

The status of oak breeding and domestication as food for people and livestock

In South Korea, Spain, and the United States



Eric Toensmeier
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Perennial staple crops are trees and other perennial plants that produce starch, oil, and/or protein for human consumption and to feed to livestock. Oaks are but one of many such crops, from perennial grains like kernza to chestnuts and almonds. Some are already fully domesticated and widely grown, but they need to be much more widely adopted if humanity is to stay within its carbon budget and avoid catastrophic warming. Others, like oaks, are waiting patiently for humanity's attention. Perennial crops have many additional benefits as well, from soil health to water quality and wildlife habitat. I'll be hosting a workshop on perennial staple crops at my farm in Massachusetts, USA this fall. Visit perennialolutions.org to see my upcoming in-person events and webinars.



Can the acorn take its place alongside widely-grown staple crops like hazelnuts, almonds, pistachios, walnuts, peanuts and chestnuts, as shown here? Image courtesy Joan Montserrat of BalanoTrees.

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Here I focus on the selection and breeding of oaks to feed people, livestock, and wildlife. I'm working on a whole book about Indigenous people and their curation of the ecosystems and food plants of the Eastern Forest region of North America, both before colonization and today, with chef Neftalí Durán and Dr. Courtney Lewis. There we will be exploring the past and present of Indigenous people's long and rich relationships with the oak and the acorn in more detail.

Thanks for interviews to the following: Jesse Marksohn of Yellowbud Nursery, Ricardo Romero of Las Cañadas, Lincoln Smith of Forested, Dale Hendricks of Green Light Plants, Joan Montserrat of BalanoTrees, acorn champion Lucky Pittman, Dudley Phelps at Mossy Oak NativNurseries, Ken Asmus of Oikos Tree Crops, and Buzz Ferver of Perfect Circle Farm. Thanks as well to everyone who shared photos.

Cover image: 'MASTadon' burr oak. Image courtesy Mossy Oak NativNurseries.

Oaks as crops

Oak trees are symbols of longevity and resilience. They can live for centuries. There are oaks for virtually every kind of difficult soil, for steep slopes, desert oaks and swamp oaks. They are anchors of ecosystems, serving as a source of food and habitat of critical importance for birds, mammals, insects, and fungi. For millennia acorns were the daily bread of humanity, wherever oaks grew. While our species has largely moved on to annual grains and tubers for our starch, acorns remain an important daily food in South Korea, California, and elsewhere. Climate change requires changes to food production. To avoid climate catastrophe, we must remove excess carbon dioxide from the atmosphere and store it in soil organic matter and in the living biomass of useful trees (and in long-lived products from oak wood). Meanwhile, we need ways to grow food that can handle extreme storms, drought, and heat – above all, unpredictability. Oaks could be, and already are in some places, an important tool in humanity's climate resilience toolkit.

Yet oaks have never been fully domesticated as a food plant, though Spain has come as close as anywhere. There are numerous obstacles between here and oaks becoming something like a chestnut – a tree crop that is consistently productive, bears in a few years after planting, and able to be eaten without processing.

Could oaks become an engine of food production to address the challenges of 21st century food production? Many highly dedicated people have been working for a long time to realize that dream. I decided to write this article as I was looking for the best oak cultivars to plant at my new farm. I've been hearing about oak breeding for over 30 years now, but I wanted to check in

and see where things are. What I learned is that a lot of progress has been made since I first became interested in perennial crops, and here in the US there are many more cultivars than I believed. I also took the opportunity to catch up on acorn work in South Korea and Spain, two oak cultivation hotspots. Seeing such interesting parallels and differences, it seems that it's high time for an international event where these breeders, be they government, University, nursery, or backyard enthusiast, can their share information and experience.

There's not that much information in books or online, so I interviewed some key experts. While this is the story of oak development, it's very much the story of the human "crop champions" who have carried the baton for their part of the centuries-long relay race of domesticating the oak as food.



Burr oak demonstrating tolerance of flood and fire. This species is the most common parent of US cultivars. Image Eric Toensmeier, CC BY-SA 4.0

Breeding Priorities

Oaks present many challenges to the breeder. These issues need to be overcome, and indeed there are oak cultivars that contain some of these traits, but to my knowledge it is only in Spain that we see cultivars which show them all. The biggest challenges are: waiting many years to bear acorns, producing low yields, and yielding only once every few years. Bitterness is sometimes, but not always, considered a limitation to be overcome. Keep in mind that all of these traits are relative when it comes to the cultivars currently available in the US: “high yield” may still be well below chestnuts, “annual bearing” may still be somewhat irregular, “low tannin” or “sweet” may still require leaching out of tannins, etc.



'MidMo 1' a precocious, sweet acorn, at the home of Lucky Pittman. Image courtesy Jesse Marksohn of Yellowbud Nursery.

Some traits all breeders seem to agree on.

Precociousness. First, you need to wait a long time after planting a seed to evaluate the quality of its acorns, as it will likely be many years until fruiting. White oaks can take 25 years to fruit after planting an acorn. It has taken a decade or more for Lincoln Smith's elite seedling oaks to begin bearing. Precocious trees, those which fruit at an early age, are a priority for most breeders.

Many cultivars are precocious, such as 'Midmo 1' and 'Invincible'. 'Maximus' is noted for the opposite trait, being slow to bear.

There is such a thing as too much emphasis on precociousness. Jesse Marksohn of Yellowbud Nursery tells me that relentless selection for precociousness in chestnuts has resulted in trees which bear when very young but never yield terribly well. There is apparently a tradeoff at some point. However, oaks are probably still far away from crossing that line.

High yields. Oaks typically yield less pounds of food per tree than other nut trees. Regardless of the end use for acorns, pretty much everyone wants more acorns per tree. Note that a few cultivars, including 'Dave's Giant' and 'Andrés', have been selected with low yields and great flavor, but no one thinks this is ideal. High-yielding cultivars include 'Gobbler' and 'Manna'.

Annual bearing. Most breeders are looking for trees that produce acorns every year. Some annual bearing (or close) cultivars include 'Bucks Unlimited' and 'Sweet Idaho'. Even annual bearing cultivars are not yet 100% consistent, but they are closer and produce at least some yield every year.

Other selection criteria vary depending on the goals of the breeder.

Presence of tannins. Tannins are bitter compounds present in acorns, oak leaves, and in many other plant species. Though useful (several crops are grown just to produce tannins), they make acorns unpleasantly bitter for human consumption and somewhat toxic as well. One approach is to select and breed acorns with low levels

of tannins, for eating raw or cooked. At the very least these require less processing. Among these low-tannin cultivars are ‘Dulcera’ and ‘Hershey’. For feeding livestock and wildlife, this is not nearly as much of a priority, as pigs and deer have been happily eating raw acorns for millennia. Tannins help acorns store better in the kitchen, the warehouse, the barn, and especially the forest floor, where high-tannin acorns provide winter food for wildlife. Commercial processing facilities in Asia are already set up to remove tannins, so their presence is not a dealbreaker for breeders there.

To learn about home-scale processing, check out *Nature’s Garden* and *It Will Live Forever*, both listed in the references at the end of this publication.

Sweetness and flavor. Absence of bitterness is not the only trait that matters for human consumption. Oak enthusiasts have selected cultivars with superior flavors, including ‘Manna’, ‘Nutty’, ‘Antigua’, and ‘Orta.’



Sweetness is not the only desirable trait. High-tannin acorns like these from red oak store better. Image courtesy Lincoln Smith of Forested.

Season of ripening. Breeders who focus on wildlife are also concerned with when acorns drop. This would also be a priority for people planting acorns for livestock. Cultivars have been selected for early ripening (‘ShuWillow’, ‘Early Drop’), late ripening (‘Macon’, two cultivars named ‘Late Drop’), and indeterminate ripening,

which is continuous through the acorn drop season (‘Sargent #5’).

Acorn size. We often think bigger is better, and its true larger acorns can be easier to harvest and for certain kinds of processing. Large cultivars include ‘McDaniels’ and ‘De La Campaneta’. Yet wild and domesticated turkeys cannot swallow large acorns. ‘Gobbler’ was selected for high yields of small acorns to feed wild turkeys for hunting and conservation purposes.



‘Late drop’ is a live oak with late acorns for winter wildlife (or livestock). Image courtesy Mossy Oak NativNurseries.

