Interview with Dr. Loren Rieseberg by Reese Irwin and Lindsey Bennett

[00:00] **Loren Rieseberg:** My name is Loren Rieseberg, I'm a University Killam Professor at the University of British Columbia, my academic appointment is in the Department of Botany, and I also direct the UBC's Biodiversity Research Centre, and I work on sunflowers.

So when I was collecting these wild species, I was taken aback at just the different kinds of environments they could survive in. The species I worked on as a grad student, survived on these serpentine outcrops in California. So highly serpentine soils, these are heavy metal soils, and it was thriving where most other species couldn't survive. And then when I started my first career I did my first sort of large scale collection experiment, collection field trip, for sunflower and I collected sunflowers in Arizona, New Mexico, Utah, Wyoming, Colorado, Texas and so forth.

And again I was—I found sunflowers growing on super hostile environments like sand dunes where—So sand dunes, they aren't water-limited they are actually nutrient-limited and yet there were, the sunflowers growing on the sand dunes were pretty much the biggest thing there. They were kind of the keystone species on the sand dune providing resources for many other organisms that live on the sand dunes. I also found them on, in sort of saline salt marshes in New Mexico and Arizona. And I should say that most of the cases, these people had collected them at these sites before but for me it was a first.

And I also found them growing on like the barrier islands of the Gulf of Mexico, which again, a fairly hostile environment, and also inland in Texas, and the one surprising thing about the ones that were growing in the Southern Coastal Plain is that they actually were woody annuals, that means they are annual trees. Which is a really bizarre thing.

[02:02] And, so I guess that that was what kind of stood out for me and, since then, we've been focusing more on how new species arise but also collecting sunflowers from these many different places, and in the last decade or so we've become more interested in determining how the species are surviving in these places, and moving those genes into cultivated sunflowers.

Lindsey Bennett: But why do you feel that there is the need to move those genes into cultivated species?

LR: So even though I mentioned earlier that sunflower is considered to be a drought-tolerant crop or an environmentally resilient crop, it's nothing compared to the wild species. And part of this is during breeding, early farmers, and this is pretty much for all crops, they select for yield, they select for plants that grow quickly and produce lots of seeds and many of the traits that confer tolerance to extreme environments or to pests, like insects or fungi, are actually lost during this improvement process.

And so you have a cultivated sunflower, and I've actually done experiments where we've grown these things, side by side, various crosses and so forth, in Nebraska for example where it's quite dry, and every cultivar... dies, and the wild ones do just fine. And this is—and we've also created a lot of what we call pre-bred lines, where we've crossed cultivated sunflowers with various wild species and we've grown them under drought trials in Uganda, and some where all the cultivars that they currently use die, some of our pre-bred lines that have wild integrations in them thrive.

[03:59] And so it's quite clear that we can—that even though the cultivated sunflower is an environmentally resilient plant, we can make them far more hardy and far more able to survive extreme… environments. And the thing to keep in mind is that, climate change is not just about an increase in temperature or an increase in drought. It's actually more about probably extreme climate events, and so what you're trying to do is you're trying to have crops that can survive these extreme events. And that's where I think bringing these wild species, they've survived extreme climates for millions of years. They know how to do it. And our crops really at this point don't.

LB: Can you describe the process of breeding in the wild flowers?

LR: Yeah, it's actually a very painful thing and this is why most plant breeders and most sunflower breeders don't want to do it. Essentially what you're doing is, is you're taking… you take your favourite cultivar, and you grow that, mini replicates of your favourite cultivated line and then you take your different wild species and you transfer pollen, often I just rub the heads together, and you transfer that onto the cultivated line. The problem comes is in the next generation often the hybrids are partly or completely sterile, and also the… often there's difficulty in getting them to flower at the right time.

So actually it can be difficult just to produce the first generation hybrid. And then when you start, what you do next is you start backcrossing them: that is you take your hybrid and backcross it, cross that back to the cultivated line again, and you do that repeatedly. And sometimes that works, sometimes it doesn't, sometimes there is contamination because the cultivated sunflower would like to pollen from anything than the wild or the wild hybrids. So we lose things just because of various things like that.

[06:03] And then once you have them a couple generations into the cultivated background where you're now maybe something like, 15% wild, 85% cultivated, then you start selfing them. And that's so that you get these uniform lines that breeders can work with. And you also select for certain traits, for example, we tend to select to eliminate any branching. Again, because this allows breeders to work with something that they can actually grow in the field easily. You also automatically select for things that germinate and, so breaking the dormancy. And then once you have these, typically we self them for three, four, five generations, and then we give them to public and private breeding programs and that's what the—and the public and private breeders, what they do is they look for, particular traits or genes that they're interested in. Most frequently it's for disease resistance, but also for things like drought tolerance and other things, oil content, many different traits.

LB: What's "selfing"?

