USDA Forest Service

URBANFOREST CONNECTIONS

webinar series

Emerald Ash Borer: Status, management options, and cost calculators

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TRANSCRIPT

Kathy Sheehan: Now onto today's topic: *Emerald Ash Borer: Status, management options, and cost calculators*. We will hear from three speakers: Deb McCullough, Professor at Michigan State University; Cliff Sadof, Professor at Purdue University; and Rich Hauer, Professor at the University of Wisconsin – Stevens Point.

Our first speaker, Deb McCullough, holds graduate degrees in Forestry – an M.S. from Northern Arizona University – and Entomology – a PhD from the University of Minnesota. She is a Professor with a joint appointment in the Departments of Entomology and Forestry at Michigan State University with research, extension, and teaching responsibilities. Much of Deb's current research focuses on the ecology, impact, and management of invasive insects, including emerald ash borer [EAB] and beech bark disease. She works with forest management agencies, regulatory officials, and private landowners to identify damaging insect populations and to develop long-term sustainable management strategies to protect forest health. Deb has published more than 100 papers about forest insect ecology and management in scientific journals, along with more than 200 extension bulletins and articles. She teaches *Insects and Diseases of Forest and Shade Trees* annually to students majoring in Forestry or Horticulture. Thanks, Deb! And I will turn over to you.

Deborah McCullough: Hello, everybody! This is Deb McCullough! I'm happy to be here this afternoon. It looks like we've got a number of people from a whole bunch of different states so I would like to thank you for participating today. And hopefully I can give you some useful information and maybe save you from some of the bad things that went on in the early days of the emerald ash borer here in the north central region.

Before we get started, I have to recognize and make sure that everybody realizes I'll show you a lot of information that's been collected over more than a decade. A number of people have helped with this, including people like Therese Poland and Nate Siegert. Nate used to be a graduate student and a postdoc. He’s with the Forest

Service, along with Therese, now. Rodrigo Mercader is a professor down at Washburn now. Sara Tanis is teaching at Kalamazoo College now. And I also want to point out that most of the funding for the projects that have generated the information today has come from grants and cooperative agreements through the Forest Service, and to some degree, ARS. And I point that out particularly because we -- myself and Therese, who have done a lot of this work – we've never taken funding from any of the pesticide companies for any of the work on emerald ash borer. So they take a risk when they work with us. They usually donate the product. But if it works well, we can say that. If it doesn't work, we will say that as well. We try to be really objective with the information we present.

So with that caveat, I'm sure most of you are familiar with this map. It doesn't shrink. It gets larger every single year. And if you haven't been paying attention lately, Louisiana has become the most recent state to be infested here. There is a new infestation that was identified in February just across the border from Arkansas. So we're now up to 25 states, as well as several infestations in Ontario and Quebec. And if you're not in a state that's infested yet, chances are good that you will be eventually. I think the nursery trees and ash logs are pretty well regulated now. Firewood is really difficult to regulate, as most of you are familiar with. And nobody can promise that there isn't infested firewood being still moved around the country despite everybody's best efforts.

Nobody knows how many dead ash trees there are now. We used to talk about tens of millions of dead ash trees. It's now in the hundreds of millions of dead ash trees – landscape ash trees, trees out in the forest, trees along streams and rivers, and so forth. And it just keeps progressing. If you are in an area that becomes infested with emerald ash borer, you will be dealing with the problem on your own. The federal agencies, APHIS in particular, is continuing their detection surveys. Once an area is found to be infested, quarantines will be imposed that affect the ability of people to move ash trees, logs, and hopefully firewood around. But there is as yet no national EAB strategy. And one way or another, you will end up – you being the greater royal you – somebody is going to end up dealing with all the ash trees, particularly in landscapes.

This is information that we published a few years ago. That was a large group of us and forest economists, some modeling people, some forest insect people, and we tried to identify the economic costs associated with the biggest, baddest forest insects in the country. And if you look at those numbers – this is the annual projected cost through 2020 of emerald ash borer, as well as hemlock adelgid and gypsy moth – and you can see that most of the cost is with local governments. That will be municipalities who have to deal with ash on the streets and on municipal property, and private households, private property, either spending money to treat or remove trees and having dying or declining trees affecting their property values. Timber too. Ash borer is, the cost of ash borer in timber is outstripping the other pests by orders of magnitude. White ash timber, for example, is particularly valuable – that's what we make baseball bats out of, for one thing.

