Tree Vitality: Why Should You Care?

This transcript is auto-generated. Please direct any questions to isa@isa-arbor.com.

[00:00:00] Intro music playing.

Tom Smiley: [00:00:013] Welcome to the ISA Science of Arboriculture podcast series. This is Dr. Tom Smiley at the Bartlett Tree Research Laboratory host of this podcast series, which is brought to you by the International Society of Arboriculture and the Bartlett Tree Expert Company.

Today's podcast is by Dr. John Banks. He is a researcher and manager of the Bartlett Tree Research Laboratory in the UK at Redding University. He will be speaking on tree vitality, how to measure it and how it can be applied to pest resistance and tree establishment.

Jon Banks: [00:00:45] Hi everyone. Welcome to the talk on tree vitality. Thanks for joining us virtually for the ISA Conference. It's not how we'd want to be doing it, but it gives us some great opportunities. I can welcome you to our lab based in Redding in the UK [00:01:00]. I'm Dr. John Banks based from Bartlett Tree research labs in the UK and if you're not familiar with Bartlett, we have offices all over the US and Canada, but also some offices in the UK and Ireland as well.

This is a great company to work for. We've got some really excellent clients over in the UK, some amazing landscapes that we care for. And it's a real privilege to look after some of their trees. So the aims of today's talk, we're going to talk a little bit about tree health and vitality.

Run through starting to kind of define that and a better understanding of that a little bit. I'm going to talk about some methods of evaluating tree health and vitality. Once we know what it is. And then I'll give you a quick introduction to chlorophyll fluorescence and really talk about this arbor check device that we've, we've been using extensively in the UK.

And then what's often really useful for people is to talk [00:02:00] about frequently asked questions. And we'll look at some case studies as well as that's often really helpful. So it was a little bit of science in this one. If you can, keep hold of the science. And if that, if that just flies over your head, that's absolutely fine. We'll move on. And we'll look at some real trees and get outside and, and have a look at those off to that side. So just keep running with me, would be great.

Let's start off with some definitions. Well, what is tree health? And when we're asking these kinds of questions, often the tendency is to Google it. So I did, and we found some interesting symptoms, some very hungry caterpillars, some very hairy caterpillars, some of the decay fugi. Ash die back is an emerging problem in the UK. Big problem in the UK already, was seeing more and more of that as well in the US. But we are expecting some of that potentially to come into the UK in the next few years.

So we were talking about tree health, but we're also saying these passing diseases. And if you take nothing away from this talk, hopefully you'll take away this slide, the tree health isn't [00:03:00] actually passing diseases. It's related to, but tree health can also impact a susceptibility to passing diseases. So it's more of a broad spectrum on the tree passing diseases already kind of come in separately to overall tree health.

So I know, I think, I suppose it's someone else's talking about the disease triangle, but really what I've described there is kind of the concept behind the disease triangle. And about the susceptibility of the host.

Really though, if you've got a healthy tree, then it might be less likely to get those nasty pathogens that we're worried about.

After that introduction on tree health, what happens when a tree health begins to dwindle? And we like talking about this, the stress cascade and I sometimes describe it as a scale. I've got the scale of where up on the Powerpoint slide there. So from him being really, really great, really healthy to him being dead. And what's that [00:04:00] like in a tree?

So we're already, we're starting off one of the first things that reacts to stress is stemmata. This stemmata will begin to close and that sometimes caused or in tandem with an obsessive acid accumulation.

Well it's a potential changes when the stemmata moves. So the …. if you like, of the cells and the leaf that can influence her to say, because this water is used in photosynthesis after all. When the water pressure and the leaves start changing that, so what we call tigo, which I've mentioned, targets the cells responsible for cell growth and cell growth can kind of begin to slow. So we say a reduction in growth rates.

Chlorophyll formations, the plants can start going yellow. That's something we, we see visually reductions in nitrogen content and the leaves lower down the line membrane start to become a little bit leaky. And we start seeing some cell leakage.

So I put some of these [00:05:00] acts aspects of the stress cascade in, in bold, because we'll pick up with them later with different methods of measuring tree stress. We can look at these, these different impacts as, as ways to measure tree stress.

