The Science and Future of i-Tree

Wednesday, May 13, 2015 | 1:00 – 2:00pm ET

TRANSCRIPT

Margie Ewing: And now onto today's topic: *The Science and Future of i-Tree*. We'll hear from David Nowak, who is a Project Leader with the USDA Forest Service Northern Research Station in Syracuse, New York. His research investigates urban forest structure, health, and change, and its effect on human health and environmental quality. He's authored over 250 publications and leads teams developing software tools to quantify ecosystem services from urban vegetation, such as the UFORE and i-Tree programs, which many of you are familiar with. Dave's presentational will be in two parts with time for questions in between. Now I will turn it over to Dave.

David Nowak: Thank you and hello, everybody. I appreciate the opportunity to talk to you here. I think I'm just waiting until I get presenter mode here. There we go. Okay. So, I will talk about the science and the future of i-Tree. I'm going to go about 20 minutes very briefly on the introduction of i-Tree, so everybody's on the same page. And then talk about the science. Then 10 minutes for questions, and then I'll talk about an i-Tree update for about 15 minutes and we'll take questions after that.

So i-Tree was a concept that was released in 2006, developed in the early 2000s, based on a public-private partnership with – some of the partners are not showing up on the bottom there – the Forest Service, Davey, International Society of Arboriculture, Society of Municipal Arborists, Casey Trees, National Arbor Day Foundation, and SUNY College of Environmental Science and Forestry. I don't know why some of the logos are not showing up the bottom, but there are many people that worked on this from different offices. It's basically a public-private partnership to develop tools to guide managers to assess the current or future effects of their forest, to look towards optimal tree planting. If we want to make the forest better for the future, first we have to understand what we have and help make management decisions to guide that to a more sustainable, resilient forest in the future. So it's been many people working on this and trying to engage the public in stewardship by providing them information about their forests. So we're coming up on year 10 next year with this tool.

And the purpose is basically to guide management decisions with the best available science and local data. Managers are going to make decisions about the resource whether they have information are not, so the concept behind i-Tree is to provide managers, land stewards, easy ways to get this information about their forest so they can make management decisions. So half the work, I always say, is about developing the science behind it, half the work is trying to make it easy so people don't get disengaged in collecting the data themselves. So it's designed to collect local data and people have used it in many different ways to help with management plans, advocacy, education, tree planting goals, etc. So that's the concept behind the model. Is the model perfect? No, but it's actually quite good in what it does. Does it do everything? No. Will it ever do everything? No. But we're adding more and more features to it and more and more services each year as we develop this tool. And it's an open public-private partnership. We're looking for ideas. You as the consumers can send us ideas as to what you would like.

There currently are seven tools. I'm not going to go through them; I'll show you some new ones coming up at the end of the talk. Eco is the basic core calculator that takes in field data to assess what you have in services, provided in values. Design focuses – and Streets is the same thing for street trees – Design focuses on similar information but uses Google maps to engage people in a mapping technology. Landscape's a new tool, and I'll talk about that later, coming out, today. Canopy is a photo interpretation tool to help you rapidly assess how much canopy you have in an area. Species is a quick tool to guide you as to what species to select. And Hydro's a hydrologic model that stimulates streamflow and water quality effects from the forest. So, a general overview, and hopefully you've seen these tools. I'm not going to go into them. What I am going to do is talk about some of the science.

We are currently over 36,000 users and 120 countries. We have versions that are released for the United States, Canada, and Australia and we will be releasing one for the United Kingdom later this year. So we have many partners across the world or users across the world and partners across the world.

Now towards the science. The basic structure, design framework of this model is structure, function, value. This is critical. Structure is what you have, whether you are in your backyard or a park or a whole city. The model needs to know information about your forest. This is the most critical piece. There are many things that managers may or may not know about the forest. If you're going to manage a resource, you have to know what that resource is. So part of the tool is designed to help you understand how many trees you have, what the species are, what's the health, because this is the starting basis of what we build this model off of. Once we know the structure – and to us, critical is leaf area – we can then bring in local data – pollution, weather – and simulate those trees to provide various functions that we will talk about, energy conservation, pollution removal. And those functions have a value to society. So if the users provide the structure to the model, the structural information – it could be one tree, could be a thousand trees – the model will then take local data and estimate the various services or functions provided by that forest in values.

The reason why this is critical is that if we want to design for the future, we are designing for functions of values for future generations, but it all ties back to structure. So if I want to improve air quality, the question is what species should I plant and where should I plant it. It's all tied back to things that we control, somewhat that we control – is that function. We make decisions on what to plant, what to remove. We manipulate the structure of that forest by changing the structure of the forest, whether we do it directly through planting and removals or if nature does it through storms or insects and diseases. Any change in structure will have a rippling effect on the functions and the values. So what we're trying to do is figure out how to understand what these values are in the current forest, but then how should we plan to design the forest to optimize these functions for future generations, given that many things are changing – climate change, insects, and diseases. That's the whole concept behind the model.

So getting to the science. The model itself is good at estimating population totals. We have more discrepancy when we predict individual trees. And the reason is because many times, when you collect data on a tree, you make a direct measure. We know what that tree is because you made the direct measurement. But what you didn't measure, say, was leaf area. So we use equations off of your data. If you tell us you have a red maple of a certain size and canopy and in a certain condition, we will estimate the leaf area. Leaf area is a critical piece, as is leaf biomass, the weight of the leaves. But as you go to equations, equations tend to predict to the mean. So what will happen in the end, if you have enough of the population, we are very good at estimating the population, but we may be off on the individual.

The best example I can give on this is let's say you measured DBH, but you didn't measure any – DBH being diameter of the stem – and you didn't measure any of the crown parameters. Well, we can use – and we do this – we can make an equation that says, okay I have a red maple that is 14 inches in diameter. The model might protect that the average height of that tree will be 40 feet. Well, if I'm trying to predict the individual it becomes difficult, because I don't know if that tree is 40 feet. I think over a population of trees that are 14 inches and red maples, the average will work out to be 40 feet. So the model works well over the population because you get some that are higher and some that are lower, but on average, it works out fine for the total. The problem is when the model goes to predict an individual tree, it will say 40 feet. And you walk up to the tree and say, "Well, this tree is 60 feet" or "This tree is 20 feet." The model is not off, it's that you didn't measure the height of that tree. And that's why I say structure is critical on this, particularly the dimension of the crown. We really encourage people to measure the crown dimensions because the more you measure of structure, the better the model becomes. But in essence, when we do go to the individual tree, on average it will be fine, but we may be off on the individual. So if we predict the height of a person walking in the room and Shaquille O'Neal walks in the room, we'll probably underestimate his height for the individual. But overall, for the population we'll be fine.

