Dan Staley — Modern Urban Forestry for Modern Connected Cities: Technology Opportunities

Rebekah Holtzclaw: [00:00:12] Hello and welcome to the ISA Conference Rewind video series. I'm Rebekah Holtzclaw, Editorial Assistant with the International Society of Arboriculture. Today, ISA is proud to bring you a presentation by Dan Staley, on Modern Urban Forestry and using new technology to connect cities. This presentation was originally given at the 2022 ISA Virtual Conference, so the views seen here are those of the presenters. So, if you are interested in learning about direct and remote sensing, data collection, and new technology on the market, I expect you will like this presentation. Now, sit back and enjoy.

Dan Staley: Alright, hello everybody. Thank you for attending today. My name is Dan Staley, and I'd like to talk about technology and big data. [00:01:00] But first, before I do that, I have to thank everyone who got me and my staff and crew where I am today, especially ISA volunteers and staff. They've made my life very easy to do this. Thank you very much.

All right, so, the reason why we're here today is I'm going to expand upon my recent paper about technology and arboriculture and urban forestry, specifically with respect to understanding what's coming and how to prepare for what's coming, especially with the avalanche of Earth data that is becoming available. It's out there every day. The fact is that urban forests will be imaged at least weekly, sometimes monthly, wildland-urban interface and other places as well. Also, we're going to talk about computer learning programs that are performing collection analysis, and it's being done right now. So, how do we prepare for that? [00:02:00] And for the fact that there are soon going to be people, either staff, employees, yourself, or a contractor that will be doing tasks that we're going to talk about in this presentation. So, we're going to give a brief background. We're going to talk about what's out there now, what's coming soon, what's coming in the next three to five years, and how to prepare yourself, your staff, your company, or your department for the future.

The target for this particular presentation today is consulting arborists, public sector arborists, job changers, or anybody in the urban forest industry who needs technology tools. We're going to focus on data and analysis today. We're going to discuss the rise of big data and the platforms to use and analyze big data. We're going to touch on airborne and other sensors that are getting better and better—sometimes slowly, sometimes too slowly—[00:03:00] and the analysis tools to pick apart all these data.

Remote sensing data collection is proliferating. So, data is a very big thing, and most of these data from remote sensing come from satellites, airplanes, drones, fixed sensors, and sometimes movable sensors, and we'll touch on that here later on. These data are rapidly becoming available to those who can find it, and soon everybody, and we'll all be able to find it. The remote sensing analysis is the main focus of this presentation today and is the main opportunity for the urban forestry profession as well. Urban Foresters will get these data and analyses either from staff with the appropriate training (most likely in computer science) or a contractor under direction from [00:04:00] you or your staff.

Let's talk for a moment about sensors for monitoring the urban forest. There're two types of sensors. We either have direct sensing (for example, sap flow or meteorological sensors). This is a footnote and there will be information and further reading at the end. Here's an example of a sap flow monitor right here. You may be familiar with something like this. This is, again, a direct sensing method. Remote sensing is

going to be much more typical now and in the near future. Typical remote sensing either comes from satellite aircraft or drone data, but soon it'll also be ground based data, and we'll touch on that here in a moment.

One thing that we need to think about when we talk about remote sensing is scale, and it's very important to consider scale when you're looking at remote sensing in two ways. [00:05:00] The first way is the scale of the collection. So, if you're looking at a citywide scale a drone probably doesn't make sense. An aircraft or satellite makes much more sense, because 100-square-mile city takes a very long time to fly for a drone but maybe a day or two for an aircraft. Another consideration about scale is the scale of the resulting data and images that you get from whatever method that's used to collect it. So, for example, when we look at these scales right here, we often talk about GSD or ground sample distance, and that is the size of each pixel on a side. So, for example, here a 5-cm ground sample distance is 5 centimeters on this side and 5 cm on this side. So, it's a 5-cm pixel. So, that's roughly about the size of a leaf. [00:06:00] An aircraft will be a typical 10- to 50-cm ground sample distance, and the typical good satellite data that you get today will have a 1-m GSD. Although we are starting to see satellites—commercial satellites—that are out there at 30 centimeters, which is very good. Those are not quite typically available for most people today, but they will be very soon. Also, when we talk about remote sensing, we only just don't talk about visual but we talk about spectral. We talk about LIDAR and we talk about more, but we're just going to be talking in general terms today. We won't be focusing on things such as LIDAR or 3D renderings or anything like that.

Here's an example of the difference between drone data and manned aircraft data. On the left here is data collected from one of our drones, [00:07:00] and you can see quite easily how clear everything is in this image. Then, with respect to the manned aircraft—you see, it's a little bit less clear—it’s flying higher on this particular day. Also, there is a little bit of smoke in the air. So, you never know what you're going to get. The most things that you can control are better, but you always take what you can get, and both of these are still quite usable.

So, data analysis tools. There’re two different things to think about when we think about data. We talk about collected data and we talk about discovered data. What's the difference? Data that you collect versus what you can find. Data that you collect is maybe something like a satellite or your drone, versus what you find, which should be something that is collected and just sitting there and then you go out get it. Another thing, [00:08:00] when we talk about analysis, I'd like to introduce something called the console. Consoles are something that's a little bit different than a platform or an interface. A console is actually something that you use whereas a platform or an interface of course is something different. So, I'm going to be using the term console today.

When you collect say visual images either from your drone or you download a Google Earth image or something like that, you don't need a console for something like that. You can put a drone image on your device and show it to your client. You can just do that anywhere. You don't need a console for that, but if you're collecting multispectral and hyperspectral data, LIDAR, anything like that, you're going to need a console to assemble and display that sort of thing. Other examples might be stitching maps need a console. So, you have a number of pictures together [00:09:00] that you need to put together to make into a map. You need a console for that. If you're going to do calculations for tree height, if you're going to render a 3D model for some purpose, look at plant health, you're going to need a console for that as well.

