"The Multiple Dimensions of Tree Defense to Insects"

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[00:00:00] [Introduction music]

Dr Tom Smiley: [00:00:08] Welcome to the ISA is science of arboriculture podcast series. This is Dr. Tom Smiley at the Bartlett tree research laboratory host of this podcast series. Which is brought to you by the international society of arboriculture and the Bartlett tree expert company today's podcast is Dr.

Dan Herms, who is the vice president of research at the Davey tree expert company, and formerly an entomologist at the Ohio state university. He was speaking as this year's Elsie Chadwick research award winner on the multiple dimensions of tree defenses to insects.

Dan Herms: [00:00:58] Thank you for tuning into my [00:01:00] presentation.

My name is Dan Herms and I'm vice president of research and development at the Davey tree expert company. It's a great honor to receive the 2019 LC Chadwick award for our work culture research. Especially considering the illustrious achievements of the previous winners today, I'm going to discuss some highlights of nearly 40 years of research on tree defense.

I've been very fortunate to have collaborate with so many outstanding students, colleagues and mentors. My career began in 1981. When I joined the lab of Dave Nielsen at Ohio state university as a master's student, studying resistance of honey locusts to key insight PEs. Dave was the 1986 awardee of the LC Chadwick award has been outstanding mentor and lifelong friend.

I published my first peer reviewed journal article as a master student in Dave's lab. Uh, In the journal of our border culture, the ornamental landscape as an ecosystem, [00:02:00] and this paper has served as a framework that has guided my research ever then ever since. Um, then in particular, I've focused on ecological interactions between trees and insects, uh, with a focus on treat effects and the effects of the biotic environment on tree defense, stress and cultural practices.

And work on the effects of microbes and interactions between microbes and trees, soil microbes, plants, pathogens. So today I want to talk about the many dimensions of tree defense and in particular, I'm going to highlight some of the research that I've done with my students and colleagues on mechanisms of tree resistance, to insects.

Genetic basis of resistance and variation in tree resistance to insects the effects of resource allocation on defense and how defense is integrated into the overall resource budget of the plant. The implications of that for the environmental [00:03:00] effects on defense. And I'm going to wrap up with a little bit of work on that we've done on the ecological consequences of lack of defense and the significance for significant biological invasions.

So trees and other plants are well defended from insects pathogens, other herbivores, such as deer by structural defenses, um, thicken, cuticle, spines tricombs, et cetera. And also by an arsenal of chemical defenses, tannins, phenolic glycosides. So that you see the chemical structure below, turpines the resonant pine trees, alkaloids, the cyan, agentic compounds, president cherries, uh, and so forth.

And these are really important in terms of protecting trees from insects and pathogens. Of course, there's variation in resistance to insects, genetic and environmental. And I'm going to talk a little bit about some work that we've done [00:04:00] on genetic resistance and it. Variation to, uh, what, uh, variation and resistance to wood bores in particular from a co-evolutionary perspective.

And I want to talk a little bit about some work that I was part of to study variation among Birch species and their resistance to Brian's Birch for Brian's Birch bore is a native insect in North America. Uh, it has an evolutionary history with North American species of Birch like paper Birch. It's prone to outbreaks several outbreaks occurred over the course of the 20th century in relation to major droughts and other stress events.

So my master's advisor and mentor Dave Nielsen initiated in 1981, a study on variation in Birch resistance to brunch Bridgeport. So looking at, uh, [00:05:00] seven species of birds, very highly replicated study, 200 replicants of each species. So 1400 trees. This experiment, three trees native to North America, river Birch paper Birch and gray Birch, and four species exotic to North America, native to Europe and Asia European white Birch mountain Birch.

Japanese white Birch and Monarch Birch. And at the time these exotic species were being touted in the trade literature as being resistant to North American Dave's objectives was to test this. Now in 1997, I replaced Dave took his position. At Ohio state university and picked up the study, um, we're at, uh, head left Goff and, and the results were that, uh, actually quite striking.

And so what you [00:06:00] can see is that if you look at the four exotic species here, 100% mortality, the study and in Northeast Ohio. So that's 800 trees killed. By Brian's Birch for as evidenced by exit holes, galleries, and so forth. But if you look at the three North American species river Birch paper, Birch gray Birch, uh, high survival, and this is outside their native range for all three species.

