually. Natural sponge and regulatory functions of intact upland vegetation are crucial in preventing flooding and landslides that endanger densely populated areas and infrastructure at lower elevations. As a consequence, a complex management system of slope maintenance and monitoring is in place in urban areas, consisting of individually registered trees, drainage channels and gullies, staircases and walkways. Many of the latter are open for recreational purposes and allow easy access to steep, forested hillsides, offering spectacular views over the city and, easy access to some of its fine oak species.

Photo 1/ Hong Kong Island seen from the steep, forested hillsides.

Modern-day distribution of oaks

Today, most oak species and other Fagaceae in Hong Kong are found only in upland areas as disjunct populations or on isolated mountains. It is not entirely clear to what extent this distribution pattern is natural, or if some species may have had a wider distribution which extended to include and connect mid- or even lower elevations in pre-urban times. It is thought that the first clearings, burning and other steps of habitat fragmentation in Hong Kong date back to 1,100-1,200 CE, suggesting that intact old-growth forests have not existed in Hong Kong for many centuries (Hau et al. 2005). If this is correct, it could mean that forest structure and species composition in the degraded and secondary forests we see today have little in common with the original pre-urban forest ecosystems. This is also suggested by ongoing work conducted at Kadoorie Farm and Botanical Garden (www.kfbg.org), which operates flora conservation, ecological restoration, and forest replanting programs, aimed at understanding Hong Kong's pre-urban forests in the hopes of rebuilding these.

Species performance tests in KFBG's long-term plots and tree-planting sites highlight the difficulties in piecing together a native but grossly unknown forest ecosystem. Rebuilding Hong Kong's forests requires a thorough understanding of the connection between the roles of temporally differential recruitment of species and the ecological space each occupies inside the system. Matters are complicated further by the fact that the original ecosystem that housed the more than 36 species of Fagaceae consisted of humid, closed canopy forests. Many of the larger mountains and hills in modern-day Hong Kong have been reduced to hot, windswept rocky grasslands – a hard place indeed for any subtropical acorn to germinate.

Besides *Quercus* and other Fagaceae (23 species), Hong Kong is also species rich in families such as Lauraceae, Magnoliaceae and Annonaceae. Under natural conditions, these families co-occur, although species combinations will vary from site to site. In today's forests, many of these species occur as relatively low-stature trees of modest diameters forming shallow, low-branching crowns. In some cases, like for *Q. bambusifolia* Hance, individuals even occur as shrubs or small treelets. But individual trees in protected Feng Shui village forest plots, which can be hundreds of years old, and forest fragments in more remote sites (especially those in locations historically sheltered from fire), offer glimpses of what old-growth forest trees may have looked like. Not only do these sites contain rare elements of the original flora found nowhere else but tree species like *Q. blakei* Skan assume larger, single-bole diameters and develop different canopy architectures here, allowing for a more open, high-canopy forest. Contrastingly, some native tree species (e.g., *Michelia* spp.) that develop small understory crowns under closed canopy conditions develop wide-spreading dominant habits when grown on barren slopes (G. Fischer, KFBG, pers. comm). These are not just a result of growing-site conditions (open vs. sheltered), as combined growing trials have shown the effects different species combinations have on tree growth, crown architecture and crown development. Perhaps these patterns demonstrate that the many tree species known to make up the ancient forests of Hong Kong may have had very narrowly defined ecological roles and temporal optima in the system (e.g., species confined to ridges and crests, along creeks, on seaward exposed hillsides, etc.). It also shows us that, although the oaks of Hong Kong may appear secure in the pockets where we find them today, the forest that they are a part of may be a long way off from growing and developing like it did in pre-urban times, and we need to learn more about how these drastic changes affect their genetic resilience and long-term survival.

Species descriptions

A total of twelve species are listed as native to Hong Kong, with an additional species confirmed as having been introduced in the past (AFCD 2012). Here I also report a new record which brings the total to fourteen species. During fieldwork in 2015 I collected three individuals of *Q. variabilis* Blume in the New Territories. For each species recorded in Hong Kong, a small description and locality data are provided below.[1]

Quercus acuta Thunb.

Medium-sized evergreen trees, up to 10-12 m and dbh of 30 cm. Can have a shrubby habit in cultivation. Crowns spherical. Bark smooth, covered in shallow fissures, dark grey to grey brown. Leaves dark green, glossy above, and yellow to pale yellow beneath, 5-18 cm long and up to 6 cm wide. Leaf base cuneate-rounded, apex acuminate, margins smooth and entire, wavy, rarely with any teeth. Cups covered in raised rings (5-8), covered in dense golden indumentum. Nuts oval to elliptic, warm orange brown, up to 1 cm across and 2 cm long. Cupules covering up to 1/3-1/2 of the acorn. Acorns clustered on long stalk. Flowering in April-May. Fruits maturing in the same year. Occurring in low and mid elevations (300-1,100 m). Introduced.

1. More detailed information and images can be found at asianfagaceae.com/hongkong.

Quercus acutissima Carruth.

Medium-sized deciduous tree, up 15-20 m tall. Crown pyramidal and wide when young. Bark deep dark brown to grey brown, covered with deep cracks and lighter colored longitudinal fissures. Can attain large diameters of up to 1.6 m at breast height. Wood light yellow. Twigs yellow brown to olive green, glabrescent. Leaves leathery but thin, oblong-lanceolate, ranging from 10-20 cm long and up to 2 cm wide. Leaves bright green above, but dull pale below. Young leaves reddish, soft, covered in long whitish felt-like hairs. Cups covered in long, raised, incurved bracts, covering up to 2/3 of the nut. Fruits very showy and distinct. Nut deep dark brown, up to 2.5 cm long, 1.5-2 cm across. Flowering in April-May. Fruits maturing in two years. Occurring from lowland to upland (100-2,200 m).

Quercus bambusifolia Hance

Evergreen trees to 20 m tall. Young woody part covered in short silky hairs, but smooth when older. Leaves clustered near ends of twigs, narrow lanceolate to elliptic-lanceolate, 3-11 cm long and up to 2 cm wide. Leaves leathery, whitish below. Infructescence very small, 5-10 mm, usually carrying only one single fruit. Cupule saucer-shaped, 5-10 mm × 1.3-1.8 cm, covering only the base of the nut. Cups covered in flat rings. Nut obovoid to ellipsoid, 1.5-2.5 cm wide and up to 1.6 cm long. Flowering from February-March, fruiting from August-November. Fairly rare species, occurring from low to mid elevations, up to a maximum of 2,200 m.

Photo 2/ *Quercus bambusifolia* (Hong Kong Island).

Quercus bella Chun & Tsiang

Large evergreen trees, up to 30 m tall. Often occurring in densely grouped clusters of many individuals. Known to mass fruit simultaneously in Sai Kung. Twigs grey brown, ridged or angular. Leaves oblong-elliptic to lanceolate, up to 15 cm long and 4 cm wide. Leaves light green to grey green, with age becoming thick. Leaf base cuneate and slightly oblique, upper half of leaf with serrate margin, apex acuminate. Cupules usually 2-3, disc-shaped, 5 mm long, and up to 3 cm across, covering only the base of nut. Cups covered in slightly raised rings, loosely covered in powder-like brown indumentum. Nut broadly oblate, up to 3 cm long with golden-like hairs when young, but smooth when mature. Acorns often wider than cup diameter, giving a swollen appearance. Flowering from February-April, fruiting in October-December. Only at lower elevations up to 700 m.


Photo 3/ *Quercus blakei* (Tai Mo Shan).

Quercus blakei Skan

Large evergreen forest trees, up to 35 m tall. Able to form large spacious crowns, but in shady forested gorges usually forming dense columnar crowns. Bark grey, flaky and finely fissured. Twigs without noteworthy indumentum, but older woody part with dense lenticels. Leaf blade narrow ovate-elliptic to obovate-oblanceolate. Lamina up to 19 cm long and up to 2 cm wide, thin to somewhat leathery, with clear red indumentum in young phase. Leaf base cuneate, apex acuminate, upper 2/3 of leaf serrated. Cupules usually solitary or in pairs. Cups covered in flat rings (6-7), saucer-shaped to forming a shallow bowl. Up to 1 cm across and 3 cm long, covering only the base of the nut. Nut ellipsoid-ovoid, 2.5-3.5 cm long and and up to 3 cm wide. Flowering in March and fruiting from October to December. Rare. Found in local isolated pockets from lowland to high elevation (100-2,500 m).

Quercus championii Benth.

Evergreen and ranging in height from stout 2-4 m to 20 m with diameters up to 1 m. Crowns irregular, bushy to somewhat plume like due to leaf arrangements. Bark very roughly scaled, coming apart in patches, grey to grey brown. Sapwood pale white to light yellow. Twigs with longitudinal fissures, covered in dense grey-brown stellate indumentum, but older woody parts smooth. Leaves clustered on end of branches, crowded toward twig apex. Leaves obovate, sometimes oblong to elliptic but always with distinctly revolute margin, making for easy identification in Hong

Kong. Length of leaves 3.5-13 cm, up to 4.5 cm wide, sturdy and thick leathery. Undersides pale with whitish-orange stellate hairs. Leaf base cuneate, apex with a short blunt tip. Cupules arranged in groups of 3-10. Cups covered in raised rings, with dense felt-like indumentum. Cupules bowl-shaped, 4-10 mm across and up to 2 cm long, enclosing up to 1/3-1/2 of the nut. Nut broadly ovoid to oblate, 1.5-2 × 1-1.5(-1.8) cm, hairy when young, glabrescent, base and apex rounded; scar 4-5 mm in diam., flat. Flowering from December-March and fruiting from November-December in the following year. Spread throughout lowland and up to the edge of highland forests (100-1,700 m).

Photo 4/ *Quercus championii* (Hong Kong Island).

Quercus chungii F.P. Metcalf

Evergreen trees up to 15 m tall. Twigs and young branches covered in dense brown felt-like indumentum. Older woody parts smooth. Leaves elliptic to rarely obovate-elliptic, up to 2-4 cm wide and up to 12 cm long. Thick, rough to the touch, covered in greyish or reddish-brown stellate hairs on both sides when young. Leaf base cuneate to somewhat rounded, apex acute to caudate with an elongated tip, margin sometimes serrulated towards apex. Cupules arranged in groups of 2-6, saucer-shaped, 1.5-2.3 cm long and up to 8 mm wide. Cups covered in flat imbricate scales. Cupules only covering the base of the nut, interior and exterior covered in grey-brown indumentum. Nut broad oblate, ranging from 1.5 cm wide and up to 1.7 cm long. Lowland species, occurring at 200-800 m. Flowering from April-May, fruiting from October-November.

Quercus edithiae Skan

Medium-sized evergreen trees up to 20 m tall. Twigs slightly angular, glabrous, covered in lenticels. Bark smooth, often with lenticels arranged in rings or lines. Leaves oblong-elliptic, sometimes slightly obovate, 5-16 cm long and up to 6 cm wide, leathery, bright red when flushing. Leaf base cuneate, apex with a distinct blunt tip, upper 1/3 of leaf sometimes with serrulate margin. Cupules generally arranged

Photo 5/ *Quercus edithiae*

3-4 together. Cups covered in raised rings, covered with golden felt-like indumentum. Fruits usually single or in pairs. Cupules bowl-shaped, 1.2-1.5 cm across, and up to 2.5 cm long, enclosing up to 1/4-1/3 of the nut. Indumentum outside erect, velvety orange brown and inside long, adpressed and orange brown. Nut ellipsoid to cylindrical, up to 4.5 cm long and 3 cm across. Nuts usually with a swollen appearance and wider than cup, giving a distinct appearance from most other species in Hong Kong. Flowering in April-June, fruiting in October-December. Occurring from low to mid-elevations but nowhere above 1,800 m.

Quercus fabri Hance

Deciduous trees to very large shrubs, up to 20 m tall. Bark grey brown to grey yellow, with fissures when young but sometimes becoming scale-like in older individuals. Leaves obovate to elliptic-obovate, 7-15 cm long and up to 8 cm wide. Both sides covered with short white to yellow-grey stellate hairs. Leaf base cuneate to somewhat rounded, apex obtuse. Leaf margin undulate, sometimes slightly serrate. Cupules generally only 2-4, cup-shaped, 4-8 mm across, and up to 11 mm long, enclosing up to 1/3 of the nut. Cups covered in flat imbricate scales. Nut narrowly ellipsoid to ovoid shaped, ca. 0.7-1.2 cm wide to 1.7 cm long. Flowering in April, fruiting in October. Occurring from lowlands to mid-elevation (100-1,900 m).

Quercus glauca Thunb.

Evergreen trees up to 20 m tall. Crown generally wide and spreading, but dense. Leaves obovate to oblong-elliptic, 6-13 cm long and up to 6 cm wide. Leaves thick, leathery, showing scale-like whitish hairs, but smooth at later age. Leaf base round to broadly cuneate, the upper half with small teeth. Leaf apex acute. Cupules bowl-shaped, 6-8 mm wide and up to 1.4 cm long. Enclosure of the nut variable, ranging from 1/3-1/2. Cups covered in flat rings consisting of fused scales. Nut ovoid to oblong-ovoid, or even ellipsoid. Acorns edible. Flowering from April-May, fruiting in October. Although *Q. glauca* is easy to distinguish from other oak species in Hong Kong, in the wider range where it occurs, it is very variable in appearance, leading to the general conception of it being a complex of species or subspecies that is yet to be investigated properly.

Photo 6/ *Quercus hui*

Quercus hui Chun

Evergreen trees ranging from 15-20 m tall. Crowns dense and bushy. Bark smooth, grey to grey brown. Twigs and small branches covered with dense orange-brown curly hairs, but older sections glabrescent. Leaves slightly leathery, variable in shape from oblong-elliptic, oblanceolate to elliptic-lanceolate, 7-10 cm long to a maximum of 4 cm wide. Margins recurved, entire to sometimes slightly serrulate towards the apex. Infructescence mostly with 1-2 fruits only. Cupule variable from a shallow bowl to a flat disc, 4-10 mm high and up to 3 cm wide, covering only the base of the nut. Exterior and interior of cupules covered with felt-like yellow-brown indumentum. Cups covered in raised rings. Nut big and spheroid, 1.5-2 cm wide and up to 2.5 cm long, densely golden tomentose when young. Flowering in April-May, fruiting from October-December. Only occurring in forests at lower elevations (300-1,200 m). Rare.

Quercus litseoides Dunn

Small evergreen trees, up to 10 m tall. Twigs sparsely tomentose, glabrescent. Leaves with petioles tiny or more often completely absent. Species characteristic for Hong Kong in having fairly narrow (1-2 cm) but often very long leaves (up to 7 or 8 cm). Lamina obovate-oblanceolate, smooth, glabrous. Base wedge-shaped, margins entire and apex semi-rounded. Cupules free, often in twos, bowl-shaped, covering up to 1/3 of the nut. Cups covered in flat rings. Nut ellipsoid (1.5 × 1 cm). Generally rare throughout its range, known from only a few locations in Hong Kong. Occurring only at lower elevation zones. Flowering in January, fruiting in December.

Photo 7/ *Quercus litseoides* (Lantau Island).

Quercus myrsinifolia Blume

Evergreen tree, up to 15 m tall. Sometimes forming shrubby habit in cultivation. Crown shape often globe-like. Bark grey, thin, with small lighter colored fissures. Twigs smooth, covered in grey-brown lenticels. Leaves ovate to elliptic-lanceolate, 6-11 cm long and up to 4 cm wide. Undersides whitish, but dark grey when dry, glabrous. Base of leaf wedge-shaped to rounded. Leaf base cuneate-subrounded, apex acuminate-caudate and upper half of leaf serrulate. Young leaves sometimes deep dark red. Cupule cup-shaped, 2 cm long and up to 5-8 mm wide. Cup enclosing up to 2/3 of the nut, which is ovoid-ellipsoid, 1.4-2.5 cm long and up to 1.8 cm wide. Cups covered in raised rings. Generally flowering in June, and fruiting around October. Widespread species throughout Hong Kong, but with variable morphology across the wider region. Found between 200-2,500 m.

Quercus variabilis Blume

Deciduous tree, up to 25-30 m tall. Large, spacious open crowns, distinct from other oak species in Hong Kong. Stem diameter up to 40-60 cm, with thick, cork-like bark with deep fissures. Wood a deep yellow to yellow brown. Twigs greyish brown to grey, smooth. Leaves dark green above, silver below, simple with dentate margins, each secondary vein ending in a hairlike, protruding tooth. Petioles 1-5 cm, leaves 8-20 cm long and 2-8 cm wide, with sharp apex and wedge-shaped to rounded base. Cupules are cup-shaped, 1 × 4 cm, covered in raised bracts and enclosing the nut up to 2/3. Bracts are recoiled backwards and down, with the nut becoming progressively more visible at maturity. Known from mainland sites to grow up to 3,000 m, but in Hong Kong currently know from only one seaside location at lower elevation. Flowering in April-May, fruiting in September-October.


8a

Photos 8/ (a-b) *Quercus variabilis*, newly recorded by the author in Hong-Kong.

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The Oaks of the Americas Conservation Network

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ABSTRACT

The Oaks of the Americas Conservation Network (OACN) is an international consortium of oak experts aimed at meeting aimed at filling the gaps in oak research and conservation in North and Central America. As part of their larger effort to connect science to conservation and catalyze collaboration between important oak experts, OACN held a Workshop on the Taxonomy of Rare Mexican Oaks at the Jardín Botánico of the Benemérita Universidad Autónoma de Puebla (Mexico) in September 2017. This workshop discussed the taxonomic and conservation issues facing many Mexican oak species, and it is part of a broader set of projects addressing oaks in this region.

Keywords: *Quercus*, Latin America, conservation, taxonomy, Mexico

Introduction

It was a warm sunny morning in mid-September when 30 oak experts from across Mexico (and a few from the United States) descended upon the Jardín Botánico of the Benemérita Universidad Autónoma de Puebla (BUAP) to begin a few days dedicated to talking solely about oaks. It was the beginning of the Workshop on the Taxonomy of Rare Mexican Oaks – an effort organized by The Morton Arboretum and the Botanic Garden at BUAP in response to a number of colleagues pointing out the need for oak taxonomic work in the incredibly diverse region of Mexico and Central America. The workshop was part of a larger effort to coordinate, collaborate and share oak expertise across North and Central America through the newly formed Oaks of the Americas Conservation Network (OACN). The group was welcomed by Dr. Ygnacio Martínez Laguna, Research and Postgraduate Vicechancelor.

Workshop: taxonomy of rare Mexican oaks

Photo 1/ Allen Coombes and Maricela Rodríguez-Acosta with *Quercus sebifera* guiding the workshop participants through the Jardín Botánico of the Benemérita Universidad Autónoma de Puebla.

Photo 2/ Allen Coombes with *Quercus xalapensis* at the Jardín Botánico of the Benemérita Universidad Autónoma de Puebla.

The Botanic Garden at BUAP is an ideal setting for a Mexican oak taxonomy workshop, as they have the largest *Quercus* collection in the country. Allen Coombes, BUAP's Curator of Scientific Collections, and Maricela Rodríguez-Acosta, Director of the Herbarium and Botanic Garden, led our group on a tour of their impressive Quercetum. Looking particularly remarkable was a tree of *Quercus xalapensis* Bonpl., which has distinct, large acorns on the old shoots, different from the nearby trees of *Q. sartorii* Liebm. which have acorns on young shoots. Oaks in the collection that are native to that part of the state, such as *Q. grahamii* Benth. (the correct name for the plant previously known as *Q. acutifolia* Née) and *Q. liebmannii* Oerst. ex Trel., have not surprisingly reached an impressive size, but also surviving are oaks from much more humid areas such as *Q. insignis* M. Martens & Galeotti, *Q. lancifolia* Schltdl. & Cham., and even a small tree of *Q. corrugata* Hook.

The purpose of this workshop was to gather together a group of

Mexican oak experts to discuss tricky taxonomic puzzles of some of Mexico's rarest oak species. Mexico is a global center of oak diversity. It has upwards of 170 species, many of which are rare, with little known about them. On top of that, new species continue to be discovered, meaning there are almost certainly more rare oak species even the experts do not yet know of. The tremendous oak diversity in this part of the world is caused and compounded by two factors: (1) two distinct oak clades diversified simultaneously in the east and the west, and (2) both clades experienced an uptick in speciation rate as the oaks hit the mountainous topography of Mexico. This all happened as oaks made their way south from the temperate forests of the U.S. and Canada over the past 45 million years (Hipp et al. 2018). The high species richness, coupled with oaks' tendencies to easily hybridize, makes for a challenging and scintillating taxonomic puzzle, with much work still to be done to properly identify and define species in the region.

Participants at the two-day workshop came from all across Mexico, and their areas of expertise spanned every region of the country. The first day was dedicated to presentations on particular species; each presenter selected a complex of species within their region of expertise. These complexes included species that were often misidentified, that were newly described, or that were altogether understudied.

Dr. Susana Valencia Avalos, one of the leading oak experts in the country and a professor at the Universidad Nacional Autónoma de Mexico in Mexico City, began the workshop with a talk on the huge diversity of oaks in the southern states of Mexico: Oaxaca, Chiapas, Guerrero, Hidalgo and Veracruz. This area of Mexico has the highest diversity of oak species in the country, and as is the case in many parts of the world, with great diversity comes a number of taxonomic problems. Species are easily confused, and some that are treated as synonyms may actually be valid species for which the proper material and fieldwork are lacking. Such is the case with *Q. bumeliodes* Liebm., a White Oak found in Chiapas and Central America that in the past has been treated as a synonym of various Red Oaks, like *Q. eugeniifolia* Liebm., *Q. seemannii* Liebm., and *Q. sapotifolia* Liebm. Moreover, in Costa Rica it gets confused with *Q. copeyensis* C.H. Mull., *Q. pacayana* C.H. Mull., and *Q. costaricensis* Liebm. Dr. Valencia argues that *Q. bumeliodes* shows enough difference to be its own species, but it still lacks the field and herbarium work needed to determine if it is synonymous with *Q. pacayana* and/or *Q. copeyensis*.

Tackling various species from northeast Mexico were Juan Encina of the Universidad Autónoma Agraria Antonio Narro, José Luciano Sabás-Rosales and Oscar Javier Soto Arellano of the Instituto Nacional de Estadística y Geografía (INEGI), and Leccinum Jesús García Morales from the Instituto Tecnológico de Cd. Victoria. Together, these experts examined 15 difficult species, from *Q. cordifolia* Trel. in Nuevo Leon, all the way to *Q. diversifolia* Née in central Mexico. To round out the day, M. Socorro González-Elizondo from the Instituto Politécnico Nacional, Centro Interdisciplinario de Investigación para el Desarollo Integral Regional in Durango, and Liliana Rubio Licona, who works on species in the Baja California Peninsula for UNAM, presented species from the northwest of Mexico.

Moving away from strict taxonomy, the second day of the workshop was focused on related fields of research and conservation that affect, and are affected by, how we define oak species. Andrew Hipp of The Morton Arboretum spoke on the phylogenetic side of things, explaining the process and challenges involved in recovering a complete oak phylogeny. He also told the story of the history of the Red and White Oak lineages in

Photo 3/ Workshop participants in the Jardín Botánico of the Benemérita Universidad Autónoma de Puebla.

the Americas: from their origin in northern Canada and subsequent spread down into the U.S., where they rapidly diversified southward into Mexico and Central America (Hipp et al. 2018). Dr. Hipp provided important context for the rest of the workshop by explaining that the high diversity of oaks in Mexico is not because Mexico is the origin of American oak diversity, as previously thought, but because oaks diversified at a remarkably fast rate once they arrived in Mexico from the northern reaches of the continent.

César Andrés Torres-Miranda of UNAM Escuela Nacional de Estudios Superiores (ENES) provided biogeographic perspectives by presenting the modeling and mapping of oak diversity hotspots within Mexico, for example, the northern Sierra Madre Oriental and the Serranías Meridionales of Jalisco (Torres-Miranda et al. 2011). Hernando Rodríguez-Correa of UNAM ENES analyzed the effectiveness of in-situ and ex-situ conservation of oaks in diversity hotspots under current and future climate-change scenarios. Dr. Rodríguez-Correa's ongoing work to develop climate change models for all Mexican oak species will contribute to a future position paper for the Oaks of the Americas Conservation Network. Antonio González-Rodríguez of UNAM Morelia explained how hybridization affects oak taxonomy, and Oscar de Luna Bonilla, a student of Dr. Susana Valencia, explained how morphology, the study of the external, physical form of a plant, can be used to delineate species within the genus *Quercus*.

In addition to the presentations, workshop participants worked together to create an up-to-date working checklist of all Mexican oak species. Together they went through a list of over 170 species names, gathered from a variety of sources by the Global Tree Conservation Program team at The Morton Arboretum, and designated each name as either valid, not valid, or in need of more taxonomic and/or field work. Given the fast-paced, ever-changing taxonomic revelations that affect oak species, many checklists are often outdated, and there is an almost constant need to check in with expert consensus on the current correct status for certain species names.

Photo 4/ *Quercus durifolia* in Durango (Mexico).

At the end of the workshop, after two days of fascinating and animated oak discussions, the group collaboratively updated IUCN Red List threat assessments for 16 rare Mexican oak species, including: *Q. agrifolia* Née, *Q. cedrosensis* C.H.Mull., *Q. cordifolia* Trel., *Q. deliquescens* C.H. Mull., *Q. devia* Goldman, *Q. durifolia* Seemen ex Loes., *Q.*

microphylla Née, *Q. peninsularis* Trel., *Q. saltillensis* Trel., and *Q. striatula* Trel. This marked the beginning of The Morton Arboretum's much larger effort to complete Red List assessments for every Mexican oak species, a project that depends on an accurate species checklist since we cannot assess the threat level of species until we accurately define them.

The Oaks of the Americas Conservation Network (OACN)

This workshop on the taxonomy of rare Mexican oaks was one of three meetings organized this year by the Oaks of the Americas Conservation Network (OACN), an international consortium of researchers and conservationists at universities, botanical gardens, arboreta, NGOs and government agencies working to conserve threatened oak species throughout the Americas, with a focus on Latin America as a global hotspot for oak diversity.

The idea for OACN was born out of an increasing recognition of the need to link science with practice when designing and implementing conservation actions for threatened species. It is well known that oaks are keystone species in a wide range of habitat types across North and Central America. However, preliminary estimates indicate that at least one third of New World oak species are threatened with extinction (M. Westwood and D. Jerome, pers. comm.). Despite the ecological importance and declining biodiversity of the genus *Quercus*, much work is still needed to understand drivers of threat and population decline. So, in early 2016, staff at The Morton Arboretum's Global Tree Conservation Program forged a collaboration with the members of the Oaks of the Americas research group, a US National Science Foundation (NSF) funded research initiative including oak experts from The Morton Arboretum, the University of Minnesota, Duke University, the University of Notre Dame, and the Universidad Autónoma Nacional de Mexico. This collaboration between research- and conservation-focused experts formed the seed of OACN.

In March of 2016, a founding meeting, the International Workshop on Oak Conservation, was hosted at UNAM's La Escuela Nacional de Estudios Superiores Unidad Morelia by The Morton Arboretum (Nicole Cavender, Murphy Westwood, and Andrew Hipp), The University of Minnesota (Jeannine Cavender-Bares), and UNAM (Antonio González-Rodríguez). The workshop brought together 50 oak experts from 7 different countries. It was there that OACN was officially formed, starting with those 50 members from across North and Central America, and even Europe. The group has since grown, more than doubling in membership. In 2017, OACN held three meetings and developed various projects for two threatened oak species in the region, *Q. brandegeei* Goldman and *Q. insignis* (described below).