And some of the questions that come up frequently are where and when should I be looking for EAB? Are there certain trees I can look at to see if they're going to be infested first? Are there any species that are more or less resistant to emerald ash borer? And we started looking at this in Michigan. There're four major ash species that occur here: green, white, black, and blue ash. I'll show you a little bit about some of this. If you think about what ash borers are doing, the host tree that the female beetles select is critical. Those mature females are making all the decisions about where the larvae are going to feed. I'm sure most of you know the basic biology. The adults are active through most of the summer. They're going to nibble on ash leaves that whole span of time. But the beetles won't show any interest in mating until about a week after they've emerged. And the females won't start producing and laying eggs until close to three weeks after they've emerged. That's important for a number of reasons. But if you're an arborist or a landscaper trying to protect landscape ash, that's a really good window to target because if you control the beetles before they lay eggs, you can save a lot of larval feeding. So once mamma selects the tree and lays the eggs, then the larvae don't have any choice. And they're going to feed – usually in southern Michigan, we'll see larvae starting to feed by the middle of July. They'll feed all through the fall and then most of them will pupate in the following spring and emerge as adults here.

So, one of the things we know is that stressed trees are going to be more attractive to ash borer adults than healthy trees. And I think this goes back to Asia and China where these insects are native. They are secondary pests in their native range. They do not colonize healthy ash trees in China. They colonize very stressed trees. And if you girdle a tree and you take off the outer bark and the phloem, the inner bark, that seems to be just perfect for the beetles. The tree slowly more or less starves to death. The volatile chemicals that come off of the leaves and the wood and the bark, the profile, the compounds in those emissions change and the beetles are very perceptive. And this graph here, what this is showing is the ratio of larvae on girdled trees compared to larvae on adjacent, non-girdled trees. This is larvae per square meter. When the density are very low, and the infestation is three, four years old, you're going to see anywhere from five to ten, maybe fifteen times more larvae on a girdled tree than you will on a healthy tree. And to give you some perception of what that means, over here, around 25 or 30 larvae per square meter is where you will start to see symptoms of the canopy. The canopy might be thin, or you might start to see some dieback up at the top. And once you get out here, around 90 or 100 larvae per square meter, that is all that can develop on a given tree. They need about 10 square centimeters of phloem to finish, to feed and develop. So out here is where the tree is going to be dead.

The other thing we know is that beetles really, really like to be in the sun. Any kind of open grown tree is going to be attractive to them. Trees on the edge are going to be more attractive than a tree in the middle of a wooded area, and so forth. We also know there's differences among ash species in terms of which ones are preferred by the beetles for hosts. And I won't show you all the stuff that we've done. We'll just cut right to the chase. The two most common ash species are green ash, *Fraxinus*

pennsylvanica, and white ash, *Fraxinus americana*. The map shows their native range, but if you look, every state in the continental U.S. has green ash and white ash ornamental trees, landscape trees. So these are the ones that a lot of people are very interested in. And we can tell you that green ash is going to be colonized first and almost undoubtedly killed before white ash trees, when they co-occur. And they do co-occur often. If you look at this graph here on the left, this was one of our very first studies. We had three different areas like this where the green and white ash trees were either intermixed, or green ash were on one side and white ash on the other. This is the green here in the green bars, and the purple is the white ash. This is the number of adult exit holes per square meter. We started with 12 green ash and 12 white ash, and as the exit hole density increases, the green ash trees die. We're down to only 7 trees up here. And you can see by that density, if we can only get about 100 or 110 beetles per square meter, these trees were dead at the end of 2005.

These data over here, this was a plantation we had. Every other tree was a green ash, white ash, green ash, white ash, and so forth. And you can see, if you compare green ash to the white ash, they much – heavier colonization of the green ash. And even if the trees are girdled, they still like the green ash much better. We see something similar when we go out into the forest. This is information that came from a study where we had had eight sites in southeast Michigan in the core of the ash borer invasion, eight sites where the densities of ash borer were peaking – we call that the crest – and then eight sites that had become recently infested, but you really couldn't see any sign of ash borer yet. We did a lot of surveys there. But the bottom line is that in the core, very, very few trees, almost none of the large trees, are still alive. You can see even over a year, more mortality occurred. You can see as the population builds up in the crest, we lose ash trees, and even in the cusp, we're starting to see the ash trees, the green ash basically be functionally extirpated, by and large. What's really concerning is that there are no seedlings germinating. We've lost the seed source in the core and even in the crest area. So that doesn't bode well for the future of green ash.

White ash is a little bit different. We have – we looked at 40 different sites. We ended up picking 28 sites that had a lot of white ash. We're doing some surveys – this is an ongoing project. But in these 28 sites, we have anywhere from 100% mortality to almost 100% survival of white ash. And a lot of the sites, this is stems here, this is phloem here. You can see we have sites where much of the phloem remains alive. The trees have been attacked. We can see old galleries, but the trees are starting to heal. The density of ash borer is lower, so it will be interesting to see what happens with this.