So none of these three species are native to Northeast Ohio. Um, so there's probably some inherent stress. There was a severe drought in 1988. Uh, probably the most intensive outbreak of would-be bore in this two acre plot that had ever been seen in North America until Emerald Ash borer, um, but still a very high survival of these North American species.

So here you can see, uh, [00:07:00] The S the start difference. And the conclusion here is that we're yet no evolutionary history, no resistance. And indeed, if were to be introduced to Europe and Asia would have devastating impact there much like Emerald Ash borer is having in North America where it has just devastated and continues to devastate North American Ash species here, you can see a Ashland.

Street and Toledo where the trees were rapidly killed over a three-year period. Woodlots for us. Um, and continuing to kill trees as EAB continues to spread based on the results of the Birch study. We were pretty sure that this was a similar phenomenon occurring, where the North American trees lack the evolutionary history and thus lacked resistance.

Uh, but we initiated a common garden study to test that. And in fact, that was the case. This is man cheering, an Ash native to Asia, and has an evolutionary history with Emerald Ash borer. [00:08:00] And it is quite resistant. So we found that only become susceptible when it's severely drought stressed or stressed by girdling otherwise inherently resistant here, surrounded by North American Ash trees.

And you can see in the background. Um, the study site and Southeast Michigan North American trees. So again, no evolutionary history, no resistance. We've looked at mechanisms of resistance in North American birches, and then. Ash Manchurian. Ash has a number of phenolic compounds in the flow, them that are not present in the North American species.

And furthermore, they're more rapidly oxidized. Um, some work that Chad Rigsby did in his PhD research at Wright state university. Chad now works for Bartlett tree company, Bartlett tree experts and found that the phenolic [00:09:00] compounds. Are powerfully oxidized when they're fed upon by in the phenolic compounds and maturing Ash oxidized, when fed upon by Emerald Ash borer causing damage to the, to the mid gut.

So we've also looked at how environmental factors can affect expression of tree resistance to insects. And I want to talk about some work we did to look at how drought stress affects resistance to Broughton's Birch board. And as I mentioned earlier, Brian's Bridgeport outbreaks in North America on native paper, Birch have been associated with episodes of drought throughout the 20th century.

So to look at this experimentally, we can constructed these, uh, in ground soil microcosms. We trenched to a depth of, of one meter lined these trenches with [00:10:00] PBC landfill liner material. Creating in ground pots, bottomless in ground pots into which we planted Birch trees. And we constructed these beneath canopy tests, which would exclude precipitation.

So we have these replicated isolated soil environments and the experimental approach was to manipulate water availability to create a simulated drought, average rainfall. And above average rainfall based on. The environment in central Michigan, where this research was conducted when I was a PhD student.

And so, uh, then we created a simulated outbreak by cutting down these infested trees. And this happened to be during 1988, during a severe drought, a lot of infested Birch placed them into rows and aisles and let the bronze Birch for adults emerge and colonize the experimental [00:11:00] plantation. And what we found is that Brian's Birch for colonization was much higher on the drought, stress trees, trees that only received a, uh, 10 centimeters of irrigation, 30 centimeters for the summer.

His average 90 centimeters would be the equivalent of one inch of rain per week, which is an extension recommendation for irrigating trees. And as the ring, as precipitation or irrigation, I guess, went down. Uh, or went up insect, colonization went down. So this consistent with the fact that these stress trees are more susceptible, the literature suggested.

That a mechanism of resistance of Birch to Brian's Birch forest. This wound induced paradigm tissue, this callus that forms in response to wounds be they mechanical wounds. For example, from pruning or initiated by insect feeding [00:12:00] and on thin bark trees like Birch, you can see the manifestation of this.

Callus formation. This wound induced periderm under the bark as ridges that form over the galleries. And so the, a thought is that, um, the larvae are feeding just under the bark on the floor. So eventually, essentially in two dimensional space under the bark and they're moving forward. As they feed at the callus is growing fast enough.

It can encapsulate the insect at the insect is moving fast enough or the callus is slow enough. The insect can stay ahead of that and win this race in the flow. That's the hypothesis. And so we measured the rate at which this callus formation was growing and found that when the callus formation dropped below, oops, I'm sorry.