OACN works closely with the Global Trees Campaign, a joint effort between Fauna & Flora International (FFI) and Botanic Gardens Conservation International (BGCI) aimed at preventing extinction of the world's threatened trees and protecting them in their natural habitats. As with most large environmental problems, OACN recognizes that to achieve these goals of tree biodiversity protection on a large scale there is a great need for cross-sector, interdisciplinary work. As such, our network includes a range of stakeholders and experts. On the side of botanic gardens, in addition to BGCI, we have members from the Asociación Mexicana de Jardines Botánicos (AMJB), as well as from prominent botanic gardens from across the U.S. and Mexico, including the aforementioned Botanic Garden of BUAP in Puebla.

Photo 5/ *Quercus brandegeei*

Complementing the ex-situ conservation work done by gardens, OACN also has members from conservation organizations that focus on in-situ species protection, like Ya'axche Conservation Trust in Belize, a non-governmental organization that protects land of high biodiversity value and promotes sustainable land management techniques. To inform conservation work, there is a clear need for science and research on oaks and their landscapes. The group was born, after all, out of a research group. As such, we have members from universities across North and Central America, including the Instituto de Ecología in Xalapa, Mexico, the Escuela Agrícola Panamericana Zamorano in Honduras, and all the universities of the original Oaks of the Americas NSF group mentioned above.

In involving such a wide range of collaborators, we hope to integrate ecological and social science to applied, on-the-ground conservation. We recognize both the need for basic scientific research, as well as the application of such research to conservation, land management, agriculture, and to all human uses that affect oaks. OACN aims to bring together stakeholders across geographic and professional borders to translate science from the top minds in oak research into effective conservation of oaks both in gardens and within natural landscapes.

The funding for the taxonomy workshop in Puebla came from a suite of OACN projects that support oak species conservation in Mexico and Central America that span a variety of species, audiences, and methodologies. These efforts include much-needed survey, identification, and threat evaluation for rare and poorly-known oak species in Mexico, as well as two species-focused projects, one which tackles the narrowly endemic *Q. brandegeei* and another focused on the more widespread but extremely rare *Q. insignis*.

Quercus brandegeei is an endangered oak species that is endemic to Mexico and exists solely within an extremely small range at the southern tip of the Baja California peninsula. This oak grows on the edge of sandy streambeds that seasonally fill with water from hurricanes. *Q. brandegeei* can grow to be a fairly large tree; the largest individuals recorded have diameters well over 100 centimeters and heights measuring up to 20 meters tall. The tree has small, elliptical leaves, flowers appearing in spring, and unique, elongate acorns which fruit, fall and immediately germinate around December, directly following the rainy season. There are fewer than 1,000 individuals remaining of this species, and there has no observable regeneration in the wild for perhaps the past 100 years. To protect this species from extinction, project partners are growing ex-situ collections while simultaneously researching the effect that drought (caused by long-term climate change) and cattle grazing (as livestock are a large part of the local economy) have on seedling survival. Research findings will be used to formulate a reforestation effort within the species natural habitat.

Quercus insignis is a tall, broad-leafed oak, easily recognized by its extremely large acorns. *Q. insignis* grows in cloud forest habitat and is distributed from Mexico to Panama. Despite its large range, the species is exceedingly rare and increasingly threatened by habitat loss as forests are cut for agricultural land use change. Unfortunately, this species of oak occurs within the ideal range for coffee production. The Morton Arboretum and the Escuela Agrícola Panamericana Zamorano organized a workshop to bring together researchers and conservationists from across the species range to discuss what is needed to conserve the species across national borders. As a result of this meeting, various projects have been initiated, including collecting of *Q. insignis* acorns for genetically representative ex-situ collections in botanical gardens and reforestation experiments within cloud forest restoration sites.

Conclusion

These projects, along with the 2017 Workshop on the Taxonomy of Rare Mexican Oaks in Puebla, represent just the beginning of OACN's efforts to address the gaps in oak research and conservation in North and Central America. In the future, OACN aims to expand our efforts towards this end, but we recognize that such an ambitious goal cannot be achieved without collaboration. This year, through our network, we aim to complete Red List Assessments for all Mexican oak species, analyze oak conservation priority areas in Mexico, further our on-the-ground projects for *Q. brandegeei* and *Q. insignis*, and conduct much needed oak taxonomic fieldwork. If you are interested in joining OACN, please contact Murphy Westwood at The Morton Arboretum (*mwestwood@ mortonarb.org*).

Photographers. Title page: Béatrice Chassé (*Quercus insignis*). Photos 1, 3: The Morton Arboretum. Photo 2: Maricela Rodríguez-Acosta. Photo 4: Béatrice Chassé. Photo 5: Tim Thibault.

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Linking Science and Practice for Oak Ecosystem Recovery in the Chicago Wilderness Region

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ABSTRACT

The Oak Ecosystem Recovery Plan (OERP) aims to preserve, protect, and enhance the resiliency and integrity of oak ecosystems in the Chicago Wilderness Region through collaborative management practices and policies. Identifying best practices requires translating the current state of scientific knowledge into feasible actions that can be performed by a range of land managers, public or private. The impact of these actions should then direct future research. In reality, direct communication between scientists and land managers is rare. To facilitate a dialogue between these two communities, The Morton Arboretum hosted the Midwest Oak Ecosystem Managers and Scientists Meeting. First, we surveyed land managers to determine the major topics of concern from their perspective. Their responses were forwarded to the scientists to find commonalities and overlap with their research efforts. During the meeting, the two groups discussed the OERP generally and split into focus groups on high-priority topics. Several key outcomes are: 1) ground-truthing of the quality and condition of mapped "core" oak ecosystems and their environs is needed; 2) private landowners must be part of the dialogue; 3) potential impacts of climate change should be incorporated into management plans; and 4) management objectives should work positively across geographic scales, from landscape to oak remnant.

Keywords: Oak Ecosystem Recovery Plan, land management, oaks, *Quercus*

Introduction

During the Euro-American settlement of the Chicago region in the 1830s, the majority of the native vegetation was dramatically modified by human activity. In a relatively short period of time, 83% of the original oak ecosystems had been converted to other land uses (Fahey et al. 2015). The documentation and scientific knowledge of these native oaks ecosystems, before they were converted, is limited. What was the structure and composition of these native oak ecosystems? How did they function? How did they regenerate? We lost not only the original ecosystems but also the ability to understand them and their natural cycles of expansion and contraction. Oaks are keystone species for many organisms, from insects to squirrels to fungi, forming the base of ecosystem biodiversity. Because these ecosystems have seen dramatic reduction in their area and connectivity, we clearly need to make active management decisions for the improvement and maintenance of these highly disturbed and threatened ecosystems.

The Oak Ecosystem Recovery Plan

In 2015, Chicago Wilderness published the Oak Ecosystem Recovery Plan (OERP): Sustaining Oaks in the Chicago Wilderness Region (Fahey et al. 2015) to pull together the existing knowledge and data available and to develop a strategy for maintaining these iconic and vital ecosystems. As outlined in the OERP, oak trees do not seem to be regenerating, even in remnant native ecosystem patches, possibly due to several factors including changes in land use, fragmentation, increased herbivory, insufficient light in overgrown forests, pests and diseases, and impacts from invasive species (Fahey et al. 2015). The major outcomes from the OERP were the basic mapping of oak ecosystems in the Chicago Wilderness Region (Fig. 1); recommendations and strategies to improve their health and function; the steps required to increase their resilience to impacts from the built environment; and potential effects of climate change. Finally, a vision of the future of oaks and oak ecosystems was provided:

A physical landscape in which:

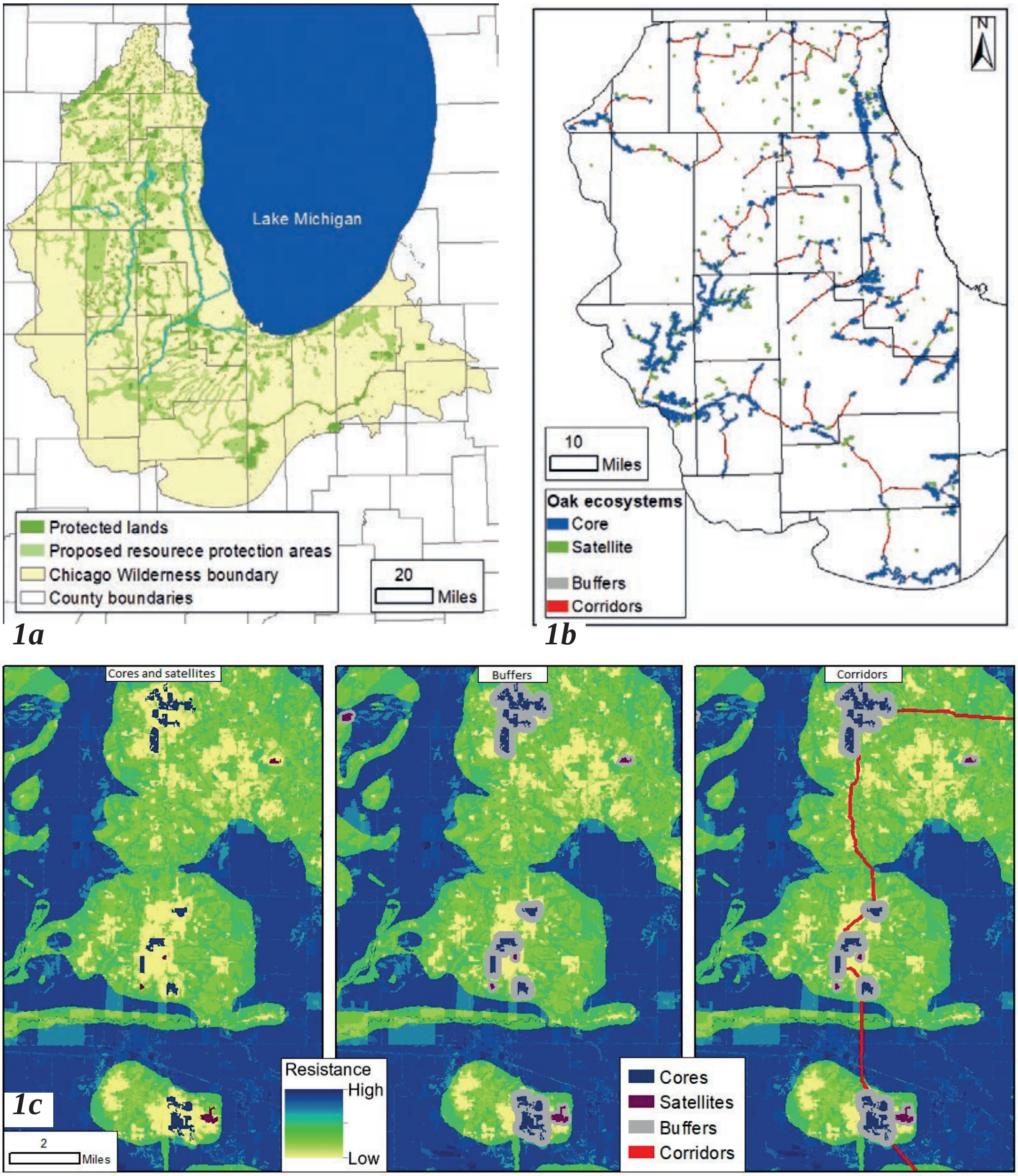
1. A regional network of oak ecosystems is developed and maintained that maximizes high quality interior habitat and landscape-level connectivity.
2. Remnant oak ecosystems are protected and managed to restore or maintain biodiversity and ecosystem structures and functions.
3. Oaks are planted, and oak ecosystems are created or restored across a range of land uses and ownerships.
4. Threats to oaks and oak ecosystems are managed proactively and removed whenever feasible.

A social landscape in which:

5. The story of the regional oak legacy is told widely to a variety of audiences in an authentic and engaging way.
6. A coordinated regional stewardship network is focused on maintaining and enhancing oaks and oak ecosystems in all of their incarnations.
7. The many values and services associated with oaks and oak ecosystems are understood and promoted to a wide variety of audiences.

Table 1/ A vision of the future of oaks and oak ecosystems provided in the Chicago Wilderness Oak Ecosystem Recovery Plan.

To implement the plan, an OERP work group was formed consisting of professional natural areas land managers from organizations such as county forest preserve districts,



Figures 1/ (a) Chicago Wilderness Region; (b) Oak ecosystems in the Illinois portion of the Chicago Wilderness Region; (c) The conceptual basis for the cores, buffers, and corridors. (Courtesy of (a) the Chicago Metropolitan Agency for Planning and (c) Chicago Wilderness.)

the U.S. Forest Service, the National Parks Service, The Nature Conservancy, The Morton Arboretum, The Field Museum, the Illinois, Indiana, and Wisconsin Departments of Natural Resources, and others. This group, using 1830s survey notes and 1939 and 2010 aerial photography, has identified public- and privately-owned land that could form networks of interconnected sites achieving 500- to 1,000-acre oak ecosystem complexes. The foundation of the plan is developed around the concept of multiple-use modules (MUMs) (Noss and Harris 1986; Bishoff and Jongman 1993) with the identification of **core** areas – high quality interior remnant oak ecosystem habitat, **buffer** areas – adjacent land managed in a compatible manner that provides some protection, and **corridor** areas

- land that connects **cores** and **buffers** across the entire region, allowing the movement of plants and animals and creating a single cohesive landscape. The stated goal of the plan is to identify twenty 500-acre complexes and ten 1,000-acre complexes across the Chicago Wilderness Region. While we may not expect this landscape plan to recreate the original oak ecosystems of the 1830s, it should improve overall ecological function and protection for some species and will certainly be an important learning process about the key factors for preserving and protecting these important but remnant ecosystems in the Chicago region.

In this region, **core areas** are typically publicly owned and professionally managed. On the other hand, **buffer areas** and **corridors** are typically privately owned by many property owners, usually do not have any protected status, and are not professionally managed. In fact, 70% of oak ecosystems in the Chicago Wilderness Region are privately owned (Fahey et al. 2015). Therefore, a large part of the success of the implementation of the OERP relies on education and engagement of private property owners. Through the identification of these components of the overall oak ecosystem landscape, a targeted strategy can be developed so that the management can be coordinated across sites and compatible goals can be set to maintain and improve overall biological diversity and resilience. The implementation of these strategies must also be feasible across a range of engagement and management skill levels. In order to achieve the vision of the OERP, best management practices must include a strong engagement and education program for landowners with little to no professional training, experience, or interest.

In order to begin implementation, the OERP work group determined that input was needed from the land management and scientific community including identification of existing research, potential research needs, how best to engage landowners in conservation practices, and opportunities for collaboration with scientists. Unfortunately, a disconnect exists between land managers, particularly private landowners, and professional scientists about the current state of research on oak ecosystems and their functions and the importance of and priorities for research on improving land management strategies and outcomes (Dey 2014; Knoot et al. 2010). Because most of the area is owned privately, 70% in the Chicago Region according to OERP and 83% of forestland in the Eastern United States according to Smith et al. (2009), this disconnect has the potential to disrupt conservation and restoration efforts. The recovery of oak ecosystems in the Chicago Region requires effort to bridge this divide to bring together land managers and scientists to jointly develop research priorities and goals (Arthur et al. 2002; Christensen et al. 1996; Dettman and Mabry 2008).

Bridging the divide between research and management

To provide an effective forum and environment to create this dialogue between land managers and scientists, the Chicago Region Trees Initiative (CRTI), with the assistance of the Center for Tree Science (CTS) (both at The Morton Arboretum), developed plans for a one-day meeting to bring together roughly equal numbers of participants from each category. To identify key concerns or questions about oak ecosystem restoration we created the Oak Ecosystem Land Manager Survey, composed of 8 questions and directed at professional natural areas land managers (Table 2). The survey yielded 46 responses

Question	Type
1. Which of the following ecosystem types do you currently manage? Check all that apply. (Definitions from Chicago Wilderness Oak Ecosystem Recovery Plan)*	Checkboxes (multiple selections allowed)
2. In acres, how large is the collective property you manage?	Open-ended
3. Please describe the configuration of your property (e.g. multiple isolated fragments, one large property surrounded by agriculture or urban space, a long narrow property with low quality edges, etc)	Open-ended
4. Is the land you manage public or private property?	Multiple choice (single answer required)
5. What research topics are most appealing to you? Select up to 5 topics.**	Checkboxes (5 selections allowed)
6. How do you access current land management research?	Checkboxes (multiple selections allowed)
7. Contact Information	Open-ended
8. Please add any additional comments below.	Open-ended

Table 2/ Oak Ecosystem Land Manager Survey

*Forests—60-100% cover, >100 trees/ha: dense canopy and understory dominated by spring ephemeral forbs; Woodlands—25-60% cover, 50-100 trees/ha: intermediate canopy density with a mixture of shrubs, forbs, and grasses in the understory; Savanna—10-25% cover, 10-50 trees/ha: open canopy conditions with a mostly grass-dominated understory; Open savanna/barrens—>0-10% cover, >0-10 trees/ha: very little canopy, mostly small stunted trees with grass-dominated groundlayer. **Adaptability of oak species and genotypes to urban habitats; Benefits analysis of oaks and related species: biological benefits (carbon sequestration, air filtration, wildlife habitat, etc); Benefits analysis of oaks and oak ecosystems: socioeconomic benefits (health factors, crime reduction, property values); Best management practices: conservation of high-quality sites; Best management practices: herbivore management; Best management practices: invasive species management; Best management practices: prescribed burning; Best management practices: thinning; Best management practices: wildlife management; Climate change: management strategies; Climate change: modeled effects on our region's natural areas; Creating ecosystem corridors; Genetics; GIS/mapping; Growth rate analysis of oaks and other oak ecosystem species; Human perception: oak and oak ecosystem value; Human perception: threats by invasive species; Inter-species competition for resources (e.g. *Acer* vs. *Quercus*); Intra-species competition for resources (e.g., *Quercus macrocarpa* seedlings competing for the same patch of light); Invasive species: buckthorn and honeysuckle biomass utilization programs and feasibility studies; Invasive species: impacts to natural areas; Invasive species: horticultural introductions; Invasive species: hybridization; Mapping status of oaks (composition, size structure, age structure) in the current regional forest at fine scale; Modelling oak population and oak ecosystems under different scenarios of inputs (management, funding, outreach) and stressors; Nursery availability: how to increase availability of locally-sourced, native trees; Nursery availability: assess expected demand and supply needed to meet near and long-term planting and restoration goals; Nutrient cycling; Plant pathology; Physiology (photosynthesis, respiration, transpiration); Propagation of native species; Protection of rare species; Pruning and other cultural practices as applied to oaks; Restoration of degraded sites; Silviculture (growing and caring for trees); Site characteristics and environmental conditions required to grow healthy oak trees; Site Quality Analysis; Soil ecology; Trees in urban settings; Hydrology; Wildlife: impacts of herbivores on oak regeneration; Wildlife: habitat restoration and conservation

from professionals managing approximately 8.5 million acres of land in Illinois, Wisconsin, Indiana, and Michigan. While the overall response rate was low (16%), the responses represented a diverse mix of land managers, including those working on public land (65.2%), private land (6.5%), or both (19.6%) with property sizes ranging from 10 to 4,000,000 acres (average size was approximately 200,000 acres). Overall, the land managers work on woodlands (88.4%), savannas (79.1%), forests (74.4%), and to a lesser extent, open savannas or barrens (58.1%). The survey participants also described their sites in an open-ended response. These sites ranged from multiple fragmented parcels to large single sites in a variety of landscape settings, including surrounded by natural areas, agriculture, residential tracts, transportation, industry, and urban developments. Some managed high-quality sites while others worked with degraded sites. Occasionally, these sites were associated with significant surface water, along rivers and lakes. In short, the 46 responses to the Oak Ecosystem Land Manager Survey were varied and representative of myriad land manager situations across the Midwest.

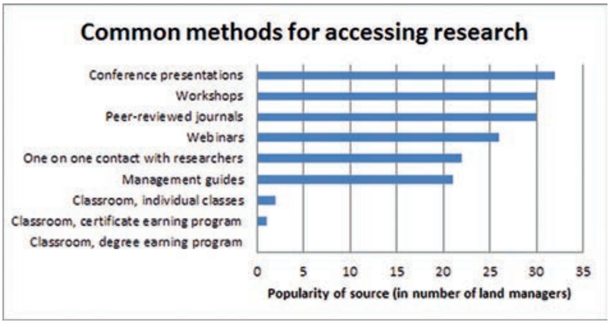


Figure 2/ Common methods for accessing research. Oak ecosystem land managers selected methods that they regularly use for accessing current research (N=44).

Additionally, the survey asked respondents to identify potential research topics that would be most useful for improving their land management practices. From a list of 43 potential research topics, the most commonly identified topics were best management practices for invasive species management (43.5%), best management practices for prescribed burning (41.3%), restoration of degraded sites (39.1%), best management practices for thinning (37.0%), best management practices for high-quality site conservation (30.4%), and habitat restoration and wildlife conservation (30.4%, Table 3). Furthermore, land managers were asked how they obtain news and results from current research. The most common source of information was conference presentations (72.7%), followed by peer-reviewed journals (68.2%), meetings (68.2%), and webinars (59.1%) (Fig. 2). These results will assist researchers and science communicators to better disseminate important scientific findings. However, a strong potential self-selection bias exists in the survey results, i.e., that the survey was predominantly completed by well-informed land managers and a more proactive and comprehensive survey may be necessary to fully engage a majority of land managers.

Research topic	% of land managers
Best management practices: invasive species management	43.5%
Best management practices: prescribed burning	41.3%
Restoration of degraded sites	39.1%
Best management practices: thinning	37.0%
Best management practices: conservation of high-quality sites	30.4%
Wildlife: habitat restoration and conservation	30.4%
Benefits analysis of oaks and related species: biological benefits (carbon sequestration, air filtration, wildlife habitat, etc)	26.1%
Wildlife: impacts of herbivores on oak regeneration	26.1%
Best management practices: herbivore management	23.9%
Climate change: management strategies	23.9%
Protection of rare species	23.9%
Invasive species: impacts to natural areas	21.7%
Other*	21.7%
Best management practices: wildlife management	19.6%
Invasive species: buckthorn and honeysuckle biomass utilization programs and feasibility studies	19.6%

Research topic	**% of land managers**
Site characteristics and environmental conditions required to grow healthy oak trees	19.6%
Soil ecology	19.6%
GIS/mapping	17.4%
Mapping status of oaks (composition, size structure, age structure) in the current regional forest at fine scale.	17.4%
Modelling oak population and oak ecosystems under different scenarios of inputs (management, funding, outreach) and stressors	17.4%
Propagation of native species	17.4%
Site Quality Analysis	15.2%
Benefits analysis of oaks and oak ecosystems: socioeconomic benefits (health factors, crime reduction, property values)	13.0%
Inter-species competition for resources (e.g., *Acer* vs. *Quercus*)	13.0%
Invasive species: horticultural introductions	13.0%
Pruning and other cultural practices as applied to oaks	13.0%
Hydrology	13.0%
Climate change: modeled effects on our region's natural areas	10.9%
Creating ecosystem corridors	10.9%
Growth rate analysis of oaks and other oak ecosystem species	10.9%
Human perception: oak and oak ecosystem value	10.9%
Human perception: threats by invasive species	10.9%
Plant pathology	10.9%
Silviculture (growing and caring for trees)	10.9%
Genetics	8.7%
Nursery availability: assess expected demand and supply needed to meet near and long-term planting and restoration goals	8.7%
Adaptability of oak species and genotypes to urban habitats	6.5%
Invasive species: hybridization	6.5%
Nursery availability: how to increase availability of locally-sourced, native trees	6.5%
Nutrient cycling	6.5%
Trees in urban settings	6.5%
Physiology (photosynthesis, respiration, transpiration)	4.3%
Intra-species competition for resources (e.g., *Quercus macrocarpa* seedlings competing for the same patch of light)	2.2%

Table 3/ Priority oak ecosystem research topics. Research topics ranked by highest priority by oak ecosystem land managers in the Midwest according to 2017 survey. *Respondents listing “other” suggested the following topics: identifying the most cost effective strategies, structural versus functional restoration, restoration of non-oaks in oak ecosystems, and oak generation light requirements.

The survey results were forwarded to 61 scientists specializing in regional oak research, or related topics, so they could provide input, identify existing research on these questions, and indicate whether they would be interested in attending a meeting to discuss these questions with land managers. The scientists generally acknowledged the disconnect between their research priorities and those of the land managers. Digital copies of the existing published research identified by the scientists were compiled on a thumb drive and distributed at the meeting to the land managers. The additional research topics identified by the scientists were compiled with previous survey results to create small group discussion topics for the meeting.

Research Topics and Key Terms	Relevant publications via Google Scholar (out of 50)*	Relevant publications via articles submitted by attending researchers (out of 48)**
Best management practices for invasive species management (43.5%)	Total: 52	7
Invasive *Quercus*	7	
Buckthorn *Quercus*	28	
Honeysuckle *Quercus*	22	
Best management practices for prescribed burning (41.3%)	Total: 57	24
Quercus prescribed burning	23	
Fire management midwest *Quercus*	37	
Restoration of degraded sites (39.1%)	Total: 74	3
Quercus degraded midwest	41	
"Poor quality sites" *Quercus* midwest	10	
"Disturbed sites" midwest *Quercus*	25	
Best management practices for thinning (37.0%)	Total: 54	20
Thinning *Quercus* midwest	33	
Selective removal *Quercus* midwest	26	
Best management practices for high-quality site conservation (30.4%)	Total: 33	8
Conservation *Quercus* midwest "high quality"	22	
Quercus midwest management "high quality"	19	
Habitat restoration and conservation for wildlife (30.4%)	Total: 46	14
Quercus wildlife midwest conservation restoration	21	
Quercus habitat management midwest	28	

Table 4/ Google Scholar search of manager-selected topics. *Relevant publication published between 1998 and 2018 on oak ecosystems in the Midwest were tabulated from the first 50 search results. **Researchers submitted their publications that addressed oak ecosystems in the midwest prior to the summit. This column is the number of papers from those submitted (48) that address each manager-selected topic.

As the land managers identified research topics that would be most valuable to their work, we needed to clarify how much research already exists, and is accessible, on those topics. A Google Scholar search was performed using keywords associated with the top six land manager-selected topics. Two to three key terms per topic were entered into the Google Scholar search engine with publication dates limited to 1998 to 2018 so the results would reflect current research trends. Google Scholar was used for the search because it is commonly available, includes all publications, and is free to use without special software or subscriptions. With each key term search, we tabulated all of the peer-reviewed papers related to the given topic presented in the first 50 search results. Additionally, the publications from scientists that were compiled on the thumb drive were reviewed for content related to these top six priority topics (Table 4).

Of the 52 articles found in the Google Scholar search for invasive species management, most were primarily focused on impacts of invasive species, not actual management strategies, suggesting a gap in the knowledge base. The articles found with the key terms for prescribed burning and thinning were similarly focused on the effectiveness of those management strategies, with a few papers highlighting communicating about those strategies to landowners or about the natural history of a site that justifies these management strategies. The 74 articles found using the restoration of degraded sites key terms touched on myriad topics. Of note were several papers addressing soil scarification techniques and artificial regeneration. The 33 articles found with the high quality site conservation key terms mostly covered case studies or conservation of rare ecosystem types, such as shale barrens or Ozark highlands. Of the 46 articles on restoration and conservation for wildlife, most focused on birds, but cases were made for restoring habitat for insects, bats, generalized “small mammals”, and a snake. A few others recommended considering habitat and specific wildlife supported by a given site when setting restoration goals. Overall, there is a consistent body of work being published on each of these topics, so it seems the land managers and researchers are not as disconnected on these subjects as was feared.

