Sarah Beck: You're listening to Garden Futurist. I'm Sarah Beck, here with Adrienne St. Clair. Hi, Adrienne.

Adrienne St. Clair: Hi Sarah.

Sarah Beck: You know, sometimes we meet someone who is so deeply passionate about a topic that it allows us a window into what is amazing about that topic. Our guest today will be sharing his passion for oaks. Dave Muffly is a California-based arborist and horticulturist who has devoted much of his professional life to the genus *Quercus*.

Adrienne St. Clair: Yeah, so to define some terms that maybe you haven't thought about since high school biology, when you hear the word *Quercus*, that's referring to the genus, the plural is genera, which you can think of as general, so the larger group of all the different species of oaks.

Sarah Beck: So when you talk about all the different species of oaks, that's when you say hey, it's a white oak, or it's a red oak.

Adrienne St. Clair: Yeah, exactly. So you can think of species as being more specific than genus. And then there's this umbrella term that covers all of them, and that's the term family.

Sarah Beck: I'm so glad we have a botanist with us. But seriously, you don't need to be a specialist to appreciate this conversation, because I think Dave really takes us on an exciting dive into a conversation that we just might not think that much about normally.

Adrienne St. Clair: Great, let's listen.

Sarah Beck: So can you talk a little bit about just biodiversity in terms of one individual tree and how the organisms are adapted to them?

Dave Muffly: I'll confine myself largely to talking about oaks, of course, and really talk about coastal California, northwestern Mexico, which are my areas of familiarity.

So let's start out by remembering the California is a global biodiversity hot spot. And I think it's one of roughly 36 such hotspots globally, and California is home to more species of plants and animals than any other state in the United States.

So we have a reservoir of endemic organisms here in California. We've got this mediterranean climate, which is rare around the world and isn't found elsewhere in the United States and oaks have been present in this environment for millions of years. And it's quite a unique environment, but there's always connectivity between the flora of one place and other places because biodiversity has been moving over the planet as long as there's been biodiversity and as long as the climate's been shifting.

Sarah Beck: When we talk about biodiversity or surrounding these individual trees, what are we missing? What are we not seeing?

Dave Muffly: Well, part of it is that a lot of the organisms are so small or so un-dense that, that we don't really see them. The oaks can provide food and protection for a lot of organisms. And there's a surprising portion of the entire natural world of all biodiversity that either rests in or on an oak tree.

And another huge portion of biodiversity uses oak trees for food. So an oak can produce 3 million acorns in its lifetime, but only a tiny handful of those, if any, will create trees, but those extra acorns are there on the ground waiting to feed just a huge number of organisms from tiny ones all the way up to bears.

And then, in addition to the acorns, you've got an oak that can produce something on the order of 500,000 leaves every year. And they provide food for caterpillars and other critters, and then the leaves fall, and the oak litter is, in general, pretty slow to break down. And that means that it's there as a blanket over the ground for a long period of time, providing a durable habitat for possibly an even bigger number of decomposer and otherwise beneficial organisms, while building up the soil quality. Fisherpeople know that if you need to go find earthworms, go look under oak leaf litter.

And then don't even get started talking about all those little oak galls that are on most oak species. There are thousands of different kinds, and each one's a different species. So the oaks are like the nexus of an entire universe.

Sarah Beck: Wow, no, I love this. Do we just not notice what's right in front of us sometimes?

Dave Muffly: Yeah, for sure. And there aren't many of us who are like really hardcore naturalists that are going around and digging through the leaf litter and looking at all the crevices.

Sarah Beck: Right.

Dave Muffly: There's so many tiny things that make up our world. We love our charismatic megafauna, and we also love our charismatic megaflora, which is the big stuff. So the big stuff is easy. Little stuff is subtle. And it's often years of science and observation that has allowed us to be aware that there is such a richness of life associated with the oaks.

Sarah Beck: Oh sure, and even just the things we can't see under the soil and the mycelium, I mean, this is just an endless story, right? You could really dig through this.

Dave Muffly: You could dig through this for a lifetime.

Sarah Beck: So, yeah, tell me more about tree biodiversity in the Pacific region.

Dave Muffly: There's a huge amount of biodiversity and it's currently associated with native oaks, but we're also in a place where humans have been profoundly disrupting the ecology now for at least hundreds of years.

So in these areas, we've brought in a whole bunch of new plants, new creatures. So to some extent, we are no longer in historically native ecosystems. We're now in these weird mixed ecosystems. And it's not like that's really going to change. So we mix things up. But now on top of it, we are shifting the climate very, very rapidly.