So the concept is ease of data collection versus more variables and instrumentation. We're trying to make this model as easy as possible with as few data requirements needed as possible so to make it easier on the users. We typically have, I think, nine variables that we want to run everything. You may want to collect more yourself but there are core things that we have to have. You have to tell us the species and DBH. And then we bring in local environment data from your city, the pollution and weather. And this has another issue. We don't know the weather conditions in your backyard nor do we know the exact pollution conditions in your backyard. We use the monitors from the EPA and the monitors from the weather service and take the average of the monitor data from the region. So that means that if the average temperature in your city is 72 degrees, everybody gets 72 degrees. So the model is back again to the population average. It works well across the city on average, but it's going to miss your backyard temperature because we don't know – there's no monitor data for the backyard.

To get around that, to get at local variation, you can see that we are using NEXRAD, which is radar-based precipitation data. So instead of using one rain gauge to collect the data on precipitation, we can actually use radar now. We're building that into the Hydro model. We're adding infused data from the EPA, which estimates pollution concentrations at a finer scale than just using the monitor data. Monitor data is point data where they collect within a city. And we're building a new temperature model that can estimate temperatures hourly at about a 300 meter resolution data. So we're trying to get to this local variation, but right now the base version uses local data, but it's averaged across the city. And again, structural variables are critical for the premise of this model.

To get at structure there's two ways: you can go top-down or you can go bottom-up. Top-down will tell you how much cover you have or where it is, but it relates to coverage, so it's two-dimensional. You can use i-Tree Canopy to photointerpret your area and you can get the cover probably within 2% accuracy for your city within a day. Or you can use UTC maps, these high resolution cover maps, which will then display where the cover is and how much cover. But again, it's still two-dimensional. That's the top-down approach. Bottom-up, we go in the field. We need information on the size of the trees, we need information on the leaf area, information on species, information on conditions. That's the bottom-up approach. If you collect every tree in your area – let's say you have 10 trees in your backyard, that's inventory. In the case of the model, if you put 10 trees in, the model will give you an estimate for 10 trees. There is no bounded error on it. We assume that the data you put in are measured without error. So if you tell us that it is a red maple and it is a Norway spruce, the model will not know. But we assume it's measured without error. There is no sampling error if you count every tree.

Often it is inefficient across the city basis to measure every tree, so we go to sampling procedure. This is where we have the issue of standard errors. Standard error is a measure of how precise the estimate is within a certain bound. So if we estimate 1 million trees, it would be ± maybe 100,000 trees. It depends on how many plots you put in and how much data you collect. So we have standard errors on the measured variables because you measured them directly. The number of trees, diameter, species count, height – the things that you measured are very straightforward on standard error. No problem with that. We use standard statistical techniques to do that. However, when we take derived variables, which means you've measured DBH and crown parameter, and we estimated the leaf area, or we estimated the leaf biomass, or we derive the functions from those estimates, we're still using the sampling error as the estimation of error. But there is also the error of estimation, which means the formula that we are using has a set of errors that we don't really know what that is. We are assuming that the formulas are accurate, and most everybody in modeling has the same issue. We are good at the sampling error of measuring the trees, but when we go to derive the leaf area, we assume the formulas are correct. And actually we tested the formulas, or other people have, and actually the formulas work fairly well. There is – we are underestimating the true error of the estimation because of the models that we use. We don't know the estimate model.

Hopefully, these slides will be distributed. We can show you some of the structure, there's a lot of data behind the measurements of structure. Again, that is the first thing. We started this with my dissertation back in 1991. We've had papers through the 1990s and the 2000s of how do we measure structure to get estimates of the basic core information: How many trees do we have? How do we photointerpret? There're papers on testing the leaf area and disease and derived estimates from that. Also plot precision and how many plots do we have. There's a bunch of data out there on structure references, so we're pretty solid on estimating the core structural data.

So now we move to what do we calculate in terms of the benefits. The yellow ones here – air quality improvement down to the health benefits – are things that are in the model already. The green ones are the ones that we're working on that will be out in the next year or so. So we're trying to derive all of these new services and benefits and values.

The basic concept of the model is shown here in this schematic. The user – I'll use the pointer here if it will show up. There it is. The user enters the field data. That's what you are required to do. You're required to tell the model what do you have. You can either count the trees or you can sample. But we don't know what forest you have. All we know is, if you tell us, where you are. So the user's entering the field data. Behind that, there's a database of 6,400 species right now and information about the trees. There's location information for every city in the United States and that contains the weather data. It also contains the pollution data, so you don't have to get that. It's all in the background information. All of this pre-data down at the bottom loads into i-Tree and you load the field data in. And so we're going to talk about the processes behind, in this box here, and outcomes information for you on structure; air quality; storm water runoff, reductions; carbon; energy; and various evaluation processes. We're going to talk about that. But that's the basic process. You're required to put in the tree data and tell us where you are.

So the functional processes. This is where the link is. You've given us structural data. We feel comfortable with that if it's measured without error. The science behind this is building a link between the structure and the function. So if you have a red maple versus a sugar maple, if you have so much cover, or more cover versus less cover, or certain locations. How do we determine air pollution removal? How do we determine the energy? And what is the impact of that air pollution removal on human health? That's what we're trying to get at. So we have a lot of peer-reviewed papers on the methods. There's additional documentation on i-Tree, of all the specifics of the methods that may not be in the peer-reviewed journals, but are more detailed on the webpage. And then we test the outputs against measured data where possible. And we match up fairly well on many of these and we'll talk about this coming up, about how well we match for the various routines that we run.