The 48 papers submitted by attending researchers gives us some background on their personal research interests. Of those top six land manager priorities, seven articles were related to best management practices for invasive species management, 24 articles were related to best management practices for prescribed burning, three articles were related to restoration of degraded sites, 20 articles were related to best management practices for thinning, eight articles were related to best management practices for high-quality site conservation, and 14 articles were related to habitat restoration and conservation for wildlife.

The CRTI organized this meeting to provide an opportunity for professional land managers and scientists to discuss the survey results, existing and potential research, and to provide a platform for professional networking. The meeting invitation was sent to natural areas land managers and scientists and listed the 20 most popular research topics identified from the land manager survey. Attendees were asked to select from the 20 topics those they wished to discuss in a small group discussion format. The goal of this step was to ensure that regional land managers were present to represent their most pressing concerns. Furthermore, by focusing on topics of interest to the land managers in the room, professional connections could be strengthened and meaningful research questions identified.

The Midwest Oak Ecosystem Managers and Scientists Meeting

A total of 51 participants took part in the meeting, including 26 scientists representing 8 universities, 2 U.S. agencies, 4 not-for-profit organizations, 1 environmental consulting business and 1 county conservation organization, and 25 land managers representing 6 county conservation organizations, 7 not-for-profit organizations or land trusts, 1 municipality, 1 university, and 1 ecological consulting business. The composition of the meeting was quite balanced between the two perspectives and some participants had difficulty placing themselves in one category or the other. As an introduction, an overview of the OERP was provided, including a description of the strategies implemented to date and the intended goals of the meeting. Then, the participants reviewed the discussion topics as one group and were asked if any important topics were missing. By general consensus, communication with private landowners was identified as an important discussion topic and was added to the list of topics.

Concluding this introduction, and based on the pre-meeting survey and refinements made during the registration process, participants were divided into three sets of small discussion groups, with 5-6 topics covered in each session (Table 5). Participants self-selected a discussion group to share their current research interests and establish potential priorities for future studies. From these discussions, three important themes evolved to guide future research opportunities and collaboration: 1) mapping, 2) mixed management strategies, and 3) private landowner engagement. In identifying these themes, the work group recognized the importance of moving beyond cataloging what has been achieved and towards implementing management strategies that promote oak ecosystem health.

Table	Session 1 Topic	Session 2 Topic	Session 3 Topic
1	Restoration of degraded sites (1)	Restoration of degraded sites	Protection of rare species (9)
2	Benefits analysis of oaks and related species (2)	Benefits analysis of oaks and related species	Soil ecology (10)
3	Climate change: management strategies (3)	Best management practices: conservation of high-quality sites (6)	Climate change: management strategies
4	Mapping status of oaks (composition, size structure, age structure) (4)	Best management practices: prescribed burning (7)	Mapping status of oaks (composition, size structure, age structure)
5	Invasive species: impacts to natural areas (5)	Wildlife: habitat restoration and conservation (8)	Invasive species: impacts to natural areas
6	Collaboration among landowners (topic requested at meeting)		

Table 5/ Research Priority Topics discussed in each of the three small group sessions. The top 10 research priority topics, as identified by the pre-summit survey and registration filter, were covered at least once in small group topics, with the top 5 covered twice so attendees had a chance to join their desired topic discussions. In the first session, an additional topic, Collaboration among landowners, was added by request and was well-attended.

The groups determined that the use of mapping to identify the quality of oak ecosystem sites is crucial to OERP implementation, and one discussion group explored how high-quality remnants can be used as references to inform restoration in lower-quality sites. Remnant stands of oak ecosystems have been mapped, but many have yet to be assessed from the ground level, which is a very important and necessary step. The OERP work group had previously identified the need to conduct site assessments of cores, buffers, and corridors. Site assessments would allow for determination of species diversity, protected

Photo 1/ Participants at the Midwest Oak Ecosystem Managers and Scientists Meeting.

status, and ownership. The first round of testing for a site assessment tool, aimed at public land managers, has been completed and further work is needed to adapt the tool to the private landowner. Site assessments then would allow prioritization for where work is needed first, types of restoration practices needed, opportunities for protection, and what training and education might be required. Understanding their characteristics and qualities, particularly any features that indicate degradation or poor quality, will help to guide priorities for restoration, preservation, and landowner engagement. The results of these assessments could also shape and establish the need for more of an emphasis on restoration of the lower-quality counterparts. Identifying these sites and their characteristics also provides opportunity for developing appropriate management and conservation strategies.

Likewise, assessment of lower-quality sites can help to establish clear steps for their restoration and management. According to attendees of the meeting, the Illinois Natural Areas Inventory (INAI) mapped some higher-quality oak woodland, but did not incorporate the characteristics of savannas, so those systems cannot be included as high-quality sites using their criteria. Furthermore, INAI favors plant-based definitions and does not include fauna, so their approach misses the full suite of ecological characteristics that we hope to include. The INAI provides a foundation model for site assessments, but input from attendees of the meeting can be used to develop a stronger system.

Along with discussions of site quality assessments and use of remnant populations, a few other groups discussed topics relating to mixed management: restoration, control of invasive species, prescribed fire and selective thinning, and habitat restoration and wildlife conservation. Discussions for each of these topics addressed the importance of establishing a goal for each management activity. Restoration goals, for example, should differentiate between reestablishing pre-settlement conditions versus adapting for future climate change. Beyond individualized implementation strategies, each group recognized the need for mixed management, notably the need to integrate selective thinning and canopy restoration into a prescribed burning regimen in order to preserve the seed bank and promote oak regeneration. These proceedings recognize the importance of and encourage a holistic approach that will augment the positive impact of isolated activities.

Lastly, beyond developing management strategies for large landowners, the importance of engaging private landowners in conservation and restoration efforts was also discussed. Given that 70% of remnant oak woodlands in northeastern Illinois are on private lands, this aspect of the OERP is obviously vital. Many public landowners recognize that engaging adjacent property owners is crucial to creating buffers that will protect management efforts. However, while the motivations of farmers and private landowners of larger parcels (> 5 acres) are assumed, the motivations of small landowners (¼ - 2 acres) remain elusive. Future social science research should explore how best to reach landowners with smaller holdings – perhaps by working through economic development organizations, homeowner associations, real estate agents, developers or contractors, and corporate campus managers. In municipal settings, the impact and value of ordinances and regulations should be examined for their potential to inform homeowner decision-making. Exploring and mapping known private landowner management strategies and motivations concurrently employed on higher quality and remnant sites could provide insight into what types of outreach would be most successful.

Finding mutual priorities and research needs

Though the registration filter was not designed to be compared to the results of the survey, some interesting trends emerged (Table 6). For example, although climate change management strategies was a moderately important topic for land managers (23.9%), the mixed group of scientists and land managers who attended the meeting considered it a high priority (48.9%). In addition, the most commonly requested research need by the land manager survey was management of invasive species (43.5%), however at the meeting, only one individual, a land manager, sat in that topic group and therefore was redirected to another discussion topic. Finally, perhaps unsurprisingly, mapping oak ecosystems was of much greater interest to the scientists (44.4%) than to the land managers (17.4%). These discrepancies were unexpected and will be looked into in more depth with future efforts. However, discussion at the meeting did supply some possible insight. For example, although the impacts of climate change have been observed by land managers in changes in phenology and in plant community composition, the larger challenges are long term and many land managers said they are busy enough working on immediate threats, such as invasive species. It was suggested in the climate change small groups that part of the disconnect may be a matter of communicating the urgency of climate change or relating it to current land management practices.

The overarching goal of the meeting was to identify key research priorities and to foster collaboration between land managers and scientists on projects addressing these priorities. In some fortunate cases, relevant research projects already exist and collaborators were able to touch base in person – as with Kristin Floress of the USDA Forest Service and Dave Apsley from Ohio State University. To spur new collaborations and projects, the Center for Tree Science at The Morton Arboretum is inviting proposals for small grants to conduct research focused specifically on the priority issues identified during the meeting.

Research topic	% attendees interested in topic	% land managers interested in topic in survey
Restoration of degraded sites	55.56%	39.1%
Benefits analysis of oaks and related species: biological benefits (carbon sequestration, air filtration, wildlife habitat, etc.	53.33%	26.1%
Climate change: management strategies	48.89%	23.9%
Mapping status of oaks (composition, size structure, age structure) in the current regional forest at fine scale	44.44%	17.4%
Invasive species: impacts to natural areas	42.22%	21.7%
Best management practices: conservation of high-quality sites	44.44%	30.4%
Wildlife: habitat restoration and conservation	42.22%	30.4%
Best management practices: prescribed burning	33.33%	41.3%
Protection of rare species	26.67%	23.9%
Soil ecology	20.00%	19.6%

Table 6/ Research topics discussed at the Midwest Oak Ecosystem Managers and Scientists Meeting and the support for those topics from the land managers survey and the event registration filter.

The immediate pressing issue of invasive species and the more nebulous but fundamental impact of climate change emerged as high priority topics. For invasive species, while controlling them simply requires the investment, our understanding of their ecological impacts is limited and how these impacts might be linked to climate change effects needs long term monitoring. Comparative studies of different management strategies and intensities are also needed, examining the results from both ecological and practical standpoints to determine whether the management actions are leading to effective and appropriate changes. While monitoring studies are not "high impact", they are essential for truly understanding dynamics and responses of ecosystems and their component species to change, both seasonal and on longer cycles. Additionally, private land-owners will be key to the ultimate success of the OERP. Research is needed on the what type of actions or agencies can best engage these people who control a significant portion of the region's oak ecosystems. Please contact the corresponding author for inquiries about this funding opportunity.

Photographers. Title page and Photo 1: The Morton Arboretum.

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New and Recently Published Cultivars

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ABSTRACT

The registrars of the International Oak Society are responsible for registering, updating and locating new selections of oaks throughout the world. The majority of these come from North America and Europe. New cultivars are selected for a variety of reasons, including fall color, unique foliage, habit, form, or fruiting characteristics. These cultivars come to us in many ways. Although some are notified to us by their originators through the registration link on the IOS website, most must be tracked down individually via the Internet, nursery catalogs, various publications, and data from collections. In many cases, this work requires traveling to gather information from breeders, nurserymen or collection holders, and to collect the Standard Specimens. The registrars welcome information about new cultivars or older cultivars that have not been registered yet. Please send this information either to Eike Jablonski (Eurasia, Africa) or Ryan Russell (The Americas).

Keywords: ICRA, *Quercus* cultivars, oak cultivars

Introduction

The International Oak Society was appointed by the International Society for Horticultural Science (ISHS) as International Cultivar Registration Authority (ICRA) for the genus *Quercus* in 1998. The system of ICRAs aims to promote stability in the naming of cultivated plants by publishing lists of authenticated names in a number of important groups of plants which are commonly cultivated (Trehane 2005). Guidelines for oak cultivar registration can be found at oaknames.org, the International Oak Society's searchable taxonomic database that includes all names of botanic taxa and registered cultivar and Group names. This database is also accessible through the IOS home page at internationaloaksociety.org.

A selection that is represented by a single plant in a collection or nursery is not a cultivar; it is just a single specimen. A cultivar is a taxonomic unit made up of a number of plants with the same set of characters. Therefore, a single selected plant needs to be (vegetatively) propagated to obtain a certain number of identical plants. The number of new oak cultivars selected or raised by nurserymen or collectors, or originating in botanical collections, has risen rapidly over the last few years. The ICRA registers cultivar or Group names, describes the new cultivar and maintains records of the origin, characteristics, and history, without judgment of the value or distinctness of the cultivar. This is up to the breeder or finder of the cultivar. The cultivars described here are (or will be) accompanied by herbarium specimens that are deposited as Standard Specimens in the Harold Hillier Herbarium (HILL) at the Sir Harold Hillier Gardens, the International Oak Society reference herbarium.

Europe

Again a certain number of new oak selections have been brought into cultivation in Europe. Described here are cultivars that have been raised in Belgium, Germany, Luxemburg and The Netherlands.

Belgium

Vicomte Philippe de Spoelberch (Arboretum Wespelaar and Herkenrode Gardens Herkenrode) is a well-known dendrologist, President of the International Dendrology Society, and creator of Herkenrode Gardens and Arboretum Wespelaar. The Arboretum has several unique collections of woody plants, many of them wild collected, including the Belgian *Magnolia* reference collection and a fine collection of oaks. Together with the Director of Arboretum Wespelaar, Koen Camelbeke, Philippe has named some fine selections with interesting features, always after careful observation and study, and documented with meticulous notes.

Quercus alba L**. 'Laura' (section** *Quercus***).** New cultivar. Deciduous tree, bark light gray, scaly; buds dark reddish brown, ovoid, ca. 2 mm; leaf blade obovate to narrowly elliptic or narrowly obovate, 14-30 × 9-17 cm, base narrowly cuneate to acute, margins moderately to deeply lobed, sinuses extending 1/2-2/3 distance to midrib, surfaces abaxially light green, adaxially light gray-green, dull or glossy, petiole 1-2.5 cm; autumn color of leaves according to the RHS Colour Chart bright red - red: RHS 46A (Currant Red), red brown: RHS 172A + RHS 173A (Terra Cotta), brown: RHS 177A. The original tree (from Esveld Nursery, Boskoop, The Netherlands), was planted in 1998 (accession 84370-esv-209). In 2016 it measured 15 m in height for a width of 10 m with a circumference of 156 cm at 150 cm. Selected for the unusual large foliage and regular dark red to burgundy red autumn color. Named by Dirk Benoit after Laura Wester, employee at Arboretum Wespelaar. Standard Specimen (EJ-161022-30) collected by Eike Jablonski, Philippe de Spoelberch, Koen Camelbeke and Joke Ossaer on Oct. 10, 2016, from ortet in Arboretum Wespelaar. Harold Hillier Herbarium (HILL) No. 8069.

Photo 1/ *Quercus alba* L. 'Laura'

Quercus stellata Wangenh**. 'Artois'** (section *Quercus*). New cultivar. Deciduous tree, bark light gray, scaly. Twigs grayish, (2)3-5 mm diam., densely stellate-pubescent; leaf blade obovate to narrowly obovate, (8)10-22 ×10-12 cm wide at widest point, base rounded-attenuate to cordate, sometimes cuneate, midvein reddish, petiole 1-1.5 cm long, pubescent; most of the leaves significant undulate, color of leaves dark, lustrous green above, lighter below, autumn color orange red (according to the RHS Colour Chart greyed red: RHS 178A (Attic Rose) to RHS 178C, RHS 185A (Chrysanthemum Crimson), greyed orange: RHS 172B). The original tree (from Pavia Nursery, Deerlijk, Belgium) was planted in 2006 (accession 04172-pav-243) and measured 4 m tall × 6 m wide in 2016. Selected for bright orange red autumn color and undulate leaves. Named by Philippe de Spoelberch in honor of the Artois family, former owners of the Wespelaar estate and original brewers of the well-known Belgian beer, Stella Artois, today brewed by AB-INBEV. Standard Specimen (EJ-161107-01) collected by Joke Ossaer on Nov. 7, 2016, from ortet in Arboretum Wespelaar. Harold Hillier Herbarium (HILL) No. 8070.

Photo 2/ *Quercus stellata* Wangenh. 'Artois'

Dirk Benoit (Pavia Nursery, Deerlijk) not only cultivates more than 150 oak taxa but regularly introduces new selections into cultivation, many of which are his. Pavia Nursery could indeed be considered a cradle of new oak selections.

Quercus alba L. **'Clara'** (section *Quercus*). New cultivar. Deciduous tree, bark light gray, scaly; buds dark reddish brown, ovoid, ca. 3 mm; leaf blade obovate to narrowly

Photo 3/ ***Quercus alba* L. 'Clara'**

elliptic or narrowly obovate, 12-25 × 6-12 cm, base narrowly cuneate to acute, margins moderately to deeply lobed, sinuses extending 1/3-1/2 distance to midrib, surfaces abaxially light green, adaxially light gray-green, dull or glossy, petiole 1-2 cm; autumn color of leaves bright red, in spring remarkable red color of young leaves. Seedlings raised at Pavia Nursery from acorns collected in Asheville, North Carolina, USA, during the International Oak Society Conference in autumn 2000 and selected as young plant. Selected for remarkable red leaf color in spring and consistent bright red autumn color, which is not always the case with *Q. alba* seedlings in Western Europe, and for very good grafting compatibility. Named by Dirk Benoit after his granddaughter Clara. Standard Specimen (EJ-161022-30) collected by Eike Jablonski and Dirk Benoit on Sept. 9, 2017, from the mother plant (ortet) at Pavia Nursery. Harold Hillier Herbarium (HILL) No. 8071.

Quercus frainetto Ten. **'Meteora'** (section *Quercus*). New cultivar. Deciduous tree, leaves widest close to the apex, 10-15 × 6-9 cm, variable in shape, on each side with 5-7 very deep lobes with sinuses extending 5/6 distance to midrib, sometimes until

Photo 4/ *Quercus frainetto* Ten. 'Meteora'

midrib, which are usually divided into 2-4 sub-lobes; petiole 0.2-0.6 cm; base auriculate, marcescent. Found by Dirk Benoit on Nov. 2, 2011, during the IOS Tour in Northern Greece, on wild location near the monasteries of Meteora. Selected for the shiny, deep green foliage with very deep and regular double lobes. Named by Dirk Benoit after the location in Greece. Standard Specimen (EJ-171009-04) collected by Eike Jablonski on Oct. 9, 2017, from mother plant at Pavia Nursery. Harold Hillier Herbarium (HILL) No. 8072.

Quercus serrata Thunb. **'Léon'** (section *Quercus*). New cultivar. Deciduous tree, with an open habit, 6 ×12 m after 23 years. Leaves in shape narrower than is typical for the species; with variation in size, up to 12(14) × 5 cm, oblong-obovate to ovate-lanceolate, margined with gland-tipped teeth, bright green above, grayish-white beneath; leaves fall very late in the year. The tree was first raised as a seedling at Waasland Arboretum, (Nieuwkerken-Waas, Belgium) by Michel Decalut. In 1994, Dirk Benoit noticed the elegance of the tree, and grafted it. Since then, plants that have been sold at Pavia either as *Q. serrata* or as *Q. glandulifera* (today a synonym of the former) are from this plant and therefore the same clone. The name first appeared in Pavia Nursery's 2017-2018 Catalog. Selected for the regular, good orange red autumn color, narrow, elegant leaves, and overall elegant appearance that distinguishes it from the form typically cultivated. It was named in 2015 by Dirk Benoit after Léon Labeeuw (the grandson of a Pavia patron). Standard Specimen (EJ-171009-33) collected by Eike Jablonski and Dirk Benoit on Sept. 9, 2017, from mother plant at Pavia Nursery. Harold Hillier Herbarium (HILL) No. 8073.

Photo 5/ *Quercus serrata* Thunb. 'Léon'

Quercus ×jackiana C.K. Schneider **'Guy'** (section *Quercus*; *Q. alba* L. × *Q. bicolor* Willd.). New cultivar. Tree, deciduous; twigs reddish, becoming gray, glabrous. Leaves: petiole (4)10-25(30) mm. Leaf blade obovate to narrowly elliptic, 10(-13) × 5-7 cm, base narrowly cuneate to acute, margins moderately 3-4 lobed, sinuses 1/4-(rarely)1/2 distance to midrib, apex rounded to ovate; abaxially light bluish-green with whitish hairs (dominantly along midrib), adaxially dark glossy green; petiole yellowish with red hints, 0.7-1.5 cm. Dirk Benoit selected the plant from a tree growing at Starhill Forest

Photo 6/ ***Quercus ×jackiana*** **C.K. Schneider 'Guy'**

Arboretum (Petersburg, Illinois, US), propagated it and later named it to honor the founder of Starhill, Guy Sternberg. It differs from other selections of this hybrid with its healthy, regularly-lobed foliage and nice, consistently, autumn color. Standard Specimen (EJ-171009-14) collected by Eike Jablonski and Dirk Benoit on Sept. 9, 2017, from mother plant at Pavia Nursery. Harold Hillier Herbarium (HILL) No. 8074.

Germany

Dieter Lappen (Lappen Nursery, Nettetal). The Lappen Nursery has been in existence since 1894, and comprises more than 650 hectares of cultivated land. They are known for many of their own selections of trees and offer a wide range of *Quercus* in their catalog.

Quercus robur L. (Fastigiata Group) **'Dila'** (section *Quercus*). Lesser-known cultivar. First published in the Lappen Nursery catalog around 1995 as *Q. robur* 'Fastigiata Dila'. A selection of *Q. robur* of fastigiate habit, with a narrow and regular compact crown. Leaves in shape typical for the species, up to 12 × 5 (7) cm, adaxially dark green, abaxially bluish-green; petiole 1-3 mm. The 47 year old mother plant reaches 21 × 3 m. Differs from the similar 'Koster' in its very good trunk growth, stem thickness, and lesser susceptibility to oak mildew (*Microsphaera alphitoides*) and other fungal diseases such as oak leaf-spot disease (*Apiognomonia quercina*). Until December 2016 the cultivar was protected in the EU by breeders rights (No. EIC 1 – 3809 German Federal Plant Variety Office, Hannover). Selected for its mildew resistance and better trunk growth than the selection 'Koster'. Named by Dieter Lappen from a seedling of *Q. robur* 'Koster' in 1970 and released to the market in 1995 by Lappen Nursery. The cultivar epithet is formed from the first two letters of Dieter and Lappen and has been used by Lappen Nursery to name various other woody selections. Standard Specimen (EJ-160930-01) collected by Eike Jablonski together with Dieter Lappen from a 25-year-old grafted tree at Lappen Nursery on September 30, 2016. Harold Hillier Herbarium (HILL) No. 8075.

Luxemburg

Horticultural Department of the College of Agriculture (LTA) in Ettelbruck houses an arboretum with some collections of European importance. In a breeding program involving students and under the management of Eike Jablonski, selections of woody and perennial plants with horticultural value are raised and, after long-term monitoring, named, and propagated in the arboretum's nursery.

Quercus ×hickelii A. Camus **'Mme Aimée Camus'** (sections *Quercus* × *Ponticae*; *Q. pontica* K. Koch × *Q. robur* L.). New cultivar. Deciduous tree, but leaves quite stable in marcescence, leaves are retained throughout the winter. Leaves 25 × 10 cm, obovate, base truncate to narrowly auriculate, 7-9 pairs of lobes, margins moderately to deeply lobed,

Photo 7/ *Quercus ×hickelii* A. Camus 'Mme Aimée Camus'

sinuses not extending more than 1/3-1/2 distance to midrib, surfaces abaxially light green, adaxially light bluish-green, glossy, petiole 0,5-1,5 cm; fruits matching *Q. robur*, 1-2 cm, on thin peduncle 3-7 cm; cup hemispheric to deeply goblet shaped, enclosing 1/4-1/3 nut, scales closely appressed; original tree after 18 years measured 4 × 2.5 m, with compact habit. From three seedlings raised in the LTA propagation unit in1998 from an old plant of *Q. ×hickelii* cultivated in the Botanic Garden Berlin-Dahlem that was selected as a superior and healthier clone with elegant foliage, compact habit, and marcescent leaves. Named in 2015 by Eike Jablonski to commemorate the 50th anniversary of the death of Aimée Antoinette Camus (1879-1965), French botanist and author of the oak monograph, *Les Chênes*; in cultivation at the LTA propagation unit, Pavia Nursery (Belgium) and Szmit Nursery (Poland). Standard Specimen (EJ-160926-01) collected by Eike Jablonski on Sept. 26, 2016, from the original plant at LTA arboretum. Harold Hillier Herbarium (HILL) No. 8076.

Quercus frainetto Ten. **'Ville de Nancy'** (section *Quercus*). New cultivar. Deciduous tree; leaves widest close to the apex, 15-25 × 12-16 cm, variable in shape, on each side with 6-8 very deep lobes with sinuses extending 3/4 distance to midrib, sometimes to the midrib, which are usually divided into 2-4 sub-lobes; petiole 0,2-0,6 cm; base auriculate, marcescent. Found by Eike Jablonski in November 2016; planted tree with loose habit, 7 × 5 m, Place Charles de Gaulle in Nancy, a city in eastern France in the Meurthe-et-Moselle department. Selected for deeply and irregularly lobed leaves. Named by Eike Jablonski with the permission of the Nancy City Department Park Service. In cultivation at the LTA propagation unit, and at Pavia Nursery (Belgium). Propagation material

Photo 8/ *Quercus frainetto* Ten. 'Ville de Nancy'

collected in February 2017 together with Yannick Andres and Stéphane Harter from the Nancy City Department Park Service. Standard Specimen (EJ-161119-01) collected by Eike Jablonski on Nov. 19, 2016, from ortet in Nancy, France. Harold Hillier Herbarium (HILL) No. 8077.

The Netherlands

The vivid nursery sector in the Netherlands introduces new woody ornamental selections every year, including cultivars of *Quercus*. New selections are described and published in various journals of the nursery sector. The following new cultivars have already been published and are only very briefly described here for registration.

Photo 9/ *Quercus* 'Garden Brillant'

Quercus **'Garden Brillant'** (synonym 'Garden Briljant') (section *Quercus*; putative hybrid of *Q.* ×*streimii* Heuff. 'Pungens' and *Q. robur* L.). Recently published cultivar. Name with short description and picture first published in 2013 by Ruud Jacobs in *Boom in Business*. A short description with pictures of habit and leaves was also published by R. T. Houtman in *Dendroflora* 50: 123 in 2013. Selected and named by A.C. van Aart Boomkwekerijen from Oudenbosch, The Netherlands, and marketed in 2013 by the same company. ‘Garden Brilliant’ has a compact shape with large, firm and leathery, deeply incised, 7-lobed leaves that remain on the tree during the winter; fruits 1-2 cm on a 3-4 cm-long peduncle, very similar to those of *Q. robur*. Selected for its deeply-lobed leaves, compact growth habit and mildew resistance. In celebration of their 50th anniversary, Van Aart Boomkwekerijen presented *Quercus* ‘Garden Brilliant’ at the GrootGroenPlus horticultural exhibition in October 2012. It won a bronze medal in the Best Novelties section of the event’s plant awards. Standard Specimen (EJ-161022-30) collected by Eike Jablonski and Dirk Benoit on Sept. 9, 2017, from a grafted tree at Pavia Nursery. Harold Hillier Herbarium (HILL) No. 8078.

Quercus petraea (Matt.) Liebl. **‘Green Joy’** (section *Quercus*). Recently published cultivar. Brought into cultivation in The Netherlands by nursery E. de Jong, Dongen, the mother tree was obtained in a Danish nursery (name not known). Name and short description published in 2011 by Ronald T. Houtman in *Dendroflora* 48: 165. Columnar growth, rare in *Q. petraea* cultivars, with remarkable dark green foliage that lasts until mid-winter on the twigs. Selected for its upright, columnar growth and dark green foliage. According to a French website, Le Lien Horticole (www.lienhorticole.fr) it is resistant to *Oidium* spp. (powdery mildew), whereas Houtman says, au contraire, that it is prone to this fungal disease. The cultivar received a Silver Medal at the horticultural exhibition GrootGroenPlus in 2011. No Standard Specimen deposited as yet.

Quercus **‘Tromp Deerpon’** (section *Ponticae*; putative hybrid of *Q. pontica* K. Koch × *Q. sadleriana* R. Br. ter.). Name published and illustrated in the quarterly journal of the Dutch Dendrology Society (Nederlands Dendrologische Vereniging) (Fortgens 2016a). The story behind the selection can be found on the International Oak Society website (www.internationaloaksociety.org) “Quercus ‘Tromp Deerpon’ an Extraordinary Hybrid” by Gert Fortgens). Selected and named by Gert Fortgens, director of Arboretum Trompenburg (Rotterdam). The first part of the name is taken from “Trompenburg” and the second, a contraction formed from the common names of *Q. sadleriana* (deer oak) and *Q. pontica* (Pontic oak). No Standard Specimen deposited as yet.