This is a brief summary. If the tree is out in the sun, the beetles are going to like it. If the tree is stressed, particularly if it's girdled, the beetles are going to like it. I don't think you have much black ash in the West, but if you do have black ash – very much preferred, and it's the most vulnerable species we've worked with. Green ash is going to be attacked before the white ash trees are. We don't know exactly what's going on with white ash. You could have anywhere from most of the trees surviving to every

single white ash being killed. Blue ash we have in this part of the country. It's the most resistant. We're getting 60-70% survival of blue ash. And as far as native ash trees go, so far this one looks like the one that's going to survive. The important part of this is that you can watch these trees, the really vulnerable trees, to try to watch for ash borer early on. Any time you have stressed ash, and especially if they're green ash or black ash trees, look at those, and particularly if they're out in the open.

Woodpecker attacks. You can see woodpecker holes here. They're quite a bit larger than the little tiny D-shaped exit holes the beetles leave. Woodpeckers are really good at finding infested ash trees. A lot of new infestations have been found because somebody noticed woodpecker holes up in the upper part of the canopy. That's what this graph is showing. The very first colonization usually takes place up in the canopy of the tree. So if you're looking for ash borer, be sure you're checking up high on the main leader of the large branches.

Another question that always comes up: When do I have to start treating my ash trees? That one is a little bit fuzzier. We talk about the core, the crest, and the cusp. You don't want to treat trees too early because you're wasting money and wasting insecticide. But you also don't want to wait too long. And what makes it difficult is how hard it is to find newly infested trees and new infestations. None of these beetles in the family Buprestidae, and certainly not in the genus *Agrilus*, these beetles do not produce long-range pheromones. The traps and lures that are used, the lures are based on volatiles that are emitted by the ash trees. That means that a trap is competing with all the ash trees in the area. And you have to hope that the beetles end up on the trap or you're going to miss them. And the other thing that makes it difficult is that once a county is found to be infested, or some unit of government, the regulatories stop. So you can have one infestation going in part of the county, and much of the county will be un-infested, and it's very difficult to find that until you see symptomatic trees.

The other thing that gets difficult is the dispersal. Most of the females – this graph is showing that most of the eggs laid by a generation of females are going to be within about 100 meters of the point where the females emerged. But then you get these females, the mature females that are overachievers. They fly further for whatever reason. We don't know how many do it. We don't know why. But you can't find those trees that are way out there that have just a few eggs and a few larvae laid on them. And that's what this graph is showing. This is something that we've modeled based on a lot of field data. This is showing that if you are, say, 1,000 meters from the origin of an infestation, a new one, that's about a kilometer, somewhere out here, five years after that infestation has become established, you have almost a 0% probability of detecting it. You have to wait until the infestation builds up, the population gets higher, and you see some symptoms. And what happens is typically outliers, new infestations are not found until they have been there for four to six years. And as the population builds up, you enter this really bad time period where you have most of the trees dying within about a three to four year span. And that's really unpleasant and really what you don't want to get into.

These are photos that Dan Herms took. You can see in 2006, these green ash, all of these trees were infested. You don't see symptoms. But you look three years later, and they're all dead. And now somebody's got to pay and deal with those trees. So you assume that all the landscaped trees that are not being treated with insecticide are going to die. You either have to remove them or you have to treat them! There's just really not a lot of other options. You have to think about the tree. You can't let it get too stressed. If the tree cannot carry these systemic insecticides up the trunk and into the canopy, they won't be affected. So once you see more than 50 or 60% of the canopy becoming thin or starting to die, it's probably too late. And I guess if there's one thing to take home from all of this today, it's that we are always behind ash borer. We're always lagging behind ash borer. And if you know that ash borer is within about 15 miles, you need to really think seriously about protecting some of those trees.

Now in terms of what products to use, this list of insecticides, these are all systemic products that move up through the tree and up into the canopy. None of these were available in the early years of ash borer. All of them can be effective. I would say TREE-äge is still the most effective product out there. We've finished two studies. One of them went for six years, and we're getting three years of almost 100% control, even at the lowest rates of application. You just don't see that with any of the other products. Azadirachtin is a new one. It's a Canadian company producing TreeAzin. Also applied as a trunk injection. A little bit different mode of action, but it can be effective, especially if you apply it annually. A couple of the other active ingredients. There's lots of Imidacloprid products. There's Safari, which you can spray, you apply it as a basal bark spray. You can see what Therese is doing here, just spraying the lower 1.5 meters or so of the tree. It goes right through the bark and is carried up to the canopy of the tree. These can be effective. You have to put them on every year.

And this is where you want to go to get a lot of information [www.emeraldashborer.info]. This is a multistate bulletin we just updated last spring. Cliff Sadof is a co-author on here, Dan Herms, myself, and a couple of other folks. So that's available on the emerald ash borer website. Feel free, make as many copies as you would like!