So air pollution removal. The model's based off of leaf area, the leaf area that is provided from the trees that you measured, and the hourly weather and hourly pollution data. And what we've built is a dry deposition modeling routine that basically does gas exchange on an hourly basis based on the weather and the leaf area that you have. And the hourly rates that we measure, which are called deposition velocities, are in line on an hourly pattern both in magnitude and pattern with measured data from field stands. We give you max and min values based on the maximum and minimum so that that's how you know the uncertainty of the measurements versus what the model actually predicts. And the limitation we have on this program right now is drought. We assume urban trees have ample soil moisture, that they do not go into drought. We're working on a drought routine right now because they tested in Rome and the model matched up very well except for that in Rome they go into a drought. So at midday, we would overestimate and we knew we would. The issue that we have of bringing the drought routine into urban areas is when to turn the drought routine on because there's data that we have that shows that even when a natural forest goes into drought, many urban areas do not go into drought because of supplemental watering from humans or leaky pipes. This is another issue. Even if we put the drought routine on, we don't know when to turn it on, or where to turn it on. So we're working on that right now and you could see below that, there are various papers that detail the methodology behind that. But we're pretty good on the hourly rates of removal line up with the data. So we're pretty confident with this model. We see there's a bunch of papers here that document the methods or the outputs from the various models.

Carbon storage and sequestration. In this case, we use species diameter, condition, location – where you are in this country – and crown competition. Is it open grown or in a forest stand? And we basically used allometric biomass equations that predict biomass based on DBH and height for various species. That's for carbon storage. For sequestration, we take the storage numbers and we grow the trees. And tree growth is based on the condition of the tree, which means dead trees sequester no carbon. They don't grow. Length of growing season, which is the location data. So trees in Georgia will grow faster than trees in Minneapolis because they have longer growing seasons, for annual rates. And crown competition, so open grown trees will grow faster than trees in closed canopies. We have, I think, 64 different carbon equations in there right now and we're adding many more from Forest Inventory and Analysis and with them the conversion factors. So this will be updated in the next year so with new equations, or more equations.

The certainty of the estimates are standard errors based on sampling errors, which we talked about earlier. And, the rates, which is the standardized rate, which means how much carbon you have per meter squared of canopy cover, is right in line with the Forest Inventory estimates ± a fraction of a kilogram per meter squared. So we feel confident that our estimates are in line with measured field data, which are often based on other models anyways. So we're comparing model against model. The difficulty of this process is if we knew how much carbon we had, we wouldn't have to model it. And because we're measuring the diameter and the height and we have multiple equations that are being used, we take the average of all the equations that are available for that species, and we feel fairly confident that the numbers are fairly close based on the measurements of those models. If you really want to know how much carbon you have, technically you should probably cut down the whole forest and weigh it and figure out the carbon, but you still have a standard error associated with that. But because we can't do that, we have to use models and that's a process that we line up with measured data from various studies there. And you can see here, again, that we started back in 1991, and the various papers that document the methods. But that is a general review of the science behind that.

Oxygen production is pretty much the same as carbon, it's just inverted. So if a tree is taking in carbon and growing, it's giving off oxygen. If the tree is decomposing, it's a straight conversion. It's consuming oxygen and giving off carbon dioxide. Same method that I just talked about, but basically it's based on the measurements of the tree and these equations that predict biomass.

VOC emissions – that's volatile organic compound emission. They're chemicals given off by plants and they vary by species that lead to ozone formation depending on weather conditions. So what we use here is your daily leaf biomass, so the leaves on the model change daily based on length of growing season. So, midseason, all the trees are in leaf and winter season only the evergreen trees are in leaf. And we do that daily. And we take the hourly weather data and we use what's called the BEIS modeling methodology, which is the Biogenic Emissions Inventory System produced by the EPA. And you can see the papers there below that detail that methodology.

The certainty of the estimates – again, we test the standardized estimates of emission rates per meter squared of forest type from the EPA versus but what we are coming up with, and we're right in line with what they have, too. I mean, they're obviously going to vary slightly, but they're not off much. And they will vary because based on species composition and weather condition. So we're quite comfortable that these numbers are doing well. We are going to add standard errors to these coming up based on the standard error of sampling based on leaf biomass.

Now, getting into energy conservation. This one is dependent upon tree height, the condition of the tree, distance and direction of the tree from a space-conditioned building, and geographic location. And geographic location has to do with weather conditions and energy costs. This is all built off of work of Greg McPherson and Jim Simpson. You can see the document there. And they did a bunch of model runs using micropaths and shadow pattern simulators that had this lookup table that says for various size trees and various distances and directions, here's the energy impact on these two-story buildings that they modeled. The modelling that they did is good. The question is the certainty of the estimates. We don't know. We're relying on the lookup tables. We don't know the variations, and what we do is update the energy costs locally, but the model simulation is all built off these micropath and shadow pattern simulator modelling that they did. And that's pretty much used for the U.S. conditions.

Hydrology, which gets at water flow and streams and reduced water runoff. Again, we use leaf area index, or leaf area, hourly weather data, and digital elevation maps. And we look at the precipitation coming in. The methods are based on what's called the TOPMODEL design. The model is calibrated against stream flow data, so we know if the model is simulating, in the calibration, how well the model is simulating actual flow data. And then what you do is you change cover to impervious in the model to see how the flows have changed. We're also working on trying to do model simulations to look at if you vary temperature in various parts, how these models, the bound of certainty might change based on input data that might change the outputs a little bit. So we're fairly comfortable with that because we are calibrating to measured stream flow data.

Models in development. The process to get into the i-Tree is the methodology that goes from structure to function has to go through a peer-review process. So there are six pieces that you saw in the green slide earlier that we are working on. Three of them are ready to go now because they've gone through peer-review. That's what we are working on right now. So truthfully, when we start the process, it probably takes about four to five years to get it into the model because we have to do the science, we have to write the papers, then we have to write the code, and then we have to write the interface to make the code easy for people to use. So these are the ones that have been through peer-review already and we're working on the code right now to get it out. So it will probably be out, all of these will be out next year, I would bet. And it's air temperature effects, which will go into Landscape, which we'll talk about later, wildlife habitat, and UV radiation reduction. So, there's more coming.