Photo 10/ *Quercus* ‘Tromp Deerpon’

Quercus cerris L. **'MVE 281968'** (MARVELLOUS), (section *Cerris*). Recently published cultivar. Selected by nursery Mari van Els, Landhorst, The Netherlands, and then bought by Udenhout B.V. in Udenhout, The Netherlands, who introduced it to the trade. The name first appeared in the catalog of Udenhout nursery (before 2012). Application for EU Plant Breeders' Rights (PBR), number EU19982, on Dec. 13, 2002. MARVELLOUS is the trade designation (variety denomination). Medium-size tree with strong growth and an upright central leader. 'MVE 281968' forms a regular pyramidal tree with a broad pyramidal crown that spreads later; leaves 6-12cm long, glossy, dark green with pointed lobes like the species. Its regular form makes it suitable for lanes, wide green borders and verges; it is very wind resistant and healthy. No Standard Specimen deposited as yet.

USA

Many recent oak introductions come from the United States. In addition to the great number of naturally occurring oak taxa in North America, good selections for different purposes are getting more and more attention.

Oregon

Talon Buchholz (Buchholz & Buchholz Nursery, Gaston) is a wholesale grower of Japanese maples, dwarf and unusual conifers, and other choice ornamental trees and shrubs. Owner Talon Buchholz and staff have introduced many selections of *Acer*, *Cornus* and various conifers to the trade over the years.

Quercus robur L. '**Butterbee'** (section *Quercus*) New cultivar. Young twigs are slender to stout, reddish-purple in color, covered in whitish, waxy cuticle. Older stems develop a gray color. The stems covered in numerous lateral buds and conspicuous white lenticels. The ovoid shaped buds are 0.3 × 0.3 cm (pointed lateral buds) to 0.5 × 0.5 cm (pointed terminal buds). Leaves are 3-6 cm wide by 6-10 cm long with 6-9 rounded lobes extending out 1-2 cm. The bases are auriculate with very short petioles (0.3 cm). Thick, leathery leaves are buttery yellow above, paler below. Acorns not yet observed, but assumed to be typical of species. Location of original plant is unknown. Selected by Talon Buchholz from a batch of *Q. robur* seedlings around 1994. Originally propagated by Buchholz in 2001 and was offered for sale in limited numbers by his nursery. No longer in production at Buchholz & Buchholz but can occasionally be found for sale in other nurseries. Selected for its golden foliage. Plant of cultivated origin found growing at Buchholz & Buchholz Nursery. Ortet tree was sold many years ago but remaining propagated plants average 30-45 cm of growth annually. Easily confused with the better-known cultivar *Q. robur* 'Concordia', this selection reportedly holds its color better and is less prone to scorch when grown in full sun. Standard Specimen collected by Ryan Russell from a grafted stock plant (RR-9-14-17). Harold Hillier Herbarium (HILL) No. 8068.

Missouri

Ryan Russell (Fulton) is the Horticulturist for the City of Columbia, Missouri and is an ISA certified Arborist. He is a current IOS Board member, Taxonomy Committee Chair and ICRA co-registrar for oak cultivars.

Photo 11/ ***Quercus ×humidicola*** **E.J. Palmer 'Flat Branch'**

Quercus ×humidicola E J. Palmer **'Flat Branch'** (section *Quercus*; *Q. bicolor* Willd. × *Q. lyrata* Walter). New cultivar. Plant of cultivated origin found growing in Columbia, Missouri at Flat Branch Park by Ryan Russell in 2010. Young plant, estimated at 20 years old, broadly pyramidal 10 m tall by 8 m wide. Tree was bought and planted as a *Q. bicolor*. Twigs are reddish/brown, slender to stout (0.5 cm), glabrous with numerous lenticels with short, sparse stipules at terminal ends. Ovoid terminal buds are 0.3 × 0.3 cm, brown. Lateral buds are globose to ovoid - 0.2 × 0.3 cm, brown. Obovate leaves are 12-22 cm long, 6-12 cm wide at widest point. Leaf shape shows intermediate characteristics, some with an affinity towards *Q. lyrata*, 9-11 lobes with deeper sinuses towards middle of leaf blade, nearing the midrib on some leaves. Dark lustrous green, glabrous above, finely tomentose and whitish below; base acute to cuneate. Petiole 1-3 cm long, bright orange yellow color. Acorns are intermediate between parents: peduncle 4.5-6.5 cm long, cups 2.5-3 cm wide by 1.3-2.5 cm deep, covering 3/4 -7/8 of acorn, appressed scales slightly revolute at ends. Acorn medium brown, glabrous 2-2.5 cm wide about same long. Bark light gray with thin flaking plates, peeling on branches like *Q. bicolor*. Plant has been propagated by originator and Pavia Nursery. Selected for its ornamental foliage and strong branching habit. Cultivar epithet derived from the location where ortet was found. Standard Specimen collected by Ryan Russell from the ortet (RR-8-10-11). Harold Hillier Herbarium (HILL) No. 8067.

Quercus ×fernowii Trel. **'Bethel Park'** (section *Quercus*; *Q. alba* L. × *Q. stellata* Wangenh.) New cultivar. Plant found growing in Columbia, Missouri at Bethel Park by Ryan Russell in 2012. Young plant, estimated at 30 years old, broadly pyramidal 10 m tall by 8 m wide. Found as a sapling in the park, the tree was moved to its current place around 1990. Young twigs are tan colored and covered with fine pubescence, slender to stout (0.5 cm). Ovoid lateral buds are 0.3 × 0.5 cm, reddish color. Terminal buds are 0.4 × 0.5 cm, surrounded by 4-6 lateral buds. Leaves are obovate, 12-20 cm long, 9-12 cm wide at widest point, leaf shape showing intermediate characteristics, 9-11 lobes with deeper sinuses towards middle of leaf blade. Leaf color is medium green, glabrous above,

Photo 12/ *Quercus ×fernowii* Trel. 'Bethel Park'

paler green and finely tomentose below. Leaf base is acute to cuneate. Petioles are 1.3 cm long. Acorns intermediate between parents (though favoring *Q. stellata*), light brown in color. Borne singly or in pairs, 2-2.5 cm long by 1.2 cm wide. Peduncle 0.5-1 cm long. Thin cups 1.3 cm wide by 1 cm deep, covering 1/3 of acorn, with tightly appressed scales. Bark is light gray with thin flaking plates, reminiscent of *Q. stellata*. Plant has been propagated by originator and Pavia Nursery. Selected for interesting foliage, consistent yellow fall color, and strong branching habit. Cultivar epithet from the location where ortet was found. Standard Specimen collected by Ryan Russell from the ortet (RR-9-14-17). Harold Hillier Herbarium (HILL) No. 8066.

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Photographers. Title page: Eike Jablonski (*Quercus stellata* 'Artois'). Photos 1-3, 5-9: Eike Jablonski. Photo 4: Dirk Benoit. Photo 10: Gert Fortgens. Photos 11-12: Ryan Russell

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Scouting and Collecting Rare Oaks in the Trans-Pecos for Ex-Situ Conservation

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Introduction

In 2016, the UC Davis Arboretum and Public Garden partnered with the Lady Bird Johnson Wildflower Center on a conservation project targeting five rare and threatened oak species native to West Texas. We received a tree gene conservation partnership grant from the American Public Gardens Association and US Forest Service that supported three scouting and collecting trips in spring, summer, and fall. The targets of the project were *Quercus carmenensis*, *Q. depressipes*, *Q. graciliformis*, *Q. robusta*, and *Q. tardifolia*. The primary goal of the project was to increase the representation of genetic diversity of these rare taxa in living public garden collections by collecting and distributing acorns sampled from multiple individuals across their range. We also aimed to further document the current distribution of these species by identifying the locations of individuals and populations as well as any current conservation threats.

The genus *Quercus* is known to have recalcitrant seeds that are not suitable for traditional seed banking (Walters et al. 2016). The targeted taxa were selected due to their rarity and their limited distribution within a concentrated area of West Texas. Due to the small population sizes and close proximity of ranges for these species, it was realistic to target multiple species for a combined scouting and collecting effort. When the project was undertaken, most of these taxa were not represented in ex-situ collections within the American Public Gardens Association Plant Collections Network *Quercus* Multisite Collection or in institutions participating in Botanic Garden Conservation International's PlantSearch database.

The far western region of Texas, the Trans-Pecos (referring to the area west of the Pecos River) is home to an exceptionally high diversity of oaks – 22 species occur here,

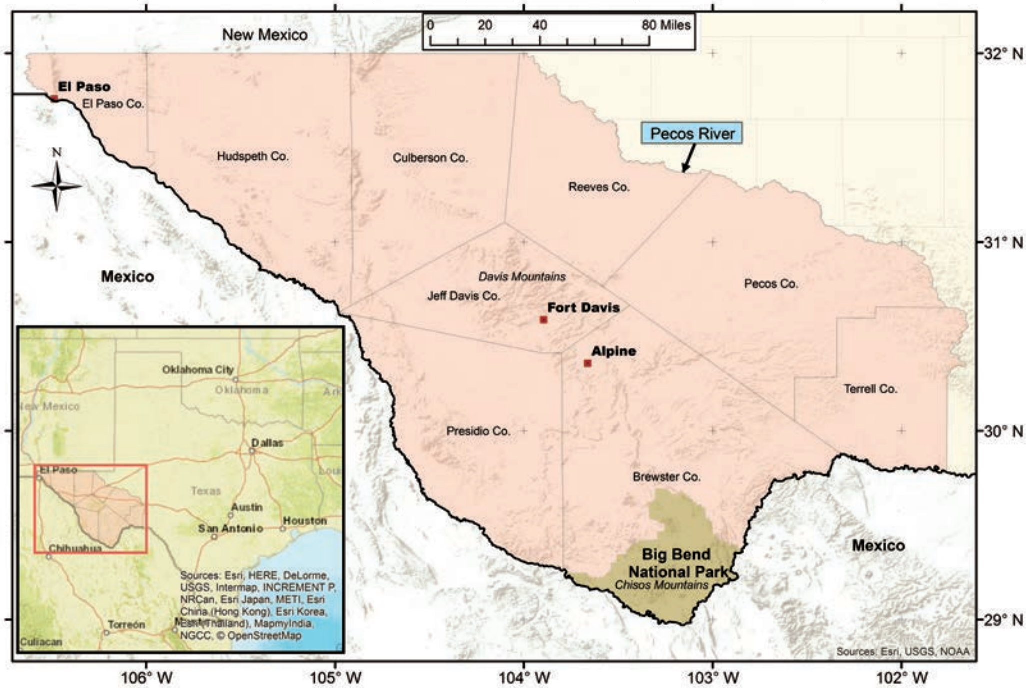

Figure 1/ The Trans-Pecos region of Texas is to the west of the Pecos River, and includes nine counties. Big Bend National Park is in the southern part of Brewster County. The Davis Mountains are primarily located in Jeff Davis County.

representing almost a quarter of the taxonomic diversity of oaks in the United States. Oak diversity in the Trans-Pecos region is concentrated in a series of “sky island” mountain ranges – the Chisos Mountains, Davis Mountains, and Guadalupe Mountains – that are isolated from each other by lowland Chihuahuan Desert vegetation. Due to their isolation, the sky islands of Texas harbor four endemic oak species as well as relict populations of species that were previously more widespread. The West Texas mountains also have unique floristic affiliations with the Sierra Madre Occidental and the Del Carmen-Sierra Madre Oriental of Mexico and serve as the northernmost limit of 5 Mexican oak species that do not occur elsewhere in the United States.

One of the major challenges associated with assessing priorities for conserving oak genetic diversity from the sky island mountains of West Texas is taxonomic. Hybridization is common among the many species of oaks that grow in close proximity. This has resulted in confusion about species identification and definitions. *Quercus graciliformis*, *Q. robusta*, and *Q. tardifolia* have all been considered by some to be hybrids at some point since they were first described. Especially when a taxon is poorly documented, it becomes difficult to assess whether it is a rare species that should be prioritized for conservation or a chance hybrid that does not warrant high conservation attention. By increasing documentation of these taxa through the collection of herbarium specimens, we hope to generate more scientific resources that can be studied to shed light on these taxonomic questions.

The sky island mountains of West Texas are well protected within Texas National Parks, State Parks, and Nature Conservancy holdings. However, the oak species in these

Photo 1/ Descending the Oak Spring Trail in Big Bend National Park.

mountains are still vulnerable to climate change. As the climate becomes warmer and drier, their migratory paths are quite limited. For this reason, ex-situ conservation in curated living collections will be critical for ensuring the long-term survival of these species. For those species that extend into Mexico, capturing the genetic diversity for the populations at the northern limit of their range is valuable, especially in the face of climate change. None of the target species for this project are currently ranked as federally endangered or listed as threatened or endangered by the state of Texas. However, most have been ranked with some level of conservation status by IUCN and NatureServe (Beckman 2017a, 2017b, 2017c; NatureServe 2017; see Species Profiles, p. 142 for more details).

Due to the distribution of our target taxa, we focused our scouting and collecting trips in the Chisos Mountains and the Davis Mountains. A critical component to the success of our project was securing permission to collect from the property owners. The Lady Bird Johnson Wildflower Center had an existing permit with Big Bend National Park (BBNP), and we were able to perform our fieldwork under this permit, including the collection of seeds and voucher herbarium specimens. We were unfortunately unable to secure permission from the Nature Conservancy to collect *Q. depressipes* from their property in the Davis Mountains.

We completed three scouting and collecting trips during 2016, as detailed below. One scouting trip occurred in May, before the collecting trip. The collecting trip occurred in late August and a follow-up scouting trip took place in late October and early November. Information gathered over the course of these scouting and collecting trips has helped to further knowledge about these oaks, their specific ranges, their phenology, and threats to their long-term conservation.

Spring scouting

From May 10 through 16, Andrew McNeil-Marshall and his colleague Nick Richman from the Lady Bird Johnson Wildflower Center went on an initial scouting trip to BBNP, where four of the five target taxa are known to occur. Located on the southern border of the United States, along the “big bend” in the Rio Grande River, BBNP covers over 800,000 acres. Chihuahuan Desert vegetation dominates most of the Park’s land, and the Chisos Mountains stand tall and isolated in the center of the Park capped by Emory Peak at 7,825 ft. The mountains were formed by volcanic activity more than 30 million years ago. The high peaks of the Chisos, where all the oaks are found, are concentrated in an approximately 30,000-acre area of rugged peaks and canyons above 5,000 feet in elevation. Average annual rainfall in the Chisos Basin is 19 inches, with most precipitation falling during summer thundershowers in July, August, and September (Powell 1998).

The goals of this first trip to the Chisos Mountains were to determine the location of several known *Q. graciliformis* populations, to find if possible a unique population of *Q. carmenensis* on Casa Grande Peak, to locate a known population of *Q. tardifolia,* and to cover as much ground as possible to form the basis for a collecting trip in August.

Much of this hiking, covering approximately 25 miles on foot, was over very rugged terrain and although there was very little sign of acorns or catkins, specific locations and trees were identified for the projected collecting trip. It was interesting to note that most of the oaks were in the process of shedding last year’s leaves and forming new buds.

Summer scouting and collecting

From August 24 through 29, Emily Griswold, Shannon Still, and Andrew McNeil-Marshall led a second trip to BBNP and the Davis Mountains, this time focusing on collecting. Figure 2 shows routes the group explored in the vicinity of the Chisos Mountains of BBNP.

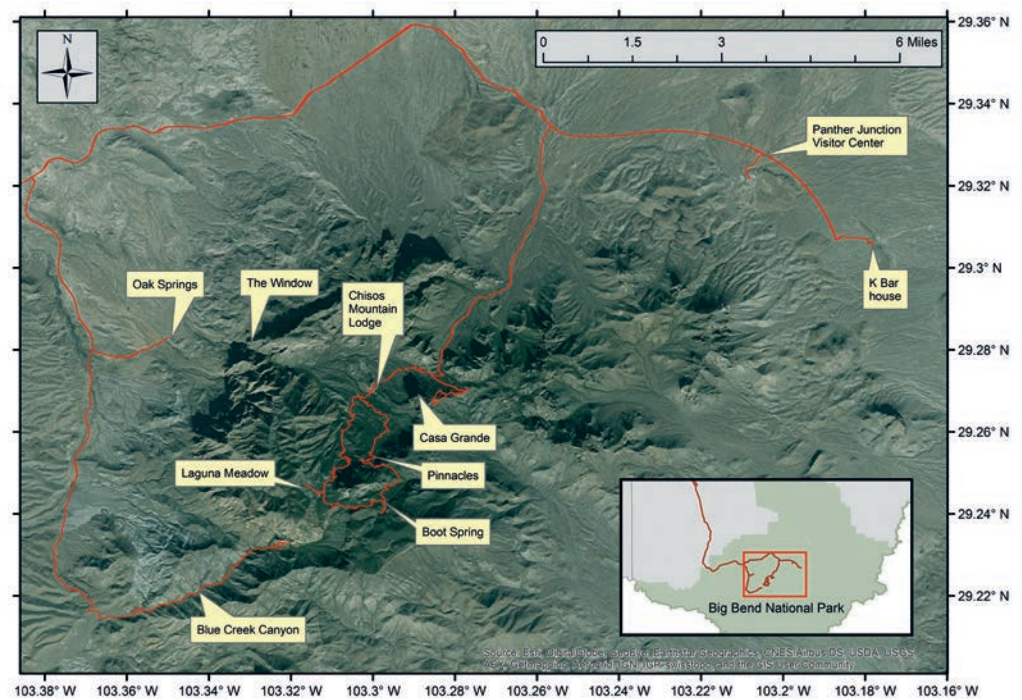

Figure 2/ Landmarks, trails, and routes explored during the summer scouting and collecting trip, August 24-28, 2016, in Big Bend National Park.

<u>*Setting the stage*</u>

After stocking up on provisions the day before, we left Austin on the morning of August 24 and drove west. The first stop of the day was the Herbarium at Sul Ross State University in Alpine. Here we met with Dr. A. Michael Powell, Distinguished Professor Emeritus and Director of the Herbarium. Powell is the foremost living expert on the flora of the Trans-Pecos region and has authored several books on the subject, including the excellent *Trees and Shrubs of the Trans-Pecos and Adjacent Areas* (Powell 1998). At the Herbarium,

Photo 2/ A normally dry wash become muddy river after heavy rain.

Photo 3/ From left to right: Shannon Still, Emily Griswold and Andrew McNeil-Marshall in front of the K-Bar Ranch house in Big Bend National Park.

the group examined oak specimens from BBNP and the Davis Mountains and discussed the variation in the targeted oaks with Powell who provided further insights into identifying characteristics and recommended collecting locations.

As we departed for BBNP, heavy rain brought out the smell of roadside *Larrea tridentata* (creosote bush). Rainy weather earlier in the month had resulted in lush new growth in the lowland desert vegetation, and we stopped in wonder to view a muddy river flowing by cacti in an area that would typically be a dry wash. After checking in to the BBNP headquarters, we headed to our accommodations at the K-Bar Ranch house. Located at the end of a dirt road near Panther Junction, this historic ranch house is available for researchers working in the Park. Tucked away from other roads or structures at the foot of the Chisos Mountains, the house gave us the sense that we had the whole Park and spectacular star-filled sky to ourselves.

Stalking the Chisos oak (Q. graciliformis)

On August 25, we started our first day of targeted collecting with a stop at the Visitor Center in Panther Junction. As luck would have it, the Seasonal Interpretive Park Ranger who greeted us was Joselyn Fenstermacher, a botanist who had done her graduate research on the flora of the Dead Horse Mountains in BBNP. Fenstermacher was able to provide us with a plant checklist for the Park that was very useful for identifying species that we encountered on our hikes. According to Fenstermacher, drought, a cold winter freeze, and fire had taken their toll on the plants in the Park over the last year. It rained in early June but then the weather had been hot and dry until early August when heavy drenching rains started descending.

We started on the Blue Creek Canyon Trail, on the southwestern side of BBNP, previously scouted by McNeil-Marshall and known to have nice specimens of *Q. graciliformis*. Although oaks were our target, we found many other intriguing plants along the trail. The recent heavy rains had resulted in abundant growth in this otherwise very dry landscape. *Fallugia paradoxa* was in full bloom, and many xerophytic ferns were green and lush. The *Selaginella lepidophylla* (resurrection fern) that typically curl up into a ball when dry, had unfurled their fronds like green snowflakes against the rocks. Most remarkable was the *Macrosiphonia lanuginose*[1] (low-growing rock trumpet) with its extravagantly large, fragrant white flowers.

Along the trail we encountered *Q. grisea*, *Q. emoryi* and *Q. graciliformis* all without acorns. Higher into the canyon we spotted oaks at the base of a rock face up a grade to the north side of the trail. After climbing a steep slope and traversing a scree field, we reached

1. Now a synonym of *Mandevilla lanuginosa*.

Photos 4/ A few of the inhabitants of Big Bend National Park: a) *Macrosiphonia lanuginosa*; b) *Leucophyllum frutescens* along Oak Springs Trail; c) *Selaginella lepidophylla*; d) Mexican jay.

our destination: a line of multi-trunked mature *Q. graciliformis* in full fruit growing in the heavy mulch of their own accumulated leaf litter. The acorns had the characteristic longitudinal striping but varied in color from green to tan to brown, ranging in length from 0.55 to 0.75 inches (with one tree having exceptionally small acorns of 0.35 to 0.46 inches). Mature acorns and voucher herbarium specimens were collected from each individual. *Quercus graciliformis* is a distinct species that is relatively easy to identify with its biennial fruit maturation and pendent lanceolate foliage. There does not appear to be too much hybridization with other species in the area. This is important as some other taxa in BBNP are hybrids, and can be difficult to differentiate.

Photos 5/ a) The very elegant leaves and acorns of *Quercus graciliformis*, endemic to the Chisos Mountains; b) *Q. graciliformis* population growing in a thick layer of leaf litter.

Chasing the ghost of lateleaf oak (Q. tardifolia)

Starting on August 26, Mickey Merritt, a Texas State Forester, and Oscar Mestas, a retired Texas State Forester for the Trans-Pecos region joined the group for the next two days in BBNP. Mestas was very familiar with the trails, trees, and terrain of the Park, and he took the trip as an opportunity to introduce Merritt, a recent transplant to West Texas, to the tree diversity of the Chisos Mountains.

We started our hike from the BBNP Lodge, located in the Chisos Basin. Our route took us up the Laguna Meadow Trail, then along the Colima Trail and back down along the Pinnacles Trail. Since this route took us into higher elevations in the Chisos, we encountered different species of oaks as well as a greater diversity of trees and shrubs. *Juniperus flaccida* (weeping juniper), *J. deppeana* (alligator juniper), and *Pinus cembroides* (Mexican pinyon pine) are common trees in the Chisos Mountains and frequent oak associates. A well-developed understory of native grasses (including *Muhlenbergia emersleyi*, *Stipa tenuissima*, *Bouteloua gracilis*, and *B. curtipendula*) was also notable on this route, many of which are grown as horticultural ornamentals. Meanwhile, the *Nolina*, *Dasylirion*, *Opuntia*, and *Agave havardiana* provided a constant and dramatic reminder of our proximity to drier desert environments.

Photo 6/ *Stipa tenuissima* thrives in an open juniper-pine woodland along the Laguna Meadow Trail.

Along the first leg of the trail to Laguna Meadows, we encountered *Q. grisea*, *Q. vaseyana*, *Q. gravesii*, and finally *Q. intricata*, all with no, or only immature, acorns. The shrubby *Q. intricata* was most abundant near Laguna Meadow, again with no acorns. We were unable to locate a supposed population of *Q. carmenensis* in the vicinity of Laguna Meadow, which Michael Powell had mentioned. As we ate our lunch in the Laguna Meadow area we were visited by a rather tame and inquisitive Mexican jay. This fellow acorn-hunter kept us company and was kind enough to pose for a few close-up photographs.

Along the Colima Trail, the habitat changed for the wetter and we encountered some of the largest trees we had seen so far, including sizeable individuals of *Q. arizonica*, *Pseudotsuga menziesii* (Douglas fir), and *Cupressus arizonica* (Arizona cypress). We saw some oaks that looked similar to *Q. tardifolia*, but are likely large-leaved *Q. gravesii*.

Once we reached Boot Spring, we made our way through the lush creek-side vegetation with abundant *Acer grandidentatum* (big-tooth maple). We were unable to collect acorns or vouchers of anything that was definitively *Q. tardifolia*. The species description is based upon very few individuals (Muller 1936, 1951); it is thought that this taxon might be of hybrid origin but further taxonomic work is needed. We did collect some vouchers of some individuals that might be *Q. tardifolia*, but there were no acorns. Also along Boot Spring, we collected foliage from a large individual of *Q. rugosa*.

On the way down the Pinnacles Trail, we hiked through the pine, juniper, and oak

Photos 7/ (a-b) *Quercus intricata*

woodland. Beautiful, smooth-barked *Arbutus xalapensis* (Texas madrone) caught our attention along the trail. There were many *Q. grisea*, which were not nearly as abundant along the Laguna Meadow or Colima Trails. We also found more *Q. gravesii* and *Q. rugosa*, and some plants that we believe to be *Q. graciliformis*, even though they had not been previously recorded in this area of the Park.

Although we were unable to collect acorns on August 26, we were pleased to explore and document more of the oak and habitat diversity of the Chisos Mountains. We rounded out our day with dinner at the Chisos Mountain Lodge and enjoyed views of a glorious sunset over Big Bend's famous "Window". On the drive back in the dark to the K-Bar Ranch house, we were surprised to encounter a mother Mexican black bear and her two cubs on the road.

Scrambling for Carmen oak (Q. carmenensis)

Once again accompanied by Mestas and Merritt, on August 27 we experienced the true drama and power of summer monsoons in the Chisos. We hiked up the Lost Mine Trail, with the goal to eventually hike along an area known as the Chinese Wall in hopes of finding *Q. carmenensis* on the bluffs below Casa Grande Peak. The population of *Q. carmenensis* located there is the only vouchered collection in the United States, as the range of the species is primarily in Mexico. On the way up the Lost Mine Trail, we found *Q. emoryi*, *Q. grisea*, *Q. vaseyana*, and *Q. gravesii*, along with their typical juniper and pine associates.

Photos 8/ a) Along the Pinnacles Trail, a tree thought to be *Quercus graciliformis*, in a location not previously recorded in Big Bend National Park; b) *Q. rugosa.*

Photo 9/ Sunset over the Window viewed from the Chisos Mountains Lodge Restaurant.

When we reached a saddle, we departed onto a smaller unmarked trail following the ridgeline west towards Casa Grande Peak. As the terrain got steeper, we did our best to traverse the steep, southwest-facing slopes of the mountain, scratching our way through prickly shrubs and knife edged *Nolina* to keep our footing. At this point dark clouds began to fill the sky and prompted us to consider where we would seek cover in the event of lightning strikes. Still and McNeil-Marshall broke away from the rest of the group and while they attempted a steep scramble to get higher on Casa Grande in search of *Q. carmenensis*, the storm caught up and doused us all with heavy rain. Still and McNeil-

Photo 10/ *Quercus grisea* (front left) frames a view along the Lost Mine Trail.

