

Hi, welcome to Triple P- Pest, Pollinator, Peril. I'm one of your hosts, Jaren Baluyot.

I'm Malia Naumchik.

I'm Rachel Rafter.

I'm Sarah Krementz.

Jaren: In today's episode, we'll be talking about native pollinators, pests, agriculture, and how climate change affects it all. Let's get started.

Malia: Alright, so first we're going to be talking about how climate change impacts native bees. We talked to Hannah Levinson, a postdoc at NC State who did her PhD dissertation on how planting pollinator habitat next to agriculture, agricultural areas, helps conserve native bee species to get her take on how native bees are being affected by climate change and what that means for agriculture

Rachel: So Malia, what species are being affected by climate change?

Malia: So, bees are particularly at risk for climate change because they're partially endothermic and are capable of producing some of their own body heat. Certain bee species, including bumblebees, are more at risk than others. Hannah Levinson noted that bumblebees' large and hairy bodies are adapted to colder climates, and that puts them at risk for climate change. In particular, the Rusty Patched Bumblebee has seen drastic population losses from climate change. Hannah Levinson said that this bee prefers higher elevation colder areas and so as temperatures warm, it is getting pushed more and more north. In fact, this bee has been historically found in the Appalachian Mountains and here in NC, but due to changing temperatures, NC is no longer a suitable habitat for them, and they haven't been documented here in several decades.

Sarah: So are there any other species that are affected as well?

Malia: Hannah Levinson says that another group of bees that are particularly at risk are specialist bees. Specialist bees only forage on specific plant genera and families like the sunflower bees or squash bees. She told us that because these bees are very limited in where they can get their resources from. They're at high risk from climate change. If their host plant is impacted by climate change, then the bee will not have enough resources. If temperatures get hotter, the blooming times of flowers might change and the specialist bees that have co-evolved, their emergence with these flowers might not be able to adapt as quickly. Another group of bees that might be affected are solitary bees, solitary female bees forage and make their own nests and do not live in social colonies or hives. However, each spring a new generation of solitary bees emerge and begin foraging to create their own nest. However, with increased temperatures, this lifecycle may be altered if we start to emerge earlier than this mismatch between flower blooming and foraging might negatively impact their survival. A study by "Schenk, et al." showed that a mismatch and timing of only six days dramatically decreased their survival rates, activity levels, and brood and mass production. Some species declined in reproduction after a mismatch of only three days.

Jaren: What in a bee's physiology makes them susceptible to climate change.

Malia: So increased temperatures have been thought to be the major factor influencing the declines. The critical thermal maximum is the internal temperature of which bees can no longer operate and will die. Some bee species have lower critical thermal maximum than others and may be more susceptible to a kind of heatstroke. Another less studied factor is critical water content. As temperatures increase drought may increase in certain areas, some species of bees dry up more quickly, and that may put them in a higher risk of extinction than increased temperatures would. Both of these factors are important to study further to see the individual risk of each species. To date, there have been only a few studies on the desiccation limits of bees, mostly on honeybees, there's only been one study investigating multiple bee species critical water contents by "McCluney, et al."

Rachel: So how is this affecting their pollen foraging activities?

Malia: Pollen foraging will shift to earlier in the morning or later at night, which might not correlate to when flowers open. We might see a shift towards nectar foraging instead of pollen foraging. Nectar foragers can cool themselves down by regurgitating their crop load onto themselves, but pollen foragers don't have this ability. They also might not be able to forage for as long, or for as much pollen restricting their ability to pollinate different flowers. A study by "Maia-Silva, et al." found that one species of bees decrease their pollen foraging, trip duration and distance significantly with increased temperatures. This is a very important study because bees might not be able to pollinate as many flowers in a much shorter radius in the future. I'm also conducting my own study right now looking at whether bee thoracic temperatures increase as the amount of pollen they carry increases. This study would show that pollen foraging could be impacted in the future as they have to decrease their activity to stay under the critical thermal maximum.

Sarah: That's so cool that you're doing your study. That's awesome.

Malia: Hopefully we'll see some results soon.

Sarah: Yeah, I'm really excited to hear about that. How's it affecting their distribution?

Malia: Like can Hannah Levenson said, bees like the Rusty Patched Bumblebee have been moving north over time. Also a study by "Lopez, et al." predicted that as temperatures increase, we might also see a shift in suitable habitat 100 to 500 meters upslope in altitude by 2050. If bees have to move higher up mountains, they might become genetically isolated and will have less floral resources available to pollinate. So now we're going to hear about how climate change is impacting agricultural pests from Rachel.