Drop below a threshold [00:13:00] value of 0.02 millimeters per day. Then resistance broke down dramatically. And the percentage of the Trump that was colonized increased to levels that resulted in the death of the tree, 60 to 80% of the flow consumed. Uh, but if it was higher than 0.02 millimeters, the treats stayed healthy and resistant.

So this negative power function suggests that there's a threshold that's above this rate. The tree wins. If it's below this rate, the tree loses. Furthermore, we found that this rate of callus formation was correlated in an exponential way with rate of photosynthesis, net photosynthesis rate. And so as photosynthesis dropped down to very stressful levels.

The rate of [00:14:00] callus formation slowed to the point where the trees reached this threshold of being susceptible. So if you integrate these results, we generated the hypothesis that Birch resistance is in fact, related to this rapid wound induced callus formation. And the rate of this is dependent on current photo sent date, being translocated from the canopy.

To the truck. So if this prediction were true or if this hypothesis were true, then this prediction should be true. That trunk girdling, which would restrict transport a photosynthetic from the canopy to the trunk would decrease the rate of callus formation and bronze Birch bore resistance below the girdle.

But the portion of the tree above the girdle would stay resistant. So we tested this experiment by girdling trees and this [00:15:00] native stand in central Michigan at about six feet, two meters off the ground. So we flow them, girdled the tree predicted that this portion of the trunk would stay resistant. But this portion of the trunk, which would be isolated from the current photos, sent they in the canopy.

Would become susceptible because the callus formation could not be supported by photosynthetic. The flow of transport of which would be disrupted by the girdling. So this resulted in four treatments. We had a girdle tree where we looked at resistance above and below. And then we had a paired control. Uh, we didn't actually girdle the tree, but we looked at the corresponding position that would correspond with the location above the girdle versus the location below the girdle and the lower six feet of the tree.

So this was to control for any effect of spatial variation, [00:16:00] um, and distance from the canopy. And so then we conducted autopsies at the end of the year. We let the trees become infested. Naturally, cut them down, deep bark them, and you can see the impact that girdling has on flow transport. Uh, obviously blocking flow and transport to the lower part of the trunk.

You can see increase radial growth above the girdle, um, relative to below. And what we found is that callous growth above the girdle. Was actually higher even than on the control trees because of this super access to photosynthesis. But below the girdle callous growth dropped to a rate below 0.02 millimeters that we predicted would make it susceptible on the control tree.

That was not girdled. Callus formation [00:17:00] was high enough that it should remain resistant. So we looked at the length of galleries, which conforms with larval feeding and larval growth, and found that above the girdle, the galleries were stunted this associated with short galleries with, uh, dead stunted insects, but above, below the girdle, the larvae did very well long well-developed.

Galleries healthy larvae and on the control tree also stunted galleries. So here you can see a short stunted calloused gallery above the girdle versus healthy well-developed galleries below the girdle. So consistent with the predictions that stress decreases Birch resistance to paper Birch by week in the act of defense response of the trunk.

Which is dependent on carbon translocation from the canopy to the trunk. So [00:18:00] when stress reduces carbon availability, carbon translocation to the trunk, the Birch trees become susceptible. And we found that even moderately stressed trees are highly resistant, which also would explain the high survival that we saw of Birch North American Birch and the common garden studies.

Now we've also, um, my students and I have done a number of experiments to look at the effects of soil fertility on insect resistance, including natural variation in nutrient availability, fertilization, mulching, and so forth. These are quotes that I have pulled from extension bulletins on fertilization.

From various universities, including one from my former university, Ohio state university, where I was a professor until 2017, [00:19:00] uh, that propagate the idea that fertilized trees are more resistant to insects and disease. And so as a PhD student, I was interested in studying the mechanisms behind this, and I did a literature review for my thesis.

And was actually kind of surprised to find out that the peer reviewed literature did not support this paradigm. In fact, fertilization decreased insect resistance of Woody plants and almost every study and no study that I could find that was properly controlled, showed. Fertilization to increase tree resistance to insects.

And so why is this well, one it's well known that fertilization increases the nutritional value of plants is true for four H crops. It's true for trees increases the nitrogen and protein content of the leaves. But perhaps more [00:20:00] counter intuitive is that fertilization often decreases the chemical defenses, the secondary metabolite concentrations in trees.