Marshall found individual plants in the known locality that resembled *Q. carmenensis*, but we could not positively identify the individuals. We collected some voucher specimens but no mature acorns were present. The oaks in the bluffs below the peak appear to be hybrids, with some individuals more like *Q. intricata*, and others more like scrubby *Q. grisea*. Ultimately, molecular taxonomic work may help to sort these species, and this would be a good locality to study further.

Left with more questions than answers, the full group reunited and made a soggy slog back to our vehicles. The wet weather and overcast skies highlighted the vivid colors of the vegetation with an assortment of vibrant hues of blue, silver, green, and chartreuse. The rain let up by the time we reached the trailhead, at which point we did our best to remove and start drying our wet socks and other soaked articles. After a wardrobe change and a bit of a rest, we took off again to the Cattail Falls trail in search of *Q. robusta*. Alas the rain returned in a

Photo 11/ Stormy weather on the way to the Cattail Falls trailhead.

heavy downpour just as we were about to start on the trail dampening our enthusiasm enough to send us back to the K-Bar Ranch house for a final evening of storytelling and plant pressing and sorting.

Pondering robust oak (Q. robusta)

On August 28, after bidding farewell to Merritt and Mestas, we drove back to the west side of the Chisos to visit the type locality for *Q. robusta* at the trailhead to Cattail Falls near Oak Creek. After a short hike through desert scrub with beautiful blooming *Leucophyllum frutescens*, we reached Oak Creek and a dramatic change in vegetation from low scrub to a high tree canopy. *Salix* (willow), *Toxicodendron* (poison ivy), *Celtis* (hackberry), and *Vitis* (wild grape) are part of the riparian vegetation that, like *Q. robusta*, colonizes the perennial water source of Oak Spring. This small population contains a few large trees that certainly earn their robust name. The trunk (30 inches) of the most impressive tree arched over with several stout lateral branches spreading skyward to 40 feet or more. Eleven trees of varying ages grew in the vicinity of the large mother, all of which had similar looking leaves. While there were no acorns to collect, we did collect voucher specimens from most of the individuals in the population. These specimens could be useful for population genetic studies to better reveal the parentage, which is putatively *Q. emoryi* and *Q. gravesii*. Although the weather had been clear and sunny in the morning, another rainstorm hit us hard as we studied this population. Within minutes we were drenched again and unable to collect photo documentation of all the individuals in the population.

Photos 12/ (a-b) *Quercus robusta* at the trailhead to Cattail Falls near Oak Creek.

Davis Mountains

At this point, our attention shifted to the Davis Mountains to search for *Q. depressipes*, and we drove north to leave BBNP. Unfortunately, we were unable to access the Nature Conservancy land where the species occurs, and could not collect leaves or acorns from this rare species. At this time, it is unclear if the property manager for the Nature Conservancy

Photo 13/ Shannon Still and Andrew McNeil-Marshall collecting an especially blue-leaved form of *Quercus grisea* in the Davis Mountains.

land will allow collecting in the future, but it was clear that ex-situ collecting was not a current priority for the management of the species.

Located about 100 miles north of the Chisos Mountains in the vicinity of Fort Davis, the Davis Mountains are also volcanic in origin. The largest (but not the tallest) of the Texas sky island mountain ranges, the Davis Mountains stretch for approximately 60 miles and contain more than 90 peaks over 5,000 ft. in elevation (Handbook of Texas Online 2017; Warnock 1977). Most of the Davis Mountains are in private ownership. Protected lands include Davis Mountains State Park and Indian Lodge, the Nature Conservancy land holdings, and conservation easements and agreements on private lands. The Nature Conservancy's Davis Mountains Preserve contains the 8,378-foot Mount Livermore, the highest peak in the range, and the known location of *Q. depressipes* (Nature Conservancy 2017)

Despite not being allowed to collect the target species, we were able to gain access to a private residential development in the Davis Mountains. Testing the endurance of our rental minivan on steep, deeply rutted, and wet dirt roads, we found a good spot to collect acorns of *Q. hypoleucoides*, *Q. emoryi*, and *Q. grisea*.

Chihuahuan Desert Botanical Garden and Nature Center

Photo 14/ A cultivated specimen of the federally endangered *Quercus hinckleyi*, fruiting at the Chihuahuan Desert Nature Center and Botanical Garden.

On August 29, we visited the Chihuahuan Desert Botanical Garden and Nature Center near Fort Davis to deliver some oak plants that McNeil-Marshall was donating and to tour the Garden. The Garden has a small arboretum featuring well-labeled shrubs, succulents, and trees of the Trans-Pecos, including most of the oaks. The intermediate elevation of the Garden allows them to grow both mountain and desert species, including the federally endangered *Q. hinckleyi*. The Garden's largest collection is held in a greenhouse on site devoted to cacti. Although we didn't have time to explore the trails through natural areas and native *Q. grisea* and *Q. emoryi* populations on the property, we couldn't help but peruse the bookshelf in the Visitor Center's Gift Shop. After our visit to the Garden, we made the long drive back to Austin, satisfied with our collections but hungry for the next visit to the Trans-Pecos to further our explorations and understanding of the enigmatic oaks in this region.

Fall scouting

From October 31 through November 3, Emily Griswold made another trip to BBNP with her husband Nikhil Joshi. The goal for this third trip was to scout for maturing acorns from species we were unable to collect in August, to note phenological changes that happened during the year, and to identify future collection locations. The 2016 growing season had high summer precipitation, particularly in August around the time of our second trip, and that had been followed by warm, dry fall weather. By late October, many of the grasses and herbaceous understory plants had taken on tawny tones and were heading towards winter dormancy. The oaks, on the other hand, had a more delayed response to the summer rain, and many had pushed substantial new vegetative growth since the summer visit.

Griswold drove into the Park on October 31, stopping to look at some oaks on the way into the Chisos Mountains. The new leaves of *Q. grisea*, with long shoots of fall growth had leaves that were significantly larger and greener than the previous spring and summer growth we had seen earlier in the year. The difference in leaf size, color, and internode length between new and older shoots was quite striking.

On November 1, Griswold did an out-and-back hike from the Chisos Mountain Lodge to the Window Trail and the Oak Springs Trail. The group had been unable to explore this trail during the summer trip. Along the Window Trail *Q. gravesii* and *Q. emoryi* were common as well as a whole series of hybrids between them. *Quercus emoryi* typically has small, thick evergreen leaves with entire margins or spinose teeth, and a short hairy petiole. *Quercus gravesii* typically has larger deciduous leaves and larger lobes, and a long, glabrous petiole. The

Photo 15/ Collected from populations along the Window Trail, leaves of *Quercus gravesii* (from the bottom), *Q. emoryi* (from the top), and hybrids between the two.

Photo 16/ *Quercus gravesii* in heavy fruit along the Pinnacles Trail.

hybrids showed a complete range of intermediate characters. It would be worth returning to the Window Trail to document this variation more thoroughly. This region would be ideal to study variation in molecular and morphological taxonomy. Descending down the Oak Springs Trail from the Window, Griswold then revisited the *Q. robusta* type location and once again did not see any evidence of flowering or fruiting. On November 2, Griswold revisited the Laguna Meadow Trail loop that we had taken in August. While there were immature acorns on *Q. gravesii* and *Q. arizonica*, there were no acorns on the rare taxa we were seeking.

Collections and germplasm distribution

Although acorns for only one of the five target taxa were collected, we were still able to obtain valuable occurrence data and voucher specimens for three other taxa. The acorns of *Q. graciliformis* have been distributed to the UC Davis Arboretum and Public Garden, Lady Bird Johnson Wildflower Center, Chihuahuan Desert Botanical Garden and

Nature Center, Boyce Thompson Arboretum, and Bartlett Tree Research Laboratories and Arboretum.

Replicate herbarium voucher specimens collected on the trip are in preparation for distribution to the UC Davis Herbarium (DAV), the US Herbarium at the Smithsonian Institution (US), the Lady Bird Johnson Wildflower Center, and The University of Texas Herbarium (TEX). All specimens collected in BBNP will be assigned National Park Service accession numbers and labels. These specimens will serve as enduring scientific documentation of the locations, phenology, and genetic composition of the individual trees collected.

Conservation considerations

None of the *Quercus* we targeted have an immediate threat to their populations. However, the small size and isolation of the populations of these species make them vulnerable to climate change in the form of increased drought, heat, and wildfire prevalence. *Quercus graciliformis*, *Q. carmenensis*, *Q. robusta*, and *Q. tardifolia* are protected within the boundaries of BBNP. The greatest threat to *Q. robusta* and *Q. tardifolia* might be reclassification. More careful evaluation is needed to determine the taxonomic status of *Q. robusta*, which may be a hybrid. Due to the tenuous nature of species description for *Q. tardifolia*, more work might identify this taxon as a subspecies or variety of another species in the Park.

Conservation assessments for the IUCN Red List were revised for *Q. graciliformis*, *Q. robusta*, and *Q. tardifolia* following our scouting and collecting trips, and Andrew McNeil-Marshall was a contributor to Emily Beckman's assessments. Based on McNeil-Marshall's observations and information gathered through this project, the listing status of *Q. tardifolia* was changed from Critically Endangered (CR) to Data Deficient (DD) due to the high level of taxonomic uncertainty about this species (Beckman 2017c).

The location for the *Q. depressipes* in the Davis Mountains is currently managed by the Nature Conservancy. While the species is safe from development, unless management of the land changes their views on ex-situ conservation, this species will not find its way into conservation collections.

Conclusion

Conserving the genetic diversity of oaks in the sky islands of the Trans-Pecos presents a compelling challenge. Remote settings, steep terrain, and restrictive landowners are the first set of challenges to overcome. Even more difficult are the prevalence of hybridization and need for more taxonomic study. Also, oaks in this area have been shown to have variable phenology based on weather conditions that make study and collecting even more difficult and make repeated visits essential.

Our scouting and collecting work in 2016 has contributed to the successful collection and distribution of *Q. graciliformis* germplasm for growing in ex-situ conservation collections. We also contributed to increased understanding about the taxonomic status, locations, and conservation threats to four of our target taxa. Looking forward, we plan to return to the Trans-Pecos to continue our exploration, conservation, and documentation efforts in this rich and complex region.

Species Profiles

***Quercus carmenensis* C.H. Mull.** Occurs from Coahuila, Mexico to the Chisos Mountains in Brewster County, Texas, in the US, a very narrow range. These small shrubs grow on a high, wooded ridge on Casa Grande, ca. 7,300 ft. elevation. One distinguishing characteristic for the species, according to Michael Powell, is the acorn cap that is reddish with white tufts of trichomes. *Quercus carmenensis* is assessed as Endangered [EN; B1ab(iv)] through the IUCN Red Listing, last assessed in January 2017. This species has a G2? threat rank as listed by NatureServe.

***Quercus depressipes* Trel.** Distributed throughout Chihuahua, Durango, South Zacatecas, and North Jalisco, Mexico, and extends into Texas. In the US, this species grows in openly wooded grasslands at high elevations (ca. 8,000 ft.) in the Davis Mountains in Jeff Davis County, Texas. It has been recorded in the vicinity of Mount Livermore and near Mount Locke. *Quercus depressipes* is listed as of Least Concern [LC] through the IUCN Red Listing, last assessed in January 2017.

***Quercus graciliformis* C.H. Mull.** Endemic to the Chisos Mountains of Texas. This species of medium-sized trees is found in multiple rocky canyons at intermediate elevations, and is usually associated with a high-water table. *Quercus graciliformis* is assessed as Critically Endangered [CR; C2a(ii)] through the IUCN Red Listing, last assessed in November 2016. This species has a G1 threat rank as listed by NatureServe.

***Quercus robusta* C.H. Mull.** Endemic to the Chisos Mountains of Texas. This species of medium-sized trees is found in moist wooded canyons at intermediate elevations. Thought by some to be a hybrid between *Q. gravesii* and *Q. emoryi*, USDA acknowledges *Q. robusta* as a distinct species. *Quercus robusta* is assessed as Data Deficient [DD] through the IUCN Red Listing, last assessed in November 2016, and has a G1Q threat rank as listed by NatureServe.

***Quercus tardifolia* C.H. Mull.** Endemic to the Chisos Mountains of Texas, or possibly crosses over the border into Coahuila, Mexico. This species of small, erect tree is found along arroyos and canyons, in woodlands at about 7000 ft. Like *Q. robusta* there is some question as to the true nature of this USDA acknowledged species, as it may prove to be a hybrid. *Quercus tardifolia* is listed as Data Deficient [DD] through the Red List of US Oaks. This has changed from 2016, when the species was listed as Critically Endangered. However, the change is due to taxonomic uncertainty, and not for a change in the low number of individual trees. This species has a G1 threat rank as listed by NatureServe.

Photographers. Photos 1, 2, 4b-d, 13, 15, 16: Emily Griswold. Photos 3, 4a, 14: Shannon Still.

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More Texas Travels September 4-22, 2017

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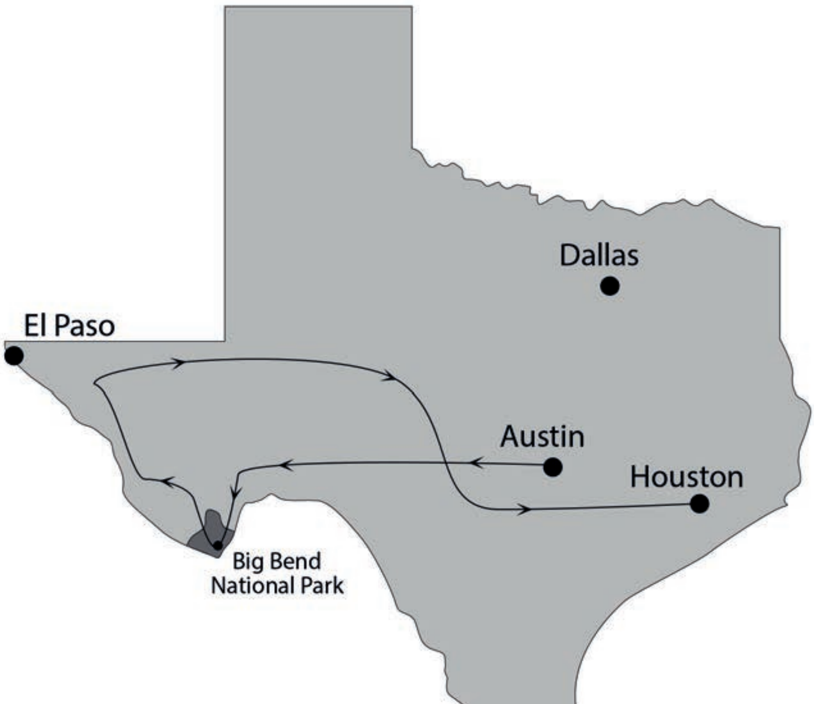


Introduction

Last September, Adam Black (Director of Horticulture, Peckerwood Gardens) and I spent a little under three weeks on an incredible road trip in Texas that took us from Austin all the way to Hudspeth county on the very western border of the state and then back all the way across to a few of its very eastern counties with, of course, a prolonged stop in the most extraordinary Big Bend National Park, as well as some exploring of the Edwards Plateau in the middle.

Emily Griswold, Shannon Still and Andrew McNeil-Marshall give in this volume (pp. 125-142) a very detailed account of their Texas adventures in 2016 (mainly in the Chisos Mountains) so the present article is intended rather as a supplement to that story.

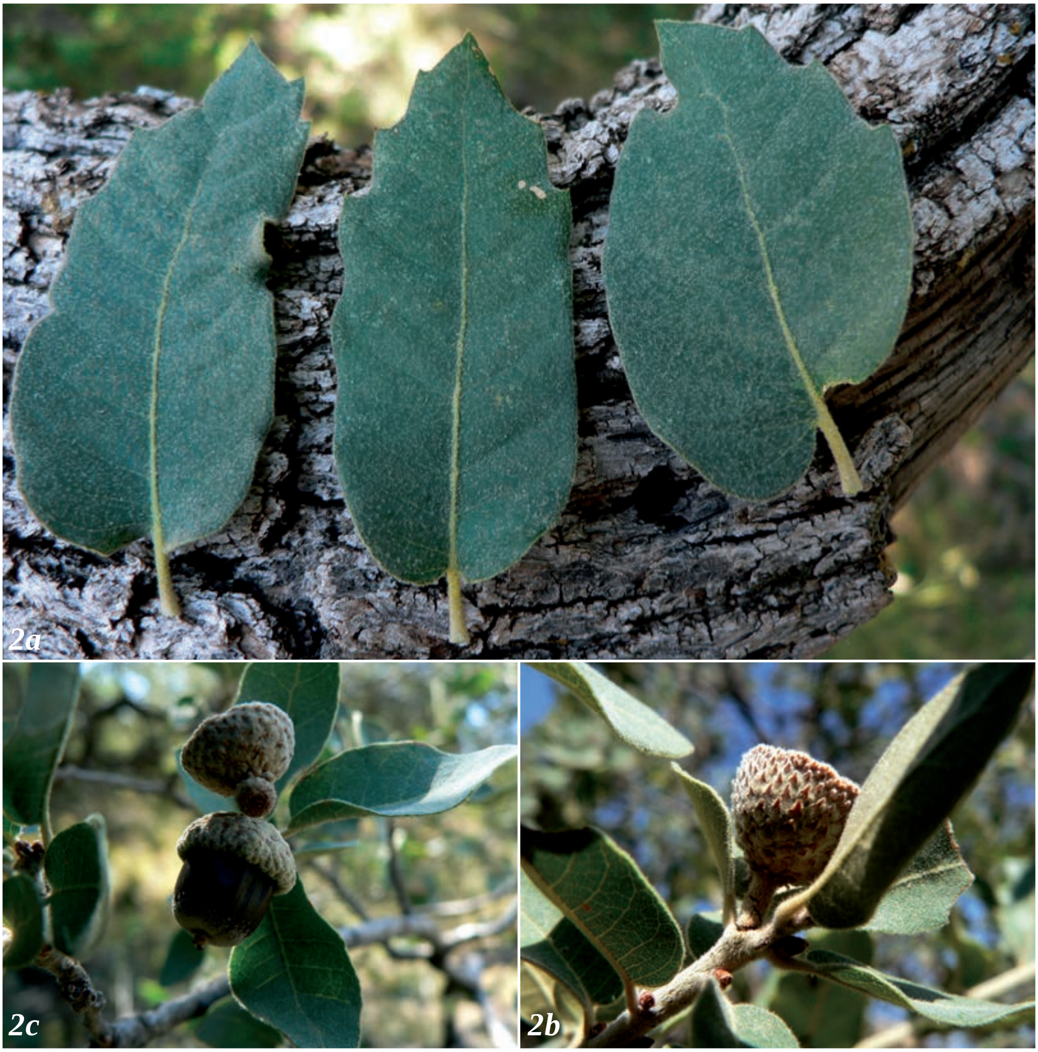
Frenchman's Canyon

Photo 1/ Frenchman's Canyon (Eagle Mountains, Hudspeth County).

William Trelease (1924) writes, "*Q. chihuahuensis* is a distinctive species throughout its range, mostly in dry montane western Mexico; it occurs in the United States only as putative hybrids with *Q. grisea* (Eagle and Quitman mountains) and *Q. arizonica* (Hueco Tanks) in Texas." In 1945, C.H. Muller collected specimens in the Eagle, Hueco, and Quitman Mountains that were deposited in the Lundell Herbarium. C.H. Muller 8195 was identified by Mr. Muller as *Q. grisea*/*Q.* aff. *chihuahuensis*; 8197 as *Q. grisea*; and, 8228 and 8237 as *Q. turbinella*. All of these specimens were later identified by B.L. Turner as *Q. chihuahuensis*.

Adam and I had decided that we had to go and have a look and were lucky to be able to contact the owner of property in the Eagle Mountains that gave us access to Frenchman's Canyon, right in the area designated by Muller and other collectors. Frenchman's Canyon because, as Kit Bramblett, the owner, explained to us, at the end of the 19th century a Frenchman had come to raise sheep here and after a bit his neighbors put him and his animals on a train and sent him out east. With a chuckle, Mr. Bramblett ended the story explaining that this Frenchman was lucky because that was not usually the way Texans dealt with people they wanted to be rid of.

This is harsh country, where one would rather not have a flat tire or any other problem for that matter! We drove up to about 1,600 m to a propitious spot and proceeded on foot to find many, many shrubby *Quercus*, nothing looking like *Q. turbinella*, and everything looking like *Q. grisea* with a lot of variation. A few of these did indeed have some *Q. chihuahuensis* characteristics.



Photos 2/ (a) *Quercus chihuahuensis ×grisea* ?; (b) typical *Q. grisea* cupule; (c) cupule with distinctively *Q. chihuahuensis* characteristics (glabrous red tips to the scales) but shorter-stalked peduncle as in *Q. grisea*.

A Chisos conundrum

The never-ending quest for *Q. tardifolia* in the Chisos Mountains!

There is much confusion surrounding this now mythical taxon described by the indefatigable Mr. Muller (1936). "The species was encountered in only a limited locality in the oak wood above "Boot Spring" at an altitude of about 7,000 feet where it grows in a small clump…"

One can read in various secondary sources that *Q. tardifolia* is thought to be a sterile hybrid – but there does not seem to be any basis to this as Mr. Muller did describe acorns (albeit juvenile ones). Conjecture that it might in fact be a hybrid has led Muller and Nixon to suggest that its parents might be *Q. gravesii* and *Q. hypoxantha* (Flora of North America). In a photograph taken by Betty Alex (Poole et al. 2007) the pubescence on the underside of the leaf is very suggestive of *Q. hypoxantha*. Mr. Muller indicates that the stellate hairy pubescence on the underside of the leaf is detachable and Le Hardÿ and Lamant (2010) that the mature leaves are pale green and glabrous below (as shown by their photographs). After having seen the enormous degree of variation in the pubescence (and everything else) of *Q. gravesii* in the Chisos Mountains I tend to think that this characteristic might very well be quite variable in any hybrid that it were a part of.

Precisely because of the stupendous variation we saw in *Q. gravesii*, neither Adam nor I were convinced that what we found was *Q. tardifolia*. But, the location, the description of the clump of trees, other photographs that I have seen since, and the opinions of Allen Coombes, Thierry Lamant, Mike Powell, and Jackie Poole (based on our photos) tend to corroborate this identification.

Nevertheless, the question that lingers in my mind is, is *Q. tardifolia* really something? Or is it just another expression of the phenomenal phenotypic plasticity of *Q. gravesii*? Adam, who is also not entirely convinced about what we found, will be returning to the Chisos Mountains this year so perhaps we will get to the bottom of this one day.

Photos 3/ (a-e) *Quercus tardifolia* (?); trees to the left of Boot Creek Trail, slightly before Boot Creek.

A close look at a recurring problem

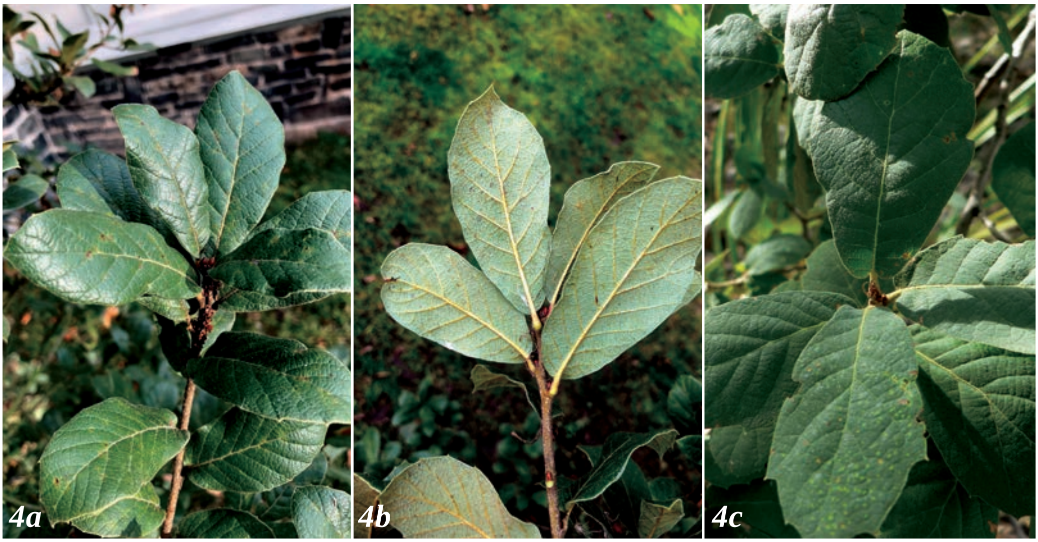
This part of my story starts in Poděbrady (Czech Republic) and ends in the Chisos Mountains.

During our visit of the Plaček Quercetum during the Oak Open Days in the Czech Republic (see this volume pp. 161-175) James MacEwen drew our attention to a plant that was labelled *Q. rugosa*, grown from seed collected in Catwalk Canyon, New Mexico. Allen Coombes suggested that this was probably *Q. arizonica*, and later confirmed his opinion about this. He also suggested, knowing that I was leaving for Texas, that I have a good look at the plants habitually thought to be *Q. rugosa* in the Chisos.

Interestingly, Sargent (1895) writes of *Q. arizonica*, "Last spring I found at Fort Huachuca, in Arizona, trees of this Oak mostly covered with leaves of the ordinary form which bore individual leaves on fertile branches that were broadly obovate, and not distinguishable in shape and size from those of Quercus reticulata, a species with long-stalked, spicate fruit, of which, at first sight, this tree might be considered an extreme form, especially as its leaves resemble those of that species in their pubescent covering and prominent reticulate veinlets, but these trees differ in the character of the bark, in the length of the peduncles, which on Quercus reticulata are often five or six inches long, in the size and shape of the fruit, in the thickness of the cup-scales and in the cotyledons…. As this species is without a name, I propose to call it Quercus Arizonica…In characters it is nearly intermediate between Quercus reticulata and Quercus oblongifolia…"

Quercus reticulata is of course a synonym of *Q. rugosa*. In naming *Q. arizonica* Sargent was actually distinguishing it from *Q. undulata* var. *grisea* (which has since been reduced to *Q. grisea*).

All that being said, I believe that we did find one *Q. rugosa*, along Boot Creek Trail, but all of the other ones that Adam pointed out as thought to be *Q. rugosa*, appeared to me to be *Q. arizonica*.



Photos 4/ (a-b) *Quercus arizonica* (Plaček Quercetum), labelled as *Q. rugosa*; (c) *Q. rugosa* (Boot Creek Trail, Big Bend National Park).

Mosquito country

In Texas, *Q. similis* is very rare, reported in a few locations in the eastern counties of the state. Many of the records that one finds in various herbaria seem often to be *Q. stellata*. It lives at low altitude in alluvial valleys, in rich, often water-logged soil – in other words, mosquito country. And indeed it was.

After a few unsuccessful searches, we found what we were looking for a few miles south of the town of Bon Wier in Newton County. A single specimen of *Q. similis* growing here with more abundant *Q. alba*, *Q. falcata*, *Q. laurifolia*, *Q. lyrata*, and *Q. nigra*.

For most, this is perhaps not quite as exciting a taxon as *Q. tardifolia*, but it is quite special to me: during my first-ever oak expedition in 2006 in the Southeastern United States where this species is quite abundant, it was the one species on my list that I did not find.

Photos 5/ (a-c) *Quercus similis* (Newton County).

Suggestions welcome

In Jasper County (East Texas) on private land belonging to the Campbell Company, that we are able to access thanks to Peter Loos, there are beautiful stands of *Q. arkansana* and quite a few other oaks as well: *Q. alba*, *Q. falcata*, *Q. incana*, *Q. margarettae*, *Q. marilandica*, and *Q. velutina*.