We've talked about oaks being a foundation for an enormous amount of biodiversity. Well, 30 years ago, forest ecologists first started to warn us that, "Hey these trees, they are the underpinnings, they're the foundation of biodiversity. And if the climate changes around them, they can't get up and walk. So they would have to be moved." There are many kinds of other smaller organisms that can get up and

move. As the climate shifts, they have the ability to move to different areas. Well, trees do not have that ability.

And unfortunately at this moment in history, if you look carefully in the news, it's not really talked about a ton, but you'll find that there are mass tree die offs occurring all over the planet. Pretty much everywhere that there are trees, you're seeing these kinds of die offs, and depending on the area, they relate them to different specific problems. But what I see is that the forest ecologists' warning from 30 years ago is coming true. And the foundation stones of our ecosystems are, in many cases, dying in place.

And at the same time, we have scientific studies that have been done for a decade or more, that actually project what the new ranges of a variety of plants are going to be. And when you look at those studies, you see that our native trees are moving and they're going to move and I've experienced that in my own career.

If we want to keep anything approaching the level of biodiversity we currently enjoy, we're probably going to be in for some pretty serious global planetary management in ways that are completely different than the disruptions that we've created in the past, which are more often than not just unintended consequences on some other resource extraction activity.

We are in a global biodiversity hotspot, which is currently under assault from a variety of areas. And one of the things that's happening is that the range is shifting, the range of adaptation is shifting. So then we start looking toward climates that mimic what we are projected to experience here in California.

So that usually entails looking toward the equator, no matter where you are. In the Southern hemisphere, stuff's moving south. In the Northern hemisphere, it's moving north or uphill. So then we asked the question, "Okay, if we're having difficulty with adaptation of our global hotspot species, what do we start bringing in that may be helpful in supporting. moving biodiversity?"

Well, guess what? Northwestern Mexico, just south of us, is also a global biodiversity hotspot, especially for oak trees and pine trees. And this area is really a surprisingly deep reservoir of native plant diversity with potential application to coastal California, all of California, and even going north into the Pacific Northwest.

We live on a planet in motion, whether we like it or not.

So trees and other plants have always moved around on the planet. And I want to give you an example. The rarest of all California tree oaks is called island oak *(Quercus tomentella*), and it grows natively on the islands off Southern California and into northwestern Baja. Well, island oak used to be native in the Bay Area 5 million years ago.

Sarah Beck: Wow.

Dave Muffly: Now, now the closest native island oak is about 350 miles away, but the climate is actually shifting back toward what it was 5 million years ago. So now we've found one of our climate change migration native species is island oak, and we have been planting and fairly intensively in the Bay Area in a variety of projects for about 15 years. And what we're finding is that island oak is once again thriving in the Bay Area.

So that gives you an idea how that works, but let's talk about slower climate change from our geological past. So, how is it that oak trees move?

So oak trees evolved right along with jays, the birds, 60 million years ago in what's now Southeast Asia. Well jays and oaks work hand in hand, and each jay can plant somewhere in the neighborhood of 3,000 acorns every year of its seven-to-17-year life span. Often it's sticking those acorns a couple hundred feet from the mother tree, a thousand feet, a quarter mile. Jays cover some distance.

So it's been the jays shifting the acorns around that's been the, one of the key elements of oak trees moving, and other species, but especially oaks and jays moving around in the past. Now we're in a position where the jays can't really move the oaks fast enough.

Sarah Beck: If you're talking about the Bay Area or really any Pacific region urban space that you're making decisions about planting, what strategies can be employed here? I mean, you're making some guesses and making some bets, but you want to end up with the greatest survival.

Dave Muffly: Yeah, no, that diversification of strategy is critical because we don't know any one plant that's going to be right. So when I started talking about moving

trees that are native to areas outside California we're not really in a position to plant those in our wild areas. We're still using the strategy of letting nature take its course. And it's not really appropriate. But we still want to create some corridors and our cities are already enormously disrupted. So, hey, why don't we take these nearby native trees and plant them in the cities where there aren't that many native plants typically, and we aren't really going to mess with the genome in the way that we would if we were planting in the wild.

So now let's talk about those corridors. Usually when people talk about biodiversity corridors, they're talking about those big overpasses over freeways that are built for large animals, the charismatic megafauna, if you like, but the corridors discussed here are for the little creatures. It's not for the big stuff. And the corridors don't have to be continuous. Because birds can fly from tree to tree and insects can move from tree to tree. The trees just have to be in proximity. And okay, so there we go. We have the potential to build corridors through our cities with absolute minimal disruption of the native oak genomes.