And so this combination of increased nutrition and reduced defenses results in a much more suitable diet for the insect. And so. This effect on defenses can be understood in terms of resource allocation trade-offs and carbon allocation. That for example, that we just discussed. And so it's become increasingly clear that there are trade-offs between growth and defense.

So plants have limited resources to support their various physiological functions. Growth maintenance, reproduction, storage defense. These cannot be maximally supported simultaneously. And so plants kind of go through [00:21:00] different phases during the growing season. Um, here, the trade off between growth and reproduction that you can see here as well documented, but there's increasing evidence that we reviewed in this plant strong evidence for a trade off between growth.

And defense we reviewed in this paper. So you can think about this in terms of the plants have carbon that they can budget to these various processes. The size of their budget is dependent on the photosynthetic rate per unit leaf area times, total leaf area, and then integrated over the growing season.

So this is. How the plants carbon budget is determined. Studies have shown that fertilization has various effects on this carbon [00:22:00] acquisition, the income of the tree, and essentially fertilization has little to no effect on the photosynthetic rate of the tree. Talking about nitrogen fertilization here, nitrogen being the element that is most commonly limited for trees in most environments, phosphorus and potassium rarely limited, except on the most disturbed soils.

Fertilization does have a. In a consistent impact on total leaf area. So when you fertilize a tree, you increase the growth of the tree by increasing total leaf area, but with really minimal impact on the photosynthetic rate per unit leaf. And so the tree grows by. Exporting photos sent they from the tour leaves, which are photosynthetic sources via flow on [00:23:00] transport to support the production of new leaves.

And these new leaves are not able to support themselves until they're about three quarters of the way expanded. So you have flown transport from mature leaves to support new leaves or at certain times a year. You get export of photosynthetic to support things like row storage, carbohydrates, and so forth.

Any carbon that's exported out of this leaf is not available in this leaf to support defenses. And you can measure changes in the density and the weight of leaves in relation to the growth rate of trees. So we've studied and tested these physiological principles using a computer controlled fertigation system with, uh, these willows high degree of environmental control, high degree of genetic control.

And we looked at the effects of five [00:24:00] levels. Of fertilization. This work was done by Carolyn Glenn, who was a post-doc in my lab and now works for the Swedish agricultural university in Oop Sola as, um, a director of research there. And we looked at five different nutrient levels. Fertilization levels, zero parts per million to 200 parts per million nights.

And we varied phosphorous potassium and micronutrients in the same proportion. So when we doubled nitrogen, we also doubled phosphorus. And what you see, this is total plant biomass. No surprise. As we increase nutrient availability, we. So all a substantial response in terms of plant growth, but what we did didn't see was any effect on photosynthetic.

Great. So even the trees that I'm the shrubs that were planted that received no fertilization had a high rate of [00:25:00] photosynthesis, anything above 20, he was rocking and yeah. And, um, so they were all doing very well in terms of photos and. Photosynthesis, they weren't water limited. This is Carolyn Glenn, Brian Chambers working in my lab.

And so, um, you asked then, you know, how can plants that have the same photosynthetic great end up growing at different rates? So these are representative plants from the five different treatments. And so what it means is this, well, the plants all started at the same size because we selected plants for the same size.

They have the same photosynthetic rates. So initially they had the same carbon budget, but the faster growing plants are allocating more carbon to the production to noodle leaves, which pays, um, compounding interest, new leaves produce more carbon that can be used to produce more leaves. [00:26:00] The slower growing plants export more carbon to route production at a higher root shoot ratio.

Um, as this carbon has moved out of these leaves from sources to sink, we also found that the slower growing plants had higher concentrations of chemical defenses, fennel, propane weights. So this is the. Um, tannins and phenolic glycosides in willows as the relative shoot growth. The growth rate of the willows increased the concentration of the chemical defenses dropped pretty significantly from 350 milligrams per gram down to, you know, close to.

200. And so this is consistent with the trade-off between growth and defense and has had implications for insect resistance because these phenolic glycosides are known to be toxic to gypsy moth. And you [00:27:00] can see here that gypsy mot growth rate was twice as high, more than twice as high on the plants that received the high fertility rate.