Ending here – I only have a couple minutes left for this part of the talk – is value processes. So now we've gone from structure to function. We say, "you have this many trees, or you have this much carbon or pollution removal or whatever, how much is it worth?" Well, it depends on various processes. We probably hang our hat most on the functions. The valuation will show you how we do it. If you don't like our valuation, some of them are straight multipliers. You can just change the multipliers yourself, but we've gone through the literature and basically come up with this methodology. So, for structure, what is the value of the current forest for the structure? We use the Council of Tree and Landscape Appraisers approach – you can see a couple of papers there –

to get an estimate of what the value of the current structure of the forest is. For pollution removal, there are two methods. One is called externality values, which are estimates of the external cost of having pollution in the atmosphere based on human health costs, cost of damage to materials, visibility, damage to crops. Economists estimate this value per ton of pollution. It’s a constant value that’s applied as a straight multiplier. So if a tree removes a ton of ozone, if a *forest* removes a ton of ozone, you would multiply that ton by of a value of dollars per ton, which is probably around the order of $6,000 or $7,000 per ton for externality. The new approach we're using is BenMAP, which is the EPA Benefits Mapping Program, which ties the change in, what we do in the model is estimate the change of pollution removal to the change in concentration of the atmosphere. Then we link that change in the atmosphere to how many people are being affected by that change in the atmosphere within this BenMAP model that says if we have these many elderly people or young people, it’s susceptibility to certain diseases or heart attacks, asthma, and mortality. So we’re using the BenMAP process and the BenMAP evaluation. So now it gets very locally specific. So if there are no receivers of benefits, the value of the pollution removal goes down. If there are more receivers, and some pollutants are worse than others, like PM2.5 or ozone, the value goes up. So you are getting a variation in value. So we’ve linked to the EPA BenMAP model as of last year. But you can also do externality, which was the older way of doing it.

Carbon, we use the Interagency Working Group report on social cost of carbon. It is about, I believe around $138 per ton of carbon right now. They use a 3% discount rate in the report, but we’re using the U.S. government values. If you don't like it, in the model you can change it. But we are going with whatever the U.S. says.

Energy, we use the state, average state utility costs as reported from various national organizations. We update that every few years. That is a straightforward multiplier.

Lastly, runoff reduction. We use average treatment costs from a report of McPherson, Peper, and Vargas. They have 16 regional community tree guides. We took the national average of the effects, or cost per gallon of reduced runoff.

Oxygen. If you read the paper down there, we wrote that in 2007, oxygen actually has no value. And the reason behind that is because there is so much oxygen in the atmosphere, the change in oxygen, the marginal change, is not worth anything.

And VOCs is tough to value because VOC in and of itself is not really the issue, it's the conversion of VOCs to ozone and particulate matter that’s important. So we have to figure out, and the EPA does this with larger models, to convert the VOC to the actual pollutants and then we can value the impact on the pollutant. VOCs would be a negative value, but it’s very difficult to value that directly without converting it.

I think this is my last slide before questions. Differences here – two models: Eco and Design. Eco is the core engine and Design is the one that uses Google maps – requires field data. You have to measure trees. Moving down below, if we go to the top-down approach, which is Canopy, which is the photointerpretation program, and Landscape, which is coming out this year, which I will show you later, it does not require field data. This is what I call an entry-level program, if you will. We're loading all the national maps from NLCD into this. I'll show you this coming up. And we're estimating the effects of carbon based on state or county averages, and then pollution. I'm sorry, state or national averages for carbon; county values for pollution. We run the whole country. We have all the monitoring data, the pollution and the weather. So you're getting county-based estimates per meter square that are being applied to the map. It is not based on your local data. It's only based on your local tree cover based on NLCD, which tends to underestimate tree cover, but it gives you an idea. I'll show you coming up. It's very quick, very easy. It gives you a ballpark estimate and the hope is that Landscape will engage people to collect data going back to Eco. And once you collect data in Eco, that data from Eco can be passed back to the mapping program to give you your local values which will then be applied. And you're not relying on state averages or county averages, your local data will loop in. But I will show you that coming up and that's the new thing coming out next year. But it's really simple and it will engage, hopefully, a lot of people in terms of landscape scale issues.

So with that I will stop. I ran a little bit long and we have time for questions here.

Okay, I have one here – Paul West: Why is the CTLA value not redundant to ecosystem function values?

The difference here is that we separate CTLA value as a structural value away from the function because CTLA is based on the cost of planting the tree. And then, as it is formulated, it goes up as the tree grows bigger. So it's dollars per square centimeter of cross-sectional area. The way I liken this is if you have a factory that produces radios, the factory is the brick and mortar and the machinery that produces the radio. The radios are then sold for a profit or loss. The structure of the building in essence for the forest is the CTLA value. So if the forest burns down, what would it cost to rebuild the forest and be compensated for that loss? That's what we're using the CTLA for, however the profit and loss that that factory may have made in the future are these services that were provided by the forest and that we're not really compensated for in the insurance claim, which basically – pollution removal and carbon. So we separate out the annual values produced by the trees as the functional values, but the value of the resource itself, the structure itself like the radio factory, is the CTLA value. We separate the two out. CTLA values are much higher because they are cumulative. As the tree gets bigger, that CTLA value gets fairly high.

Okay, a couple more are coming in. Randy: Will i-Tree Eco calculate functional benefits with DBH and species input, but not crown measurements?

Yes. As of this version coming out later this summer, we are allowing people to use DBH. And we will use equations we developed off of all the field data we have collected to estimate the crown parameters. You will also be required to add species DBH and condition because we need to know if the tree is dead or alive pretty much because some of these services require to know if there are leaves on there. The only caution I have writing this up when you do this is that the model is going to predict the tree height. So when we say, like back to that example I had that if you put a 14-inch tree and we say it's 40 feet, and you go out and say this tree is 80 feet and you say the model is no good because it's not correct, that's not our problem. That's because you didn't collect the height of the tree. We require height as a basic variable. We will fill it in because we understand many street tree inventories or past inventories do not have the crown parameters. But we are encouraging people when they collect new data, don't shortcut around collecting the crown parameters because those are critical to getting at the leaves. And the leaves are critical to getting at the services. So we're building that in to allow past data to come in and encouraging people to measure the crown data. But yes, you don't need the crown measurement, but if you are collecting data we certainly encourage you to collect the crown data because it makes the data better.