Real quickly here, the biological control, we can talk more about that if you have questions. Woodpeckers, you got to love woodpeckers. They're still the most important source of mortality. They feed on larvae typically in the winter time. But you can't count on the woodpeckers. Sometimes they eat a lot of the larvae, sometimes they skip the tree. And by the time they're feeding on the larvae, the larvae have finished developing, and they've already done their damage. There are native parasitoids that will get after ash borer. We're seeing them learn to go to ash trees. This is a parasitoid larva here. It's feeding on an emerald ash borer larva, which you see here. It takes them a while to learn about emerald ash borer, but we are seeing more and more commonly and more and more abundantly. Unfortunately, it's typically when the trees are heavily infested and pretty much dying. But it may be important in the core areas

as maybe some of the young ash starts to grow and maybe the parasitoids will have a bigger effect there.

This is the classical biocontrol program, the Asian parasitoids that the federal agencies are releasing. That's – they've really ramped that up. It's going pretty well. They've released more than, I believe, more than half a million parasitoids in various states. The good thing is that the parasitoids and woodpeckers will be compatible with systemic insecticides. In other words, those systemic insecticides are not going to affect or harm the predators or the parasitoids. The downside is that predators and parasitoids are not having an effect on the growth of EAB populations or the rate of ash mortality so far. And again, it may be really important in the core areas. That's where we may see these natural enemies become most important.

A lot of places are starting to talk now about IPM [integrated pest management] and doing IPM. It begins with an inventory of urban trees, particularly your ash trees. What size? What's the species? Are they healthy? Do they warrant being protected or should they be removed? If you're going to remove them, a lot of places now are girdling the trees in the spring, leaving them out there for a summer, then taking them down. And that way they serve as trap trees for that crop of larvae that year. We're also finding that if you mix girdled trees with TREE-äge trees, that can be very effective. The girdled trees attract the beetles to the area and you increase the chance that they are going to encounter a toxic tree that way. You can treat the trees, and if you get the opportunity to release some of the Asian parasitoids, that's certainly a good idea. It's not going to hurt anything. And at some point, that may become very important. So I think in terms of urban trees, we have lots of good options. The forest is more difficult. I'd say we have many fewer options there. We're still trying to figure out what to do. But that's – I think that's all I have. So I will stop there and turn it over to Kathy.

Kathy Sheehan: That's right. Thanks, Deb. Our next speaker is Cliff Sadof. He is a Professor of Entomology at Purdue University and has been the State Extension Specialist for insects of ornamental plants since 1990. Cliff leads a substantial outreach effort in response to the invasion of emerald ash borer. In that effort, he has developed a number of tools, including the emerald ash borer cost calculator to help municipalities compare the costs and benefits of management responses over a 25-year period. With the help of his colleagues in Ohio and Michigan, he also runs a national webinar series that draws on the national experts to train individuals about emerald ash borer, Asian longhorned beetle, and other invasive pests. And now I will turn it over to you, Cliff.

Cliff Sadof: Thank you very much. Okay, so I'm going to talk about the emerald ash borer cost calculator. And I really got to commend Deb for being able to summarize

about 13 years of research in 20 minutes, so she really had to go through at quite the clip. What I want to do is mention that this calculator, which runs probably best on Google Chrome, it's available on the web, and it allows you to use inventories. And this sort of dovetails into what Deb was talking about with this IPM approach. If you can do nothing else but one thing this year in preparation for emerald ash borer, that would be to make an inventory. You would just have to find out how many ash trees you have, and I'm specifically talking about urban areas, so that you have an idea how big your problem is. It's very difficult for urban foresters and cities to get the attention of the officials who is have the money unless they have an idea of how big the problem is. And that's pretty much why we developed this calculator – to give these managers an idea of how much money it was going to cost, whether that meant cutting down and replacing the trees or treating the trees. And either way, it's going to cost us some serious, serious change.

So, what we did with this emerald ash borer cost calculator, is that we took a lot of Deb's ideas that she has developed through her research about this invasion wave concept. And what we did, was we tried to translate that into some management activities. So as you can see, what we have here on this graph, is on the y-axis is the percentage of the maximum, and then the x-axis is time. And the darker line is the affected ash, and basically the model assumes that the number of ash that are affected double every year. So in the cusp, in the early stages, we go from 1% to 2% to 4% to 8% damage. Then all of a sudden you go from 4% to 8% to 16% to 32%. Then all the way up to 100% in the course of eight years. So typically, this model suggests that the trees, ashes, will all die over an 8-year period. What I want to draw your attention to here is this line over here. This is the estimated numbers of emerald ash borer that are actually in a forest. There have been some studies that have been conducted in Ohio where they looked at the number of ash trees that were dying in forests, and as luck would have it, they were able to put emerald ash borer traps in key places in these forests, and they tracked the abundance. And what they found was that when the population of – when half the ash were dead, the population of emerald ash borer was at its peak. And then the next year when it went from almost half dead to about 100% dead, the population of emerald ash borer dropped down to about 20% of what it once was. So from the standpoint of management, we want to be very, very aggressive in this cusp and this crest period. And then in this post-crest or what Deb calls the core, where you're now in the center of the infestation, you can ease back on the amount of insecticides that you use and just wait until you start seeing early symptoms, and then periodically cure them with applications of insecticides.