Some of these methods, some of the, maybe more historic methods, but certainly, certainly still valid methods still being used today. How much is the tree growing? If it's growing less than it might be under more stress. If it is growing really well, then it will be under less stress. I know these are potentially really obvious. But we'll get to the less obvious stuff later on I’m sure.

Again regrowth potential, how much are the roots growing? Official index, still a really valid measurement and something that I know we're using every day when we're out looking at trees. How how's the tree growing? Is it green; is it yellow? What does it look like? Does it look stressed? And then maybe more of a lab measurement, the electrolyte leakage. Is it, is it getting leaky? [00:06:00] It has been used for so many, many years to measure how healthy trees are and compare how healthy trees are. So these are pretty simple measurements.

Maybe moving into more current measurements, we can measure …. temperature and that will indicate whether the stemmata are open or closed. The stemmata will allow the evaporative cooling and beliefs. When stemmata closed the leaf start getting hotter.

You may have come across it, it may even be mentioned in some talks at this conference, the normalized difference vegetation index. I'm really that’s a measure of how, how green the plant is, how much chlorophyll to a certain degree. There are pros as well. And we can bring in chlorophyll content as well.

Stemmata conductance. We do actually now have machines that can measure this stemmata conductance by measuring the humidity of the undersides of the leaves. Not so really valid measure. I mentioned water potential a few times. This is a water potential machine. She gets the one of the best logos [00:07:00] for a company I think I've ever seen, for our water potential machine. And it does exactly what the logo says. It tells us how thirsty the tree is, how hard the tree is working to remove water from the roots.

Okay on this slide on the next slide because there's been some huge advances in infrared gas analyzes, and this is one of the direct ways of measuring photosynthesis.

So again, I've mentioned this bottom right photo is a really direct measure of photosynthesis and of the gases that are coming out to the leaves, infrared gas analyzer. Hyperspectral imaging is really kind of the next level on the chlorophyll content on looking how green the leaf is. And you can see that photo in the top, right showing just such a broad range of wavelength measurements. Really advanced measurements are moving into kind of future research. Clarified fluorescence. I'll talk about clarified fluorescence later on. There is a device that I won't mention later on they called [00:08:00] the PhotosynthQ which you might have seen around….[audio broken up]…it measures, a whole lot of really interesting parameters altogether. And there's already interesting concept behind it. We've already found kind of currently that it's got some issues with speed and consistency, but certainly something to the future.

Now price kind of drives everything when we're looking at whether we can buy any shiny new equipment.

And unfortunately the Ag is really expensive. Potentially just reserved for the research world. Hyperspectral imaging is even more expensive. The fluorescence is coming back down to kind of normal levels. On the PhotosynthQ sorry, is as much more affordable, but like I say, it's potentially got some problems that, that we found, but maybe much more useful in the future. It's always being updated.

So I mentioned chlorophyll fluorescence and just to [00:09:00] start off the discussion on chlorophyll fluorescence let's look at what photosynthesis actually is because we're talking about chlorophylls, you've probably guessed, we're talking about photosynthesis.

This is the basic equation for photosynthesis. And as often seems to happen in schools, unfortunately it's a little, all wrong. Really? It's all much more complicated than that I'm afraid. (10:06)

And what's happening in here is, is this, and you might be more familiar with these a few some, if you've done some therma study. But what, what we're talking about with chlorophyll fluorescence is this pink membrane plastic window and it's labeled in the membrane there. And it's inside the thylakoid stack in the chloroplast. So that's exactly where we're at. And we're looking at …. moving energy through the membrane, from photo system two to photo system one.

Like I said, we will get out of this deep dive into science quite quickly and look at look at some pretty trees. So if it's all getting a bit buggy, don't worry too much.

Like I mentioned where we're looking at [00:10:00] this membrane transfer, this electron transfer across a membrane this is the Zed scheme, which some of you may be maybe a little bit familiar with. And that's, this is the section that fluorescents, it gives us measurements from if we were doing this live, then I'd, I'd love to show you a great little demo. I can hold up some, some chlorophyll and put it under a UV light and you can actually see chlorophyll clorece as you can see that section of fluorescents happening and it changes color. It's quite exciting. A good one to, to show your kids potentially.

So chlorophyll fluorescence is an overflow mechanism happening in that position, on the graph. And it's a proxy for measuring photosynthesis. So it's not directly measuring photosynthesis like the infrared gas analyzer but it's, it's a proxy for measuring. It can give us an indication of how it's working. It's been used

really widely particularly in the research fields that's been used, first visually discovered in the 1930s. [00:11:00] So that's a very widely accepted methods of measuring plants.