Okay, Naomi. Hi, Naomi. She says, "Hi, David. How and when will data for the rest of Europe be input?" Great question. And "are you depending on each county, each country, to provide the data?"

To go international, yes. We are working with Scandinavian countries right now. Like we said, we're doing the UK. The model will work anywhere in the world, but there are two databases. One is the species, which I showed earlier, one is the species database and one is the location database. So the species database, we're pretty good for temperate areas. We're fairly, well, getting better, but we're still missing a lot of tropical species. We have 6,400 species in our database. There are over 7,000 species in Brazil. And they're all written in Portuguese. So it's very difficult for these tropical plants that we don't know what they are. We have to put them in the database, but they only have to be put in once. So for most of Europe, that wouldn't be a problem. You may encounter new species we don't have, but if you do, you just enter it in and we are good to go. The problem of going country by country over in Europe is that each European system – two things. We need the location. We need to know where you are. So we need a database for the cities, which means: what's your latitude, longitude, elevation? Can we run the solar angles on every hour? So we need to know the exact geographic location of the cities. So we need the information on the cities is one piece and also we need the European pollution data. And the problem is that unlike the United States where the EPA has it in one format, each European country has it in a different format. So therefore, it takes some work with partners over in Europe to do this because often we don't speak the language or know where these data are residing. So we're working, I think right now, besides the UK and Scandinavia, we're trying to do this for Germany, Brazil, and Korea right now. We have people that are locally helping us to do that. So we're looking for partners because we cannot do it all ourselves.

Some people are typing, but it's not showing up yet. Rebecca. Hi, Rebecca. Can any of these models be used to predict the benefits of a new tree planting program?

Yes. The best way to do that is probably Design. But you could do it in Eco also, but it wouldn’t be as easy. Basically what you would do is enter in – I’ll show you this coming up. Eco has a new model coming out this year called Forecast. So in Eco you would load your newly planted tree population as an inventory of your populations and then use Forecast to simulate what these trees would do. And I’ll talk about that coming up. But that would be one way if you have a population. Design already does that now, but in Design you have to go on to Google Maps and put the tree down. And you have to pin each one on the map and enter information on that. So if it’s a small population, I would go to Design to do it. If it's a larger population, then I would go to Eco and try to load it in. But both of those models will provide simulation forecast and it is a fairly new feature in Design. I think it just came out last year. And in Eco, it will be out later this year.

Robin: On the pending wildlife habitat model, how much emphasis is on strictly native trees? Our Southern California region suffers from too few appropriate urban-tolerant native species.

Okay. A couple of things there. The wildlife habitat that we are entering in, based on the paper from Susannah Lerman, is mainly for 10 bird species in the Northeast. So it’s a habitat-based model. So it looks at species composition, downed woody debris, and the context of habitat. However, and that won’t help you at all. However, what we are working on this summer – and we have students working on this – is two things. One, incorporating wildlife habitats maps within i-Tree so you can know whether you have bear, beaver, or whatever it may be, squirrels in your area. So, one, does the animal even exists. And two is how, and the other piece is the species database, what species are connected to what tree species for habitat? And that’s where you may get – and in our database we also have native versus exotic. So my guess, like some of the work of Doug Tallamy that says insects are related to native and exotics, I'm sure animal species – although I don’t know for sure, I’m not a wildlife biologist – are probably more adapted to the native species than some of the exotics. It may be difficult for a squirrel to eat eucalyptus but maybe they do. So we’re trying to look at that. Right now we're building a database about these common wildlife animals versus what species do they require. So we are working on that and that might help answer your question.

Another thing we're working on is in that species program we're revamping that to answer some of these questions to get at – the species question is trying to get at what species should I plant? So when we get the wildlife component in there, that will help guide the users. It will ask you a series of questions and will try to make recommendations on appropriate species for your area based on what you want. If you want squirrel habitat that may be one thing, but if you want air pollution removal, that may be a different species. So you have to weight what you want to try to come up with the best species. We are working on that.

Another question that came from Bill: Will i-Tree work on the Apple platform?

The answer is yes, but you have to use, it won't work directly on the Apple platform. There are apparently, and I'm not the expert, but apparently there are emulators that you can have on Apple that will emulate the PC environment. We're not making Apple-based products. These are all PC-based, but they will work on Apple products and you can call the help, tech line, and I think Al Zelaya and Jason are on the line, too, but there are ways you can emulate it from an Apple environment.

Mary says, “In my area of Michigan, we’re having a lot of invasive crowding natives. Can we do models of benefits of natives versus invasives to justify control costs?”

The answer is yes, you can do natives versus invasives in the model. And I don't know if it would actually justify control costs, though, because some of the invasive plants will actually provide ecosystem, well, they *would* provide ecosystem services. So the question would not be so much – the services for air pollution removal, the model doesn’t care whether it is native or exotic. It cares whether it is exchanging gases. So, it does not matter on that point. I think the argument may not be on the benefits, but it might be on the issues of the dis-benefits. So we're working with Doug Tallamy now on trying to incorporate some of his work about how insect feeding may have changed if you go from not native to exotics? So some of these things – VOCs would be specific to species composition. And air temperature cooling and gas exchange would be species specific. But there’s no, I don’t know the answer yet, that may be that some of the exotics might do better than the natives in terms of some of the services. But there are other costs of having the exotics based on natural habitats and wildlife and insects that need to be considered. So I don't know if it would help directly in the answer but it would help to inform, at least from the services side. So we’re trying to get at that.

We have Rory and I will probably end here. So, I guess, Margie or someone tell me when to cut this off because we have about 15 more minutes on where we are going.

Margie Ewing: Take one more, Dave.

Dave Nowak: Rory: i-Tree is wonderful at modeling services (Thank you). Please consider adding trophic interactions (herbivory, pollination) as this informs all biodiversity and ecosystem services. Hopefully this will fit in the Wildlife module.