Ease of processing. Certain traits besides size make for easier processing. First, acorns of some cultivars come free of the cap easily. Burr oak, widely used for its large acorns, is often not great in this regard as the cap can almost encase the whole acorn in some cultivars. ‘Acornlandia 2’ and ‘Invincible’ both fall free of the cap easily.

Second, in some acorns the flesh come free of the shell easily. Some shells crack easily for ease of extracting the flesh. Some dry better than others. Ken Asmus says that some *Q. robur*, though bitter, are of very good quality in terms of these processing characteristics.

Weevil resistance. Weevil resistance is often cited, because so many acorns are lost to weevils. Interestingly, Joan Montserrat reports that in Spain it is often the bitter acorns with more weevils, rather than the sweet ones as one might think. He suspects that this is because the weevils ‘know’ that bitter acorns are less likely to be eaten. Low-weevil cultivars include ‘Acorntopia’, ‘Invincible’, and ‘Giving’. Another route would be to spray for weevils, but every oak expert I spoke to on the subject would rather see resistant cultivars developed. Jesse Marksohn says there is essentially no weevil resistance at all among chestnuts, so oak breeders have a great opportunity.



Weevils are a major pest of acorns. Fortunately many cultivars show strong resistance. Image Dorte Stokholm, CC BY 4.0.

Other priorities. Oaks are tough trees and can grow on many challenging sites. Many wildlife oaks are noted for performing in extreme conditions of one sort or another. There’s also breeding work and grafted cultivars for ornamental, timber, and functional uses (like the USDA Plant Materials Center *Q. macrocarpa* cultivars ‘Boomer’ (windbreak), ‘Ekalaka’ and ‘Lippert’ (windbreak, riparian buffer). Don Cobb suggests that working with smaller

trees and shrubby scrub oak types could be useful – ‘Manna’ is such a semi-dwarf cultivar.

No single oak cultivar could have all of these qualities. But once a breeder knows what they are looking for, they can get selective.

Breeders are working many species and hybrids. The Spanish cultivars listed here are all *Q. rotundifolia*, though some other species are under development there as well including *Q. suber*, *Q. ilex*, and *Q. faginea*. In South Korea it is *Q. acutissima* and *Q. serrata* that are the source of cultivars.

US cultivars include eight pure species, with *Q. macrocarpa* (13 cultivars) and *Q. bicolor* (5 cultivars) as the most common. US hybrids represent 28 cultivars, with the most common crosses being Bebb’s (*Q. alba* x *Q. macrocarpa*) and Schuetts (*Q. bicolor* x *Q. macrocarpa*), and the species most commonly used in hybrids *Q. macrocarpa* (9), *Q. robur* (7), and *Q. alba* (6).

Oak Breeding “Ideotypes”

An *ideotype* is the ideal form and behavior a plant breeder is looking for. It’s sort of the goalpost the breeder is aiming towards, whether selecting from wild trees, seedlings of elite trees, or doing active crosses. There’s not one oak ideotype breeders are looking for, but rather a number of different goals with associated traits.



'Ooti F1, selected by Lucky Pittman, produces large, sweet acorns. Image Jesse Marksohn of Yellowbud Nursery.

Large, sweet acorns for a ‘new’ nut crop.

This group of oaks (some of which already exist, like the grafted sweet selections of *Q. rotundifolia* in Europe), are essentially similar to chestnuts. They produce large, low-tannin acorns with good flavor, and ideally bear precociously, heavily and annually. To date no cultivars in South Korea or the US have all of these traits, but many do in Spain, including ‘Antigua’, ‘Casallana’, ‘Castanyeca’, ‘Dulcera’, ‘Finojosa’, ‘Orta’, and ‘Rozas’. The closest we have in the US is probably ‘Nutty’, itself a cross of our native *Q. macrocarpa* with the Spanish *Q. rotundifolia*.

High-yielding, annual bearing, precocious acorns for commercial processing. In South Korea and adjacent China, there are already factories which remove the tannins from acorns, and produce starch for human

consumption. Some orchards in the region produce *Q. acutissima* and *Q. serrata* for processing in these facilities. Yield, precocity, and annual bearing are far more important than low tannin for this group of cultivars. We were not able to obtain names for either the Korean or Spanish cultivars selected under these criteria, nor are they easily available here. Meanwhile the cultivars listed below for wildlife and livestock should serve the same purpose. Even sweet acorns have tannins and phytic acid. These can be toxic in several ways, including limiting your ability to digest



'Shuwater', selected by Dudley Phelps, has high tannins but is annual bearing with large acorns and high yields. A promising cultivar for oil production. Image Mossy Oak NativNurseries.

nutrients from the other foods you eat. More than one expert I interviewed suggested that even “sweet” acorns might best be processed before eating. Part of the reason is that tannins are still present in these sweeter cultivars, even if they are difficult to taste. Some acorn enthusiasts feel that all acorns should be processed before eating. Meanwhile in Europe, people have been

eating roasted (unleached) *Q. rotundifolia* for millennia, and they are sold in markets to this day. There may be differences between species.

Large acorns for deer and pigs. There are a number of cultivars moving in this direction, with 'Bucks Unlimited' likely the most developed US example. The goal for these species is high, annual, precocious yields, to attract deer and other wildlife for hunting. These cultivars are also a good choice for feeding pigs. Tannin levels are not important, though sweetness could be an asset. These cultivars would probably serve well for commercial processing as well. Cultivars that are high-yielding, precocious, and annual bearing with large acorns include 'D'en Pere Andreu' and 'Bucks Unlimited'. While some people (including the great George Washington Carver) recommend acorns for cattle and small ruminants, quite a few sheep and cows are killed every year by the gallotoxins in acorns (especially unripe acorns), so I can't recommend that for the moment. Lucky Pittman is not only an oak expert but also a diagnostic veterinary pathologist. He states: "whitetail deer and goats possess proline-rich salivary proteins which bind and inactivate tannins, allowing them to consume acorns and browse high-tannin leaves and forages with impunity. Cattle and sheep lack these proline-rich salivary proteins, and as a result 'acorn toxicosis' can be a significant concern during 'on' mast years, if these animals have access to large amounts of acorns. During my early years in veterinary practice, and the latter 30 years or so of my career as a diagnostic veterinary pathologist, I saw numerous cases of acorn toxicosis in cattle."

Small acorns for turkeys and poultry. These cultivars aim to produce high yields on a consistent basis, but with small acorns that are easily consumed by turkeys, to



Small but productive acorns of 'Gobbler'. Image courtesy Mossy Oak NativNurseries.

attract them for hunting. Such cultivars are probably also a good choice for domestic turkeys, pigs, and perhaps chickens (most acorns need to be cracked before turkeys and chickens can eat them). The standout cultivar here is 'Gobbler'.

Oaks for oil production. This is a category that does not appear to be actively under development: oaks as oil producers. Some species have high levels of oil, referred to by Sam Thayer as the 'orange flesh' group of oaks. These are characterized by small acorns and orange flesh, with oil content of 35-55%. Species suited to oil pressing according to Sam Thayer and others include *Q. nigra*, *Q. falcata*, *Q. phellos*, *Q. texana*, and *Q. imbricaria*. Some additional members of the red oak group are high in oil and worthy of investigation as oil crops. Tannins are not important, as they are removed in the oil extraction process.

No one I interviewed knew anyone working on selecting cultivars for oil, but many recommended it including both Don Cobb and Ken Asmus. However, wildlife oak

breeders have selected plus trees of oil-rich species. Their cultivars would be a good place to start for an acorn oil orchard. These potential oil cultivars include 'Behemoth' (*Q. nigra*), 'ShuWater' and 'Texas' (both *Q. nigra* x *Q. texana*), Shuwillow (a *Q. phellos* hybrid), and 'Macon' (a *Q. nigra* hybrid).

Development of oaks as oil crops might parallel the fantastic work being done on yellowbud hickory, which like these oaks is bitter but produces sweet oil.



Acorn oil pressed by Sam Thayer. Image courtesy Lincoln Smith of Forested.

Types of Breeding

Most of the US oak cultivars listed here were identified as impressive wild trees with desirable traits like sweet acorns or high yields. Oak enthusiasts collect acorns from these trees, and often grafting wood as well.

Grafting is an ancient cloning technique. A twig or bud from the tree you wish to propagate is carefully inserted into a matching cut in a seedling tree, or sometimes a mature tree which has been cut back (this is called “topworking”). The resulting tree will be genetically identical to the original tree. Grafting is used to propagate most temperate tree fruits and nut species.