The emerald ash borer cost calculator has got some tutorials that are available, teaches you how to get started and the like, as well as how to print and share reports. And what I'm going to do is just talk about a standard forest. This is sort of a made-up forest that I'm going to plug through the emerald ash borer cost calculator. And I'm going to assume that a community has 1,600 ash trees, and that some of the ash trees – 50 of the ash trees are between 3 and 6 inches, 200 are between – 50 are between 1 and 3 inches DBH, 300 are between 3 and 6, and 300 are between 6 and 12, and so on until we get up to greater than 36 inches. We have a nice bell-shaped curve. And

this is based on the city of Indianapolis. The cost of stump and grinding removal of the stumps is based on the size of the tree. It's more expensive in larger trees. And what I'd like to do is compare three strategies. The first strategy I want to compare is replacing unsafe ash, which uses this doubling mortality curve to estimate the number of trees that will have to be replaced as the infestation progresses. And the second strategy would be to replace all the ash in a proactive manner over an 8-year period. And the third one would be to treat the best 80%, assuming that for whatever reasons, about 20% of the ash probably are going to have to come down either because they're in poor health or because there may be a construction project. And then what I'm going to do is run these analyses under the assumption that it costs about $10 per inch for a TREE-äge injection every two years. And we get this, this is sort of a typical estimate that we get when your emerald ash borer is new to an area, you start calling arborists, they give you somewhere between $10 and $15 per inch for the recommendations.

When I run the calculator, the black lines refers to what happens if you do nothing and replace the unsafe ash. You can see that over the last, over years 6, 7, 8 you lose about 68% of your ash trees. And it's quite expensive. The proactive removal keeps the cost nice and low. And the treatment also lowers the cost. But when you project the costs over time, and this is what is called the cumulative cost of year 1, 2, and so forth, you find that the treatment becomes very, very expensive. And it makes more sense to actually remove the trees. But in practice, that's not really what's happening. The city of Chicago, lots of funny things happen in Chicago, but lots of good things are happening. And they have been treating their trees with emamectin benzoate, and according to their statements, it costs $46 to treat a tree versus $1,000 to remove. And they have a 93% success rate.

So I was trying to figure out how all this came from. What we did was we surveyed cities that have actually been implementing treatment programs. And I plotted the price per inch, which is this X-axis over here. I think I lost my arrow. Oh, yes. So on this axis over here, this is the price per inch, and this is the number of trees per bid. And when you get more than, when you're less than 200 trees per bid, the price jumps all over the place, anywhere from about $4.25 up to about $12 per inch. But when you get above that, it pretty much goes somewhere between $4 and $5. And this is the $4.25 bid of Chicago. This is Fort Wayne. These are some real things. So basically, if you are in a city, it really pays to get the bulk discount and work with outfits that can give you a reasonable price. So that when you change – so basically, I ran the analysis again using the, rather than using the $10 per inch, I used the $4.35 an inch that Fort Wayne actually uses to treat their 1,000 trees that they protect. And what you see is a much more favorable outlook. It turns out that saving the best 80% of your trees is less expensive on an annual basis than either proactive removal and replacement or removing the trees as they die. And that over time, over a 25-year period, you wind up spending less money over time. And interestingly enough, for spending less money you wind up having a much larger forest. This is what I would call – I measured the size of the forest in terms of the cumulative DBH over time. And basically this is the total DBH of the size of the forest. So basically for a lower price, you get more than twice the amount of forest. So it seem to be pretty much a no-brainer that if you have

trees that you want to save, you can save them and it's going to be a lot less expensive than it would be to remove and replace them.

There's been some optimality, economic optimization work that was done by one of those papers that Deb mentioned, by Kovacs. They found that in order to optimize the amount of benefit you get on trees that you as a city have invested in, the 12-inch tree would be the optimal. So if you wanted to view this in an economic manner and not necessarily with politics, you'd want to save all the trees that were greater than 12 inches. So, for more information, I did mention that we do have a webinar that I work with, Deb and I are both involved in this thing, and Richard has talked on it, too. This is Emerald Ash Borer University at the, at www.emeraldashborer.info website. And we have webinars on a regular basis. And tomorrow we'll have a webinar by Joe LaForest on reporting invasive species using apps. So with that, I'm ready to turn it back to the moderator.