So I have a graph for you, sorry, if you adverse to graphs, but this is the measurement. This is a measurement of chlorophyll fluorescence taken across a second. And when people say that our plants are boring because they're slow. Well, they don't move. This really springs to mind. So this is, this is in fractions of seconds seeing the, the overflow of the fluorescence actually, if I can go back to this slide, there's a few analogies you used for fluorescents, which I think are quite helpful to say here.

One is an overflowing bucket. So we start with an empty bucket. And actually in the leaves, we call this “dark adaptation”. And then we look at how quickly that bucket overflows, and that's kind of what you can see in that slide that was coming. Up the river analogy, which is, is also sometimes helpful is if we're measuring a car, how healthy is the car? Deep, deep down, how healthy is that car? And I, I don't know what happens at garages, but [00:12:00] they often plugged lots of computers and wires and, and they might turn the car off and let everything cool down. And then see how quickly it's turning on.

So that’s literally what's happening here in this graph. We're going from zero, a nice, cool state. Everything's dark, everything's calm. And then we're flashing it with light and it's going up to a maximum state and FM. So fluorescence maximum. So you already understand two parameters from the fluorescents and these other one other points in between have been, have been set out.

If we take the maximum away from minimum, we get the variable at the fluorescent variable. And this is a parameter that's been around for many, many years after FV/FM. Which is, is very simple to calculate because you can, you can say you just take, take these numbers. And divide them together. And that gives us a really good indication of how healthy the tree is.

But like I said, that was developed a few years ago, much more recently, 2003 or 2004 there’s this performance [00:13:00] index parameter. It's a whole lot more complicated. But you can see the basic fundamentals is still actually the same. We're just pulling a little bit more information out from that same graph from zero to maximum.

So, and that amount of time, and there's a whole lot more parameters that have been developed. I mean, I do feel a little bit like this dog sometimes as a scientist to have so many different parameters to select from.

But I've already focused on these, these two parameters, FV/FM and performance index PI. So if you're, if you're looking at kind of basic fluorescence, I feel looking to buy a therameter or you've got a therameter, and these are two that I'd really suggest you could use to measure tree vitality and we’ll look at some case studies, like I said.

There's some other parameters that we're using quite widely. FV/FM I've mentioned, CC is chlorophyll content and that’s a really useful parameters of how measuring, how green the leaf is. This actually comes from a separate chlorophyll content meter which is very widely [00:14:00] available.

And then we've got these other four parameters that we're calling stress indexes. And you can kind of see this similar other than the area, the area is the measurement over that curve. And a good way to describe these, those first ones and the vitality indicators. So how has your vitality, how have you been eating healthily? So kind of deep down are you healthy? And then the stress indices. So you can be of good vitality. You can be of bad vitality. You can have been eating really helpfully, but you can still be stressed and you can be eating really badly and you can still be stressed. The stress may influence the vitality later down the line.

And that's true with these parameters as well. It's often, almost a bit like a forecasting parameter sometimes. You can think of the mastery of half bow. The FV/FM if any of those stress indices are low and the vitality indices might start to follow.

So a question we're often [00:15:00] asked is how do these numbers compare to what I can actually see? And that's a really important question, or a useful question, to ask because we also need to combine these measurements with what we're seeing as well to give it some sort of grounding.

But if we're seeing that fluorescence has completely agreeing with everything that we're seeing, when we say a tree is good for us, fluorescence should be getting us a really high reading. If we see the tree dead, then hopefully we, we haven't got much reading in these fluorescents parameters.

If the florescence is working really well, if the measurement is working really well, maybe we'd see more sensitivity in the good region. So we'd say align a little bit like this. So that's one way of saying it's good fluorescence they're saying, or maybe it's 50% less than you're actually seeing, you're seeing a perfectly healthy tree and maybe it's a little bit less than and again, further on the line.

Maybe it's not so good. Then we'd see a tree that we think has maybe, maybe a 50/50 and [00:16:00] the, the florescence is actually reading it absolutely fine. So we're going to show you some, I'm going to show you some graphs coming up and we'll see how, how they agree to this idea.