A grafted selection of *Q. insignis* by Ricardo Romero of Las Cañadas, with acorns from the ortet. Image Eric Toensmeier, CC BY-SA 4.0.

The ‘Lint’ white oak is an example. This work is very much ongoing, with nursery folk headed into the woods every year to collect acorns from favored trees to grow out stock, and always looking for new cultivars. If the original tree is cloned using grafting, it is called an **ortet**. The identification and propagation of wild fruit

and nut trees is an ancient practice on every inhabited continent. We’ll see some examples below from Spain, South Korea, and the US.

Promising oaks are also found in botanic gardens and oak collections. These sometimes represent a second generation – the seedlings of excellent trees may also show desired traits, sometimes even better than their parents.

Whether they originate in the wild, on farms, or in botanic gardens, tree breeders call these elite individuals **plus trees**. Plus trees are valuable on their own as a source of grafting wood, for their seedlings, and also for their potential genetic contributions to future generations of their offspring.

Oak breeders also intentionally cross plus trees with each other, often using hand pollination. This allows breeders to choose both parents. The seedlings of these crosses need to be grown out, often for decades, until they can be evaluated. As most oaks are quite large trees, this takes a lot of time and space. Some breeders recommend grafting material from these seedlings onto mature trees to accelerate their fruiting, to reduce the wait for the first yield.

Outside of Spain, few oaks have gone through more than one or two generations of selection. Of the US cultivars, only one I know of, ‘Manna’ is a third-generation tree. Its grandparent is ‘Ashworth,’ a wild burr oak selected by Fred Ashworth of New York. It is the ortet for grafted ‘Ashworth’ trees and one parent of ‘Ashworth’ seedlings. Miguel Marquez of Texas next picked up the baton, hand-crossing ‘Ashworth’ with other selected burr oak forms. Ken Asmus grew out seedlings from

Marquez's crosses, one of which was 'Manna' – one of our very best sweet acorn cultivars and a glimpse at the future of oak cultivation.

An advantage of oak breeding is how readily the trees hybridize with other oak species.

Hybridization is when two species cross and make offspring. Sometimes these hybrids go on to become new species of their own. Oak hybrids are very common in nature, wherever two similar-enough species grow together. These hybrids are often precocious (forming acorns at an early age) and can display high diversity that offers an interesting menu to the breeder.

Spontaneous hybridization also happens in collections of oak species. In arboretums, up to half of oak seedlings are hybrids of the many species present. Breeders have worked with this desire of the trees to hybridize to develop many cultivars.

More than 20 US cultivated cultivars described below are already hybrids or two or more species. Once trees are already hybridized, it's even easier to get them to cross a species barrier the next time. In *Growing Hybrid Hazelnuts* Phil Rutter lays out a program of **neohybrid** crop development for hazels and chestnuts which could apply well here. Neohybrids are a mix of at least three species, with selection for at least six generations. Some of our wild oaks are already hybrids of three species, like 'Concordia', a naturally-occurring mix of swamp white, dwarf chestnut, and chinkapin oaks. This technique, which involves planting out multiple hybrids, and crossing them with each other, can generate new oaks with many species in their genome and thus with incredible genetic potential. If planted in an area with no other oaks present to "contaminate" with their pollen, such a hybrid oak collection would cross with itself naturally, and the seedlings would be a

random mix of hybrids with three or more species in their genes. In areas with oaks already (at least oaks likely to cross, for example in the white oak group), hand-pollination would be necessary to obtain guaranteed hybrid progeny. Hand pollination would probably be needed even in areas without other oaks, to obtain certain very desirable crosses. Neohybrids can exhibit an astonishing diversity of traits and represent a treasure trove of potential from which to select new cultivars. When wild or cultivated species growing in proximity cross with each other again and again, they form a **hybrid swarm**: a population of hybrids, interbreeding and backcrossing with their parents. This is not only a natural way new species are formed, it is also how many of our crops were developed, from corn to wheat to beans. Phil Rutter lays out a whole neohybrid tree breeding program in *Growing Hybrid Hazelnuts* that could serve as an excellent roadmap for oak breeders.



'McDaniels Burenglish' is a sweet, high-yielding hybrid oak cultivar. Inch scale. Image courtesy Lucky Pittman.

A named form of any crop is a **cultivar**, often called a "variety" informally, though this has a different meaning to botanists. A **stable cultivar** is a cultivar that breeds true from seed, so the offspring are like the parents. Most oak cultivars are not stable, though 'Bucks Unlimited' is when grown in

seed orchards, and certain oak hybrids, like Burgambel, fit this definition. Some of the oaks we are dealing with are cultivars, and some are hybrid strains and not proper cultivars, but they may in practice be similar. For example, Beadles oak hybrids (white x swamp white) tend to be low-tannin, but they are not cultivars unless singled out as individuals.

I heard a lot of different experiences with grafting oaks in my interviews for this article. John Hershey recommended a modified cleft graft. Joan Montserrat in Spain tells me that grafting *Q. rotundifolia* is rather tricky even using a hot pipe, and some cultivars cannot be grafted at all. Ken Asmus of Oikos Tree Crops says that getting at 30% success rate is pretty good. Others, like Lucky Pittman and Jesse Marksohn, tell me its rather simple (harder than apples but easier than mulberries or walnuts). Don Cobb found that after 15 years, 80% of his grafts failed due to graft incompatibility, and recommends grafting onto seedlings of the ortet. Meanwhile Ken Asmus has seen little or no graft incompatibility after 30 years. I suspect the great diversity of oak species and their hybrids may be behind these inconsistent reports, as all of these growers are highly skilled grafters. For example, swamp white oak has a reputation for being easy to graft compared to other oaks. Mark Coggeshall trialed many combinations of seedling rootstock provenance (population of origin) and grafted cultivar in the process of developing 'Bucks Unlimited'. He found that rootstock provenance made no difference on the performance of the tree. Buzz Ferver says that in some cases it is much better to use two-year-old scionwood. He says "on mature oaks that bear heavily, the one-year-old scion wood can be very, very small. Two-year wood is easier to graft in this case". He also reports that it is quite easy to topwork existing trees, and that this

is a much more successful technique than bench grafting in pots in the greenhouse. Finally, he clarifies that oak grafting should be performed when it is warm out and the rootstocks have already leafed out.

Hand pollination is quite complex. Techniques were worked out by Miguel Marquez, and I refer the reader to his article "Storing viable oak pollen".

Oaks in Spain

If you want to fast forward a few centuries to see what US oaks might look like as a crop, visit Spain. I was fortunate to speak to Joan Montserrat of BalanoTrees, a Spanish nursery specializing in grafted sweet oaks.



A grafted oak in Mallorca, where this is an ancient tradition. Image courtesy Joan Montserrat of BalanoTrees.

We begin on a Mediterranean island, the Spanish state of Mallorca. This may be the only place in the world where the use of grafted oaks in agriculture is an ancient tradition (as described in *Tree Crops: A Permanent Agriculture*). They have been used to feed people and pigs there for untold centuries. Yet even there, cultivars were being lost. Some 15 cultivars have been collected and propagated there by the Associació de Varietats Locals de Mallorca (an heirloom crop organization), the best of which are described below. Unfortunately at the moment these can't be exported due to

presence of *Xylella fastidiosa*, a disease pathogen that attacks many crop plants.

The oak species grown in the region is the holm oak or *encino* (*Q. rotundifolia*, formerly *Q. ilex ballota*). In *The Carbon Farming Solution* I described this species as basically already fully domesticated. Since then, and in conversation with Joan, I've learned that while there are outstanding individual trees that meet all the criteria we want, they have been neglected and many of the best are lost. So while Spanish acorn crop champions are way ahead of the US in terms of the raw material available, they have a major task of preserving and propagating plus trees ahead of them.

In mainland Spain the use of sweet oaks has been in great decline through the 20th century. There it is seedlings rather than grafted trees that have been the emphasis (Smith describes some oak grafting in mainland Spain and Portugal). Joan's emphasis has been on collecting the best of what's out there. He traveled to Mallorca to learn oak grafting techniques. His goal is to rescue and propagate the best plus trees. These superior individual seedling trees across Spain are often locally known by individual names. Joan has visited some 200-300 of these plus trees. Each is evaluated for flavor both raw and roasted. Yield and annual bearing are also evaluated. Joan has a small nursery propagating 1,000 grafted trees per year of elite cultivars (listed below). Currently their limitation is scionwood availability.