Kathy Sheehan: Thanks very much, Cliff! Our next speaker is Rich Hauer. Rich is a Professor of Urban Forestry at the University of Wisconsin – Stevens Point. He teaches courses in urban forestry, introductory forestry, nursery management and operations, woody plants, and dendrology. He has conducted research on tree biology, urban forest management, trees and construction, and ice storms and trees over 20 years. Prior to coming to Stevens Point, he coordinated the Shade Tree Program at the Minnesota Department of Agriculture, where he was responsible for the certification and training of over 900 tree inspectors statewide. He has worked in tree biology research, natural resource consulting, and landscape maintenance, as well as as an arborist. He received a B.S. in Urban Forestry and Botany from the University of Wisconsin at Stevens Point, an M.S. in Tree Biology from the University of Illinois, and his PhD. in Urban and Community Forestry from the University of Minnesota. He has been active in scholarship through publishing over 90 popular and peer-reviewed papers and presenting at over 200 professional presentations. With that, I'll hand it over to you.

Richard Hauer: Thank you very much! It's a pleasure to be here today and talk with Deb and Cliff on this important topical area. I have to first recognize one of my good mentors when is I first got in this field back in the 1980s, Mark Stennes. And a phrase that Mark said about Dutch elm disease and management, whether you liked it or not, it's going to cost you money. And to me, that's one of those take-home messages that with any pest problem or any pathogen problem, it's going to cost you money. As managers, our job is to minimize the cost and actually look at the benefits.

We can take American elm as one of our models. We have a lot of cool historical evidence to say that if do you this, one outcome will happen. I'll talk briefly about that. Or if you do another outcome, another opportunity will await you. But one thing with

Dutch elm disease or emerald ash borer, if you do nothing, it's going to cost you money. Trees are going to have to be removed. And if you choose to replant the trees, there's also that additional cost. One important message from Dutch elm disease, which actually it's kind of cool with emerald ash borer, is with DED, it took about 40 years to get this graph up and technology transferred to people. Basically what it says, if you actually do nothing (we can just call that no control), and this no control right here is most all the trees are going to be dead within one or two decades. But if you practice sanitation – that was the technology. It still works today for elms and with a lot of other pest problems. You take care of diseased trees, reduce them before they become a brood site for insects. And you can actually greatly minimize the loss of trees.

Now, we can also look at this and say what happens if you actually do very little. In the case of Minneapolis, I'm going to use that as a model city. If they did nothing, actually, they're going to have most all their trees gone in about a 12-year time period. Now, if they actually practiced intense sanitation, they'd have most all their trees, well, half their population remaining about a quarter century later. What was an outcome in Minneapolis? It's kind of interesting to note that most all their elms, their elm management program, which was very intensive sanitation, did follow what you'd expect. So if I was a decision-maker and I said, "Yeah, go ahead, we're going to fund you for intensive sanitation" back in 1978, and 25 years later, you can come back and you can say, "This is the outcome, very close to what we predicted." That's a great success story.

We're starting to develop that with our ash. But I just wanted to point out, we have this historical, very neat information that says that if you follow the biological basis for decision-making, you will potentially get this outcome. Another important message, and this was pointed out with both Cliff and Deb, that if you do nothing, there's this big pulse of money upfront, where you have to spend a lot of money, in this case removing dead elms. Now, if you actually practice intensive sanitation, it's still going to cost you money, but what you're doing is you're equalizing this cost of money over time. Now again, use Minneapolis as a model. What did they expect? They expected some years maybe to be right on track with what the cost would be for removal of trees – some years maybe slightly above; other years, slightly below. But over a great time period, you greatly stabilize the cost of this particular disease.

Some recent work we did with the city of Milwaukee, actually, we had a question. Now Milwaukee was about a decade too early in the game of getting Dutch elm disease. They didn't have the technology. So the status line is the actual loss of elms over time in Milwaukee. So we did some modelling to say what would have happened if they did best, good, or fair. Again, they didn't have the technology available to do these practices, about a decade behind the times. And if you look at no control, this would be kind of the outcome. Our question actually was on stormwater as one of the questions that we're modeling right now. But we built the simulator basically to do this.

If you're looking at tree canopy, here's what's neat. What do you see? Over time with the best scenario, or you could apply this also to your emerald ash borer work, that over time your canopy is going to grow. Cliff pointed this out with one of his last slides. Your canopy is going to grow. You can actually do good sanitation. You're going to stabilize the canopy over time. Or if you do nothing, you're going to lose canopy over time. The nice thing here is it gives you some opportunity to stabilize canopy or grow canopy while you're doing tree replacements with [indiscernible].

So let's get to the emerald ash borer. I got into this research probably five, six years ago. I needed a tree inventory for an urban forest class I teach. So I convinced some students that work to collect about 2,000 trees on campus to see what species we have, their sizes. Then we had this inventory. And I started asking the question, what would be the impact of managing for emerald ash borer? What if we got rid of all our ash? And we could just call that, Getting rid of all our ash in five years. Or if we used approved insecticides treatments or if we do nothing? Or if we remove all the ash and replace them? Or we could also compare what if we didn't have emerald ash borer. So, when we start doing our modelling, you can look at it in a couple different ways. You can look at the compensatory value, and the functional. Functional would be stormwater benefits, energy conservation, air pollution amelioration. Comppensatory would be the value of a tree if it was lost. So let's say someone runs over a tree with a car. What would be the cost of the tree, the value that they would have to compensate you for the loss of that tree?