So here's some data there's performance index on the left and FV/FM on the right. And you can pretty quickly see these, these lines kind of emerging in that data. Performance index is I'd say on that, on that side of being more sensitive than we can see with our eyes. And remember, this is quantifiable, so it doesn't matter if I say it, or if you say it or if anyone else down the road says this tree is healthy. Actually, we can get a completely independent view of it. Is it, is it healthy or not? Without any, any emotive issues coming in.

FV/FM it doesn't look too good for the first for the highest visual index, but it drops down much lower down. So maybe FV/FMs a bit more useful for how's the tree kind of dropped off back there. Is it, is it really hitting the unhealthy point? Or is it [00:17:00] dead potentially, or is it time to give up. Or is it worth trying to save. I'd say that that data is already really shine there. It does draw the line that kind of crossover line that we showed before.

So what's a healthy value? I mean, you can combine it with vision index, but we're seeing the potentially these parameters of better than our own visual assessment of trees already. Or we can look to the literature and back in the late eighties people were talking about FV/FM value. So roundabout, going eight point 0.8 per eight. Looking pretty good values. And again, the lights are on. People are agreeing with this.

So that's a really useful parameter if you've got no idea of where it should sit, if it's at .8, its rpetty good, your trees are healthy. They're respective of who says what essentially. But it does like say it does need to be combined with a visual assessment.

But that's only one parameter. And it's also, you've seen in the [00:18:00] earlier slide, even with FV/FM there's variation between species. So let's kind of delve into that a little bit more. Taking some different leaf colors as an idea for the variation.

We're seeing huge differences. Even with that stable FV/FM value. From the variegated plant pretty far down there. And more so for PI for this more sensitive reading. And now that reds, or variated green, in this case they're not unhealthy trees, they're lower values, but that's just naturally lower. So it's, it's a difficulty

with research the healthy performance index was a seven. Then we'd be, we'd be doing a disservice to the variegated plants.

So more data equals more knowledge in this this area. So we've teamed up or …[unknown]…has really teamed up with us. They had us talking about fluorescence and asked us to come across and have a look at their nursery and texts and readings. And we'd got, got the [00:19:00] facility that botch themselves, the facility to measure a huge amount of different leaf types of different tree types. We're measuring nearly five hundreds leaves. Currently that we've got collected, but in terms of the largest container grown tree nursery in Europe so our really large facility and a really great facility for testing, these kinds of things.

So me and my colleagues from Bartlett's and some colleagues from …[unknown]… make the instruments really interested in getting them both. They're great to work with.

And we went out and we measured all the nursery and we've been getting on with them seven or eight years now. And we definitely found this one size really doesn't fit it all, but we did find the most species have a point that we can say. Yeah, that's, that's a pretty good a good value for the species. So is it green? Is it Amber? Is it red? We can start setting limits on those species. And it's kind of important to be species specific. Yeah.

So it was a bit of an elephant in the [00:20:00] room. I'm talking about a UK based nursery and to potentially a, a largely US-based audience. We like to say that the UK does, does have quite some climate variation. Scotland does get cold in the winters. But it's certainly nothing in comparison to the States and we're, we're well aware of that. So I don't find me problems, find me solutions.

Well, some possible solutions you can use, you can use those benchmarks from the papers. You're predominantly going to be using FV/FM. You could potentially find a healthy tree, and we'll talk a little bit about that later in the case studies. On the, the other thing we can do is in the UK, we set up this benchmark through…[unknown]. They, they approached us to measure how healthy their trees were.

So if you speak to your nurseries, if there are any nurseries, listening would be really happy to collaborate with you and speak about looking at vitality if you, of your tree stock as well. And that can lead to a [00:21:00] a benchmark that can be available to others as we got in the UK.

Okay. So hopefully I haven't made to many of you fall asleep before I've shown pictures of trees. We'll get on to onto some case studies. Here's some Birch trees planted in in a client's property. And it was actually a tree surgeon and he called us in to have a look at this tree that wasn't looking too good.

And typically I'd ask an audience to kind of shout out how healthy do you think this tree is? And typically, maybe between three and four out of five, we might get it's not looking to good. And then the tree next door to it. It's looking, I'd say a whole lot better. Typically we hear fives. Sometimes there's a few fours but it's, it's a pretty good tree. It's a healthy, healthy looking tree. It looks much greener than the tree next door. Which that certainly looks promising. So I like to say I was called and have a look at this tree. And I had this arbor check device that was able to measure is it green? Is the amber? Is it red?