First and foremost they are selecting for flavor, and secondarily for yield and annual bearing. Many are less bitter but not necessarily sweet – these insipid oaks are not a priority. Another issue: some cultivars won't graft, while others will.

Joan says that sweetness in acorns is actually a combination of a) low levels of bitter tannins, and b) the presence of sugar and other good flavorings. Drying for 2-5 weeks helps them become sweeter, a process called *avellanamiento* in Spanish, meaning “becoming more hazelnutlike”. These sweet acorns last some 5 months in the refrigerator. Joan notes that most of the largest, sweetest acorns are from the southern region of Spain. Some are bitter raw but sweet when roasted. Some are not bitter but are insipid. Some are too greasy. He says there are many layers to flavor besides bitter and sweet – a thought echoed by Ken Asmus and others in the interviews for this article. I would have thought that the sweet acorns had more weevils, but he has observed the opposite. He speculates that weevils choose the more bitter acorns as they are less likely to be eaten by wildlife or livestock. Eliza Greenman of The Plant Hunters came to sample these acorns in Spain last year, and said that the best sweet oaks from the US were almost as good.

Researchers in Spain have begun work on an ambitious program to identify and propagate elite oaks. These trial orchards are pruned as hedges for intensive, mechanized production using modified grape harvesters. The acorns produced will be for production of high-value pork in the form of *jamon iberico*. They began collecting elite cultivars in the early 2000s. They have selected and grafted cultivars of *Q. suber*, *Q. ilex*, *Q. faginea* and some hybrids. They also report that grafting *Q. ilex* on *Q. faginea* gives better results than on *Q. ilex* itself. Their test planting was laid out in 2012, and as of 2017 contained over 2,000 grafted trees. Several other groups are working to identify and propagate superior oaks in Spain including Junta de Extremadura (in Extremadura), and Quercus Real. I was not able to obtain

names or descriptions of these cultivars for this article.



Roasted acorns of *Q. rotundifolia* ready to eat. Image courtesy Joan Montserrat of BalanoTrees.

Oaks in South Korea

In South Korea large amounts of acorns are consumed each year (one to two million tons annually as of the 1990s, and increasing today). The government began breeding work in 1950s. They collected scionwood from plus trees of *Q. acutissima* and *Q. serrata* and established clonal seed orchards. The goal was to produce superior seedlings from known parents (this is the same technique used to produce ‘Bucks Unlimited’ seedlings in the US).

Nevertheless, oak orchards have not become popular, and the great majority of acorns consumed today in South Korea are still wild-harvested and sold to processors.

Large commercial processing facilities in South Korea and China remove tannins and prepare acorn starch for making *dotorimuk*, a popular acorn dish. Because of the existence of these factories, sweet acorns are not a breeding priority. Instead, high and consistent yields are the goal.

Among other research topics, scientists there have determined genetic markers that are correlated with high yields. This enables testing of seedling progeny to see if they will be high yielding without having to wait until they fruit.

I was unable to obtain names or descriptions of these cultivars for this article. They are maintained by the Korea Forest Research Institute.



*Dotorimuk, a popular acorn-based food in South Korea.
Image CC BY-SA 4.0.*

Oaks Breeding Elsewhere

Several improved cultivars of *Q. insignis* have been selected and offered as grafted plants by Ricardo Romero of Las Cañadas in Mexico. This species has enormous acorns the size of a tennis ball. Tannins are high, and yields are relatively steady year to year. These cultivars are as yet unnamed, and are selected from wild plus trees in the area. I have had several opportunities to sample these acorns, and they tasted about the same as the average acorn from the US: starchy and a bit nutty after leaching. They are truly enormous, but the shells are fairly thick.

Spain is not the only place in Europe with acorn crop champions. Joan Montserrat points to commercialization efforts like Freixo do Meio in Portugal and Marcie Mayer's Oakmeal in Greece (where not only are they processing wild-harvested acorns, but also exporting 100 tons of caps annually for tannin extraction).

In the UK, Martin Crawford of the Agroforestry Research Trust has selected low-tannin forms of *Q. ilex* from local trees in southern England. He has a trial orchard of seedlings of these sweet cultivars of *Q. ilex* and other species including a number of US hybrids.

Q. brantii is cultivated in Kurdish regions of Iraq and Turkey. I was unable to find much information on its cultivation, or any on the cultivars used.

Do please let me know if you are aware of work breeding oaks to feed people, livestock, or wildlife elsewhere in the world.



Q. brantii, cultivated in Kurdistan. Centimeter scale. Image Aso, CC BY-SA 4.0.

Oaks in the US

As mentioned above, this is not an article about historic Indigenous oak and oak landscape curation in the US, but a bit needs to be said to set the context, because J. Russell Smith (a great inspiration to myself and many others) was far from the first to think of selecting the best oaks in North America.

In fact, there's some evidence that oaks, along with other nuts, moved north after the glacier receded quite a bit faster than they could have on their own. One theory is that Indigenous people helped these tree species by repeatedly carrying acorns north and planting them, some 8,000 years ago. The same phenomenon has been discussed with hazelnuts in post-glacial Europe.



A restored, fire-managed oak savanna in Wisconsin. These productive landscapes were much more common under widespread Indigenous landscape curation before colonization. Image Eric Toensmeier, CC BY-SA 4.0.

Indigenous people identified plus trees and cared for them by weeding, removing competing trees, burning to control weevils and diseases, and planting their acorns in new places. There's some evidence that live oaks (*Q. virginiana*) were being grown in orchards in the Southeast at the time of colonization.

Some oak ecosystems depended on Indigenous landscape curation, like controlled burns. In fact, some of these productive oak landscapes, like the Midwestern oak savanna and some California ecosystems, disappeared with fire suppression and the loss of Indigenous sovereignty over their traditional lands. This sophisticated ecosystem curation not only ensured acorn yields but also increased availability of game, wild vegetables and berries, and some mushrooms. See the USDA guide *Indigenous Uses, Management and Restoration of Oaks in the Far Western United States*, and the comprehensive *Tending the Wild: Native American Knowledges and the Management of California's Natural Resources*.

These relationships between oaks, oak landscapes, and Indigenous people continue as an unbroken tradition in parts of California and surely elsewhere in the country as well.

Julia Parker reports that relationships with individual plus trees were handed down from one woman to another well into the 20th century in *It Will Live Forever: Traditional Yosemite Indian Acorn Preparation*. I can't count the number of times I've read that Indigenous people "used to" perform certain activities, only to learn years later that these practices continue strongly today in their communities, so I assume this practice continues today.

Modern oak breeding work in the US goes back at least a century. George Washington Carver was an early advocate of acorn utilization for livestock feed in his 1898 article "Feeding acorns". Carver wrote "I know of no wider and more valuable field for experimentation than... a thorough test of their [acorns] feeding value..." He noted that the species with smaller acorns are less

prone to sprouting in storage, and more resistant to weevils as well.

J. Russell Smith's *Tree Crops: A Permanent Agriculture* was first published in 1927, and laid out a program for developing US oaks to the standard set by the Spanish *Q. rotundifolia*. His vision has not yet come to pass here, but he has been a great inspiration to many 20th and 21st century crop champions. He may have been a bit overenthusiastic about how long such a breeding project would take. He wrote "I am confident that in every county there are oak trees of such productivity that if made into orchards they would in any decade yield more food for beast and possibly for man than has been obtained on the average in any country in any similar period on the hill farms of this wide region." This has certainly not been shown to be true as yet, but to be fair it has never been attempted in any well-funded way. Smith made many plantings of tree crops, and Buzz Ferver and other contemporary acorn and tree crop champions have visited to evaluate and collect.

A national contest in the 1930s asked contestants to send in the sweetest acorns from local plus trees. The winner for white oaks was 'Lint'. Eliza Greenman and Taylor Malone of The Fruit Explorers recently tracked down the ortet, still alive 90 years later. They plan to offer grafted trees in the near future. Meanwhile Ken Asmus has selected 'Dynamo', a high-yielding hybrid descendent of 'Lint'.

Eugene Cottam was an early US oak breeder, who hybridized many oak species, working with Rudy Drobnick. Cottam helped develop Burgambel hybrids, and selected the wild burr oak whose seedling is the cultivar 'Giving'.