Actually, if anybody has any information on that. We are looking at, we have pollen indices that we're building for the plants, not pollination, and we are working with Doug Tallamy on the insect feeding. This is something we want to tackle because we have a lot of the structural data, but a lot of the work involves finding partners that understand this.

"Also, structural heterogeneity including density variation would be useful."

That, we can handle that.

"Glad to hear you are working with Tallamy. Overall, we need to better understand how to maximize resiliency of our urban forests, as well. Thank you for such an incredible tool."

Thank you for saying that. We appreciate that. And we are working towards resiliency. That's one of the big things we're trying to do right now is how to get at resiliency from different angles: climate change, trying to maintain native species, and things like this. But if you have any ideas besides working with Doug – others that may have this information? Going into wildlife and insects is relatively new to us. I come from an atmospheric background and we have been doing the physics and chemistry, but we understand not only that, but other things related to people viewing vegetation and human health – talking to Kathy Wolf and others, Bill Sullivan, and try to incorporate that. So there's an opportunity. We built the framework or structure, we just need more people who have better science, or different science, to help bring this in.

Ian. Hello, Ian. Will a web service be available at some point to incorporate i-Tree benefits into app development?

That is a better question for Scott than myself, but the answer is probably yes on that. We have some web services. We are building some apps right now. We're building a *What's My Tree Worth* app. Some of the tools are already web-based. And Scott has already talked about building a web service, but I'm not sure where that's at because [indiscernible] and we'd have to have a call on that with Scott directly. But the answer is, I would say, probably yes. It's an issue of is that a high priority versus some of the other things that we are working on.

Margie Ewing: All right, Dave, I think we need to go on to the Next Up.

David Nowak: Okay, thank you, I'll move on. I have about 15 more minutes here then I'll open it up for questions after that.

Last thing, and this is fairly quick. There are three things I want to talk to you about the i-Tree update that we have been working on. One is Urban FIA, which is Forest Inventory Analysis. Two, is our 2015 release coming out later this summer and specifically what's new which is related to i-Tree Eco, Forecast, and i-Tree Landscape. And then, upcoming features that we are working on for the next couple of years. And Ian, that web service may be one of those upcoming features.

So Urban FIA. The U.S. Forest Service's Forest Inventory Analysis measures forest data across the country at a rate of about one plot every 6,000 acres. So they're our national inventory group for forests. We started pilot testing doing urban areas in the late 1990s. We started in Indiana, did Wisconsin, Tennessee and Colorado, and we're out west right now. We're doing it at state assessment levels, following their grid with one plot every 6,000 acres, doing the whole state areas. So we had about 15 years of pilot testing i-Tree and this process at the state level. Well, last year in the Farm Bill, Urban FIA was introduced in the Farm Bill. At that point the shift went away from the states to looking at metro areas, similar to what we've been doing in i-Tree. So, the Forest Inventory Analysis group, which is our national inventory group, we partner with them – and we had been working with them in the past, but now we are merging i-Tree systems with FIA systems so that the Forest Service will have a national urban forest inventory and they started this last year.

Let me explain this a little bit. It is a panel-based system. And what that means – let me step back, I'll explain that in a second. The difference between FIA plots and i-Tree plots typically: i-Tree plots can be any size you want. Typical users in a city collect about 200 1/10-acre plots to do their assessment. And the reason for that is because that's the way I started it back in the early '90s and it is about what a crew of two can get done in a summertime. FIA, what they're doing in cities now, because their plot design is a little bit different, they're doing 200 1/6-acre plots – so their plots are bigger than ours, and that's okay – and they have microplots, which means within a plot there is a plot. So they measure all trees over 5 inches on the 1/6 acre plot in the microplots, they measure the trees that are under 5 inches, which are pretty much all trees in the micro plots. i-Tree collects all trees over 1 inch across the whole 1/10 acre area. So it's slightly different in protocol, but similar processing so that's not going to be a problem.

The other difference is this panel-based system. So you can see the first two cities we did in 2015 is Austin, Texas and Baltimore, Maryland. Austin did 200 plots across the whole city last year. They did all 200 in the first year. Baltimore is on a 7-year panel, which means they did 1/7 of their plots last year and they're doing the next 1/7 this year. So after seven years they'll have all 200 plots collected and then in year eight, they will re-measure the first year's measurements, in year nine they'll re-measure the second year's measurements. So, it's a rotating – you measure plots every year, but at 1/7 the frequency on a 7-year panel. Austin did all of them at first and now they're jumping to the panel system, so they're measuring 1/7 this summer, but they'll be able to show change analysis because they have the base data in. i-Tree, typically – I don't think anybody has done a panel outside of the U.S. Forest Service – is not a panel-based system. We typically measure all of the trees one year, come back maybe five or seven years later, and re-measure all of the trees again. We don't have this annualized panel system. And there's a reason why the panel system is a good idea and there are efficiencies and inefficiencies of doing so, but it's up to the users.

But FIA is on a panel- based system except for the ones that have asterisks. So this year they're going into Houston and they're doing all 200 plots. They're doing Madison and Milwaukee, Wisconsin; St. Louis, Missouri; and Providence, Rhode Island; and Des Moines, Iowa. How do these cities get selected? It's based on partnerships. So if you're interested in your area you have to talk to Greg Reams or Mark Majewsky or somebody, but you have to come to the table as a partner because the Forest Service is not coming in to do these unless they have established partnerships to do so, which is a great way to do it. And that's the way we typically work with i-Tree. Unless you do it yourself, you partner with – if we're coming in, we need a partner.

The goal is incorrect there. I typed that in wrong. The goal for the U.S. Forest Service is eventually to cover the top 100 metro areas, not 200. So many areas will not be covered. People can always use i-Tree and it will take a lot of time to get in there. You can see they did two and now they'll be up to eight cities after next year. And they'll be doing continuous measurements. So it's up to finding those partners to get in there. I think that's all I have to say on that. It's a good program. We're working on integrating the systems. We're actually meeting this week with FIA trying to integrate their system within ours. But you'll be able to do what FIA does in these cities plus what i-Tree does in these cities. And eventually the i-Tree users will gain because we'll be adding some FIA statistics to the urban areas, such as maybe board feet volume, and timber, and downed woody debris, and things like that as optional variables. So it's going to work its way across based on partnerships.