And this is the output from the device. [00:22:00] And even if we've no real understanding of what fluorescence is, you could still interpret this. Now we got, of course you're all experts. So you can, you can totally understand, understand this tree isn't looking too good.

And the fluorescence agrees with us that so that's, that's really good. The independent assessment has completely agreed with what us as arborists are saying.

We can delve into those parameters, the vitality parameters, the stress parameters if we want to as well. What about the tree next door? It looks pretty healthy, so we'd expect it to be to be in the green region.

And I was certainly expecting it to be in the green region, but I thought, well, we're out with them recommending treatments just for this one tree. Let's just double check that this tree next door is, is actually healthy. Oh, and it's displaying results that indicate that it's really not. It's under some sort of stress.

But like we were saying in the versus fluorescent specialist visual index. [00:23:00] We're not seeing that stress come out in the results. So again, we can delve into the parameters, but overall we're seeing the vitality not so good. And the stress is still not so good.

So what we were able to say from doing this kind of assessment was really not very much difference between those trees, despite visually seeing a big difference. So the key here is to treat both of those trees.

Like since I used trees it actually looking around at the trees most of them would deep planted or have a few suffering from water stress that which typically drop lots of the leaves almost immediately after a water stress event. So it would be important to, to address that deep planting. Maybe fifth among the irrigation system, we took a soil sample and had to look for any nutrient issues as well that might affect them. So in that scenario, it was a really valuable lesson for us from the from the research side, from the kind of consultancy side.

But it's really valuable to [00:24:00] the client. Rather than getting asked in once to look at the unhealthy trees and then getting us in again, to look at the trees that were previously healthy. But we know from this study that they'll likely start to dive and not look as well as again. So really valuable that we could come in only one student assessment and then say, these are the trees we need to treat.

So frequently asked questions often come up. There's a huge variety of things that we look at as arborists. Crown partitioning is, is one question that often comes up, where do I need to take my samples from? Well, I've got a tree that's got half of its crown, not looking too good. And half of it looking good.

And this is where it's really important to clarify that we're arborist out doing our job. We need to open our eyes. And we need to measure these trees with our eyes open and with our, with our visual assessment on. This can be the best tool in the world. I'm not going to stand here and say that it's the best tool in the world, but [00:25:00] it needs to be combined with your, with your visual assessment.

And it can help with us is all I'm saying. Hopefully teach us some lessons about how the trees are growing around us as well. So there's two examples here. The example on the left was a tree with a car park that was put to one side of it and it was grassed on the other side. We're able to quantify the percentage difference in these parameters that are showing that.

So we're getting nearly 35% difference in PI as a result of that carpark or reduction in the values. So we're able to put together a good case for remediating some of that compaction that had gone underneath the car park.

The photo on the right was from an oak tree, it's an ancient tree or a real privilege to be able to work on these. These really old trees or able to take a few leaves off just to make it easier to take the readings, but basically no damage to the tree at all. No drills into the tree. [00:26:00] We split it up into units because it's

pretty much split itself up. Actually, so we split it up into what we're calling functional unit one, two and three. And we were very, very clear able to see that functional unit one isn't looking as good as the other functional units. So we really wants to prioritize our treatments towards that side of the tree more than the other side. Although the other side is still under stress, we're still seeing nice kind of amber levels coming up to that.

So we have a question that we're often asked is how do we measure needles? And it's fairly simple. You can, you can see from the photos it does make a massive needles as close together as you possibly can. And you put them in these little dark adaptation clips, that they're essentially like close pegs or allow the device to fit to. And these are the clips that we'd have to take the readings with any way to allow that photosynthetic system to cool down reading.

One kind of note of caution on making these maps with sellotape, some sellotape is apparently florescent [00:27:00] So it's worth taking a quick kind of precautionary reading of the sellotape before you take it. To see if you get a reading from it, then maybe swap brands and try something else. I don't think there's a huge amount of that fluoresce, but it's quite interesting to know that.

So when can I take measurements? Obviously for deciduous trees, they're going to lose the leaves. We can't measure that leaves through the winter or fall. We're looking during the summer months, once the leaves have hardened up fully.