More than 100 of his hybrids are still growing in "Cottam's Grove" at the Red Butte Garden and Arboretum in Salt Lake City, and others are planted all over the University of Utah campus. The Arboretum listing, accessible online, includes many hybrids of western oaks including some with great importance as food. Burr oak is partly or fully the parent of more than half of all US acorn production cultivars, and the Cottam Grove contains Cottam's crosses of burr oak with many western native oaks. There are crosses of burr oak with California blue oak (*Q. douglasii*), California black oak (*Q. kelloggii*), California white oak (*Q. lobata*), interior live oak (*Q. wislizenii*), and shrub live oak (*Q. turbinella*). There are of course many Burgambels as well.

The Cottam grove also contains hybrids of western oaks crossed with each other. These could save western oak enthusiasts a lot of time in getting started. There are hybrids of shrub live and interior live oak, shrub live and valley oak (*Q. lobata*), and more. Many of the hybrids in the collection are of unknown parentage, but surely worthy of close examination.



A Cottam hybrid of cork oak (*Q. suber*) and the western native *Q. turbinella* at Cottam Grove in Utah. Image Andrey Zharkikh, CC BY 2.0.

John Hershey was active from the 1920s through 1960s, and working on a number of tree crops. He organized national contests for the best acorns, probably including the acorn contest won by 'Lint'. Much of what

was once his Pennsylvania farm is now suburbs, but many of the trees still stand. In the past few years a number of nut and fruit enthusiasts, including oak crop champions, have been collecting seed and scionwood from the mature plus trees. Dale Hendricks of Green Light Plants tells me that while some of these cultivars are already available (like 'Hershey'), there are many more waiting to be released. Buzz Ferver of Perfect Circle Farm is propagating many of these elite oaks including the 'CDS' series. He tells me that often when they return to a tree to collect seed or grafting wood, they have been cut down.



Grafted oaks from the Hershey planting in Downingtown PA. Image courtesy Jesse Marksohn of Yellowbud Nursery.

Louise Bugbee was an associate of Hershey. She planted a number of his grafted selections of oaks and other species at the Louise W. Moore State Park in Pennsylvania.

In the last line of the excellent article "Exploring North America's oldest food forest" is a link to a remarkable archive of old articles by and about Hershey, among many other nut and acorn articles. These were scanned and assembled by Eliza Greenman and Taylor Malone.

Miguel Marquez was a Northern Nut Growers Association (NNGA) member and

a key crop champion for the oak. Miguel began his work in the 1950s. He developed techniques for pollen storage and hand pollination described in his article "Storing viable oak pollen" in the Journal of the International Oak Association. He selected superior wild trees like the 'Bing' burr oak, and made many controlled crosses including a number of Burgambel hybrids. 'Manna', among our top North American sweet acorn cultivars, is a seedling from one of Miguel's crosses. He also crossed burr oak with the sweet Spanish *Q. rotundifolia*, giving us the delicious 'Nutty' cultivar. He corresponded closely with Ken Asmus, who has taken Miguel's work another generation of selection further. They exchanged acorns, and Ken tells me that acorn exchanges were common among oak enthusiasts in that period, and that he still does some exchanging today.

The NNGA has long featured an oak subgroup. I had the good fortune to interview Don Cobb, who headed this subgroup for many years. He has selected many plus trees over the years including collecting acorns from a Cornell collection (perhaps the legendary McDaniels grove?), which grew into the elite cultivars 'Cobb's Sweetie #2" on the farm of Lucky Pittman. Don collected acorns and grafting wood across the US and in Europe, but perhaps his most lasting contribution is inspiring and organizing a generation of oak breeding enthusiasts.

'Gobbler' sawtooth oak was developed by the USDA Quicksand Plant Materials Center as a wildlife food tree. It has high yields of small acorns for wild turkeys, and pest and disease resistance. It's one of the most widely available cultivars from wildlife nurseries today. Sawtooth oak is starting to turn up on invasive species lists, and some people think it's a bad idea to plant

‘Gobbler’ for wildlife when there are so many good native oaks. It’s worth considering that the non-native oak cultivars listed here could certainly hybridize with native oaks – indeed that’s how some of them, like Burenglish oak, came about in the first place. If conservation is your prime goal, we have many native cultivars to choose from. Yet for truly domesticating the oak, hybridizing with Eurasian oaks is already proving fruitful.

Ken Asmus of Oikos Tree Crops has been one of the leading champions of oaks in the US for decades. He has selected many cultivars and shipped out thousands of seedlings of plus trees, including a great many hybrid trees.

Ken described some changes he has seen during his thirty years of work on oaks. One is that the orthodoxy that only species in the white oak group are low in tannins, which was shattered by wild edibles author Sam Thayer. Not only are some in the red oak group low in tannins, but many are high in oil. Lincoln Smith of Forested primarily uses red oaks for his acorn flour product. They must be leached but they store much better. Another change is that USDA at last allows processed acorn flour as a food ingredient, removing a barrier to commercialization. Ken also describes a huge decline in wild acorn harvesting during his lifetime, yet notes that few acorn orchards have been planted. A final change is a wave of interest in breeding for wildlife, especially by deer hunters, rather than only a search for the sweet acorn for human consumption. I describe several such efforts in a few paragraphs.

Ken says sometimes heavy bearing is bad. It can cause trees to take many years off from production to recover. Some of his trees have even died after an especially high yield

(I’ve heard this from Phil Rutter about extreme chestnut yields as well).

Apparently, there is a ceiling breeders should not push through. He suggests that annual bearing with high but reasonable yields may be a better goal. Ken also notes, as others have, that biennial bearing is acceptable if you have a diversity of cultivars in your orchard so that some are always bearing in any given year.

Ken thinks several things are needed. One is planting orchards of the best grafted cultivars and crossing them with each other (ideally where there are no other wild oaks that might cross with them, but controlled hand crosses could still work). This could be a route to neohybrid oaks, as so many cultivars are already hybrids of two species. He would also like to see plantings of seedlings from the best trees, and of acorns from controlled crosses. New cultivars could be selected from such plantings, as was the case with cultivars like ‘Cobb’s Sweetie’. He notes that it can take 30 years to properly evaluate an oak seedling, but the process can be sped up by grafting scions from the seedlings onto mature trees. As for what’s next, Ken is doing demonstration events with chefs to increase interest in acorn consumption among the public. He feels that chefs are important advocates, and people are paying much more attention to them than to plant breeders so its wise to get chefs excited about acorns.

Lucky Pittman began with an interest in oaks for wildlife, and moved into edible oaks after being influenced by Don Cobb and Ken Asmus. One of his early projects was developing large acorns. Lucky says processing large acorns is easier, and while standard oaks might have 100 acorns per pound, large burr oaks and hybrids can have 25-60 acorns per pound, and elite southern cultivars of burr oak as little as 6-8 acorns

per pound. Jesse Marksohn and Eric Cornell of Yellowbud Nursery visited Lucky recently at acorn season. They sampled many cultivars and identified the sweetest forms including ‘Cobb Sweetie #2’, ‘MidMo 1’, and ‘Ooti F1’. Lucky describes some of his Bebbbs and Humidicola hybrids as sweet with a “crispy crunchy” texture like water chestnuts.

Lucky notes that growing conditions, not just genetics, change tannin flavors. He believes that storage is key, and the white oaks don’t store as well. He’d like to see people breeding for oil production, and tells me that some people are getting paid to gather oil-rich acorns for small-scale commercial oil pressing.

Buzz Ferver of Perfect Circle Farm nursery was inspired by John Hershey’s work. Ferver’s goal is to collect and preserve the cultivars selected by Hershey and other breeders, because humanity needs the domesticated oak for food and livestock feed. His nursery is one of very few that offers grafted acorn cultivars.

In recent decades much of the breeding work, and planting of improved oaks, is driven by people interested in wildlife, including hunters, conservationists, and hunter/conservationists. Many are hunters looking to attract and increase populations of deer. I spoke to Dudley Phelps of Mossy Oak NativNurseries, who offer a great diversity of wildlife oaks including many hybrids. He has been working with these oaks for 25 years now, trekking deep into the forests across the South to find the best wild plus trees, especially naturally-occurring hybrids.

Dudley thinks the focus on low tannins can be misleading, as high tannin acorns keep better in storage and last longer on the forest

floor, being eaten later in winter by hungry animals. He also fears that annual bearing, though he is selecting for it, could lead to greater weevil damage. Among the other traits he likes are late acorn drop, early acorn drop, indeterminate acorn drop ongoing ripening and dropping over a long period from a single tree). He says precociousness is the top request he gets from customers.