Now for the cities themselves, pretty much every city has street tree planting lists and lists of trees that are acceptable for parks and commercial properties that are given to landscape architects. So in Northern California and areas north, these lists in recent decades have become dominated by water-loving, low-biodiversity, fall-color trees, like red maples. And those are available at low cost and huge numbers from all those commercial nurseries up in Oregon.

But the truth is these trees are reverse climate change trees for California. In addition to their being biologically inert, they all come from places that received much more precipitation than California does now and likely will in the past and evolve for colder temperatures.

So we need new tree lists and we need new trees. So on a personal level, I'm currently working with several Bay Area cities to update their street tree planting lists and their other tree lists to enhance climate resilience, not only biodiversity, but also greater drought tolerance.

The good news is that at this moment, we're on the cusp of entering a new world of tree availability from commercial nurseries in California, with dozens of new tree types being offered by some nurseries. Devil Mountain Nurseries, which is now the largest provider of trees in California, has taken a substantial commercial risk to grow new trees.

So now's the time to educate cities and landscape architects about these new trees, most of which are evergreen or semievergreen. And some of them are beautiful. And the good news is these are selling as we can produce them and are getting planted out.

Sarah Beck: So are there any tree species besides all of the *Quercus* that you've mentioned already, that you also think have great potential for these corridors? Can you give us a little hint of what's going on these lists? I'm so curious.

Dave Muffly: Among real dry land tree species, oaks really are the number one tree for supporting biodiversity and the the trees are pretty ubiquitous throughout California, American Southwest, into Mexico.

But the number two tree typically are pine trees. So in that vein, one of my favorite trees to plant is the Torrey pine (*Pinus torreyana*) from down around San Diego. Well, we've been planting Torrey pines in the Bay Area in small numbers for like 140 years. And they're fantastic performers. They're really incredible trees and I don't really know why we don't plant more of them. So yeah, let's bring some Torrey Pines into the corridors.

And typically number three on your list of tree types that support biodiversity are cherries. And we have some really lovely evergreen cherries in California, like *Prunus lyonii*, the Catalina cherry, from the islands off Southern California, and those have been used extensively in the Bay Area. They're a great screen tree and they really do provide some substantial biodiversity support. So there's some examples from outside oaks.

Sarah Beck: And it sounds like the cherries are another one that there's probably some great bird relationships.

Dave Muffly: Oh, of course. So, yeah you can't plant the cherries everywhere because our native cherries do produce quite a bit of fruit, but boy, along screening edges, it's a great one.

Sarah Beck: Dave, please share some of your favorite oak species.

Dave Muffly: Okay. So I want to talk about three oaks that, that are showing enormous promise as elements of these corridors. So the first tree is a California native and it's the rarest of the California native mainland species.

And it's Engelmann oak from San Diego County, Riverside County, well down into Southern California. In this time period, I'm busy collecting acorns from Englemann oaks so that we can start having them for our cities. So I've made several trips down into habitat near Ramona and Julian to collect acorns.

So *Quercus engelmannii* is a tree that's seen limited planting in Southern California cities. But as I was looking for oaks to bring to the Bay Area to diversify our plant list, Engelmann oak was the first one on the list.

And over the last 15 years, we've gotten quite a few Englemann oaks planted up in the Bay Area. And man, they are performing beautifully. They're a really attractive tree with bluish foliage. A lot of people mistake them for California blue oaks, but they're proving much better adapted to the climate changed climate in the Bay Area than blue oak is.

And there's a special feature, which is proving far more important than I ever anticipated, of Engelmann oak and some of the other oaks that I'm going to talk about, and that is these trees are adapted to monsoonal moisture, which means they're adapted to receiving part of their rainfall during this. Well, most California's a true mediterranean climate where you really don't have.

Sarah Beck: That's summer dry.

Dave Muffly: Yeah, and what happens when we start putting lawns and summer irrigation on our mature oaks? Well, what we've learned is they get root rot and die on us really quickly. And that's been a problem in our landscapes for a hundred years. Well, an interesting thing about Engelmann oak is that from evidence from Southern California and increasingly from the Bay Area, you can throw summer water at Englemann oak, and all it does get happy.