And here's some data from the literature that just shows that those readings are decreasing even on an evergreen plant. So even on evergreens we're sticking to within the season the growing season, when the leaves are fully hardened.

We tried to replicate this. So we looked to replicate this in 2018 in the UK. And what we saw was this decrease and increase in some parameters, we saw some stress happening which is a bit worrying. If we got a reading that we can we can [00:28:00] say as reliable and what's happening here? Well, what was happening in 2018 in the UK? That was a really terrible drought event.

Many of these soft light images taken of the UK, showing that basically the whole of the UK had gone brown. We've had a really bad drought and had a really bad heat wave. And actually, if you look at those values, I think the kind of yellow colored ones off from a …[unknown[…And they I react really strongly to heat stress. We saw a reduction by about 30% in that parameter. So that really tells us that rather than measuring a stable reading, we're actually measuring trees that are under stress. So you actually useful.

As a way for the future that we're seeing in the literature, we're looking to do, to do further research on, which can this kind of a series of parameters kind of this measurement be used as a diagnostic tool. And certainly the research case studies and the examples in the literature [00:29:00] really say that it can. It looks like a really exciting diagnostic tool.

It's not quite there yet. And as we're seeing with these differences between species are also getting differences between stresses, which we can, we can pull out. But we need that benchmark. We need that database to compare against, to you'd potentially use this as a diagnostic tool. So really for this one, this there's more research required. But we're working hard on that.

So you're just to wrap up as I was talking about at the start, if you don't remember anything from this it’s tree vitality and past diseases are all connected. I remember that disease triangle a passing disease load will

influence tree vitality, but it also works the other way around. If the tree is stressed, then it can get pest and diseases.

Well, we've got all this technology available. And I hope you from this talk, you've got a better understanding of potentially some of the different types of [00:30:00] technology that is out there to measure this kind of fundamental tree vitality and chlorophyll fluorescence.

It's kind of fits in that hopefully at a fairly cost effective reading that we think it's kind of available now that it's cost to be potentially useful and usable by some arborists.

Now this this final point that I have chlorophyll fluorescence, isn't a decay detector on hope that's come, come across. We are measuring tree vitality and their kind of overarching effect on the tree. But it, it does sometimes happen. And then in all kind of workings with fluorescents we've been around and we measure trees that have unfortunately then failed. This was a huge eucalyptus up in Scotland that was a champion tree, one of the largest of its types certainly in the British Isles. We're able to come in and measure the vitality of the tree one day.

And we, we have look at the results and they were having maybe a little bit questionable. We were a little bit worried about it and the [00:31:00] response that was the tree looks fine. But we've got these questions for reading, so maybe we'll come back and we'll do some, some thought a more in depth assessments have a place to look at the tree.

Actually in the next day the branch fell off. So I say to a story because it, it gives us a good framework to work to. Do you, do you jump up and down if you see a bad reading? No, I don't think it's going to say that the tree branch was going to fall off. It just gave us an indication that maybe we need to go back to that tree. Maybe we need to put a little star next to that tree and just reassess it, was what was happening here.

Potentially we were picking up some destruction and they in the conductive tissue and maybe, maybe we're picking something out, but certainly couldn't give you an indication of structural stability from fluorescents, and it's really important to stress that I think.

Obviously I couldn’t have measured these trees without a number of fantastic colleagues and collaborators, Barch trees, [00:32:00] … tech… and my colleagues at Bartlett who've helped take these readings and given us I think a really interesting database and a really interesting tool. I really welcome working with anyone who's interested in in this technology already, I think, to, to further discussions on it. Particularly statisticians actually, if there are any budding statisticians in the audience, then it would be very interesting to see what we could do with this data further.

But yeah, thanks to you. Thanks to all of them. Thanks your attention and for the listening to my talk hope you enjoy the rest of the conference.

Tom Smiley: [00:32:33] This concludes the talk by Dr. John Banks from the Bartlett Tree Research Laboratory at Redding University in the UK. This talk was originally presented at the 2020 ISA Virtual Conference.

The views and information expressed are those of the presenter. If you would like. Additional information on tree [00:33:00] diagnostics, you can visit the ISA Web Store and there are numerous books on this topic. Please join us next month for another presentation in the ISA Science of Arboriculture Podcast series.