Rachel: So before I get started, I'm going to introduce another person that we interviewed. That's Hannah Burrack. So she's a professor here at NC State and she's also an extension specialist. So she works in the entomology and plant pathology department here and she studies mostly the biology and management of agricultural pests when it comes to fruiting plants and along with tobacco. And so I'm also going to be focusing on an article that was written by a student here at State and it's called "What a Changing Climate May Mean for Crop Pests" and

this includes other information given by other professors here at NC State. So one of those Clyde Sorensen and then Dominic Reisig, and then Matt Bertone.

Jaren: Yeah, Rachel, what does climate change do to insect pests?

Rachel: So one of the main things is that it adds generations to their annual cycles as the Earth warms. So Hannah Burrack mentions this in our interview questions. So this is a quote from her. So warmer summers will mean more generations, larger populations in longer activity periods for many pests. And also climate change, because it's warmer, their metabolism is increasing and that means they are having an increased appetite, and they're gonna want to eat more things. And so that kind of leads into the agriculture that we'll talk about later. They also have higher production rates, so they are having a lot more babies basically. And the good thing, or the bad thing, I guess, really, is that they have a wide range that their babies go to. So it's over a large range of areas that they're spread out.

Malia: So what makes pests so resilient?

Rachel: So by nature, pests are generalists and they are very adaptive, and insects in general, but specifically these insect pests that we see that affect agriculture. So they feed on a wide variety of host plants. So they're not very picky, like some other bees that we talked about, that have a niche that they stay in. So most of these pests, like aphids, and certain moth caterpillars don't really care so they'll feed on whatever they can have. And the thing that is affecting them through climate change is most of that we're having unpredictable weather years. So the thing about these pests is that they will persist through these really bad years and when they have good years, they're going to have a lot more babies than they would even without climate change. So with this unpredictable weather pattern, it's hard to say whether or not it's going to go down or up and that makes it hard to manage them because we don't know when we're gonna be able to use IPM, or other pest management strategies to help control their population levels. So overall, unpredictable weather and climate change means that we don't know how to stop them from spreading. So it kind of goes into the agriculture that affects them. And so Sarah is going to be talking some more about that.

Sarah: Awesome. So what we heard from Malia and Rachel before about the impact of climate change on both our native pollinators and also pests, it's safe to say that things are not looking too hot for the crops that are being affected by the changes. And it's obviously not good for NC agriculture and our farmers here. And here in North Carolina, our agriculture industry can be significantly harmed by the lack of pollinators, or the increase in pests. And lots of times, you know, it can be like detrimental to a farmer's livelihood, or the crops itself. And for the most part, it is the financial difficulties that come from this that are the worst for farmers and agriculture as a whole. Ecologically, it can be a real nightmare as well. And for example, vegetation that's already weakened from weather, erosion, development, whatever it may be, or the soil composition it's in, will be much easier for pests to consume, since it already has a weakened immune system. And with that, vegetation missing or not being able to be eaten, farmers won't be able to sell as much produce or will lose income from that as well. And it creates an even larger domino effect that can make prices increase quite a bit and makes it harder for a lot of

people to buy fresh local food that they can afford, which is really unfortunate, and Jaren will get into that a little bit later as well.

Rachel: So do native bees with climate requirements impact these crops?