A University of Missouri Horticulture and



Shibu Jose and Marc Coggeshall with 'Bucks Unlimited', which they developed through University of Missouri Horticulture and Agroforestry Research Center. Image Mizzou CAFNR, CC BY-NC 2.0.

Agroforestry Research Center breeding project led by Marc Coggeshall set out to select swamp white oak for wildlife for hunters and conservation. Unlike ‘Gobbler’ (and the many hybrids sold for wildlife), swamp white oak is native to much of the US and thus more desirable for conservation in the eyes of many. They selected four grafted plus trees from a population of selected trees, planted out in a grafted seed orchard. Seedlings from this orchard of grafted plus trees are uniformly similar to their parents. Some bear acorns just 3 years from seeding, a very impressive level of precociousness. ‘Bucks Unlimited’ is precocious, with 75% of seedlings bearing by six years of age. Yields are high, bearing is consistent from year to year, and ripening

is over a gradual period which is ideal for hunting (and for livestock).

'Bucks Unlimited' is a great choice to attract deer for hunting, and likely a great choice for pigs as well. There's every reason to assume that the acorns are suitable for processing, so this may represent the state of the art for leached acorn starch production in the US as well. More broadly, the breeding process used shows what a modest amount of funding and University support can do for developing new oak cultivars, and serves as a good model for many kinds of oak breeding efforts.

It could be noted that there is a lack of Californian and other western native oaks on this list. I was unable to find evidence of cultivars of any of these very important edible acorn producers for sale or in exchanges. Nonetheless the plus trees certainly exist.

Cultivars

I've assembled a listing of cultivars, with descriptions. These represent what's available, but are not the end of the story. Specialty nurseries and acorn crop champions have been distributing grafted and seedling plants for over a century in the US, and many thousands of these trees are growing across the country. They, and their seedlings, are out there. Perhaps among them are the best oaks for the next generation of breeding. That's not to mention the wild plus trees living among the millions of oak trees in our forests and savannas, just waiting for us to notice them.

In Spain, it's more a matter of collecting the best of what's out there, which breeders there have only begun to do. I look forward to learning more about what's happening in South Korea, and in other parts of the world as well. I hope this article inspires you to plant a few (or a whole orchard) of these extremely promising, still imperfect, magnificent trees.

For readers in the US, I imagine some of you are primarily interested in species native to your region. Tables at the back of this publication list the continent of origin of species and hybrids from which cultivars are selected.



'Ashworth' seedlings at New England Small Farm Institute in Massachusetts, USA. Planted as part of state-funded "Fruition" project in 1970s. Many thousands of seedlings of oak cultivars have been planted, the challenge is to find and evaluate them. Image Eric Toensmeier, CC BY-SA 4.0.

Spain – All Cultivar Types

‘Andrés’ (*Q. rotundifolia*). Very large acorns up to 2’ long. Very sweet, flavor similar to chestnut. Low yielding, but annual bearing. Selected in Andalucía by Joan Montserrat.

‘Antigua’ (*Q. rotundifolia*). Very large acorns up to 2’ long. Very sweet with excellent flavor. Annual bearing, high yields. Selected in Andalucía by Joan Montserrat.

‘Casallana’ (*Q. rotundifolia*). Sweet acorns, high yielding, annual bearing. Selected in Extremadura by Joan Montserrat.

‘Castanyeca’ (*Q. rotundifolia*). An ancient grafted cultivar from Mallorca, Spain, with sweet acorns similar to chestnuts (thus the name). One of the three most popular cultivars in Mallorca. It may be that several distinct clones all go by this name. Currently unable to export from Mallorca due to presence of the disease *Xylella fastidiosa*.

‘De La Campaneta’ (*Q. rotundifolia*). Large acorns, one of the top three sweet, heirloom grafted cultivars in Mallorca. Low-tannin, small acorns, but low yielding as well. Currently unable to export from Mallorca.

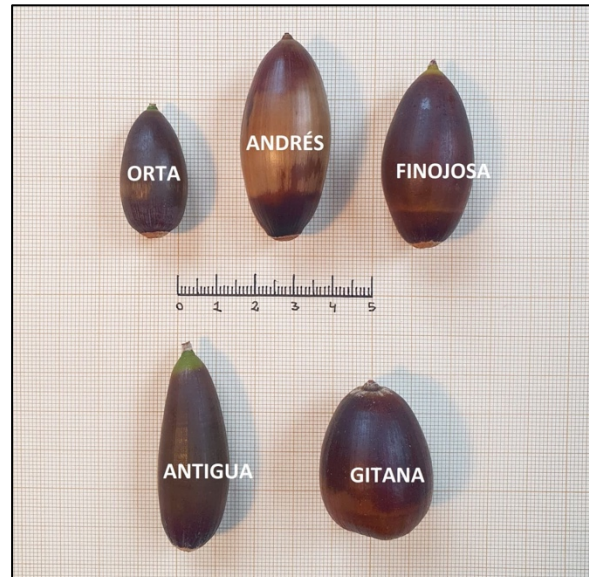
‘D’en Pere Andreu’ (*Q. rotundifolia*). Another of the top three ancient grafted cultivars of Mallorca. Low-tanning, but not sweet. High-yielding, used for livestock. Can’t be exported at present.

‘Dulcera’ (*Q. rotundifolia*). Sweet acorns, high yielding, annual bearing. Selected in Extremadura by Joan Montserrat.

‘Finojosa’ (*Q. rotundifolia*). Similar to ‘Andrés’, acorns a bit smaller, a but less sweet. High yielding, annual bearing. Selected in Andalucía by Joan Montserrat.

‘Orta’ (*Q. rotundifolia*). Acorns 1¼ inch, a good balance of sweet and bitter flavors, similar to chocolate or sweetened coffee. High yielding. More cold-tolerant than most of this species. Selected in Catalonia by Joan Montserrat.

‘Rozas’ (*Q. rotundifolia*). Sweet acorns, high yielding, annual bearing. Selected in Extremadura by Joan Montserrat.



Spanish cultivars, with centimeter scale. Image courtesy Joan Montserrat of BalanoTrees.

United States – Sweet Cultivars

‘Ashworth’ (*Q. macrocarpa*). Selected by the great Fred Ashworth many decades ago for its low-tannin acorns, high yields, and precocious nature. Many sources offer seedlings of ‘Ashworth’ but it is occasionally available as a grafted plant as well.

‘Bing’ (*Q. macrocarpa*). A low-tannin burr oak selected from a wild tree in Texas by Miguel Marquez.

‘CDS 1’, ‘CDS 2’, ‘CDS 3’. (*Q. macrocarpa*, *perhaps hybrids*). Grafted trees from the old Hershey farm, now a suburban cul-de-sac (thus “CDS”). Sweet acorns, not particularly larger. ‘CDS 1’ is similar to ‘Ashworth’ and may in fact be the same clone.

‘Cobb’s Sweetie’ (*Q. bicolor*). Low-tannin sweet cultivar, selected by Don Cobb from a Cornell planting. He says it the sweetest he has even eaten, but has somewhat low yields. Could be interesting to cross with ‘Bucks Unlimited’ to create a high-yielding sweet *Q. bicolor*.



‘Dale’s Giant’ is a large acorn burr cultivar. Image courtesy Buzz Ferver of Perfect Circle Farm.

‘Dale’s Giant’ (*Q. macrocarpa*). Selected by Buzz Ferver of Perfect Circle nursery from the farm of the great Dale Hendricks. Large acorns, but not particularly high yielding.

‘Fall Creek #1’ (*Q. bicolor*). Low-tannin, sweet acorns selected by Don Cobb from a Cornell planting.

‘Fall Creek #3’ (*Q. bicolor*). Low-tannin, sweet acorns selected by Don Cobb from a Cornell planting.

‘Hershey’ (*Q. macrocarpa*). Grafted trees available. Low-tannin, high yield. A number of other trees from the old Hershey plantings



‘McDaniels Burenglish’. Image courtesy Buzz Ferver of Perfect Circle Farm.

‘Lint’ (*Q. alba*). Winner of national contest for the best white oak acorns in the 1930s. Eliza Greenman and Taylor Malone of The

Fruit Explorers recently found the original 'Lint' oak (identified as a superior tree and propagated by Ralph Kreider many decades ago) and plan to release grafted trees soon.