Okay, where are we going? For 2015, the version coming out this summer, there are three flagships that will be on here. One is that Eco is updated. If you're familiar with Eco, this slide shows you the new interface: totally new design, the help menu is right there alongside, much more engaging, and much more modern interface. What's new is where the arrow there is: Forecast. This is what we just talked about a little bit earlier. In Forecast, you can take your Eco data that you put in there, whether it be an inventory or in this case you could put an inventory of just the trees you planted, or the existing tree forest, and you could simulate the future. Which means it will grow the trees. So the trees will increase in size. It will kill trees off based on a mortality rate that you will assign. (There will be a default mortality rate.) And you can also plant trees. And so it's up to you. It's basically a population simulator based on those three factors. There are, as you can see, canned scenarios – this is not the final look, it's an early mockup – and management scenarios. So we're trying to do pre-canned scenarios. Some of those are insect and diseases, so you can take your population and click emerald ash borer and assign that to say I want to kill off all trees that will be attacked by emerald ash borer within ten years. And so they're pre-canned ones, and it knows –

there are, I think, 31 insects – and it knows what it attacks and you could assign a mortality rate to that. You can also do canned storm scenarios and say I'm going to have a windstorm come in and do something, but show the effect of what happens to the forest itself and some of the services that are provided by the forest. This gets into what we ultimately want to do which is getting optimization. How do we have the best forest for the future means we have to consider time as a variable in this process, along with the services. So we're trying to work towards that in the model. And this is about 10 years in development, building all these forecasting tools. So that will be out in Eco.

The other thing with Eco is Streets will still exist, but Streets is being merged within Eco right now. If you are familiar with Streets and you're familiar with Eco, they do similar things but Streets was designed for street tree data and Eco designed for any tree data. Streets processes use reference city data that have lookup tables. Eco uses locally-derived variables from the weather and pollution and your locally-derived data. So the advantage is you can still run your street tree data, but no longer are you tied to the lookup tables. You can do everything you did with Streets, but now it's tied to your local weather data, your local pollution, so don't have to worry about the reference city. If I'm 100 miles away from the reference city, it doesn't matter anymore because now you can grab your local data in Eco and we wanted it live, basically, without having the lookup tables. So you get the best of both worlds there by being able to do the street trees.

The last one here – this to me, is the most exciting to us – is Landscape. This was a huge piece of work. We've loaded all the national land cover, tree cover, and impervious cover for the lower 48 states (because there are no data for Alaska and Hawaii) into the system and, where available, the local UTC data, which is the high resolution tree cover maps and impervious cover maps, into the system. I'm going to basically walk you through this in the slides to show you generally what it looks like.

So you hit the Get Started button. This is a mockup of the first of screen and then basically, you will type, the map loads up here, and you'd type your address in here. In this case I typed in Syracuse. And the map would zoom to Syracuse. Within here, then you can pick layers that you want to analyze. Some of these are crossed out because they're not in yet. We're going to add congressional districts, we're going to add National Forest and things like this. So that's your bound of analysis. So with each of these polygons here, throughout this region, we have data associated with that. So what you can do is then you go down here. You can click on canopy cover, impervious cover, or in this case I clicked on land cover so it loads the national land cover data. So if you're familiar with this, it takes like two seconds. In the past you had to download all the national land cover data and it took a while to do. Now it's all preprocessed and it loads right up for you for your area, for anywhere in the lower 48 states. You can do the same thing with the impervious cover map and the tree cover map. Right here is the tree cover, so you can see the same layers. You can put all three of them on if you want. It looks a little funky, but then you have transparency bars here that will change the shading. I don't know why you would put all three on, sometimes you get so many colors going together, but you can do that if you want.

And then what you can do is select. Up here you can select what areas you want to look at. So these are four block groups. You can also do drag and click. You drag and click your mouse and create a box and everything in that box would be highlighted. So you could do the zoom selection. Then what happens – I'm not going to show you a lot of this, there's a process [indiscernible] – it basically shows you down in here, you'll see it will give you statistics for every one of those block groups, or if you have counties or whatever you did. It will tell you the amount of canopy cover you have, percent canopy cover, the impervious cover, and the percent impervious cover. It will show you all the land cover statistics, how much is forest, how much is developed. And it actually has all, not all of the census data, but much of the census data for much of the block groups, how many people, minorities, income, education. If you're familiar with census data, this was not a minor task. This was huge because it's very quick and it loads all of the census data. We had to write our own special code just to extract census data, but it's all loaded in there for you. We will also show you the information in per meters squared. So you might want to know, not necessarily this number, but number of people per population density or some of the services per canopy cover. So here's the land cover data. You can see Developed, Open Space; Developed, Low Density.

So all the statistics for the blocks that you picked are there and the census data, but it also shows you the services. It will give you carbon estimates, air pollution, and hydrology, which is reduced runoff. And for each of the block groups it will give you the total carbon, total sequestration, and the values, same with pollution – and I'm not going to show you all of these – and with hydrology. You can then sort these columns and highlight certain ones. We're working on making this more visually attractive. In some way, as you can see, technically block groups are hard to find in terms of a census number. It means absolutely nothing to me or anybody else, but you can click on it. There's a highlight button in the new version which will highlight which of these blog groups is actually the one you're looking at. Because they don't name block groups like they name cities. They're all a number code. So there are ways, when we release this, there's going to be – some people are already looking at this and giving us ideas. Mike Binkley and Ken and others are working on this to make this more easy to use and they're doing a great job. This is an earlier version that I have.

This is something we're really excited about this one, again, coming out later this summer. But everywhere in the United States it will give you information about your area in a map-based process. So you can change tree cover and see how the services will change. You can specify certain areas, show me blocks that have, meet at least a minimum of carbon storage or whatever you want to do. I'm not sure what you want to do. There's an optimization routine right now, which will select the block groups for priority planting, so areas that may be underserved. So areas that have high tree cover and low population might be lower priority than areas that have high population and low tree cover. And that's what we're going to be working on in the next year, trying to get this optimization. We're also adding many new layers. So what you're going to see coming out later this month is just the first version. There's so much more to be coming with this. But this was a year and a half in the making. And you don't need ArcGIS, it runs right off the server and Mike and Kevin and others did an excellent job of putting this together.