So this is very consistent with the source sink, carbon allocation. Hypothesis that I talked about doing another field study to look at the effects of fertilization on Birch and pine. Again, using these microcosms isolated, uh, soil environments. And we tested a fertilizer treatment consistent with the antsy standard four pounds per thousand square feet.

18 five, four NPK over half in slow release nitrogen. Split application applied in spring and late summer and found again, no effect on Photosynth date, but the fertilized trees grew

faster. As you can see here. And [00:28:00] again, we found this negative correlation between growth rate and full-year defenses, total phenolic concentrations.

As the trees grew faster, they had lower concentration of phenolics and looking at insect survival, survival of newly hatched Larbi of forest tent, Caterpillar and gypsy moth was higher. On the fertilized trees than on the non fertilized trees. So again, not consistent with the idea that fertilization would make trees more resistant.

Looking at Pines, similar pattern of fertilized trees had lower concentrations of full-year turpines and survival of European pine soft ly was higher on the fertilize trees we looked at. Uh Diplodia. Uh, uh, canker pathogen as well on the Pines that time it was called spear Opsis. Now it's back to Diplodia again, working [00:29:00] with Enrico Brunello.

My good friend and colleague at Ohio state has post-doc, uh, Jim Blodgett and found that Diplodia cankers grew 50% faster on fertilized trees. So you're not going to fertilize your way out of a problem like this. You're only going to aggravate it. So again, This was related to a better environment for the fungus, more nutritional environment for the fundus and reduced, um, defenses in the pie.

I want to shift gears and talk a little bit about natural nutrient cycling. And of course in a forest trees are adapted to gradual. Release of nutrients from decomposing, organic matter leaves, twigs and things that fall to the forest floor rather than pulses of fertilization that may occur once or twice a year.

However, in constructed landscapes, these nutrient cycles are often [00:30:00] highly disrupted. The organic matter is low or non-existent, that's the ultimate source of nutrients. And so we've been interested in soil management practices and their effect that they may have on disrupted nutrient cycles. And for us specifically, mulches different products used for mulching and different environments.

Pine straw, common in the Southeast woodchips recycled. Wood pallets, composted bark and yard waste, for example, and I want to talk about some work that John Lloyd did. John was my first, uh, PhD student at Ohio state university. And he studied the effects of mulches on nutrient cycling and predicted that you, that different mulches.

Depending on your composition could generate a trophic cascade from microbes through plants to insect herbivores that [00:31:00] organic matter as it decomposes can have differential effects on nutrient availability, depending on the source of organic matter, which based on principle, I just talked about could impact plant growth and defense and thus plant feeding insects.

And so as organic mulch decomposes, it releases organic nitrogen, which is further mineralized into forms that can be taken up by the plant or taken up by microbes. That's immobilized by microbes. It's not available for plants. So you have this competition between plants and microbes for available nitrogen, which can be supplemented also by fertilizer.

So. The outcome of this competition between microbes and plants is dependent on the balance between mineralization of [00:32:00] organic matter, which releases mineral, nitrogen, and immobilization of this nitrogen by microbes. And this is really important because the vast majority of nitrogen. In the soil is tied up in a microbial biomass.

It's immobilized in the microbes where it's not available for plants. And this is why a standard soil test doesn't provide information on nitrogen because the total nitrogen content of the soil, it doesn't tell you anything about how plants will respond to fertilization. You have to know what proportions are in mineral nitrogen versus microbial, nitrogen, and so forth.

The carbon nitrogen ratio of organic matter is really critical in determining how the determining the balance between immobilization and mineralization and thus nutrient availability for plants. [00:33:00] So when the CN ratio of organic matter, for example, mulch is high. And that, that means that the nitrogen concentration is really low.

For example, in wood, like ground wood, pallets, very little nitrogen. When you have a high CND ratio, the microbes are going to be nitrogen limited. They're going to use the carbon microbial growth is carbon limited in virtually any soil. You add carbon to the soil. You'll stimulate microbial growth.

There's not enough nitrogen in that organic matter. They'll scavenge that nitrogen from the soil they'll tie up that nitrogen, the nitrogen availability for plants would be crease. The carbon nitrogen ratio is low, less than 30 to one. As the microbes utilize the carbon, there will be more nitrogen than they need to support their growth.