Sarah: Yeah, so many native bees are specialized and have coevolved with their certain crops. For example, Dr. Levinson, who we talked to and mentioned earlier, told us that native bees such as blueberry bees and squash bees are specialized pollinators that, like, pollinate the blueberry and squash plants the best out of other, like, native bumblebees - they just have those that they've adapted to. Since they're the best pollinators for those crops, if their range has gravitated more north due to increasing temperatures, they might not be able to sufficiently pollinate these crops. And that can be really detrimental to the farmers that grow them, and, just, the host plants won't be able to survive in that area, unfortunately, unless it's like hand pollinated or, you know, specifically with a group of bees they have there. But naturally it wouldn't happen near as much. And even though other bees could visit and pollinate them, it might not be sufficient enough for these plants to bear fruit, which is the whole point that we grow them in agriculture. And without the proper pollination from pollinators that specialize in that crop, there's a chance for the plant's decimation as well as farmer incomes. In addition to the rising temperatures, many native bees are not equipped to live in such climates and their populations will decrease since they can't survive. And this will also result in less yield for farmers and a decrease in revenue. So all comes back to you know, hurting the farmers livelihood and just the crops not being able to survive without their specialized bees. And Dr. Burke, the other person we interviewed, let us in on some results that the research and extension team have observed. And so following Hurricane Matthew and two in 2016, several blueberry farms that they were tracking and working with, since 2012, flooded after Hurricane Matthew, and they have been collecting the pollinator data at these farms. And in 2017, after the hurricane, they noted that the southeastern blueberry bee that was the most popular one on those blueberry farms that also nests in the ground - that's very important to this - it was absent from some of the places that had previously been pretty abundant. So the increase in storms from climate change, such as really intense hurricanes, or an increasing number of hurricanes, can be really detrimental to where these bees are able to live as well. Especially our ground nesting bees - they get flooded, and they can't go back into their homes, it's really sad. And while there's a wide variety in bee populations from year to year based on weather development, whatever it may be, an increase in storms and their severity could be a serious hazard to a lot of our native species. Dr. Levinson also mentioned that resources are limited for many native bees, especially ones with specialized plants making it harder for these crops to get pollinated, if they're no longer in that range. So the ones that need, you know, these colder climates that the bees can't go to, they're just gonna be gravitating north where it's colder and they won't be able to match up as well.

Jaren: Sarah, are there examples of how the presence of bees impacts crops?

Sarah: Yeah, actually, Dr. Levinson, one of the people that we interviewed, was working on a project, or, she worked on a project, that tested the relationship between pollinator habitat and

soybean fields, which is really interesting. And they discovered that there were varying species of bees and the habitat next to the soybean fields, and the ones that are pollinating the soybeans. And so the same species weren't in both all the time, there were varying ones. And there was still a significant increase in the seed weight and the crops where the habitat was right next to the soybean fields rather than the ones that were much further away and weren't as close and approximation. And, Dr. Levinson mentioned how exciting of a discovery this is since most growers and farmers see soybeans as independent growers from pollination. They don't typically have, like, the big flowers, I don't think pollinators influence them as much, and so this discovery could lead to a huge change in how soybeans are managed to better suit and support pollinators and yields would increase as well benefiting our farmers and agriculture as a whole in North Carolina.

Malia: Cool. So what areas of NC agriculture are threatened because of climate change?

Sarah: Yeah, so with an increase in agricultural pest populations, many more farmers will reach out to pesticides in an attempt to save their crops, which are quite expensive for a lot of people and not always affordable, and they don't always cancel out the money. But pests would eat up and they wouldn't be able to sell from those crops in that vegetation. So it doesn't always balance out is a gamble for a lot of farmers. And it's just another factor that puts a financial strain on farmers and agriculture and the increased use of pesticides can also lead to runoff and contaminated water sources which a lot of us learned in school and I'm sure many of us experience in real life, which is harmful for wildlife and local communities. And while there isn't a statistic for North Carolina agriculture, the FAO research shows that 20 to 40% of our global global crop production is lost solely due to agricultural pests and while bananas aren't grown in North Carolina. It's like, you get three bananas, instead of four bananas, like, you want your four bananas. It's really sad. And it's just like imagine that there were not as much blueberries available during blueberry season and that increases the prices and farmers can't get as much and consumers can't get as much blueberries. It's just really terrible. We think that the statistics will be similar here in North Carolina, but maybe a little lower in comparison to other parts of the world where the situations are much more extreme. But yeah. After speaking with Dr. Burke, we noted that cold climate, rare, and specialist bees are most at risk. So not all bees are going to be like eliminated or affected significantly, but those are the most threatened ones that we have. And they fill like a very important niche in our ecosystems. And so the places that are supported by these bees will be significantly impacted, as I mentioned before, and maybe even lost at times without their presence. And cascading effects are quite likely in these ecosystems, but so difficult to predict what will happen. Dr. Burke really emphasized that we really don't know what can happen. And it's really scary to look into a future like that. And therefore, you know, crops such as blueberries and squash which specialize in ground nesting bees will be more at risk, as well as the crops that require those cold climates that the bees adapt to and can't reach anymore. And financial loss is the most significant factor in NC agriculture, as pollinator populations decrease, but ecological damage is significant as well, even if we don't know what it'll look like. So the future is pretty scary. But what do we know about native bees and their future, Jaren?