LR: Yeah, so selfing simply means that—so most crops are, they're uniformly inbred, and what that means is that they, you just have them mate with themselves, they're hermaphrodites. The typical flower is what we call a "perfect flower," it has both male and female parts, and it's just a lot easier to do breeding if you inbreed things. So… That is another thing that actually is difficult, and in these selfing generations oftentimes you have particular genes from the wild species that are recalcitrant to selfing. So you're trying to make your pre-bred line homozygous, but certain regions will not become homozygous because they're lethal, or they're deleterious when they're homozygous.

[08:00] So some crops really are used to being inbred, and so you can actually, during breeding, you can in some cases purge these, what we call deleterious recessive alleles, and so you can produce plants that can tolerate selfing, and that actually can be fairly productive under selfing. In other crops, like sunflower and corn, we have hybrid crops, and this recognizes the fact that the inbred lines do not perform as well as an outbred line, and so you make what we call male lines and female lines, and then you cross them together and it's that F1 that's planted in the field that has this hybrid vigour.

LB: How long does this hybridization process that you're describing typically take? To produce one strand?

LR: So, typically, it takes us probably four years to produce a pre-bred line, and then to actually introduce that stuff into lines that get commercialized, you're probably talking another five to eight years. So the whole process is a ten to twelve-year process of going from wild—a trait in a wild population that you're interested in to actually seeing it in a cultivated line that's growing in your sunflower field in Manitoba.

LB: Are there any success stories that you can point to that have these processes happen successfully?

LR: So, it's been estimated that the wild alleles, or genes from wild species, bring about, add about, 200 to 400 million per year in increased productivity of sunflower. And so some of the genes that are most profitable is for example genes that contribute to disease resistance to common diseases, or genes that allow the cultivar to be resistant to herbicides, and this is naturally acquired herbicide resistance which is then introduced to the cultivar.

[10:09] Also, those—so both disease and herbicide resistance are what we call high-value traits because these bring a lot of value to the crop. And then, there's also genes now for oil content and for drought tolerance that also contribute to that estimate of value.

LB: So you mentioned earlier that a lot of the breeders and for-profit growers are very reluctant to engage in this hybridization for future climate resistance. Is there a reason for that?

LR: Oh, they're OK once you get the material that looks good and doesn't actually have a negative effect on their—on the phenotype of their cultivars or on sort of, yield under ideal conditions. And so it's a matter of getting that material prepared in a way so that the breeders are OK with it, and we do this, we screen for these things as well. You're looking for genes that have a big boost on drought tolerance, have no negative tradeoffs, and finding those are what the breeders want, and if you find those, then they're happy with it. But they're not really going to be wanting to sort of do conventional selection for drought tolerance because of the worries about the negative tradeoffs.

LB: And would you say that climate change is affecting the cultivated sunflower production?

[11:43] **LR:** We do see it, a negative effect of temperature. And so what it means is that either we'll have to breed sunflowers that are more tolerant of high or extreme temperatures, or we'll have, sunflower production will move to colder areas, like, for example, it could be that Canada will become a big sunflower producer; Russia is the biggest already and it will become even bigger, and sunflower production in like Sub-Saharan Africa. Or even Europe, where France is a big producer, could decline because the temperatures become less conducive for productivity. I'm guessing it will go both ways: I think sunflower production will probably move north, or south, depending on which half of the globe you're on. At the same time, I think that there's lots of opportunity to make them more resilient to climate change.

LB: And so since climate change isn't that big of a risk for the wild sunflowers, what would you say poses a risk for them?

LR: I wouldn't say it's entirely not a risk for the wild sunflowers, but it seems like that they're probably going to be less at risk than many plants. So in general, the problem is that your climate is the optimal climate for a given plant. Like in B.C., as Sally Aitken has shown, that the optimal climate for some of the tree populations she's working on is moving north by one kilometre a year. So that's not good. So, in sunflower it's, I think it's—because it's an annual they can adapt more quickly and, see too, I think, I don't see climate change right now as being the biggest threat.

I think the bigger threat is always habitat destruction, development, and so, we do have some species that are, like in the U.S. there is one of the species is on the U.S. endangered species list, which it's hard to get there—there are others that—it's a salt tolerant species down in Texas and New Mexico that occurs in these sort of saline wetlands and this is where cattle ranching has really been an issue.

[13:58] Another species I work, I worked on for my PhD is in the central valley of California, and it also has been threatened just mainly by farming and development just because that, the central valley has become this incredible agricultural centre. In general, also, I work a lot with sand dune species in Utah, and Colorado, and New Mexico. Some of these are protected because they're on national parks, but all, the ones that aren't actually in a—even though they're in a recreational area or monument or something, they're under threat because people like to run ATVs over them. It's a great place for running ATVs, and I think people don't notice that there's vegetation under them, so it's really habitat destruction right now more than climate change. And I would say that in general that's the general rule is that the biggest threat to plants, or to animals and plants tends to be agriculture number one, forestry, maybe two, and then, urban development maybe three. It's usually not—climate change at this point is still fairly low on the list, but that's gonna change.