[00:34:00] This will increase the nitrogen that's released through mineralization for plants and will increase nitrogen availability for plant growth. Why is 30 to one, a critical number? Well, that's the carbon to nitrogen ratio of a microbe. You are what you eat. And so 30 to one is kind of a, a critical value above 30 to one.

You're gonna get increased immobilization by microbes below 30 to one, you're going to get increased mineralization and more nitrogen available for plants. So John construct an experiment looking at two different products, growled wood pallets, extremely high CN ratio. Very little nitrogen. They grind these things up.

Diet use it as mulch, commonly, at least in Ohio, the Midwest, they also looked at compost, a yard [00:35:00] waste or compost, a yard trimming. So this is the stuff landscapers bring in to the yard. So modularized and composted and yields a product. That is fairly remarkable consistency. Once you homogenize the stuff, you know, over the course of the year, there's not a lot of variation at what and what comes in.

Um, once it's homogenized a CN ratio, well below 30 to one, so 17 to one. So these products should push nitrogen availability in very different directions and thus have very different effects on growth in defense. So again, the approach utilize the soil. Mike microcopy sums some mulched with wood, some, um, left as bare soil controls and some mulched with.

Compost applied at two inch layer every year, just before the trees leafed out planet river [00:36:00] Birch trees, as well as rhododendrons. And these plots looked at soil respiration.

This is an indication of microbial activity. The rate that CO_2 is released from the soil. And what you see is that soil respiration was more than twice as high.

In the plots that were mulched, it didn't matter with what? So you apply carbon to the soil. You stimulate the microbes. Microbial biomass increases soil respiration increases, but very different effects on nitrogen mineralization rate. So this is the rate that nitrogen is released in forms available to the plant much lower.

When you mulch with the ground wood. Higher when you mulch with the yard waste intermediate and the bare soil control. So you're reducing nitrogen availability with the highest CN wood. And this has an effect. On the growth of the river Birch trees. [00:37:00] So lowest when you mulch with the wood highest when you mulch with the yard waste.

Um, but then this also had the predicted effect on tree defenses. So the slower growing trees had higher concentrations, the foliar phenolics, um, then did the trees mulched with yard waste. You look at the growth of insects. Uh, fall web worm grew slower on the trees, mulched with ground wood than they did on the bare soil or the yard waste plants.

Japanese beetle defoliation was highest on the trees, mulch with yard waste. So these insects choosing the trees themselves quantified the amount of defoliation. So this can create the, um, impact, uh, the potential for prescription mulching. If you want slower growth, more insect resistance in multiple ground wood.

If you want faster growth, you want to [00:38:00] restore, disrupted nutrient cycling. For example, in a new landscape, you can mulch with yard waste. Now, finally, I want to end up talking about. Um, the ecological impacts in biological invasions where tree defense is lacking. And we looked at this earlier with Emerald Ash borer, North American trees just don't have the resistance mechanisms or the resistance genes, things to, um, fight.

Or resist Emerald Ash borer, widespread mortality resulting in widespread and relatively simultaneous formation of canopy gaps and fallen trees. And a number of my students studied the impacts of Emerald Ash borer in forests in Southeast Michigan, where Emerald Ash borer has impacted, uh, the longest where it was discovered in 2002, uh, was.

Well, it was [00:39:00] established by the early nineties who knows how long it's been there. Um, what we found was when we started this research in 2005 and these forests. Percent Ash mortality was 40% already. We know from tree ring analysis that had been present since at least 1994. So it took over 10 years at least to get to 40% mortality.

But then within another three years, it was up to more than 95%. The mortality by 2009, more than 99% of the Ash streets were dead. And these are trees greater than one inch DBH. So saplings and so forth. Regeneration had stopped no seedlings, no new seeds and so forth. And so we were interested in, you know, what impacts this might have.

You have this tree mortality results in gap formation, increased snags, Woody debris. In [00:40:00] this case, these impacts can cascade through to nutrient cycling. Um, ecological interactions with plants that can, uh, impact biodiversity, abundance of native and exotic plants. And my post-doc Kamala guy named reviewed these impacts in this paper where this figure came from.