So, if y'all have an idea of who the oak shown in Photo 6 is, do tell!

Photos 6/ (a-c) *Quercus* sp. (Jasper County).

Conclusion

In the United States, Texas is the state with the greatest number of species in the genus *Quercus*, not surprising really if one considers that until 1836 Texas was a part of Mexico; so much for the nationality of plants! There are 50 taxa, not including the purported hybrids, according to the Oak Name Checklist – 49, if one accepts the recent synonymy that has melted *Q. graciliformis* into *Q. canbyi* (according to the World Checklist of Selected Plant Families). All together we encountered 34 species, 2 varieties (the very lovely *Q. marilandica* var. *ashei* and *Q. sinuata* var. *breviloba*) and 2 hybrids in addition to the *Quercus chihuahuensis* × *grisea* discussed above: *Q.* × *drummondii* (*Q. margarettae* × *stellata*) without a doubt, and something which may have been *Q.* × *tharpii* (*Q. emoryi* × *graciliformis*).

Acknowledgements

My gratitude goes to Adam Black for his time and for inviting me to give a presentation about the Arboretum des Pouyouleix at Peckerwood Gardens; to Will Fleming for coming along for part of the ride; to David Richardson and Ron Lance for their good tips; to Peter Loos for his assistance in Jasper County; and to Bethany Jordan of Peckerwood Gardens for her kind welcome and assistance in all things technological. My sincerest thanks to John Fairy, Peckerwood Gardens, and David and Janet Creech for their hospitality.

Photos 7/ Black-tailed rattlesnake; a trip to Texas would not be the same without them!

Photographers. Photos 1-3a, c, e, 4-7: Béatrice Chassé. Photos 3b, d: Adam Black.

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Oaks in Iran
September 28-October 16, 2016

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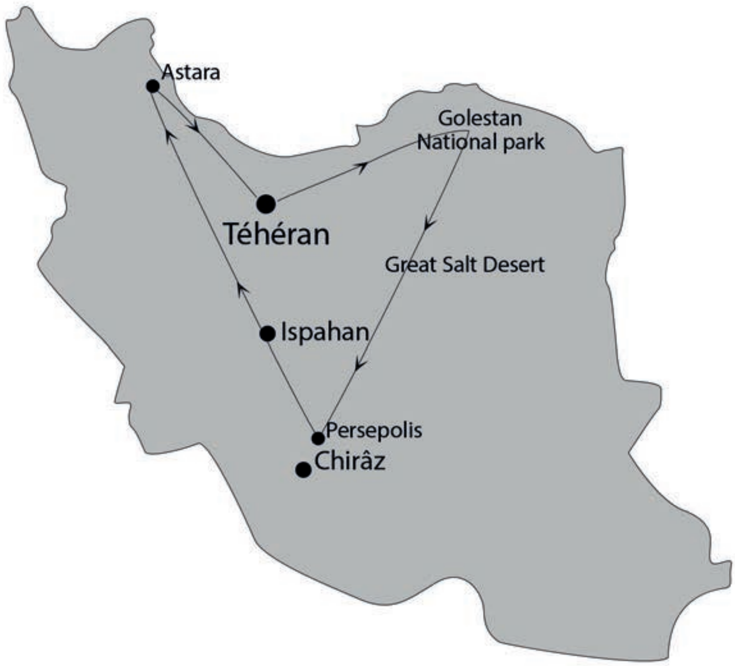

Introduction

A trip to Iran had been on the Plaček Quercetum agenda since autumn 2015. Of the dozen or so taxa found in Iran, our main interest was to find populations of those species found only in Iran and in the neighboring Caucasus and Turkey. Our primary objective was *Quercus castaneifolia* and *Q. macranthera*, both of which grow in the Hyrcan Forest in the Alborz Mountains, near the Caspian Sea, where the climate is humid, unlike in other parts of Iran. The Alborz Mountains extend roughly between the provinces of Ardabil and Golestan. These Mountains boast a rich and diversified flora, due in part to the varied climate: from the shores of the Caspian, where temperatures rarely fall below freezing, to the alpine-type vegetation in the mountains that soar to more than 4,000 m above sea level, remaining in parts snow-capped for most of the year. The presence of these mountains creates the desert conditions found throughout most of the interior of Iran.

We were also interested in finding *Q. brantii* var. *persica*, which grows in damp areas of the Zagros Mountains. Although this is an accepted name in the Oak Name Checklist (www. oaknsmaes.org), and a synonym of *Q. brantii* in the World Checklist of Selected Plant Families (wcsp.science.kew.org), Panahi et al. (2012) confirmed five of the supposed twelve taxa (Djavanchir Khoie 1967) in the *Q. brantii* complex: *Q. brantii* var. *brantii*, *Q. brantii* var. *belangeri*, *Q. persica*, *Q. saii*, and *Q. ungeri*. This large mountain range in the southwest of Iran stretches from southeastern Turkey (Kurdistan) to the shores of the Persian Gulf. The peaks of the Zagros reach 2,500-3,000 m. Average summer temperatures here can rise to 30 °C (July and August), whilst the lowest average temperatures, in January and February, fall between -6 °C and -8 °C. Most of Iran's steppes and deserts lie between these two great mountain ranges.

A little history

After attending to the required formalities, such as getting hold of visas and car hire, we set off in the autumn of 2016. I should like to point out that Iran is a completely safe and relatively hospitable country to travel in. It is definitely not a country where you will find a plethora of cheap hotels and restaurants! Present-day Iran (historically Persia) is what remains of what was once a vast Empire, the last incarnation of which was the Sassanide Empire that was conquered in the seventh century by the Umayyad dynasty. Contrary to most other Islamic nations in the Middle East, the Iranians adhere to the Shia branch of Islam though many local ceremonies and popular beliefs are still attached to Zoroastrianism (the official religion in the Persian Empire from the third to the seventh century of the present era). The Iranians are a proud people, albeit rather introverted, which is reflected in the polite, but mainly standoffish behavior of the local people. Over our entire trip, we did not encounter a single problem, display of animosity, or anything of the like, despite the fact that we were there during the most important day in the Shia religious calendar: āshūrā, that celebrates goodwill and generosity towards family, ancestors, orphans, and the poor. The only major problem we had to contend with during the entire trip was road traffic. Driving through Palermo or central Istanbul is "a walk in the park" compared to driving on a normal road in Iran! The roads are all very well maintained and of high quality, but the style of driving adopted by everyone behind the wheel is, shall we say, quite original!

Photo 1/ *Quercus castaneifolia*

Golestan Province

In northern Iran, near the border with Turkmenistan, this Province is partly mountainous, descending into lowlands towards Turkmenistan and flattening out into the dry central plateau towards the interior of Iran. The province contains the last promontory of the Alborz Mountains.

The mountains, usually partially capped in clouds, soar up from the low-lying land next to the Caspian. The lowland areas are virtually all given over to agriculture, but the foothills and mountains are covered in lush vegetation, with forests dominated by *Q. castaneifolia* at lower altitudes. Found alongside the oaks in particular are hornbeams (*Carpinus caucasica*[1] and *C. orientalis*). *Parrotia persica*, with vibrant red leaves in the autumn months, is also abundant in the

Photo 2/ The unmistakable autumn colors of *Parrotia persica.*

1. Considered a synonym of *C. betulus*.

Photo 3/ *Crataegus pentagyna*

Photo 4/ *Zelkova carpinifolia*

forests here, some growing to over 25 m in height, with trunks over 1 m in diameter. *Acer velutinum* can also be found as well as *Mespilus germanica* and *Crataegus pentagyna* in less densely forested areas. There are also specimens of *Paliurus spina-christi* on rocky outcrops at lower altitudes. In humid areas one can find *Zelkova carpinifolia* and *Alnus subcordata* while in the swampy areas *Pterocarya fraxinifolia* is not uncommon. At higher altitudes there are specimens of *Tilia begoniifolia*[2], *Acer cappadocicum*, and *Diospyros lotus*.

But, of course, what we are really interested in are the oaks! *Quercus castaneifolia* can be found here from sea level to approximately 1,200-1,500 m above sea level. Above 2,000 m there are sparsely-wooded *Q. macranthera* forests that have been heavily felled to create pastures for grazing. Even today grazing in forests makes restoration of stands virtually impossible. There is a significant site of interest above the village of Abr, north of the town of Shahrud, the gateway to the desert. From the north, starting from the town of Aliabad-e-Katul, the site is not accessible by car, so we went by foot – an interesting but quite challenging walk. The “cloud forest” is located on the highest mountain peaks and is shrouded in clouds and mist blown in from the Caspian, so the climate is unique. Growing here, along with *Q. macranthera*, are, for example, *Pyrus boissieriana*, *Carpinus caucasica*, *Acer hyrcanum*, *Juniperus communis*, *J. sabina*, along with several species of *Crataegus* and *Prunus*.

In the forest glades at elevations above 1,000 m, grows the stunted *Ilex hyrcana*, *Berberis integerrima*, and various species of *Prunus*.

Located northeast of the town of Gonbad-e Kāvus,[3] Golestan National Park extends from there eastward towards the Province of North Khorasan, and goes all the way to the border with Afghanistan. From there on there is virtually no woodland or trees, and the landscape becomes barren mountain peaks. It is interesting to note that it is over 1,000 km from here to the next forested areas – in the eastern part of Afghanistan.

Of interest here is the area around the village of Golidagh, or Goli Dagh, (in the northwestern part of the National Park), where the forests are dominated by *Q. castaneifolia*

2. Considered a synonym of *T. dasystyla* subsp. *caucasica*.

3. As is often the case with two languages that use different alphabets, transcriptions are generally multifarious: Gonbad-i Kāvoos, Gonbadekavoos, Gonbad-e Kāvūs, Gonbad Qābūs, Gonbad Qavoos, Gunbad-i-Kāwās, Gunbad-i-Kāwūs, and Gunbad-i-Kāvūs.

Photo 5/ Mixed mountain woodland dominated by *Quercus castaneifolia* and *Carpinus caucasica*, giving way in the distance to *Q. macranthera* at higher altitudes.

with *Parrotia persica* undergrowth along with other species of trees. The agricultural landscape appears "European" at first glance and can literally not be found anywhere else in Iran. Most of the trees in the forests here reach impressive dimensions – not just the oaks but also the *Acer velutinum*, *Diospyros lotus*, *Tilia begoniifolia* and others.

Across the Great Salt Desert to the Zagros Mountains and beyond

To get to the next oak habitat (specifically, that of *Q. brantii* var. *persica*) in the Zagros Mountains, you have to cross the largest desert in Iran: Dasht-e Kavir, or Dacht-e Kavir or Kavir-e Namak, in other words, the Great Salt Desert. In addition to the desert itself, much of the surrounding area and the roads to get there are bordered by semi-desert that are perhaps more steppe-like in the spring, but in October practically the entire route from Shahroud to Yazd and on to Shiraz comes across as being rather bleak, though not without charm in terms of topography and local color: an oasis surrounded by mud houses

Photo 6/ The Moalleman oasis on the southern edge of Dasht-e Kavir (the Great Salt Desert).

and date palms or pistachio orchards, Zoroastrian shrines, the *dakhma* (towers of silence)[4] in the area around Yazd, or ruins from the Persian Empire, such as Pasargadae, Persepolis or the Naqsh-e Rustam necropolis.

We recorded fairly extensive oak stands near the Naqsh-e Rustam necropolis, heading northwest towards the town of Yasuj. Large, old, formerly pollarded specimens of *Q. brantii* var. *persica* grow here alongside wild pistachio trees (*Pistacia atlantica*).

Perhaps the most interesting site we visited in the Zagros Mountains was the sparsely-wooded Poshktue Forest, dominated by *Q. brantii* var. *persica* (highest sample elevation: 2,433 m), with a mix of other species including *Acer monspessulanum* subsp. *turcomanicum*, *Pyrus syriaca*, *Lonicera* spp., *Crataegus* spp., *Berberis integerrima*, and *Rosa* spp. There is obviously quite extensive snowfall in the winter months, and rainfall over the course of the year is higher here too, but even so, other than flowering *Colchicum* species in some locations, the landscape in October was entirely devoid of undergrowth and all we could see were dry plant remnants.

Photo 7/ *Quercus brantii* var. *persica*

Sparse stands of *Q. brantii* var. *persica*, sometimes with other species, stretch almost all the way to Lake Urmia,[5] gradually giving way, to *Q. brantii* var. *brantii*.

There is another interesting location in the Zagros Mountains near Kaleybar (or Kalībar, Kalipar, Keleibar, and Keleivar) beyond Lake Urmia and Tabriz, the capital of the Iranian Province of East Azerbaijan. This is the last promontory of the Lesser Caucasus, which runs into Iran from neighboring Armenia and the Republic of Azerbaijan.

Photo 8/ From a distance the precipitated salt in Lake Urmia looks like an ice crust and indeed, it is safe to walk on.

The mountains here, that rise to approximately 3,000 m above

4. Structure used for funerary purposes by adherents of the Zoroastrian faith. This Zoroastrian practice for the disposal of the dead involves the exposure of the corpse to the sun and vultures. The dead were left on the tower of silence, where their flesh would be eaten by vultures. The stripping of the flesh and the drying of the bones are regarded as a purification process, after which the skeletal remains may be collected and deposited in an ossuary, which may be located within or nearby the tower. The English term of this structure has been attributed to Robert Murphy, a translator in the service of the British colonial government in India during the early 19th century. This funerary practice was banned by the government during the 1970s.

5. In the 1990s, the largest salt-water lake in the Middle East, twice as large as Luxembourg. Studies in 2014 have shown that it is today only about 12% of its average size (based on seasonal variation) in the 1970s. Poor water management for agricultural and other purposes is reputedly the cause, and not just climate change.

Photo 9/ *Quercus petraea* subsp. *iberica*, accompanied by other species.

sea level, are slightly more humid than the Zagros Mountains, but still receive far less rainfall than the Alborz from the Caspian side. You therefore do not find *Fagus orientalis* here, which is a dominant feature at medium and higher altitudes in the Alborz (but not in Golestan). The dominant feature of forests here is *Q. petraea* subsp. *iberica*, accompanied by species such as *Acer campestre*, *Fraxinus ornus*, *Carpinus caucasica*, and *Pyrus* sp. Shrubs such as *Cotinus coggygria*, *Prunus mahaleb*, *Cornus mas*, *Euonymus* sp., *Rosa* sp., *Paliurus spina-christi*, *Juniperus communis*, etc. can be found in glades or shallow soils near rocky outcrops. *Quercus macranthera* occurs at the highest altitudes, mixed with hornbeams. The oaks here can be found as trees and shrubs, shaped in particular by the effects of grazing.

By the sea

We then headed back towards the Caspian, to the most humid area of Iran, between the towns of Astara and Rasht.

The forests cloaking the mountains here are referred to as rain forest and with good reason. The climate here is ideal for a wide range of plant species. At lower altitudes, often intensely farmed, amongst *Q. castaneifolia* there are evergreen

Photo 11/ Between the green-yellow leaves of *Fagus* and *Carpinus*, the red leaves of *Sorbus torminalis* and the orange of *Acer cappadocicum*.

Photo 10/ At lower altitudes, along the shores of the Caspian, *Quercus castaneifolia* grows to remarkable size. This specimen, one of the largest we saw, growing at approximately 618 m above sea level, is over 50 m tall with a a circumference of approximately 10 m.

Buxus hyrcana,[6] *Ilex hyrcana*, and *Smilax excelsa*. *Pterocarya fraxinifolia* dominates in humid locations, but *Gleditsia caspica*[7] can also be found, with its fine but pronounced thorns, and *Albizia julibrissin* grows in the drier, sunnier locations. There are also abundant specimens of *Zelkova carpinifolia*, *Acer velutinum*, *Parrotia persica*, *Carpinus* sp., *Tilia* sp. and other species, all of which grow to an exceptionally large size.

Fagus orientalis occurs from roughly 1,000 m above sea level, suppressing not only *Q. castaneifolia* but also *Parrotia persica*. The *F. orientalis* are accompanied by *Acer cappadocicum*, *A. hyrcanum*, and *Carpinus caucasica*. At higher elevations, between 1,500 and 1,900 m above sea level, in the area around Rasht, we were surprised by the large number of *Sorbus torminalis*. Shrubs included *Crataegus microphylla*,[8] *Mespilus germanica*, and the evergreen *Ruscus hyrcanus*.

Approximately 2,000 m above sea level, the *Fagus* give way to sparsely-wooded forests with large *Q. macranthera*. Here too, these forests have fallen victim to the creation of mountain pastures, and still today regeneration is very limited. A variety of plants grow in the mountain meadows here, such as *Paeonia wittmanniana*[9] and a number of different types of spring bulbs.

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6. Considered a synonym of *Buxus sempervirens* subsp. *hyrcana*.
7. The proposed spelling change to *Gleditsia caspia* (more in accordance with classical Latin) has not been followed by most authorities.,
8. *Crataegus microphylla* K. Koch is an accepted name whereas *C. microphylla* Gand. is a synonym of *C. rhipidophylla* Gand.
9. *Paeonia wittmanniana* Steven is a synonym of *P. daurica* subsp. *macrophylla* (Albov) D.Y. Hong; *P. wittmanniana* Hartwiss ex Lindl. is a synonym of *P. daurica* subsp. *wittmanniana* (Hartwiss ex Lindl.) D.Y. Hong.

Photo 12/ One of the largest *Quercus macranthera* specimens at 2,000 m.

Conclusion

In total on our trip to Iran we located populations of four species of the genus *Quercus* from twelve different provenances as well as populations of thirty other species, mainly of woody plants, some endemic. Many of them are not cultivated very often, in Central Europe at any rate, even though they are often relatively attractive species.

I feel that Iran, or at least that part of it that includes the Alborz Mountains alongside the Caspian Sea, is well worth a visit by anyone with an interest in trees. Nowhere else in the world can you see such magnificent *Q. castaneifolia* or such huge *Parrotia persica* (that we saw growing to heights of over 20 meters) as well as a number of other rare trees.

Acknowledgements

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Photographers. Photos 1-12: Josef Souček.

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International Oak Society 25th Anniversary

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Individually many of us have a tendency to cringe at the idea of yet another birthday celebration reminding us, lest we forget, that the arrow of time is not bidirectional. But as a group united by a common passion, we generally enjoy, and rightly so, celebrating the accumulation of years gone by as a sign of vitality and an occasion to reflect on a shared past. The year 2017, marked by the 25th anniversary of the International Oak Society, was no exception. First with celebration in the Czech Republic in July, and then in the United States in September, IOS members gathered to commemorate our (collective) young age. Quite appropriately, the first celebration was hosted by one of our younger members, Dušan Plaček (Plaček Quercetum), and the second, by one of our…most venerable members, Guy Sternberg (Starhill Forest Arboretum).

Celebrating in the Czech Republic
Oak Open Days July 21-23, 2017

Béatrice Chassé

Photo 1/ Zámek Poděbrady, venue for the IOS 25th Anniversary Gala Dinner hosted by IOS member Dušan Plaček.

Let's start with the party

The evening of the second day (July 22) saw us all meandering along the Elbe River from our place of lodging, the very pleasant Hotel Golfi, on our way to invade the imposing Zámek Poděbrady[1] – besieged three times, in 1402, 1420 and 1426 but never conquered. Collectively the most dangerous weapon that we have with us is probably Dan Keiser's video camera, so I'm pretty certain that Zámek Poděbrady's reputation for defending itself will remain untainted after this evening.

Under the arch through which we pass to enter the courtyard there is a memorial plaque marking the discovery of Poděbrady's first mineral spring by the water diviner K. Büllov of Botkamp. "Dig here!" he said and from 96,7 metres (so says the plaque) the future of Poděbrady sprung forth. Today, many come for the alkaline water of high iron and carbon content, which is said to be beneficial to those suffering from heart, vascular and circulatory problems. But, as our 11-country delegation headed for the 5-course gala

1. Poděbrady Castle.

Photo 2/ Beautiful Bohemian crystal tumblers engraved to honor the occasion.

dinner that awaited us, I suspected that we were here this evening to pay glorious tribute to outrageously wonderful hedonistic instincts, and not, therefore, to drink water.

Amidst the good cheer, great food, and interesting conversations, IOS President Charles Snyers, brandishing the 25th Anniversary Issue of *International Oaks* (No. 28), shared a few words, as did Guy Sternberg, also with his copy of No. 28 in hand, from which he read the Foreword he had written. As the evening was drawing to a close, Dušan and his charming assistant, Adéla Kratochvílová, began distributing to each guest an elegant dark blue box containing two Bohemian crystal tumblers with the IOS logo and "25th Anniversary" beautifully engraved in the base.

In small groups we headed back to our hotel – a few strolling through Poděbrady instead of taking the riverside route, guessing correctly that this would probably be our only chance to visit the town, given the busy programme that had been prepared for us.

Two days before

I arrived in Kanín late morning on 20 July, to meet up with Dušan and Allen Coombes (who had arrived the previous day from Mexico) at the Plaček Quercetum. Passing the entrance gate, up through the main drive that leads to the house and from which one has sweeping views across the Quercetum on both sides, I was pleased to see how much the trees had grown since I had last seen them in 2015. I knew also that there were many new things to be seen, but they would have to wait until the official visit that was to take place on 22 July. Our task today was concentrated on the plants raised from seed collected in Taiwan in 2015 as well as identifying some plants still in the nursery. We also went through Dušan's new "oak pavilion": a few dozen fairly large plants that he recuperated from a Czech botanic garden and that are now all nicely set out in burlap covered pots on stone slabs, surrounding a partially shaded gravel-covered square. In this very zen ambiance, conducive to meditation and enlightenment, a few labels were changed.

Photo 3/ The very peaceful and pretty "oak pavilion".

We ended the afternoon with a late lunch at the Hotel Golfi, where IOS members and friends had started to arrive, and would continue to do so until early evening. The gracious and very amiable staff of this charming Hotel greeted boisterous arrivals and incessant trips to the bar with the utmost efficiency. After a nice dinner, during which Dušan warmly welcomed us, we regained our rooms, with visions of soon-to-be-seen oak trees dancing in our heads and alarm clocks being set for an early start the following day.

Prague Castle and Průhonice Park

Photo 4/ The city of Prague.

Photo 6/ *Quercus ×turneri* 'Pseudoturneri' (Prague Castle).

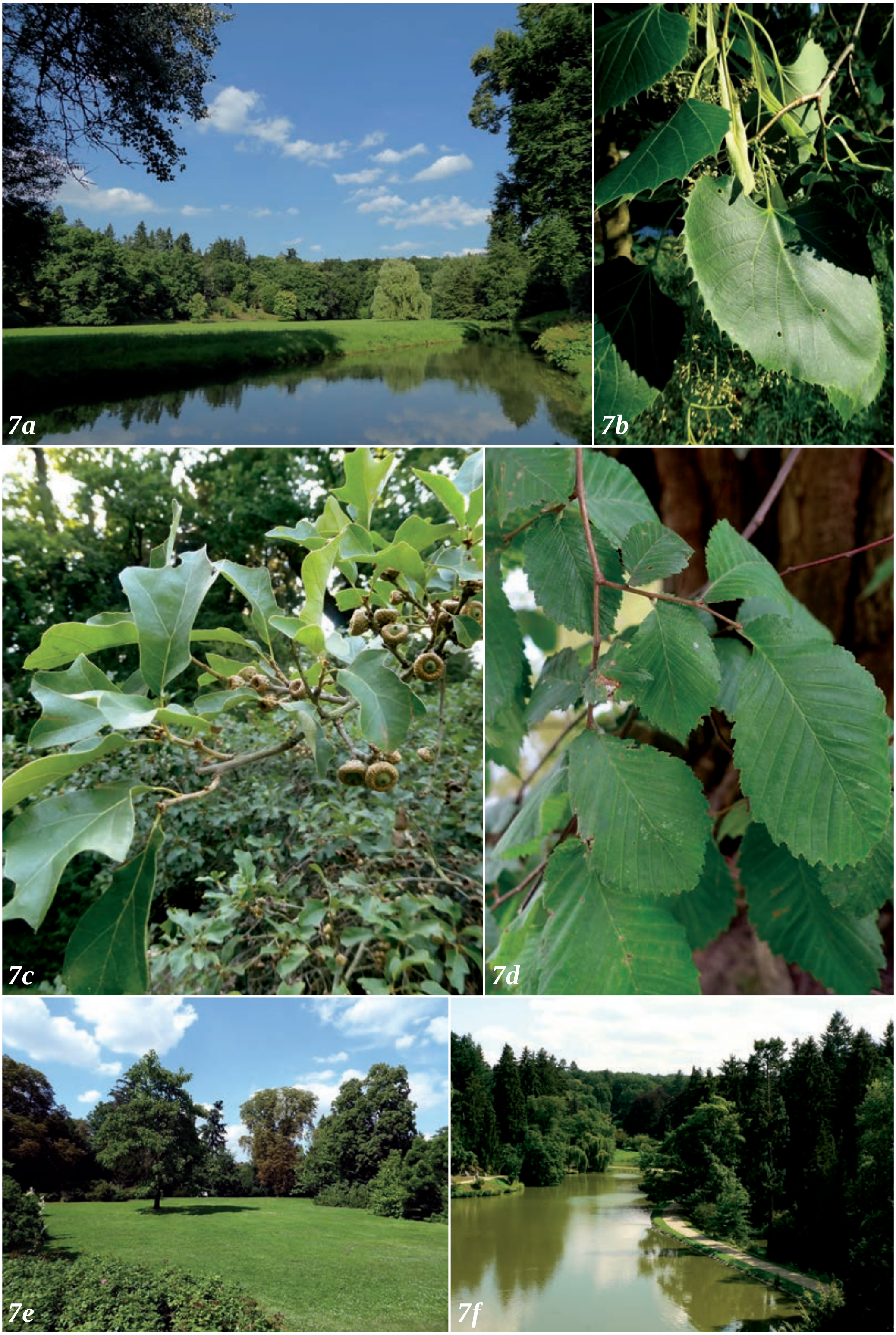
Our first destination on the morning of 21 July was Prague Castle – affording those of us who would not be staying on after the Oak Open Days the opportunity to see a little bit of this remarkable city by bus under a blue and fluffy white-clouded sky that highlighted the rooftops and monuments. The castle buildings and grounds cover seven hectares that include the Royal Garden (commissioned in 1534 by Ferdinand I, originally of Italian Renaissance inspiration, this garden was redesigned in the 19th century along the lines of the English garden), and the southern gardens (the Garden of Eden, the Garden on the Ramparts and the Hartig Garden) that spread along the southern facade of the Castle offering spectacular vistas of the Lesser Quarter, Old Town and nearby Petřín. During the reign of Ferdinand I as Holy Roman Emperor, the Royal Garden was the destination for many exotic seeds and plants that 16th century plantsmen/diplomats, like Ogier Ghiselin de Busbecq, were collecting. Although it would be difficult to make a case for the Royal Garden of Prague Castle as being the point of origin of the introduction of tulips to Europe and the ensuing tulip mania, it is certain that the Habsburg gardens in Prague and in Vienna were amongst the first to receive tulip bulbs and to actively propagate and plant them.

Ondřej Fous, to whom we are all indebted for his vast knowledge of plants but also of the history of the region of the world that he lives in, took us through the grounds and we all managed to stay together as a group just long enough to get to an extraordinary *Metasequoia glyptostroboides*. Between 25 and 30 million tourists flock to Prague every year and on July 21, 2017 one had the impression that they were all visiting Prague Castle so it was nigh impossible to stay together in the chaotic flow! Singly or in small groups we marched on trying to make our way to the Garden of the Ramparts to see a *Quercus* ×*turneri* 'Pseudoturneri'.