We have others working on how to optimize. In this case what we're trying to show here – and this is what we're working on – is where the pollution is, as I talked about that infused data earlier. It looks at population density and population concentrations so in this quadrant in the upper right are the areas of the city that have the highest density of people and the highest exposure to $PM_{2.5}$. So these blocks here are the ones that are the most polluted and have the most people receiving the pollution. So it gets to this idea of how do we optimize. We are doing the same thing – this is the priority panting which will already be in there – we're doing the same thing – this is $PM_{2.5}$ that I just showed you – we're doing it for air temperature, thermal comfort, and UV radiation protection. So the idea is in the coming years that we have all these layers, you can start optimizing where you want to do the best priority plantings or priority protection of canopy cover based on who is receiving the services and what forest you have, the distribution of the forest.

Upcoming features. You can just read down that list. These are the things that we're already working on. Wildlife – that will be out next year. That has already been through peer-review. Climate change projections we're doing with Louis Iverson. Urban soils – we have somebody working on the Century model with us. We've talked about pollen. You can just read these. These are all things we're working on and some are very close to being done, some will take a year or two. There's a lot more coming and we're still always looking for ideas from people or partners with the idea of doing resiliency and biodiversity. If people have ways to tie structure to functions, we're looking, if you're an expert in that area, we'd be glad to talk to you.

I think this is the last slide. We're also going into mobile apps. Trying to tie on your phone back to Design. So, very simple to engage people in measuring a tree and getting instantaneous measurements of services. So you can add inventories. Good for education. We're working with Dave Bloniarz and others are working on an education program with various cooperators. Citizen science – we think this mobile app will help develop some of those opportunities. So that's all I have on the update. I appreciate your time and I think I can take some more questions here.

I will start from the bottom up, I guess. Hi, Sally. Is Landscape designed to be able to handle high-resolution/UTC assessment data for entire states and regions?

The answer will be yes on that. I know that all of Maryland is being done and I hear Pennsylvania may be done. So right now, we've written the code – basically, we need to preprocess the high-resolution data to load it into the Landscape program. We're going to be loading the cities in right now. If the six county area is done then that will be loaded in. They will not all be out in the version this summer, but they will be out soon after that because it takes some processing to load. We're basically superimposing the high-resolution UTC data and taking away, or putting it on top of the NLCD 30-meter data. So the UTC data is better. But where you don't have UTC, you have to default back to NLCD, which does have some issues, tending to underestimate tree cover, but it is pretty good with impervious. So, yes, we can load that in. We've been in touch with Jarlath. We have all of his maps and we're processing this summer to get them in and so they will be out by later this year. And as more come in, we'll process more and put them in.

Margie Ewing: There is a question from Ian Hanou about…

Dave Nowak: Yeah, there it is. What year is the default 30-meter NLCD? 2011 I think is the newest.

You are correct. We're loading in 2011. We have 2001 also in there. I think we're taking it out. Right now we have a Switch button where you can pick UTC, 2011, or 2001. I think as of our meeting a couple of weeks ago – we had an argument on this – I think we're taking out 2001 because what people will do is run their analysis for 2011 and 2001 and do a change analysis. And intuitively that makes sense, but you shouldn't do that with these data because they are two totally different data sets. We're trying, we'd like to keep the 2001 data in there, but we're not sure if it's going to be misused. We might leave it in with a strong caution. But basically, the base data is 2011.

Question from Sophia: Is if there is a way for people to get in contact with people who have created projects in and out of the U.S. for collaboration purposes?

The answer is yes to that. We have a list of users. We don't post them. But if you, like we're working with someone in Brazil. I put him in contact with everyone I knew working with i-Tree in Brazil to get them collaborating so we're not building four separate projects there. So we would be glad if you have questions, I think send it to the help desk, or call Al or Jason, call or send it, or go to the form and we can get you information on people that we know that are working in those countries, *if* we know of any. We've also been talking with International Programs within our Forest Service to do that.

Rod: Can we donate our city UTC data to be used in Landscape?

The answer is – well, that is a good question – the answer is yes. I hesitate on that one because the issue is the format of the data. So, if your data is – I assume they're very similar formats. So if it's straight UTC, answer is yes. If it's high-resolution data and we have everybody collecting it differently and sending it in different formats, it becomes a really difficult for us because we have to convert all of those formats to our standard format. So we've been working with the typical UTC. So if it is pretty much done by Jarlath, we have the data, but feel free to contact us with whatever city you are in and if we don't have it – or, if we do have it then we will let you know, and if we don't, we'll ask you more about it and see if we can bring it in. So, we're trying to get all of the data that we have, or all of the data that is out there.

Naomi: Has i-Tree considered including an open soil measurement from street trees to determine soil carbon storage and other values?

We haven't considered open soil. We are considering soil, though. So, soil beneath grasses, beneath different materials. So I have Ian Yesilonis, who works for me, looking at the Century model and trying to get at the soil carbon issue, and some other factors of nutrient cycling, related to soils. So the answer is yes and no. Not necessarily open soil, but we are trying to tackle the soil carbon issue.

Okay, Ian says, "Call us anytime for UTC data at U.S. and Canada.

We will do that, Ian, thank you.

Margie Ewing: I think we should be wrapping it up for today. I'd like to thank Dave again for sharing all this information about the science behind i-Tree and all the great new developments.

If you are seeking an ISA CEU credit, it will be on the next slide. Please write down the code you see on the screen, send it into ISA using the form. You can download it from the pod to the right of the screen or from the webpage. If you're interested in receiving a Certificate of Participation to submit to another continuing education program, please type your full name and email address in the Group Chat and Questions pod and we'll keep the meeting room open a few minutes for you to do that. If you have any questions, please feel free to email us using the link on our webpage.

And then we would also like you to mark your calendars for June 10 for our next webinar series. We will be talking about *Resilient Cities* with Lindsay Campbell from the U.S. Forest Service Research and Samuel Carter with The Rockefeller Foundation.

And thanks everyone! Enjoy the rest of your day.

Dave Nowak: Yes, thank you everybody. I appreciate it.

[Event concluded]