There's two different ways we're doing our modeling. This is the part right after lunch that isn't conducive for staying awake. But here's all it says. You have a value of a tree, and you have cost to maintain that tree. If you're looking at trees that are left in a population, you have the value minus all the costs, so for maintenance, for treatment, for removal, for planting. And then you can discount this over time using some discount rate. And so what you can get is a net present value. So what you're doing is you're accounting for money over time, the value of that, the value of a tree, plus subtracting all the costs to maintain that tree.

So in our work, we actually put this all in a simulator that you can get at various sites. And one of the aspects of this simulator is when we first did the work, it's pretty easy to comprehend that if you get rid of all your trees in five years, you have none left. If you preemptively remove and replace after a 20-year time period with the normal mortality that we built in the calculator, this is the number of trees you'd expect for that cohort. If you have no emerald ash borer in an area, this is what you would normally expect. If you treat your trees using the science that Deb pointed out, highly successful with several of the insecticides, you're going to certainly lose some trees, but not much compared to what you'd expect with normal mortality. And then here's the simulation if you do nothing. This was one line that we were actually concerned about when we first did our modeling because we built it, this mathematical model, based on an abstract from Kathleen Knight. I was really happy to see about a couple of years after we got into this work, the work of Dan Herms, where they looked at the loss of ash cohort over

time in an area. And if anything, our simulator probably slightly underestimates the loss of ash trees over time.

So here, a lot of information actually to put in this calculator. At first glance, it may look like that. There're notes on what the information is about that you have to actually enter. And not all information actually needs to be entered. And I'll slightly get into some of these parameters here in the next few slides. And if you scroll over to this little red box in the simulator, it'll give you more information on where the data came from. So take something about an ash population. If you want to figure out the cost of emerald ash borer management, you have to know how many trees you have, their mean size, maybe ask the question, What would be the outcome if I got rid of all the trees in five years? And then you can simulate the growth of trees. In our study here in Milwaukee, ash put out about half an inch of growth a year. In the Chicago area, it's probably 0.60 – 0.70 inch per year.

Some other things you have to add are what are the costs for management? So, maintenance such as pruning, removing of trees or treatment? Now, these are all default values in our simulator. And one thing about those, these values – where did we get them from? Greg McPherson's work in the Midwest Tree Guide. And we adjusted for inflation. These are actually 2012 values. Our removal cost, for example, includes stumps. If you have your own record, that's even better yet. The city of Milwaukee, for example, these are production records that I developed their actual cost on the maintenance, for example for pruning. A 2-inch tree, it's going to cost you on average $20. And you probably say, "How can they do that for $20?" Well, they're doing it once every five years. So the actual cost is $100, but on a per annual basis, it's $2.03. And the removal costs and the treatment costs. Now $3.75, actually a little bit lower than the private costs in Chicago. How do they do that? They do it in-house with staff. And this is staff and pesticide cost.

So the other part is actually calculating the value, based on [indiscernible] information and there're regional guides for doing that. So what's one of our outcomes? If you see green, that's more desirable, red is least desirable. So here's the outcome, and I'm just going to focus on a few things because there's a lot of information here. But if I look at the net value of the urban forest of ash, what do I find out? That treatment retains the greatest net value. This is the value of the ash trees minus all the costs associated with maintaining this over a 20-year time period. Then we have some other important information pieces. We can look at the benefit/cost ratio of stuff. And I'll talk about this briefly here in a second. We can look at the actual removal cost, information. We can look at the planting cost. We can look at the treatment cost. So this slide illustrates it much more clearly. If we're just looking at the cost of treatment, all we have then is the least costly is getting rid of all your ash trees. But if we actually look at the cost of no control or treatment, it gives you a sense that, yeah, here's the actual outcome for emerald ash borer. If we look at the actual net present value – again, this is the value minus the cost – you find out a much different story, similar to what Cliff ended with. That treatment is actually very effective, very cost-effective, especially when you look

at benefit/cost ratios compared to doing nothing or getting rid of all your trees and replanting.

The last slide is, I'd say, with our emerald ash borer work, it's no different than any urban forest management work with the added context of we have to manage for a pest. But if I have an ash tree, I'm still going to look and say, Would I treat this tree? No, it's a tree risk of great hazard. It would come down. So that part of urban forest management still doesn't change. We have the added angle of dealing with things cost-effectively. So with that, I'll turn it back over to the moderators.

Kathy Sheehan: Great! Thank you very much, Rich! We now have just a few minutes for questions. And as a reminder, if you'd like to ask a question, type it into the pod at the upper right-hand corner of the screen. So, our first question deals with the effects of cold winters, cold temperatures during the winter. Steve of Vermont, Steve writes, "We just had a record long and cold winter in Vermont. Does this kill off any EAB?" And another responded, doubted that because she thought that the cold winters probably would not kill EAB because they're under the bark and aren't vulnerable to those cold temperatures during the winter. Deb, that's probably for you.