'Manna' (*Q. macrocarpa*). Low-tannin, high yield, outstanding flavor. Annual bearing. Scionwood and acorns available. A cross of 'Ashworth' and other *macrocarpa* cultivars selected by Ken Asmus from crosses by Miguel Marquez. Semi-dwarf.

'McDaniels Burenglish' (*Q. macrocarpa* x *Q. robur*). High yield, low tannin, very large acorn. Lucky Pittman says this is the first one the deer go for every year.

'MidMo 1' (*Q. macrocarpa*). Low-tannin, high-yield, precocious. Selected by Lucky Pittman. 'MidMo #2 is another excellent selection.



'MidMo 2' is a Lucky Pittman selection. Image courtesy Buzz Ferver.

'Nutty' (*Q. macrocarpa* x *Q. rotundifolia*)
A rare cold-hardy hybrid of burr oak and the Mediterranean sweet *encino* oak, with *encino* as the parent tree. A Ken Asmus selection from a Miguel Marquez cross. Scions and acorns available. Low-tannin, outstanding flavor, weevil resistant. My grafted tree flowered in the pot, so it is certainly precocious.

'Ooti' (*Q. alba* x *Q. macrocarpa*). Low-tannin, high yield, large acorns. 'Ooti F1' is an elite sweet seedling of 'Ooti' selected by Lucky Pittman.



'Ooti F1'. Image courtesy Jesse Marksohn of Yellowbud Nursery.

'Sweet Idaho' (*Q. macrocarpa*). Low-tannin, annual bearing.

'Sweet It Is' (*Q. alba* x *Q. macrocarpa*). A Ken Asmus sweet acorn selection, with scions and acorns available. Low-tannin, precocious.

'William Penn' (*Q. alba*). A sweet white oak formerly offered by John Hershey's nursery. He called it "the corn fields of the future".

United States – High Yielding Wildlife, Livestock and Processing Cultivars

‘Acornlandia 1’ (*Q. alba* x *Q. robur*).
Selected by Ken Asmus from Bimundors oaks, hybrids of white and English oak that often arise where they grow together. Highest yield of any oaks at his farm – and he has about as good a collection as anyone in the country. Biennial bearer. Medium sized acorns.

‘Acornlandia 2’ (*Q. alba* x *Q. robur*).
Another Ken Asmus selection. Very high yield, biennial bearing. Large acorns, weevil free, drop free of the cap.

‘Acorntopia’ (*Q. montana* x *Q. robur*). A Ken Asmus selection. Large acorns, low weevil damage.

Beadles oak (*Q. alba* x *Q. michauxii*).
Beadles oaks are hybrids of white and swamp chestnut oaks, not a cultivar. A seed strain for wildlife is collected from a wild plus tree, a natural hybrid, by Dudley Phelps. Large acorns, high yield, precocious. Ken Asmus was surprised by the low-tannin acorns of his Beadles strain. No named cultivars to my knowledge.

‘Behemoth’ (*Q. texana*). High yields, small acorns, late drop. This may be a good cultivar for oil production. Seed originally from Arkansas. Selected by Ken Asmus.

‘Big Bear’ (*Q. alba* x *Q. macrocarpa*). A Bebbs oak cross, large acorn, relatively low tannin, high yields. Wildlife type.

‘Bodacious’ (*Q. alba* x *Q. macrocarpa*). A hybrid seedling strain selected to attract and feed deer. High yielding, precocious, and annual bearing or close. Selected from an elite wild tree by Morse Outdoors.

‘Bucks Unlimited’ (*Q. bicolor*). The result of a breeding program for wildlife, and represents a very high level of breeding work for a US oak. High yield, precocious, annual bearing. Not low-tannin. Seedlings from a grafted seed orchard available from several sources.

Burgambel oak (*Q. gambellii* x *Q. macrocarpa*). Not a cultivar, rather these are hybrids of burr and Gambel’s oak, noted for being fairly uniform and of good quality. Low-tannin, high yield, precocious. Not annual bearing. Oikos plans to release improved selections which originated from Cottam and Miguel Marquez crosses.

‘CDS 4’ (*Q. macrocarpa* or *hybrid*). Fourth in the series of Hershey selections. Not sweet like the others, but very large acorns and five to ten times higher yield.

‘Chinkaburr’ (*Q. macrocarpa* x *Q. muehlenbergii*). Wildlife type. High yielding, precocious.

‘Cobb’s Japanese White Oak’ (*Q. acutissima* x *Q. robur*). Heavy producer, not low tannin.

‘Cobb’s Robur’ (*Q. robur*). High yield, not low-tannin, precocious. Collected from a tree in Germany at an ancient archaeological site by Don Cobb.

‘Compton’ (*Q. lyrata* x *Q. virginiana*). A wildlife seed strain selected from a wild natural hybrid by Dudley Phelps. Large acorn, high yield.

‘Concordia’ (*Q. bicolor x muehlenbergii x Q. prinoides*). A natural three-way hybrid, selected from the wild by Morse Outdoors. Precocious, somewhat low-tannin, planted for wildlife.

‘Dynamo’ (*Q. alba x Q. macrocarpa*). A seedling of ‘Lint’ selected by Ken Asmus. Scionwood and acorns available. High yield, precocious.

‘Early Drop’ (*Q. gambellii x Q. macrocarpa*). Selected for early dropping acorns for wildlife by Morse Outdoors. Also precocious. Somewhat low tannin.

‘English Wide Hybrid’ (*Q. robur hybrid*). Low-tannin, high yield, precocious, annual bearing.

‘Exclamation Point’ (*Q. bicolor x Q. robur*). A columnar form with high acorn yields, selected by Ken Asmus.

‘Giving’ (*Q. macrocarpa*). High yielding, small acorns, biennial bearing, acorns come free of cap easily. Short-season, weevil-free. Not low-tannin. Selected by Ken Asmus from seedlings of a wild tree selected by Eugene Cottam in Utah.

‘Gobbler’ (*Q. acutissima*). Small acorns for wild turkeys and poultry. Good pest and disease resistance. Seedlings available for \$2.50/each. High yield, annual bearing. High in tannins.

‘Invincible’ (*Q. macrocarpa x Q. robur*). Large acorn, weevil-free, high yield, precocious. Not low-tannin. A seedling of ‘McDaniels’ selected by Ken Asmus, which may also have some *Q. alba* in its genetics. Scionwood and acorns available.

‘Jumpin’ Jack’ (*Q. alba x Q. bicolor*). Precocious, relatively low tannin. Wildlife type.

‘Kimberly’ (*Q. bicolor x Q. macrocarpa*). Wildlife type with high yield, averaging 100lbs of acorns per tree each year.

‘Kreider’ (*Q. macrocarpa*). High yield, low weevils. Selected by Ken Asmus from Midwestern seed collected by Ralph Kreider.

‘Late Drop’ (*Q. virginiana*). Relatively low tannin, noted for ripening 4-6 weeks later than most live oaks, desirable for winter wildlife (and livestock) feeding. Seedlings precocious. Selected from wild tree by Dudley Phelps.

‘Late Drop’ (*Q. gambellii x Q. macrocarpa*). A Burgambel selection for wildlife from Morse Outdoors. Precocious, high yielding, late ripening.

‘Macon’ (*Q. palustris x Q. texana*). Grown for wildlife, ripe acorns hold on tree all winter even into March and April. *Q. texana* is a good oil producer.

‘Major’ (*Q. montana x Q. robur*). Long acorn drop season, very high yield. Wildlife type.

‘MASTadon’ (*Q. macrocarpa*). Precocious, large acorn. Seed strain from a wild tree with large acorns, from Dudley Phelps.

‘Maximus’ (*Q. macrocarpa*). Large acorn, slow to begin bearing. Selected from wild burr oaks in Texas.

‘Mike’s Giant Burr # 1 and #2’ (*Q. macrocarpa*). Selected by Mike Strongfield in Kansas.



'Mike's Giant Burr #2'. Image courtesy Buzz Ferver of Perfect Circle Farm.

'Overflow Pond' (*Q. macrocarpa*). Very large acorns, not otherwise remarkable. From Illinois.

'Rainmaker' (*Q. alba* x *Q. lyrata*). High-yielding. Seedlings of superior wild tree selected by Dudley Phelps.

'Rocket' (*Q. rubra*). High yielding, fast growing. Selected by Ken Asmus.