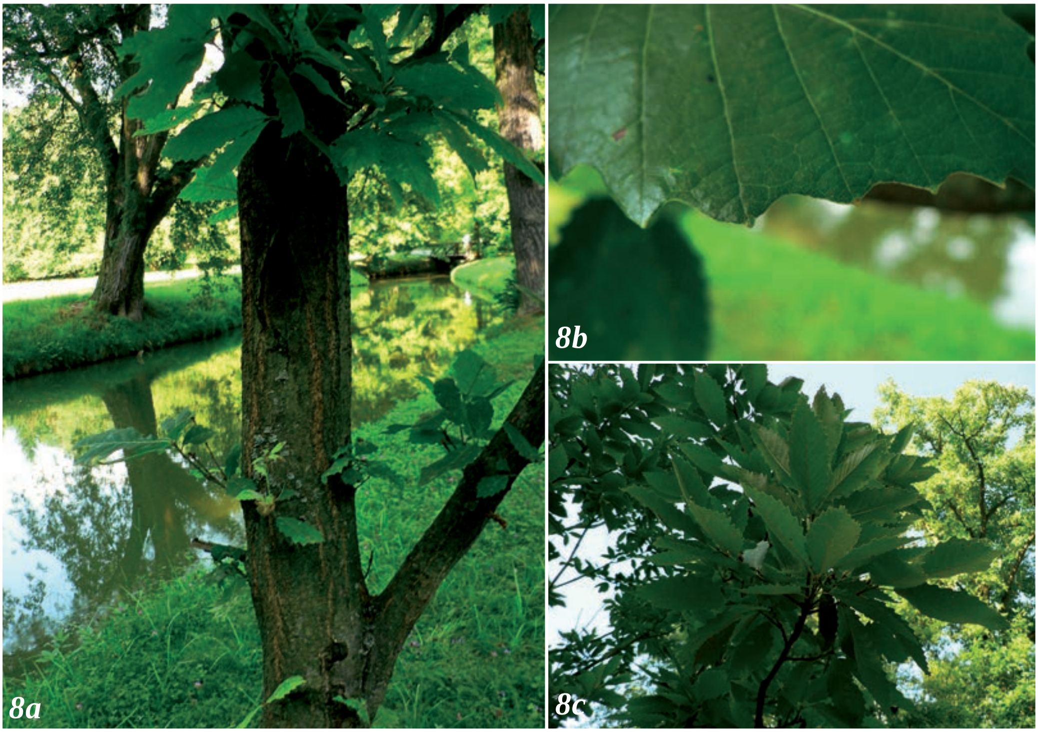
The afternoon visit of Průhonice Park (12 km from Prague and 70 km from the Plaček Quercetum in Kanín) was preceded by lunch on a lovely terrace just a few meters from the entrance to the Park where we were joined by the remaining few of our group that had not yet arrived. In the middle of lunch I managed to sneak away with Dušan to the Silva Tarouca Research Institute's nursery (just around the corner from where we were) to check out the interesting plants raised from seed from Turkey and Iran including *Q. aucheri*, *Q. brantii*, *Q. castaneifolia*, *Q. macranthera*, and others.

Josef Souček and Ondřej Fous were our guides through Průhonice Park. This 240-hectare garden was founded in 1885 by Count Arnošt Emanuel Silva-Tarouca, who eventually sold it to the state in 1927, with all the proper recommendations so that it would continue to live on as he intended. Although it is the conifers that first attract one's attention there are many magnificent old oaks including specimens of *Q. robur* L., *Q. palustris* Münchh. *Q. rubra* L., and an absolutely magnificent *Q. velutina* Lam. Some more recently planted oaks include *Q. macrocarpa* Michx., *Q. acutissima* Carruth., *Q. trojana* Webb, *Q. castaneifolia* C.A. Mey. and *Q. montana* Willd. As evening began to descend, and

Photo 5/ *Metasequoia glyptostroboides* (Prague Castle).



Photos 7/ (a, e, f) Průhonice Park landscapes; (b) *Tilia henryana;* (c) *Quercus ilicifolia*; (d) *Ulmus laevis*.



Photos 8/ (a-c) *Quercus ×maccormickii* (a hybrid between *Q. aliena* and *Q. dentata*) was the subject of some discussion (Průhonice Park).

some of us started to worry that Josef wanted us to see the entire 240 hectares, he made a point of showing us a tree labeled *Q. ×maccormickii* (a hybrid between *Q. aliena* and *Q. dentata*). There was some discussion about this, specifically, *Q. aliena* or *Q. serrata*? The *Q. dentata* part was not too obvious.

Průhonice Park is a spectacular place that truly owes its existence to one man's vision – perfectly described by Václav Brožík (Czech painter and art historian) in a conversation with Silva-Tarouca, "We artists paint canvases with non-living colors and when we finish a painting we sign it and no longer worry about it. You, however, paint and create your piece of art from living trees and plants, flowing water and flowering meadows using nature's creative energy. Your piece of art will never be finished and even when you are no longer here, someone else with the same love and understanding, will continue your artwork just as nature continues to create and renew."[2]

A wonderful dinner awaited us at the Hotel Golfi where the entire restaurant had been reserved for the group. Dan Keiser had with him his now legendary *Quercophiles Abroad*, shown for the first time at the 8th International Oak Society Conference in 2015 at The Morton Arboretum, that brought more than one tear to more than one eye during the projection near the end of our repast. After dessert – which revealed another birthday celebration (though out of respect for retired pilots, I shall not name any names) – Allen Coombes gave a presentation that touched on different subjects but was centered on Cultivated Oaks of the World. Developed in Google Fusion Tables, this tool provides a fairly easy way to upload accessions files with the aim of providing a consolidated list of oaks in cultivation across the world. The information can be filtered by garden, species,

2. Taken from the Institute of Botany ASCR website.

collection data, collector, date planted, etc…and if you provide GPS coordinates in your file, a map is automatically created. Currently there are nine gardens that have come on board. If you would like to join us, contact Roderick Cameron (roderickcameron66@gmail.com).

Plaček Quercetum

A very detailed account of this young oak collection can be found in *International Oaks* No. 26, "Taking Oaks to the Limit in the Czech Republic" (Chassé 2015) and so I will only briefly summarize it's early history, to concentrate more on what has changed since my last visit.

After the purchase of the property in Kanín in 1998, Dušan engaged in some renovation of the existing "old" garden but it wasn't until 2006, when he met Josef Souček (botanist) and Ondřej Fous (landscaper and horticulturist) that the idea of creating a collection was born. After an initial flirtation with *Fagus*, the choice was made for *Quercus* and the work began to create this collection that occupies 11.5 ha in the southeastern portion of the property. The Quercetum is roughly the shape of Florida and is crossed at about a third of its length by a 300 m *Robinia* alley that leads to the house from the main road.

The choice to base the planting strategy and design on the classification system developed by Adolf Engler (1844-1930) and Karl A. E. Prantl (1849-1893) was an esthetic one. In their system, species are grouped based on similarity in leaf shape. Engler and Prantl produced a 20-volume work, *Die natürlichen Pflanzenfamilien* (1887-1899), published by a Leipzig publisher, W. Engelmann (a slightly revised version was produced by Engler in 1964, *Syllabus der Pflanzenfamilien*, and published by the Berlin publisher, Gebrüder Borntraeger).[3] In their system, the genus *Quercus* is divided into three subgenera: *Cyclobalanopsis*, *Erythrobalanus* with four sections *(Phellos, Nigrae, Rubrae* and *Stenocarpae)*, and *Lepidobalanus* with seven sections *(Cerris, Suber, Ilex, Gallifera, Robur, Alba* and *Dentatae)*. Throughout the Quercetum, one or several individuals of a botanic taxon (grouped as indicated above) are planted in groups with their various hybrids and cultivars. All of the trees are well cared for, thickly

Photo 9/ A champagne welcome to the Plaček Quercetum by Dušan Plaček.

3. This system, that was never very widespread, is not used today for purposes of classification. It was used by Gerd Krüssmann in his *Manual of Cultivated Broad-Leaved Trees & Shrubs* (Krüssmann 1978).

mulched, adequately protected from various enemies, and all have labels.

After a champagne welcome and introduction by Dušan we enter the Quercetum from the northwest (dominated by trees from subgenus *Lepidobalanus*) and immediately evident to me as something new are the small islands planted with several dozen seedlings fairly close together of the same species: *Q. acutissima*, *Q. brantii*, *Q. libani*, *Q. macrolepis*, *Q. variabilis*. Dušan has adopted this planting strategy because he has a large number of seedlings of many species and thought it might be interesting to see what would result from planting them as though they were in a natural forest. Do the individuals benefit from being planted together? Is there synergy between the root systems? Are the mycelial networks that develop underground "better-tuned" to their hosts' needs if the roots are all of the same species? Whatever the answers to these questions may be, it seems at the very least a time saver: the best plants for that environment will survive and one doesn't have to wait until a tree dies to plant another one. It will be interesting to see what the results of this experiment are several years from now. Also new here is a very large protected bed area planted in 2015 along the western rim of the Quercetum with non-oak and oak species including *Q. monimotricha*, *Q. dolicholepis*, *Q. vacciniifolia*, *Q. rotundifolia*, and others.

Photo 10/ A newly planted (2016) *Quercus variabilis* forest (Plaček Quercetum).

Photo 11/ *Quercus ×fernaldii* (*Q. ilicifolia* × *rubra*) (Plaček Quercetum).

Moving east through the northern sector we are in Red Oak territory and although generally Dušan feels that these have a harder time than the White Oaks, there are many remarkable trees, that indeed have grown quite a bit since I was here last.

Slowly but surely we make our way towards the *Robinia* alley that divides the Quercetum in two – the southern half is about twice as large as the northern part, and I note that planting here has proceeded at a considerable pace since 2014 with new trees extending far off on the southern horizon. "According to Ondřej Fous, in the Czech Republic, as in other places with extremely cold winters, horticulturists have developed techniques to cultivate non-hardy fruit trees. Although there are variations, the main idea is to dig a trench (between 1-1.5 m/3-4.5 ft deep) in which the trees are planted and can then be easily protected during winter by filling the trench with organic or inorganic material for insulation. This technique is going to be tried in Kanín for the Mexican oaks." (Chassé


Photo 12/ The Plaček Quercetum trench.


Photo 13/ *Quercus serrata* en masse.


Photo 14/ *Q.* ×*schuettei* 'Silver Shadow' planted.

2015). What was just an idea in 2014, is now reality. The Plaček Quercetum trench, that borders the *Robinia* alley at its mid-point, has been completed, and planting in it has commenced with some Mexican species: *Q. affinis*, *Q. calophylla*, (the plant that has been known as *Q. candicans* must now be called *Q. calophylla*; see this volume, pp. 19-24), *Q. grahamii*, *Q. greggii*, *Q. mexicana*, *Q. scytophylla*, *Q. sebifera*, *Q. striatula*, *Q. subspathulata*, and *Q. vaseyana*. Not far from the trench, the "mass" planting technique that we saw earlier has been used here also for various Asian species, including, *Q. serrata*, *Q. yunnanensis*,[4] and a purported hybrid found by Josef Souček in China, *Q. aliena* ×*yunnanensis* as well as for some Mediterranean taxa (for example, *Q. coccifera* subsp. *rivasmartinezii*, and *Q. infectoria* subsp. *veneris*).

After the short walk back to the front courtyard where an elegant buffet had been prepared for us, we had an excellent lunch followed by a presentation by Dušan about the various expeditions he has been involved with, and his experience to date concerning winter limitations for his oaks. Josef, flanked by his indefatigable translator, Ondřej, began presenting his 2013 trip to China, when the sky, that had been growing dramatically dark, burst out in thundershowers depriving us of electricity. Although we welcomed the cooling effect of this after what had been a swelteringly hot morning, we were all frustrated that we could not hear his whole story. Although decidedly less charming than being told the story by our two friends, you can read about Josef's trip to China in *International Oaks*, No. 26 (Soucek 2015).

Very little rain came with the thunder and so off we went, striking out across the

4. Considered a synonym of *Q. dentata* subsp. *yunnanensis*

southern part of the Quercetum to see some of the newer plantations including a group of ten *Q. oglethorpensis*, an endangered species,[5] planted in 2016; a group of seven Q. ×*deamii* (*Q. macrocarpa* × *muehlenbergii)* also planted in 2016; and a large selection of *Q. alba* cultivars. We planted the 25th IOS Anniversary oak, the new 'Silver Shadow' cultivar of *Q.* ×*schuettei* (*Q. bicolor* × *macrocarpa*)[6] in this part of the Quercetum and then headed back towards the house to wind up the visit with a stroll through the old garden to reach the nursery and oak pavilion area. Before boarding our coach, we were treated to a shot (or several, depending) of Dušan's homemade plum brandy – setting the mood for the gala dinner that awaited us.

Libický luh and Žehuň Park

Photos 15/ a) Žehuň Park; b) *Quercus cerris*; c) *Q. petraea*.

5. For a detailed account of this taxon and its current status, see Lobdell 2017.
6. For a complete description of this new cultivar, see Russell and Jablonski 2017.

The following morning (July 23) we are headed for a quick stop at Libický luh, Bohemia's largest complex of alluvial forest (a little over 400 hectares) located at the confluence of the Elbe and Cidlin Rivers just slightly east from the Plaček Quercetum. Targeted as early as 1985 as a natural area to be protected, it was not until 1992 that part of it was officially declared a national nature reserve (Národní přírodní rezervace). The presence of *Mercurialis perennis* is an indicator of (undisturbed) ancient forests, and indeed we are here mainly to see some very venerable *Q. cerris* and *Q. robur* although a great many herbaceous (e.g., *Circaea lutetiana*, *Impatiens parviflora*, *Pulmonaria obscura*, *Alliaria petiolata*) and other woody plants (e.g., *Carpinus betulus*, *Ulmus minor*, *Acer campestre*) also attract our attention.

On the road again traveling to our next destination, Žehuň Park, we stop along the way to admire a local champion, protected, *Q. robur* that we estimate to be about 5 m in circumference at breast height and about 25 m tall. Žehuň Park is a beautiful savanna perched up high on a bluff overlooking the Elbe River. Magnificent specimens of *Q. cerris*, *Q. petraea*, *Q. pubescens*, *Q. robur*, and everything imaginable that could result from hybridization between these species are to be admired here, with their rounded, mushroom shaped canopies typical of trees growing in such ecosystems.

Arboretum FLD Kostelec nad Černými Lesy

Photo 16/ Mr. Kučera's dendrometer (Arboretum Kostelec).

Our afternoon – and final – destination was the Kostelec Arboretum where we were met by Zdenek Blahnik, Václav Bažant. This Arboretum was created in 1954 and today part of the Forestry Faculty of the Czech University of Life Sciences in Prague. A few miles from the town of Kostelec, the Arboretum covers 12.5 hectares with more than 2,000 taxa, the vast majority of which are forest trees. An important function of this arboretum is forest-tree research and practical education for dendrology students. An example that we saw of this was their on-going tree-growth measurement programme that uses a Czech-patented dendrometer that many of us had never seen. Average annual rainfall is about 660 mm; winter temperature average is around -2 °C (but -28 °C is not unheard of) while average summer temperature is about 18 °C (though temperatures as high as 40 °C can occur). There are majestic conifers (like,

Photo 17/ At the Arboretum Kostelec: a) *Quercus robur*; b) *Q. aliena* var. *acuteserrata*; c) *Picea pungens*.

Cupressus nootkatensis, *Chamaecyparis obtusa*, *C. pisifera*, *Pinus coulteri*, *P. ponderosa*, *Tsuga diversifolia*) and of course many *Q. petraea* and *Q. robur*, with a selection of the cultivars of both. Amongst the non-native oaks that seem to do very well here are *Q. bicolor*, *Q. palustris*, *Q. acutissima*, *Q. aliena* var. *acuteserrata* and *Q. pontica*. *Sorbus* is also very well represented in this Arboretum and, as we bid farewell to our hosts, marking the end of the International Oak Society's 25th birthday celebration in the Czech Republic, we were treated to a strong brandy made from *Sorbus domestica* berries and an even nicer, sweet, dark-red wine made from the fruit of the very pretty *Aronia melanocarpa*.

Photo 18/ *Sorbus graeca* (Arboretum Kostelec).

Acknowledgements

The International Oak Society wishes to thank Dušan Plaček for hosting this fine event, for graciously providing transportation and for the fabulous gala dinner. We are indebted to Adéla Kratochvílová, whose hard work and organizational skills were critical to the success of these Oak Open Days. Our sincere gratitude goes to Josef Souček and Ondřej Fous without whom a visit to the Czech Republic and its botanic marvels would just not be the same. Many thanks also to Václav Bažant and Zdenek Blahnik for guiding us through the wonderful Arboretum Kostelec.

Participants: Dirk Benoit, Katrien Benoit, Charles Snyers, Christof Van Hulle, Rita Van Hulle, (Belgium); Ondřej Fous, Dušan Plaček, Josef Souček (Czech Republic); Juha Fagerholm, Katja Fagerholm, Tuomo Isokuortii (Finland); Béatrice Chassé, Shaun Haddock, Cécile Souquet-Basiege, Nora Vogel (France); Henning Hartmann, Monika Hartmann (Germany); Allen Coombes (Mexico); Bart Schipper (the Netherlands); Ulla Dunkel, Plummer Dunkel (Sweden); Lloyd Kenyon, Sally Kenyon, James MacEwen (UK); Dan Keiser, Bonnie-Jean Berckes, Guy Sternberg (USA); Roderick Cameron, Beth Dos Santos (Uruguay).

Photographers. Photos: 1, 6, 17a, 17c, 18: Guy Sternberg. Photos: 3, 7a-c, 7e, 9, 12, 13, 15a-c, 16, 17b, 19: Roderick Cameron. Photos: 4, 5, 7f, 8a-c, 10, 11, 14: Béatrice Chassé. Photo: 7d: Charles Snyers.

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Photo 19/ From left to right: Zdenek Blahnik, Václav Bažant, Ondřej Fous, Dušan Plaček, and Josef Souček.

Celebrating in the USA
Oak Open Day September 2, 2017

Charles Snyers

After the European event in the Czech Republic in July our second 25th anniversary celebration took place at Starhill Forest Arboretum (SFA) in early September 2017. Ryan Russell had suggested SFA to organize this special Oak Open Day. And an obvious choice it was. There is no other oak collection in the world whose history is so intertwined with the history of the IOS. Starhill Forest Arboretum is a mecca for the members of the IOS.

Starhill Forest Arboretum was created by Edie and Guy Sternberg in 1976. A member of the informal oak group that preceded the IOS, Guy was instrumental in the creation of the Society and its later incorporation. He has often written about it, how he established strong friendships, traveled the world and… procured acorns for their collection, thanks mainly to the International Oak Society and its members scattered all over the planet. Guy was also the first President of the Society, a Board Member until 2012, and Editor of *International Oaks*, from 2004 until 2012 (see also *International Oaks*, No. 27, pp. 358-360). In addition to its link with Illinois College (Jacksonville, IL), Starhill has more recently established a relationship with Lincoln College (Lincoln, IL). The Arboretum is a member of the *Quercus* Multisite Collection, part of the American Public Gardens Association's Plant Collections Network (cf. publicgardens.org) since 2009. SFA is also

Photo 1/ Planting *Quercus* ×*schuettei* 'Silver Shadow' to commemorate the 25th anniversary of the International Oak Society.

an ArbNet Level III-accredited plant collection (cf. arbnet.org).

Some of the participants to the event had arrived on the Friday night, September 1, and stayed at the Riverbank Lodge in Petersburg, famous for the *Quercus* ×*warei*, a hybrid between *Q. robur* Fastigiata Group and *Q. bicolor*, planted just in front of it. This tree is almost as renowned within oak circles as the *Q. texana* growing by the I-55 near New Madrid in north-eastern Missouri, another of Guy's finds (see *International Oaks*, No. 23, pp. 50-55). The tree at the Riverbank Lodge has now been named *Q.* ×*warei* 'Riverbank' (see *International Oaks*, No. 28, p. 91). We shared a friendly dinner at the Riverbank Tavern.

On Saturday morning, 24 members and non-members showed up at Starhill. The day started with an introduction of every attendee. Twenty-three were from the USA, mostly Illinois, Indiana, Missouri, and Nebraska. Only one European attended, the author of these lines. Guy talked about some of his selections, particularly the offspring of *Q.* ×*warei*, starting with the tree at the Riverbank Lodge, or hybrids of *Q.* ×*warei* with other oaks. He then detailed the program for the day. We all received a folder with a few documents related to the day and the history of the Society. Guy's phenomenal acorn collection was also on display for the occasion.

There followed a couple of demonstrations, a pruning demonstration by Guy Sternberg in person (see *International Oaks*, No. 24, pp. 151-160), and a chain-saw mill demonstration by Scott Pantier, manager and arborist at Starhill. One of Scott's hobbies is log milling. "He is using a chain-saw mill that can be set up in the field and eliminates the need to haul the whole logs to town. His saw has a long bar and the chain is designed for end-grain cutting, with very little bevel on the lead edge. He can use large logs that otherwise would have to be cut into firewood or left to decay." (Guy Sternberg, pers. comm.)

We then walked back for lunch. Edie had brought in a local caterer. The weather was sunny and we all had lunch on the lawn in front of the field lab. We had also brought some acorns to close lunch with a traditional seed exchange.

Ryan Russell had brought a tree of the cultivar which is his selection, *Q.* ×*schuettei* 'Silver Shadow', to mirror the planting done in July at the Plaček Quercetum to commemorate the silver (25th) anniversary of the Society. This new cultivar is described in *International Oaks*, No. 28 (see pp. 92-94). Just after lunch, we proceeded with the planting ceremony in South Field.

After the planting, we split into three groups, each headed to a different part of the Arboretum. I followed Warren Chatwin to the Bur Oak Field, a field with trees from all over the natural range of *Q. macrocarpa*. The group very quickly split into smaller groups and eventually I ended up alone wandering about South Field. Although there are other species than *Quercus*, the oak collection amounts to nearly 240 taxa, of which about a third are hybrids and cultivars. "As the largest oak collection in North America, it is the goal to maintain as much oak diversity as can be managed at this facility, including representative examples of oak hybrids and a few cultivars. This includes some tender species that are protected in winter as well as desert species that are given artificially created dune habitats." (Guy Sternberg, pers. comm.)

I had just walked to West Hill when Guy called me to come back to the Field Lab. Most participants were quietly conversing on the lawn. The day ended for some of us with an early dinner at a Mexican restaurant in Petersburg.

Acknowledgements

The International Oak Society extends its gratitude to Edie and Guy Sternberg for once again welcoming our Society to Starhill Forest Arboretum.

Participants. Charles Snyers (Belgium); Marilyn Allen, Ivy Chatwin, Rowan Chatwin, Warren Chatwin, Henry Eilers, R.J. Fehl, Rachel Helmich, Debbie Jones, Jim Hitz, Dan Kostka, Margaret Lee, Paul Lee, Dave Leonard, Matt Lobdell, Scott Pantier, Karl Persons, Dalton Presswood, Russell Ryan, Tammie Russell, Tony Sears, Kim Shearer, Larry Slavicek, Guy Sternberg, Edie Sternberg, Daniel Ward, Charlotte Ward (USA).

Twenty-five Years with Starhill Forest Arboretum

Béatrice Chassé

It is probably safe to say that no other oak collection has its history so intimately entwined with that of our Society. Obviously, the seminal role that Guy Sternberg has had in both of these institutions is the bond. Over these past 25 years Starhill has seen many IOS faces, been the venue for different IOS events, and grown many seeds obtained through conference seed exchanges and from IOS members across the globe.

Through these and other efforts, Starhill has played a key role in the development of oak collections around the world, in the distribution of new oak cultivars, in increasing interest in oaks, and in sowing the seeds of long-lasting friendships.

May the next twenty-five years be acornful for the International Oak Society and for Starhill Forest Arboretum.

Photo 2/ Guy and Edie Sternberg planting their first trees at Starhill Forest Arboretum in 1976.

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International organization tours Menard County

A group from the International Oak Society recently visited several locations in Petersburg and Springfield. They were hosted for two days in the Rock Creek area by Guy and Edie Sternberg at Starhill Forest Arboretum, with help from Nurseryman Wayne Books of Books' Nursery.

The International Oak Society organization is composed of several hundred scientists and oak tree growers from four continents, and is committed to the development, preservation, study, and promotion of oaks worldwide. Approximately 160 Oak Society members were in Illinois for the First International Oak Conference at the Morton Arboretum near Chicago.

Several participants travelled to Petersburg following the seminar to see some of the unusual and notable oak trees which can be found here. Rare oak hybrids, interesting oak species, and a National Champion oak tree larger than any others of its kind can be seen in Petersburg and the nearby Menard/Sangamon County region. Starhill Forest, part of the group's tour, has been designated as the official oak collection location of the North American Plant Preservation Council, and grows many unusual oaks and other trees.

The visitors welcomed the opportunity to experience the lifestyle and historic atmosphere our area offers as well. They visited New Salem, the Historic District of Petersburg, and Washington Park, Cotton Hill Park, and Oak Ridge Cemetery in Springfield. Public Works Director Ric Lynch of Springfield met the group for a special inspection of the new oak tree nursery at Oak Ridge, a cooperative research project of the City of Springfield and Starhill Forest. The guests were treated to a country cookout by Edie Sternberg and Aquilla Books at Starhill Forest following their tour.

International Oak Society members pictured above, admiring the work of the Petersburg Garden Club at the Petersburg Gazebo, are: Front row, from left - Mark Pitman, oak curator for the Royal Botanic Gardens at Kew, England; Guy Sternberg from Starhill Forest Arboretum, rural Petersburg; Mark Coggeshall, the tree improvement specialist for the State of Indiana; Tom Burleson, U.S. Dept. of Agriculture, New Mexico; Lisa Wright, Oak Journal editor, Pennsylvania; Susan Cooper, oak seed exchange organizer from Worchester, England; Allen Coombes, botanist for the Hillier Botanic Gardens in Hampshire, England; John Gammon, an oak collector from Petersfield, England; Aytekin Ertas, from the University of Istanbul, Turkey.

Second row, from left - Nigel Wright, Oak Journal publisher from the Oak Society headquarters in Pennsylvania; Michael Melendrez, a tree-hardiness researcher from New Mexico; Stelian Radu, director of Arboretum Simeria in Romania; Jamie Friend, an oak grower from Shropshire, England; and William Hess, botanist and chief of the herbarium at the Morton Arboretum in Lisle, Illinois.

Photo 3/ The first International Oak Society Post-Conference Tour group.

Photo 4/ In 2006, another IOS group sets off from Petersburg for an oaken road trip to Texas and the 5th International Oak Society Conference.

Photo 5/ During the 8th IOS Conference at The Morton Arboretum in 2015, Starhill Forest was again a stop during the Pre-Conference Tour.

Photographers: Photos 1, 6: Charles Snyers. Photos 2-4: Guy Sternberg. Photo 5: Béatrice Chassé.

Photo 6/ A magnificent specimen of *Quercus oglethorpensis*, an endangered species, and rare in cultivation, thriving at Starhill Forest Arboretum.