Deborah McCullough: Yeah, well, I can tell you that this winter was severe, and last winter was really severe. We had record cold temperatures. All the Great Lakes froze. It was a very long, very miserable winter, the 2013/14 winter. And that's when some folks in Minnesota put out some information about the cold winter killing off emerald ash borer larvae. And it kind of got taken out of context a little bit, I think. And I can assure you that from January through April of 2014, last year, my crew felled and debarked 72 big ash trees up in, I'd say, the central part of lower Michigan. If you look at the palm of your hand, it's right in the middle of the palm of your hand if you think of the state of Michigan. On those 72 trees, they counted thousands of larvae. This is for a research project. Not a single one of them was dead or appeared to have been affected by the cold. And if you think about it, somebody pointed out the larvae are protected to some degree by the bark in the wood. And you also think about an ash tree, especially a good sized ash tree, it has to be really cold for a really long time to change the temperature of all that mass.

And the other thing with larvae is that if they have the chance to acclimate to temperatures in the fall that are going to get cooler and cooler and cooler, there's a lot of physiological things that happen in insects that enable them to survive some very, very cold temperatures. Effectively, they produce an antifreeze in their body. So I would guess that some young larvae in small trees with thin bark maybe up toward the top of the tree, they might be killed given the winter, especially in New England. But I would not expect to see a big drop-off in the density of your ash borer population because of the winter weather. Keep in mind these insects are native to places in China that get very cold. They have also successfully invaded Moscow, Russia. As far

as I know, those are cold winters, as well. The ash borers seem to be doing fine in the very northern part of the upper peninsula of Michigan. So, that's the answer.

Kathy Sheehan: Great. Thank you very much. The second question, second of three questions, has to do with Asian parasitoids. Someone raised the issue about whether those non-native parasitoids, if we brought them into the U.S., would compete against the native parasitoids.

Deborah McCullough: Yeah, I can address that. There was almost no evidence of native parasitoids attacking emerald ash borer until 2007. And one of my technicians was one of the first to see any significant parasitism and that was the *Atanycolus cappaerti* parasitoid, and it has been a learning process for the parasitoids. You see them starting to move from other species onto ash, but I would say that they have not slowed the population growth of ash borer. Not the native parasitoids. The ash trees are still dying at pretty much the same rate. Keysha had a couple of questions there about potentially competition between the Asian and the native parasitoids. If the native parasitoids were going to be effective, they had every opportunity in the world to do so and they haven't.

If you think about those native parasitoids, they attack native phloem borers, and most of those native phloem borers are only attracted to dying trees, very stressed, dying or recently killed trees. And I think that's why we see native parasitism generally be the highest in trees that are so infested that they're dying. You know, I think that when you do classical biocontrol and you bring over these species from Asia or somewhere else, it's a planned invasion. And you have to be really careful with that. There was a lot of screening that was done. It's difficult to work with these parasitoids and to figure out what, are they going to attack native phloem borers? Could they displace native parasitoids? You hope not and you try to do what you can. And I know the people involved with it were, they're all good people, and they did do quite a bit of screening. Now, having said that, one of the species, this *Oobius agrili* species, seems to be potentially attacking native phloem borers. Whether you consider that to be a problem or not – I don't know, I guess it depends on your preserve. The populations of these parasitoids, that one in particular, they're not surviving the winter very well. I'm not sure that it's going to continue to be released for a long period of time.

The other part of the equation is we don't have anything else in the forest. If you look at the benefits of having parasitoids that become effective, those benefits probably offset some of the risks that you take with introducing these. And landscape trees, we can work with those, we can save them, we can do all kinds of good things. You get out into the forest, and there's over eight billion ash trees in the continental U.S. that are at risk of EAB, and we don't really have any questions. So I think it comes down to comparing potential benefits with risks. And you end up doing the classical biocontrol.

The other point I would make is I have looked in scientific publications and literature, and so forth, the insects that feed under the bark are rarely if ever controlled or regulated by parasitoids. Not bark beetles, not wood borers, not phloem borers. And so if these classical biocontrol efforts can make a difference, it would be relatively unique. So I guess we'll have to wait and see how that plays out.

Kathy Sheehan: Thanks very much. I think we need to close off the questions now because we're running a little bit late. And so I want to start by thanking our presenters again for their time and sharing this great information about this hot topic. And thanks all of you for participating!

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And please join us next month on May 13th for the next Urban and Community Forestry Connections webinar. The topic will be the Science behind i-Tree. And we will be hearing from Dave Nowak of the U.S. Forest Service. Thank you, everyone! Enjoy the rest of your day.

[Event concluded]