She's now a full professor of forest symptomology at the university of Georgia. And she also looked at. Other insects that use ashes as a tree. So you can immediately speculate that there will be direct impacts on insects that use Ash. And she documented more than 286 arthropods, more than 280 yards are pies, insects, and mites that use Ash as a host street, 44 of these use only Ash.

And so it was ashes eliminated. Many [00:41:00] of them find themselves at risk for local, uh, population declines or even extinction, especially those that use a larger Ash trees. For example, uh, the banded Ash clear wing bore. We use pheromone trapping to determine that it was eliminated from Southeast Michigan. It needs a Ash tree.

About four inches or so in diameter, those trees were just gone and there is a powerful commercial pheromone lure, and we just weren't catching them, might be considered a pest species, but it's also a native moth and part of our native biodiversity. So direct impacts on Ash species. And then. Indirect impacts on other things.

For example, invasive plants, Wendy Glouster. Now professor at Ohio state university. Found that invasive plants grew faster in the gaps [00:42:00] where you had this sudden increase in light than native plants. The native plants that are in the understory are there because they're adapted to shade. So invasive plants get spread around by birds are lurking in the understory, but most of them are very responsive to light.

And as she found, when you got to gap formation, these species just exploded in terms of their growth rate. Kevin Rice. One of my PhD students is now a professor at Iowa state university looked at the effects of this gap. Formation on this native butterfly, the giant swallowtail butterfly. And found that in these canopy gaps, their growth and survival of the Caterpillar was reduced.

So they feed on prickly Ash, which is in the citrus family. And the citrus family produces chemical defenses called FranNet coumarin. And those frantic humans are photo activated by [00:43:00] light. And, and when they're in the gaps that Fran Akuna rooms become more toxic because. Their electrons of these compounds are elevated.

To a new orbit tool. Well, they'll more excited. Don't cross-link with DNA and their concentrations increase. And this has a negative effect on these caterpillars, their growth rate slows they're in the larval stage longer. They become more susceptible to natural enemies. So another kind of, um, Indirect effect that you might not necessarily think about.

Larry Long has finished his PhD at North Carolina state university. Did his master's with me looking at effects of Ash mortality on birds and found that as Ash trees died and changed the understory resulting in more brush growth, that the bird community transitioned from species consistent with. [00:44:00] A close it, canopy mature forest to those species that are found in open canopy and more shrubby for us things like Indigo buntings and other species.

So another indirect effect of Ash mortality. Finally, I just want to talk about the lack of defenses and implications for the most devastating biological invasions of our forests in North America. And if you look at the most devastating invasions, Emerald Ash borer, hemlock, woolly adelgid, also wooly adelgid viburnum leaf beetle, and pathogens, Chestnut blight, Beech bark disease.

The emerging Beech leaf disease, Dutch Elm disease, and every case, the North American species that lack the evolutionary history have been shown to have much lower resistance than the [00:45:00] species on which they have evolved. So the Asian Ash trees, the evolutionary hosts for hemlock woolly adelgid. For Balsam, woolly adelgid the European by Burnham species, these species, these in which they have evolutionary history are much more resistant.

So the lack of plant defense, the lack of resistance genes are responsible and every case where you have a species that's killing trees in North America on a range wide basis. Now, there are many invasive insects and which are not causing these devastations, but in the cases where they are, this is a universal pattern, the lack of defenses.

So with that, I appreciate your attention. I hope you enjoy the rest of the conference. And I want to acknowledge the funding sources of my research over the year in particular, the tree [00:46:00] research fund, which has provided a number of grants to support my research over the years. I hope you will support the tree research fund and the great work they're doing to support, support, research, education, and outreach.

Um, the USDA. Forest service, national, urban and community forestry council and the USDA national research initiative. So with that, um, I thank you.

Dr Tom Smiley: [00:46:28] This concludes the talk by Dr. Dan Herms of the Davey tree expert company. He was speaking as the LLC Chadwick research award winner on the multiple dimensions of tree defenses to insects.

This talk was originally presented at the ISA 2020 virtual conference. The views and information expressed are those of the presenter. If you would like additional [00:47:00] information on insect management in the landscape, the ISA web store has numerous books on the identification and management of urban landscape pests.

Please join us next month for another presentation in the ISA Science of Arboriculture podcast series.