Brief Encounters with Copey Oak (*Quercus copeyensis*) in Costa Rica October 27-30, 2017

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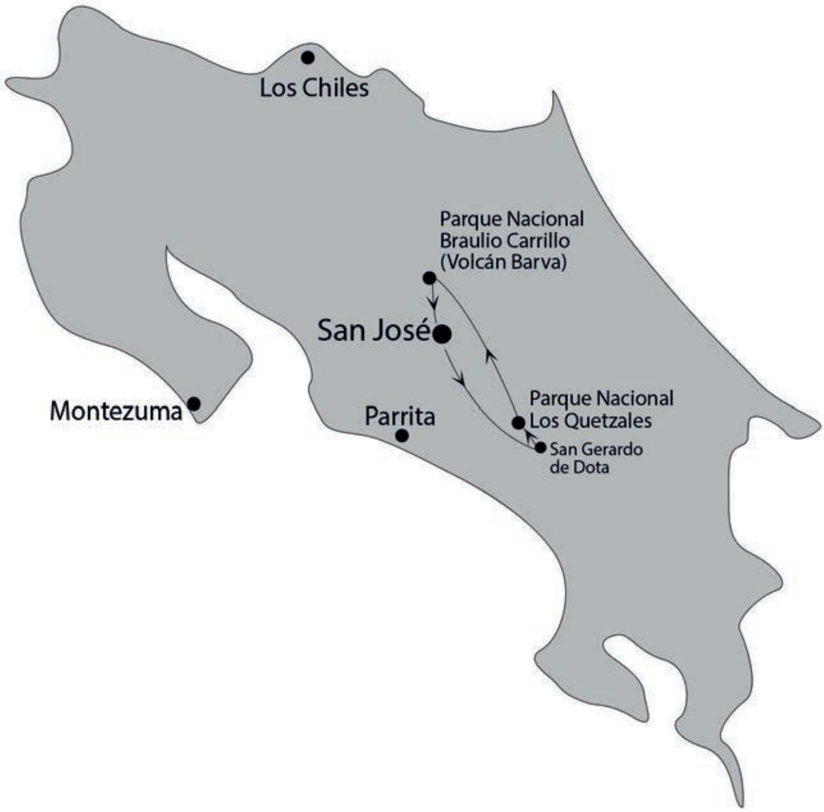

Introduction

In the October 1943 issue of *American Forests*, Arthur Bevan wrote about a remarkable discovery:

Nine degrees of latitude north of the Equator – the same latitude that runs through the Panama Canal – and here we were walking through what is perhaps the largest single stand of oak timber in the world. If that surprises you, you are in good company. The foresters in our party were amazed. It simply couldn't be true … Magnificent giants 125 feet or more tall, heavily buttressed at their base to a height of ten or twelve feet, and with diameters above the buttresses of from seven to eight feet. Here were trees to excite the imagination, a whole forest of them … To add to our awe, clouds swirled through the trees giving the whole setting a ghostly appearance … one almost expected to see witches on broom sticks and large hats flying out of the timber … We immediately dubbed the forest "The Ancestral Home of the Gremlins."

Bevan and his colleagues were members of a project field party that was in Costa Rica in connection with the construction of the Inter-American Highway that would run through all of Central America. They had been requested by army engineers building the highway to examine a stand of large timber along the right-of-way. "The giant oaks were our reward," wrote Bevan. The foresters were not able to identify the species of oak, but samples were sent to the Chicago Museum of Natural History, where Dr. Paul Standley declared them to be *Quercus copeyensis*, or Copey oak, a species named by C.H. Muller the previous year. In his article, Bevan expresses concern that a considerable portion of the stand would be logged for the construction of the highway and other uses. However, plans were in place to create a national park to preserve the remainder of the trees. "Perhaps," he concludes, "some day tourists driving over this jungle road will experience the same thrill on entering the forest of oaks that we – a group of exploring foresters – did."

In October 2017 I was fortunate enough to be one of those tourists.

San Gerardo de Dota

Photo 1/ A resplendent quetzal (*Pharomachrus mocinno*) poses on a branch of *aguacatillo* (*Persea caerulea*).

An extended layover in San José de Costa Rica on a trip from New York to Montevideo allowed me three nights in the country, the first two of which would be in San Gerardo de Dota, a valley in the Talamanca Cordillera about 50 km southeast of San José, at an elevation of around 2,300 m. I arrived in the evening and procured for the next morning a guide I was told would help me identify oaks, though his specialty was birds, which is what most tourists go there to see. Next morning at 6 a.m. sharp I met Marino Chacón who informed that we would first go to see the quetzals, a visit that was de rigeur for anyone visiting the Sagevre Valley, and we could then see a few oaks. The resplendent quetzal (*Pharomachrus mocinno*) is an attractively colored bird with a long tail. It is of little interest to the quercophile, save perhaps for the fact that it is surely the bird that stands closest to *Quercus* in the dictionary. But we climbed a hill and took our place among the multilingual battery of telephoto lenses and indeed saw several quetzals feeding on the fruit of *aguacatillo* trees (*Persea caerulea* – the common name is the diminutive of *aguacate*, Spanish for avocado).

Having paid homage to the quetzal, Marino introduced me to my first *roble blanco*, the local name for Copey oak. To the human observer it is a massive trunk disappearing into the canopy. This aspect of the trees had also impressed Bevan: "The most striking feature of the trees is the long sheer bole before the first limbs branch off about eighty feet above the ground. The trunk tapers but slightly." Marino drew my attention to the bark: light brown/grey and extremely flaky, from a distance like the shaggy fur of an animal. Flakes of bark are easy to break off and in fact can be an important resource for someone needing to survive in the forest. As cloud forests are very damp environments, it is often difficult to find wood that will readily catch fire. The bark of Copey oak is useful because it makes excellent kindling. Another characteristic that Marino pointed out is that these oaks always have one side of the trunk that is damp and mossy, while the other remains dry and clear of lichens and other vegetation. Bark from the dry side can always be counted on to start a campfire. He had learnt this from his father, who had been a cowherd and was accustomed to having to spend nights in the forest when rounding up cattle that had wandered far from home. In fact, it was on such a trek in 1954 that Efraín Chacón stumbled across the beautiful valley of the Savegre River in Dota, at that time uninhabited and unclaimed. Impressed with the picture-perfect lush and green surroundings, he applied to the government for ownership and it became the family's prosperous estate and a village his wife named San Gerardo de Dota. On the advice of visiting ecologists from the U.S., the Chacón family had converted the enterprise from agriculture to ecotourism and built cabins that became the Sagevre Hotel and Spa where I was lodging.

Photo 2/ High up the trunk the bark of *Quercus copeyensis* is sometimes extremely shaggy, forming large flakes that peel back from the inner bark at the lower end.

Hurricane Nate had passed through that area in early October, and the Sendero Los Robles (The Oaks Trail), the main trail into the hills above the hotel, was off limits due to fallen trees. However, Marino made an exception and led me through a section that was for the most part accessible. Here we saw more Copey oaks, including seedlings and young trees, which allowed us a look at their leaves. They are thick and firm, frequently polymorphic on the same tree or even on the same branch, ranging from ovate and obovate to elliptical, the tip obtuse or acute, the base slightly rounded, cuneate, or even slightly cordiform. The margin is entire, though exceptionally I saw leaves of newly sprouted seedlings with one or two minute bristle-tipped lobes. Mature leaves are 5 to 15 cm long and 2 to 6.5 cm broad. The upper surface is glabrous (hairless), but the lower surface displays tufts of hairs along the midrib and along the veins close to the midrib. We found branches that had fallen from the tops of trees, with leaves that were more rounded and bore more pubescence on their undersides than was the case with leaves growing close to the ground. These twigs came with male catkins, which can be up to 12 cm long, and the plump flowers are distinct on the rachis, with a clear gap between each one.

Acorns were scarce, and according to Marino the main season for acorns in Dota is July, but we found a few on the ground. (Acorn season for Copey oak seems to be a movable feast, and mature fruits may apparently be found in April, June, July and October). They are spherical, up to 3 cm in diameter, with a large scar at the base. I observed some

Photo 3/ *Quercus copeyensis* with its characteristic combination of yellow catkins and red new leaves.

acorns displaying epigeal germination: the strong radicle pushes the acorn up and it remains slightly above ground, the cotyledons opening either side of the stalk. This type of germination is common with beans, but most oaks have hypogeal germination, i.e., the acorn remains underground and only the plumule or stalk of the plant emerges above the surface. The cupule of Copey oak is distinctive, with a thick peduncle (2 mm in diameter) that can be up to 3 cm long.

La Georgiana

Photo 4/ *Quercus costaricensis* with the typical dense tomentum covering the underside of the leaf (San Gerardo de Dota).

Quercus copeyensis is usually described as being up to 35 m tall, and on the trail above Sagevre Hotel we were able to see specimens which seemed to fit that description. Marino suggested I explore the area around La Georgiana, a restaurant 15 kilometers further south from the turn off to San Gerardo de Dota on the Inter-American Highway, where aside from large stands of *Q. costaricensis*, the companion Red Oak to *Q. copeyensis*, I would find a giant Copey oak, "El Roble". *Quercus costaricensis*, known locally as *encino*, is easily distinguished from *Q. copeyensis* due to its dark bark, which is fissured rather than flaky, and the thick, rounded, coriaceous leaves that are shiny and dark green above, and densely tomentose below, with tan pubescence covering the whole lower surface rather than only appearing along the midrib and veins. The specimens I saw were heavily laden with immature acorns, so this was possibly a mast year.

La Georgina stands near the top of the formidably named Cerro de la Muerte (Death Mountain), at an elevation of 3,090 m, on the Inter-American Highway's highest point in Costa Rica. The mountain got its name due to the perils involved in traveling over it in the days before the highway, and to the many ill-prepared travelers that succumbed there to the cold and rain. The building dates to 1947, the year before the 44-day Costa Rican Civil War brought yet more deaths to that area. Despite these foreboding omens, the folk at the inn gave me a friendly welcome and a hand-drawn map of the trails behind the restaurant, including the location of El Roble, the giant oak. After a good half-hour walking through dark stands of *Q. costaricensis* I began to encounter *Q. copeyensis*, as I drew closer to the stream at the bottom of the valley. When I reached El Roble, I found a decapitated tree, as the oak had evidently lost its crown during Hurricane Nate a few weeks before. It appears the hosts at La Georgina were not yet aware of the fact. A topless Copey oak is still a formidable sight, and of course a lack of crown does not affect the massively buttressed base.

I did measure the trunk of the tree, at something close to breast height (easier said than done, as the buttresses raise the base of the tree onto a slippery pedestal covered in damp moss, and at one stage I practically disappeared into the gap between two


Photo 5/ A giant *Q. copeyensis* showing clearly the division between the "damp" and "dry" sides of the trunk.

buttresses; thankfully the concealed space did not harbor wildlife). The measurement obtained (an impressive 6.90 m) is not really meaningful, as the buttresses distort the true circumference of the trunk. Opinions differ as to the function of buttresses in tropical oaks (and many other tropical trees), but to my untrained eye it seemed to be clear that it is an efficient way for a tree to obtain a wider, lighter, and more stable base, using a minimum of resources. This particular tree had the added attraction of buttresses that gently spiraled as they receded up the trunk.

I did not have equipment that could measure the giant trees around me, but I suspected these oaks were 40 to 50 m tall. Not far from where I stood, near the village of Villa Mills, grows a Copey oak known as "El Abuelo" (Grandfather Oak). In a post on the Bulletin Board System of the Eastern Native Tree Society, arborist Bart Bouricius reports the tree is 60.4 m tall, with an above-buttress circumference of 5.8 m (measured at a height of 4.3 m – the circumference at breast height, which is of course augmented by the buttresses, almost exceeded Bart's 50-foot measuring tape: 14.2 m). The website www.monumentaltrees.com, which lists champion trees worldwide, states that "till now this is the tallest accurately measured oak worldwide, over 10 meters taller than all oaks measured in the United States or Europe." The same oak is pictured in le Hardÿ de Beaulieu and Lamant's *Guide Illustré des Chênes*, with three people standing comfortably in between the massive buttresses, occupying only one side of the trunk.

Nomenclatural labyrinths

I should clarify that Bart Bouricius uses a different name for the species: *Q. bumelioides*. Indeed, nomenclature of Costa Rican oaks, as with other Central American oaks, is complex. The case of Copey oak is a good illustration. The species began binomial life as a form of *Q. costaricensis*, distinguished by Trelease as *Q. costaricensis* f. *kuntzei* in his monograph *The American Oaks*, published in 1924. The type specimen was collected by German botanist Otto Kuntze in 1874, on Volcán Irazu in Costa Rica, and is preserved in the New York Botanical Garden Herbarium as Kuntze #2282, with an isotype in the Kew Gardens Herbarium. According to Trelease, what characterized the form were the less prominent veins and the scarcer pubescence on the underside of the leaf: "with cellular-pitted less impressed-veiny leaves glabrous except for long brown fleece in sheltered places beneath." *Quercus costaricensis* was named by Liebmann in 1854, based on specimens collected by Danish botanist Anders Ørsted while in Costa Rica between 1846 and 1848. However, Ørsted's collection seems to have been a mixture, as it included true *Q. costaricensis* (a section *Lobatae* oak) and the form Trelease named *kuntzei* (section *Quercus*). C.H. Muller pointed this out in his *Central American Oaks* (1942), elevating f. *kuntzei* to species status and introducing the new name *Q. copeyensis*. According to Muller, "The forma *kuntzei* is very thoroughly confused," for Kuntze's collection was also a mixture, including both true *Q. costaricensis* and *Q. copeyensis*. However, Muller's description is not entirely satisfactory, for example falling short as regards to height: "Large tree to 15 m in height or taller." Elbert Little, Jr., one of Bevan's companions in the party of foresters that stumbled on the stands of giant oaks next to the Inter-American Highway, felt that a correction was called for and published an article in *Caribbean Forester* in 1948, in which he aimed to "amend slightly the botanical description of this important species." He pulled no punches when describing the appearance of the tree: "Very large tree of forest canopy, becoming 27 to 37 m (90 to 120 ft) in height and 0.6 to 1 m (2 to 3 ft) up to 2.4 m (8 ft) in trunk diameter; larger trees having buttressed bases with somewhat larger basal trunk diameters and having clear lengths as much as 80 ft to first branches." Muller made no mention of the bark (which is understandable if he was only working from herbarium samples), but as I mentioned above, it is a useful feature for identification. Little includes in his amendment: "Bark whitish, rough, scaly to shaggy." The specific epithet *copeyensis* apparently derives from the location of Muller's type specimen, collected by Standley in 1925 near the town of El Copey, in San José Province (*copey* is the local name for several trees in the genus *Clusia*).

So much for *Q. copeyensis*. However, in the same 1854 publication in which he published the name *Q. costaricensis*, Liebmann also published *Q. bumelioides*, based on another specimen collected by Ørsted (*bumelioides* refers to a similarity to *Bumelia*, now *Sideroxylon*, a genus that includes chittamwood, a plant native to southern U.S. and northern Mexico). In 1913 Trelease identified an isotype of Kuntze's specimen #2282 in the Kew Herbarium as *Q. bumelioides* Liebm. (before Muller verified it in 1958 as *Q. costaricensis* f. *kuntzei* and therefore *Q. copeyensis*). But *Q. bumelioides* Liebm. has since been buffeted by nomenclatural storms, being sunk into synonymy by some authors, who find it to be in fact a Red Oak: for Burger it is *Q. seemannii* Liebm., for Muller *Q. eugeniifolia* Liebm., and for Valencia Avalos *Q. sapotifolia* Liebm. Other authors keep the name afloat and hold it to be the accepted name for the *roble blanco* in Costa Rica, thus reducing *Q. copeyensis* C.H. Mull. (a White Oak) to a synonym of *Q. bumelioides* Liebm. This is the interpretation of, amongst others, and the Smithsonian Tropical Research Institute in Panama. (At this point the reader may be excused for feeling, to borrow Muller's phrase, "very thoroughly confused.")

Parque Nacional Los Quetzales

Marino Chacón had also recommended I visit the Parque Nacional Los Quetzales, a 5,000-hectare national park to the southwest of the Inter-American Highway, a few kilometers north of the turn-off to San Gerardo. A reasonably well-maintained public road allows access into the park and I descended down the side of a valley from an elevation of close to 3,000 m at the entrance to 2,500 m. The road offered a different perspective for viewing Copey oaks, as I enjoyed vistas across the forest canopy, with the oaks' crowns

Photo 6/ A young Copey oak in Parque Nacional Los Quetzales, its crown flushing with new growth.

emerging clear of surrounding competitors. Close to the road, some oaks had remained standing while the forest around them had been cleared, revealing massive straight boles topped by globular crowns. More mature specimens had smaller crowns, reduced to a few leaves at the end of contorted branches, or had even lost branches or their tops, their wracked skeletons now a record of each storm and circumstance that shaped them. The remains of a recently broken trunk lying by the side of the road (Nate gratias) revealed the characteristic yellow to light brown sapwood and pinker heartwood of *Q. copeyensis*. I also came across crowns covered in flushes of ruby new growth, another typical feature of the species, and a specimen in full flower, dripping pendulous yellow catkins.

Parque Nacional Los Quetzales is the most recently created of Costa Rica's 26 national parks. The country is a world leader in conservation policies, and its protected areas, many of which are national parks, cover 25 % of the country's landmass – the highest such ratio in the world. All this is good news for *Q. copeyensis*, currently listed as Vulnerable on the IUCN Red List (as *Q. bumelioides*). Protection is necessary, as Copey oak has been a much sought-after resource. Reading between the lines in Arthur Bevan's 1943 article, you can sense the forester in him salivating, as he describes what he believes to be the largest pure stand of oak in the world in terms of potential lumber: "Estimates from a few circular sample plots indicate that the heaviest stands will run as high as 60,000 board feet an acre. In fact, an estimate of from 20,000 to 25,000 board feet an acre for the entire stand is conservative." Copey oak has been logged extensively, primarily to fuel the charcoal industry. According to Cordero and Boshier, it is estimated that in the 30 years since the creation of the Inter-American Highway through 1972, some 374,000 large oaks were felled, mostly *Q. copeyensis*, to produce around 6,000 50-kg sacks of charcoal per week, consuming between 120 and 300 hectares of forest each year. Following the creation of natural reserves, production was drastically reduced due to the limited availability of oaks outside of the reserves. In 1986, production still continued at a rate of 4,000 tons per year, consuming between 30 and 75 hectares per year. The species has also been logged for other purposes, initially for the constructions of bridges on the Inter-American Highway, and later for sleepers and pilings. During the 1960s, oaks were logged and exported to Europe for the manufacture of wine barrels and furniture. Currently, conservation and sustainable forestry programs exist to involve local communities in helping to protect the forest.

Photo 7/ The catkins of *Quercus copeyensis* can reach a length of 12 cm (Parque Nacional Los Quetzales).

Volcán Barva

For my final day in Costa Rica I planned a visit to Volcán Barva, a volcano at the entrance to Parque Nacional Braulio Carrillo, some 30 km north of San José. Fancisco Garín, an IOS member with extensive experience collecting Costa Rican oaks, had recommended the destination and had asked me to photograph an oak of uncertain identity he had found standing close to the entrance to the park. The approach to the park requires a 4×4 vehicle and is more like an assault on a fortified position, given the steepness of the track and its woeful state, more like the dry riverbed of a mountain stream than a road. Impressive Copey oaks are on view as one climbs to an elevation of 2,600 m. At the entrance of

Photo 8/ *Quercus copeyensis* (Parque Nacional Los Quetzales).

the park I was reminded of Baven's broomstick-borne witches with large hats, for the gnarled, mutilated, ancient oaks created a landscape that justified the "ancestral home of the gremlins" nickname.

From the entrance to the park, trails lead up towards the summit of the volcano. The upper section of the trail had received the Nate treatment and was closed, but in one of the lower ones, called Cacho de Venado (local name for *Oreopanax xalapensis*) I came across several large Copey oaks, which, unlike the ones I had seen in Dota, had recently dropped a plentiful crop of acorns. These acorns, which littered the ground, some still green, were larger than the few I had seen further south, and in fact larger than the sizes described by some authors for the species (according to Muller the acorns are about 1 cm in diameter, whereas the ones I found were more like 3.5 cm in diameter, closer to the 4 cm stated in the description in *Guide Illustré des Chênes*).

The specimen Francisco Garín had told me about has acorns that are quite different in shape, not spherical or quasi-spherical like standard *Q. copeyensis*, but elongated and tapering towards the tip. Another interesting feature is that a high proportion of these acorns germinate from the side rather than from the tip of the acorn, something also seen in *Q. corrugata*. Francisco has never encountered acorns this shape on Costa Rican oaks, and believes this may be in fact a species that has not yet been described, though it may also be a form of *Q. copeyensis* (see *Oak News & Notes*, Vol. 22, No.1, pp. 7-8).

Photo 9/ On the road leading to Volcán Barva, one can only wonder how tall this *Quercus copeyensis* that appears to have lost its top would have been!

Photo 10/ Atypical *Quercus copeyensis* acorns from a tree at the entrance to Parque Nacional Braulio Carrillo (top row) compared with typical acorns (bottom row).

Photo 11/ Large acorns litter the ground below *Quercus copeyensis* on the Cacho de Venado trail on Volcán Barva.

On Volcán Barva I made it up to Laguna de Barva, a lagoon that fills one of several craters on the volcano. From the viewing platform it was an eerie sight, partially concealed by mist that thinned, cleared, and then returned as clouds rolled past. On the way down I came across a mighty Copey oak that had met its match with Nate and now lay flat, its base by the side of the road. The massive trunk and roots formed a vertical wall that must have been about 5 m high and 8 m across, which implies that the tree's point of contact with the earth covered an area of around 40 m^2.

In the three-day sojourn in Costa Rica I had seen Copey oak in many forms: as a straight, flaky bole disappearing into a canopy obfuscated by cloud, as a lush ruby-tipped crown heavy with yellow catkins, as a seedling levitating the acorn from which it sprang, as a stag-headed declining giant, raising its gnarled limbs to the heavens in defiance, as a lord of the cloud forest poking its crown through the blanket of the jungle. And now, here an oak that had stood for centuries was summoning me to witness its final act, as it prepared to spend its last years dissolving back into the forest floor. It was as if it were inviting me to stand in the lee of its upturned buttresses, next to its core that for so many years had remained hidden to the world. Awed by the gesture, I lingered as long as I could before hurrying down to my rental pick-up and driving to the airport in time for my flight home.

Photographers. Photos 1-12: Roderick Cameron.

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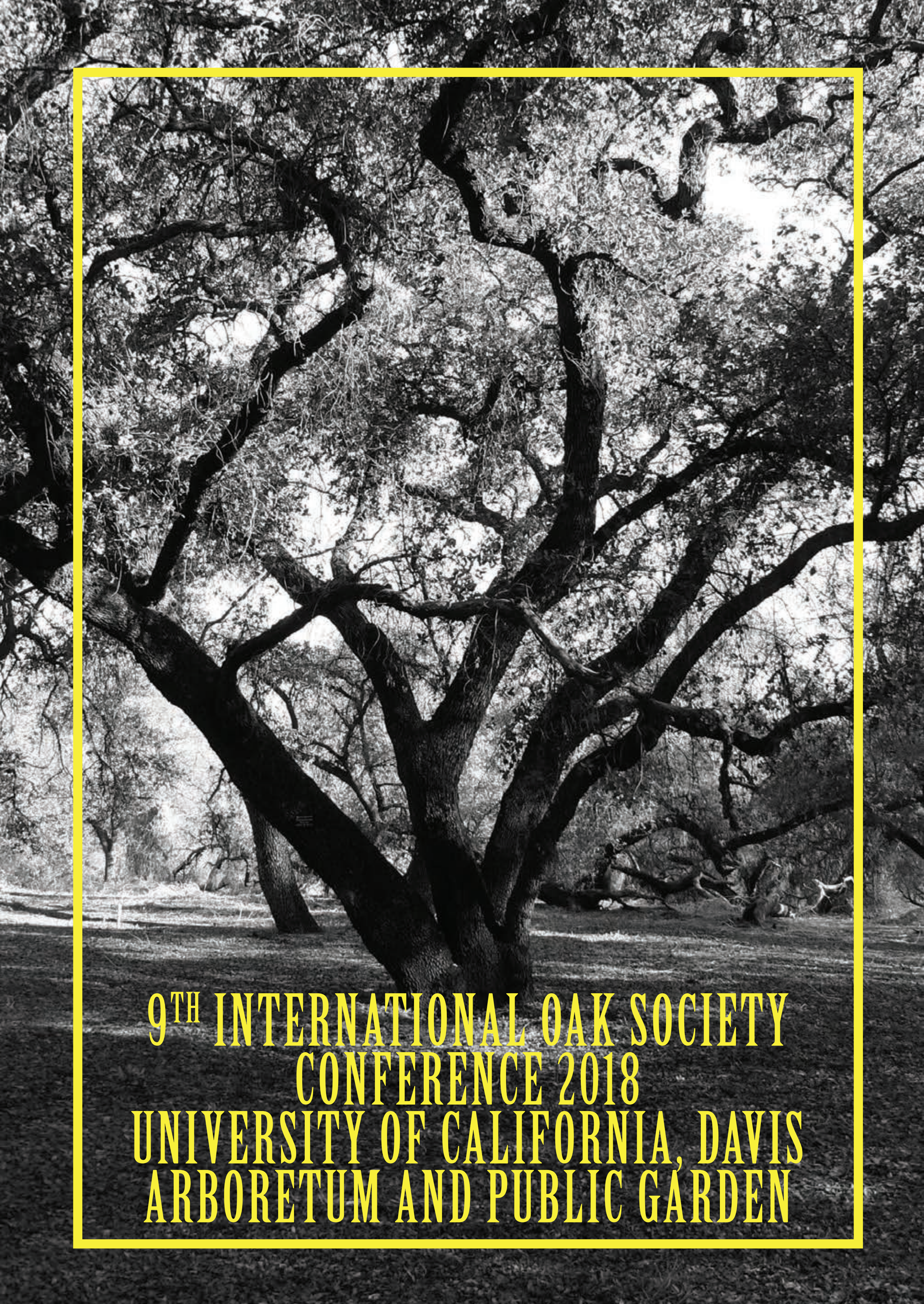
Photo 12/ Author standing in the lee of a fallen *Quercus copeyensis* on Volcán Barva.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Index of Latin Plant Names

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Conversion Table

1 mm = 0.039 in	1 cm = 0.39 in	1 m = 3.28 ft	1 km = 0.621 mi
5 mm = 0.195 in	5 cm = 1.95 in	5 m = 16.4 ft	5 km = 3.1 mi
7 mm = 0.273 in	7 cm = 2.73 in	7 m = 22.9 ft	7 km = 4.34 mi
12 mm = 0.468 in	12 cm = 4.68 in	12 m = 39.4 ft	12 km = 7.45 mi
20 mm = 0.78 in	20 cm = 7.8 in	20 m = 65.6 ft	20 km = 12.42 mi

MISSION

To further the study, sustainable management, preservation, appreciation, and dissemination of knowledge to the public about oaks (genus *Quercus*) and their ecosystems.

GOALS

To advance the state of scientific knowledge regarding oaks and oakland ecology

To locate, preserve and catalog significant oak-related literature

To facilitate the location and distribution of living material for propagation of oaks

To foster communication among members via a journal, newsletter and website, and periodic meetings

To promote the study, development, naming, and distribution of superior cultivars and cultivar groups for horticultural use, and the study of oaks for the production of timber, mast, and other useful products

To sponsor the preservation, display, and interpretation of oak-related traditions, art, and lore; and encourage the development and curation of appropriate and useful collections of oak-related pieces, such as wood samples, taxonomic specimens, or historic oak artifacts

To develop the capability and to serve as a registrar authority for oak cultivars, historic and champion oak trees, ancient oak groves, unusual or rare oak specimens, or objects of significance involving oaks

To provide information regarding the use, preservation, and appreciation of oaks, and successful techniques for oak culture and management

To encourage, recognize and honor outstanding achievements by individuals and organizations, members and non-members, in advancing these goals of the International Oak Society

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