'Sargent #5' (*Q. hybrid*). Wildlife seed strain, high yield, long ripening period.

'Sargent #7' (*Q. hybrid*). A wildlife seed strain with high yield and large acorns.

'Schubur' (*Q. macrocarpa* x *Q. schuettei*)
A Ken Asmus population (set of cultivars) selected from Schuetts oak hybrids. High yielding, poor weevil resistance.

Schuettes oak (*Q. bicolor* x *Q. macrocarpa*). A natural hybrid rather than a cultivar. Tending to be productive, weevil-free, and dropping free of the cap easily. Some are low-tannin.

'Shooting Star' (*Q. bicolor* x *Q. macrocarpa*). Wildlife type, high yielding, relatively low tannin.

'ShuWater' (*Q. nigra* x *Q. texana*). Seedlings of a wild hybrid selected by Dudley Phelps. Wildlife type. Large acorns, high yields, annual bearing. Both parents are pressed for oil.

'Shuwillow' (*Q. phellos* x *Q. shumardii*). High yielding, precocious. Wildlife type. Seedlings of a wild plus tree identified by Dudley Phelps. May be a good oil producer.

'Texas' (*Q. nigra* x *Q. texana*). High yield, close to annual bearing, late season acorn drop. A wildlife cultivar. May be a good candidate for oil production.

Cultivar Tables

Pure Species Cultivars

Species	Common Name	Origin	Cultivars
<i>Q. acutissima</i>	Sawtooth oak	Asia	'Gobbler'
<i>Q. alba</i>	White oak	North America	'Lint'
<i>Q. bicolor</i>	Swamp white oak	North America	'Bucks Unlimited', 'Cobb's Sweetie', 'Fall Creek #1', 'Fall Creek #3'
<i>Q. macrocarpa</i>	Burr oak	North America	'Ashworth', 'Bing', 'Dale's Giant', 'Giving', 'Hershey', 'Kreider', 'Manna', 'MASTadon', 'Maximus', 'MidMo 1', 'Mike's #1 and #2 Burr', 'Overflow Pond', 'Sweet Idaho'
<i>Q. robur</i>	English oak	Europe	'Cobb's Robur'
<i>Q. rotundifolia</i> (= <i>Q. ilex ballota</i>)	Holm oak, encina	Europe, W. Asia, N. Africa	'Andrés', 'Antigua', 'Casallana', 'Castanyeca', 'D'en Pere Andreu', 'De La Campaneta', 'Dulcera', 'Finojosa', 'Orta', 'Rozas'
<i>Q. rubra</i>	Northern red oak	North America	'Rocket'
<i>Q. texana</i>	Nuttall's oak	North America	'Behemoth'
<i>Q. virginiana</i>	Live oak	North America	'Late Drop'

Hybrid Designations and Cultivars

Species	Designation	Common Name	Nativity	Cultivars
<i>Q. acutissima</i> x <i>Q. robur</i>			Spontaneous in cultivation or deliberate	'Cobb's Japanese White Oak'
<i>Q. alba</i> x <i>Q. bicolor</i>	<i>x jackiana</i>	Jack's oak	Naturally occurring in North America	'Jumpin' Jack'
<i>Q. alba</i> x <i>Q. lyrata</i>			Naturally occurring in North America	'Rainmaker'
<i>Q. alba</i> x <i>Q. macrocarpa</i>	<i>x bebbiana</i>	Bebb's oak	Naturally occurring in North America	Beadles (Mossy Oak strain), 'Big Bear', 'Bodacious', 'Dynamo', 'Ooti', 'Sweet It Is'
<i>Q. alba</i> x <i>Q. robur</i>	<i>x bimundorum</i>	Bimundors	Spontaneous in cultivation or deliberate	'Acornlandia 1', 'Acornlandia 2',
<i>Q. bicolor</i> x <i>Q. macrocarpa</i>	<i>x schuettei</i>	Schuett's oak	Naturally occurring in North America	'Kimberly', Schuetts, 'Shooting Star'
<i>Q. bicolor</i> x <i>Q. muehlenbergii</i> x <i>Q. prinoides</i>	<i>x introgressa</i>		Naturally occurring in North America	'Concordia'
<i>Q. bicolor</i> x <i>Q. robur</i>			Spontaneous in cultivation or deliberate	'Exclamation Point',
<i>Q. lyrata</i> x <i>Q. virginiana</i>	<i>x comptoniae</i>	Compton's oak	Naturally occurring in North America	
<i>Q. macrocarpa</i> x <i>gambellii</i>	<i>x mazei</i>	Burgambel oak	Naturally occurring in North America and deliberate	'Early Drop', 'Late Drop'

<i>Q. macrocarpa</i> x <i>Q. rotundifolia</i>			Deliberate	'Nutty'
<i>Q. macrocarpa</i> x <i>Q. robur</i>			Spontaneous in cultivation or deliberate	'Invincible', 'McDaniels'
<i>Q. macrocarpa</i> x <i>Q. rubra</i>	<i>x macdanielli</i>	McDaniel's oak	Occurs where grow together	
<i>Q. macrocarpa</i> x <i>Q. schuettei</i>			Naturally occurring in North America, hybridized with a hybrid	'Schubur'
<i>Q. montana</i> x <i>Q. robur</i>			Naturally occurring in North America	'Acorntopia', 'Major'
<i>Q. palustris</i> x <i>Q. texana</i>	<i>x mutabilis</i>		Naturally occurring in North America	'Macon'
<i>Q. phellos</i> x <i>Q. shumardii</i>	<i>x moultonensis</i>		Naturally occurring in North America	'ShuWillow'
<i>Q. nigra</i> x <i>Q. texana</i>	<i>x neopalmeri</i>		Naturally occurring in North America	'Shuwater', 'Texas'

Nurseries, Seed Sources, and Organizations

These are nurseries that offer some of the grafted trees and seedling strains discussed above. Many of these nurseries are themselves the ones who selected the elite strains they offer. A few of these are organizations that include exchanges of information, acorns, and scionwood.

Agroforestry Research Trust

agroforestry.co.uk

England

Low-tannin seedlings.

Associació de Varietats Locals de Mallorca

varietatslocals.org

Spain

Grafted cultivars. Currently cannot export off-island.

BalanoTrees

balanotrees.org

Spain

Grafted trees for human consumption and livestock.

California Rare Fruit Growers

crfg.org

USA

Membership organization.

Forrest Keeling

fknursery.com

USA

Seedling oaks for wildlife

Grimo Nut Nursery

grimonut.com

Canada

Grafted and seedling oaks for human consumption.

International Oak Society

internationaloaksociety.org

International

Membership organization.

Las Cañadas

bosquedeniebla.com.mx

Mexico

Grafted and seedling trees.

Korea Forest Research Institute

nifos.forest.go.kr

South Korea

Collections of elite grafted cultivars. Not clear if germplasm is available.

Maryland Department of Natural Resources

nursery.dnr.maryland.gov

USA

Seedling trees for wildlife

Missouri Department of Conservation Nursery

mdc.mo.gov/trees-plants

USA

Seedling trees for wildlife.

Morse Nursery

morseoutdoors.com

USA

Seedling oaks for wildlife

Mossy Oak Nursery

nativnurseries.com

USA

Seedlings for wildlife.

North American Fruit Explorers

nafex.org

USA

Membership organization.

Northern Nut Growers Association

nutgrowing.org

USA

Membership organization with oak subgroup.

Yellowbud Nursery

yellowbud.farm

USA

Seedlings of trees for human consumption, livestock and wildlife.

Oikos Tree Crops

oikostreecrops.com

USA

Scionwood and seedlings of oaks for human consumption and wildlife.

Pavia Nursery

pavia.be

Belgium

Grafted ornamental oak specialist, moving into edible cultivars.

Perfect Circle

perfectcirclefarm.com

USA

Grafted and seedling oaks for human consumption.

Rhora's Nut Farm

nuttrees.com

Canada

Seedling hybrid oaks.

Seeds to Dreams

seedstodreamsfarm.com

USA

Hybrid seedlings for wildlife.

White Lion Farm

whitelionfarms.org

USA

Improved oak selections.

Wildlife Heritage Tree Nursery

wildlifeheritagetreenursery.com

USA

Seedling hybrids for wildlife.

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Thayer (2010) *Nature's Garden: A Guide to Identifying Harvesting and Preparing Edible Wild Plants*

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