Jaren: Yeah, so let's talk about the future for pollinators. According to Hannah Levinson, we will likely see a change in population distribution and population size. Levinson adds that the impact that climate change will have on pollinators depends on the pollinator species in question. A pollinator that depends on cooler climates may experience decreased population size, and distribution, whereas a pollinator that depends on warmer climates may actually experience increased population size and distribution. Another difference to consider are generalist pollinators versus specialist pollinators. Generalist pollinators such as most bees can visit a wide variety of flowers, whereas specialist pollinators may depend on a specific family, genus or species of plant. If the plant that a specialist pollinator depends on is threatened by climate change, then that pollinator will be threatened as well. But in the case of generalist pollinators, they're less likely to be threatened if one plant they depend on is affected negatively by climate change.

Rachel: So we've talked a little bit about some research that's been conducted on bees, and things like that, but lots of them are short term like, even like Malia is studying them and its been pretty short term. So is there any research on the future of bees that we've been seeing, like, a long term?

Jaren: Yeah, speaking of that short term, long term difference, that is important because we do need to see more long term studies. But there is an article from 2018. That was a two year study by Paul Caradonna, James Cunningham, and Amy Iler. Their field experiment took place near Tucson, Arizona, and was observing how changing temperatures may affect *Osmia ribifloris*, one of several species referred to as the blueberry bee. In this study they mimicked previous cooler, and future warmer climate conditions, mimicking climate change, and they measured emergence phenology, linear body size, body mass, fat content, and survival of the bees. In the warming treatment, which was mimicking climate change, there was delayed emergence phenology and a substantial increase in phenological variance. So, the warming treatment led to reductions in body mass and fat content for this blueberry bee. Bees in the cooling and control treatments experienced negligible amounts of mortality, whereas bees in the warming treatment experienced 30%-75% mortality, and that is so much more than the control treatment and the cooling treatment, which really foreshadows what climate change can do for, in this case, the blueberry bee. So the findings indicated that although recent temperature changes have likely had relatively weak or non-negative effects, the predicted warmer temperatures will create a high stress thermal environment for the blueberry bee. This also suggests that *Osmia ribifloris*, the blueberry bee, may face local extinction in the warmer parts of its range within the century under climate change. So, returning to what Hannah Leveson said about the future, she expects that in general, pollination services in our natural areas and also our agricultural areas will be impacted. Levenson emphasizes that lower pollinator populations in general could seriously impact food supply and peoples' livelihoods.

Malia: Wow.

Jaren: Yeah, go ahead.

Malia: I was just gonna ask, what can normal people do to support native bees or pollinators in general?

Rachel: Us normal people

Sarah: Yeah

Jaren: Right. Yeah. That's a fantastic question. Hannah Levinson suggested three awesome things that anyone, no matter who you are, can do. The first is plant flowers! As many as you can, and as many kinds as you can. Different flowers actually have different nutritional content. And they attract different pollinators. And one of the most important things about planting these different kinds of flowers is that they will flower at different times of the year. So this ensures that for pollinators that there is a food source throughout the year, and that is really important for sustaining pollinator populations. Second, is providing nesting resources. Although bee hotels are good, and they have gained popularity over the years, they only support stem-nesting bees. So leaving yard waste, and cuttings in the yard can really help ground nesting bees. So maybe just thinking twice about raking the leaves, save yourself some time and help some bees. But third, is that just considering pesticide use, to just, if you do use pesticides, carefully using them, because there is an issue with people spraying mosquito pesticides, but accidentally harming bees as well. So Levinson says that avoiding spring blooming flowers during the day can help protect bees, because bees when they're active during the day, if they are sprayed by mosquito pesticides, then they will be harmed. Yeah. That's about it.

Malia: Awesome.

Jaren: Some final words are that climate change and its consequences can be really scary. But what's important to remember is that no matter who you are, or where you are, you can make an impact.

Sarah: That's so great to know that, you know, we can have a positive impact on you know, the pollinators around us and even like our agriculture system.

Jaren: For sure.

Sarah: Awesome. So thank you for tuning in to Triple P: Pest, Pollinator, Peril. And we're excited to share more information with you guys and have some really great examples at our live forum on November 10th at 9:40am, so make sure to tune in!

Jaren: Big shoutout to our supporter and sponsor, Dr. George Hess. Thank you for allowing this to be possible.

Sarah: Aw, that's like the end credits

Rachel: Yeah it's like the end credits

Jaren: We love you.