So it's a good fit actually for our current urban landscape practices. Most of our landscapes, we give a little bit of supplemental water in the summer and guess what? That then mimics a mixed monsoonal mediterranean climate. So Engelmann

oak has a lot of potential because in addition to its drought tolerance, it also has tolerance for some monsoonal moisture.

So moving out of California, you move into Arizona, and you go up on their sky islands, which are their mountains, like Mount Lemmon, outside Tucson. Tucson's at about 3,500 feet. The top of Mount Lemmon is about 9,500 feet. So in the flat deserts of Arizona, you don't really find oaks, but as soon as you move up into the mountains, you find dozens of types.

And one of the most beautiful of these types, and one of the most adaptable is called the silverleaf oak (*Quercus hypoleucoides*). And I was turned on to the silverleaf oak by Sean Hogan at Cistus Nursery up in Portland. The northernmost silverleaf oak, it's probably around like Flagstaff, Arizona. Well, they've successfully planted *Quercus hypoleucoides*, the silverleaf oak, at Hoyt Arboretum in Portland and it's thriving and that's nearly a thousand miles north of its current range.

So. I saw that, and we started to do some plantings. I went and got seed of silverleaf oak, and they're starting to get planted and people are loving it. They're a beautiful, they're a moderate size oak, which is really useful. Huge oaks are tricky in the cities, but when you've got a moderate-size oak, we have a lot of planting spaces that are ready to take *Quercus hypoleucoides*.

It's a cousin of the California black oaks, like coast live oak and black oak itself. And it's another perfect tree that has monsoonal adaption. It's adapted to drought. It's evergreen, it's beautiful. And it supports a ton of migrating biodiversity. So we're producing as many of these as we can in the nursery industry to make them available. Because as soon as people see these trees, the landscape architects go crazy for them.

Sarah Beck: And these could work for a street tree.

Dave Muffly: Oh, they're a perfect street tree. So I'm associated with Apple Park at Apple, and we planted nearly 9,000 trees. And as one of the last plantings is a line of street trees that was chosen after a couple of years experience with the 60 different kinds of oaks we planted and *Quercus hypoleucoides* won. It's the most beautiful, it grows well. And it's now the feature street tree around the Apple Park campus.

Dave Muffly: There's so many kinds of oaks and they all hybridize. So oaks is enough for me for one lifetime.

Sarah Beck: I totally get it. I've totally been out in a forest trying to key them and going, oh my gosh, there's there like so many mixes here. I don't even know what I'm looking at, there's so many.

Dave Muffly: Everybody wants to think that oaks occur as species, but they actually occur as swarms through arms.

Sarah Beck: Swarms?

Dave Muffly: They're swarms of related trees. And when you start thinking about, rather than individual trees moving, but the swarm moving.

Sarah Beck: Because there's genetic variation across all those individuals. I can almost picture what you're saying, because it's like that swarm has some blend, there must be like a genetic blend change throughout the whole swarm.

Dave Muffly: Totally. There's a lot of kinds of oaks on the planet and oaks have been able to survive the climate change events of the ice age cycles and rise to dominance. And part of the reason that they've been able to do that is because the swarms always include weird outlier trees and sometimes your weird outlier trees, if there is a massive climate change event, sometimes it's only the weird hybrids that survive. And then those weird hybrids that were part of a previous swarm become the new species that another swarm develops around,

Sarah Beck: Oh, that's pretty mind blowing. I like that.

Sarah Beck: A large part of the concern around climate change is the loss of biodiversity. We're already seeing this and it's predicted to get worse. Something I really took away from my conversation with Dave is that he's found a way to support biodiversity through tree selection. In many contexts, he's including urban spaces.

Adrienne St. Clair: Right. And the reason it makes sense to focus on oaks is that oaks tend to be drought and heat tolerant, and with the right management, actually have

potential to expand their range within climate change. So oaks give this huge potential to buffer that biodiversity loss.

Sarah Beck: And there's something more, right Adrienne? There's a human relationship with oaks in the Pacific region.

Adrienne St. Clair: Yeah, so Western science has come to understand that these diverse oak habitats came about only because of the cyclical management of Indigenous people who have been burning the oak trees on a rotation since time immemorial. And so it's only because of this urbanization and fire suppression that the habitat loss has been so great. And with informed human action, maybe these habitats will be able to persist and, in fact, thrive.

Sarah Beck: It's really exciting to think about humans being able to again participate in a positive way in terms of building biodiversity back.

Adrienne St. Clair: Yeah, it's an exciting opportunity to feel confident that what we're doing could assist biodiversity in the future.