One thing I want to point out now, and I'm going to point this out again several times, is very few people not in the tree care industry can look at and analyze tree health. This is something that is unique and special to us and is our particular opportunity that we can use and seize and capture going forward to expand our business offerings to serve our publics, or to push solutions going forward for some of the issues that we face in urban forestry. So, what do we do with this stuff? How do we apply some of these things? So, for example, visual images, how can we use these things [00:10:00] going forward to serve our clients better? We can do plant health assessments. We can calculate stand density. We can look at permit compliance. We can do things like operation safety. To do two tasks, such as wildland fire safety preparation, for our clients in the wildland urban interfaces. We can do plant health monitoring. We can do tree risk assessments, especially level 1 and level 2 are very easily done with a drone. We can do property assessments, right? What else can we do? Maybe we can do things like insurance inspections, that sort of thing. What ideas do you have? I certainly don't have a corner on the market of ideas. Maybe you have an idea that you can bring into the marketplace, and that's one of the purposes of this presentation today, to get your mind going about what's out there, what you can do with it.

Most often visual assessments are easier, a single image or maybe a set of single images [00:11:00] or maybe a video for various purposes. For example, a video flying in orbit around one tree for your client, so they can have an idea of what's going on in the work before and after that you performed. These visual assessments, either with a drone or maybe Google Earth image, are best for explaining to your client, setting expectations for them, doing your TRAQ tasks.

Maybe you want to do some marketing with that and maybe do some interesting cinematic video or mapping for properties. Of course, you can get these visual images from satellite, aircraft, or drones, and very soon, we're going to have ground base images as well. There's been a permit or a patent offered for instruments such as this that can be mounted on vehicles that can collect data, that can drive through cities to [00:12:00] collect any number of data points, that can be used going forward. So, we can do, with spectral data, we can do plant health assessments. We can assess droughts, stress, fire risk assessments, but these are neither easy nor cheap, but it's getting better every year.

When we first started doing spectral plant health assessments, it was quite the operation. It's a little bit easier now, but it's definitely not easy, that's for sure. Having a spectral assessment of a plant or a forest or a neighborhood is invaluable, and it's something that you cannot do with your eyes to have these sorts of data analyses. Again, I want to hit that if you're going to ship out these data that you collect to a contractor to assemble and do something with, they cannot analyze that tree health. [00:13:00] They can apply a vegetation index and give that image to you, but they cannot interpret that. That is up to you to do.

One other thing I want to hit on is we definitely need better sensors for tree health. I have one of the most advanced sensors for an affordable budget out there now, and it still falls short for many things that I want. I wish I had something better. Satellites have more bands and have more data collection available, but they don't have the resolution that drones do. So, there's a little bit of a hole today for doing good spectral analysis. And we expect that to get better in the future, but it's a little bit of a slog right now, but it's still better than just visual. So, this opportunity right here is something that if you get a chance to work on to make a better sensor, it's going to push everybody forward.

[00:14:00] What do I mean by a spectral analysis, and what does it look like? If you've never seen anything like this before, this is what something like this looks like. This is a neighborhood. These are

houses right here. Here's a house. This is the road. This is the road. This is the sidewalk right here. So, these are examples of—these are two of the same species. These are red oaks, and this is a white oak right here. And so these—orange is better. There's more chlorophyll in this analysis right here. These are examples of vegetation reflectance that are analyzed for particular purposes right here. What I want to say about this is the more that you look at these sets of analyses, and then go out in the field, and then compare that with this here, you get a chance to train your eyes better, where you look at color in a different way. You can just go out in your truck [00:15:00] or on your feet, a bicycle, or something and start to take a look at trees, and you start to notice these subtle differences when you do this. And it's just really something that's just quite useful, and it's really changed the way that I've looked at vegetation. And so, that's another side benefit that you can get from doing this sort of work.

So, let's wrap up currently what we can do today. We know today that data and analysis consoles are available, and they can expand your offerings today if you put in a little bit of work to try and understand what it takes to do something like this. You can expand your business offerings. We can do this with respect to wildland fire mitigation, we could do better plant health monitoring, could do better inventories. There is a company out there now doing better inventories using big data and machine learning. We can do property mapping and assessment. We can get a better start on doing wildland urban interface mitigation. [00:16:00] We can use our drones to wrap our minds around what's out there, so we can do a better cruise. And also one of the things that we can do with drones with respect to wildland fire is to wrap our mind around the after-effects of fire.

So, how can we use the technology that's out there to better serve our clients, especially in the intermountain west, parts of the Iberian Peninsula, parts of the Eastern Mediterranean, that sort of thing, where fire is becoming much more common? We can use these tools that are out there now to better serve our clients, to look at post-fire tree and forest recovery. These are invaluable tools when you start to look at trees post-fire. It doesn't take long at all before you see the value and the use of drones. As we use these more and more, this will lower the barriers for entry [00:17:00] for all the young folks entering the work force. So, we're going to have a new set of people coming in with a different set of eyes that can only offer value to plant health care and arboriculture.

One last thing to wrap up is satellites and aircraft sensor development are better at the larger scale, drones are better for smaller scale. So, what's going to happen in the next three to five years? Three to five years-ish, depending upon how things go with all the challenges that we're facing right now. Maybe this horizon is good, maybe it isn't good. Who knows? But anyway, the next three to five years collecting data by drone, airplane, and satellite will be much easier with technological development, more platforms going up in the air into space. Drone laws and technology will lower the barriers of entry. [00:18:00] I am finally a little bit optimistic about drone laws moving forward to make it a little bit easier to fly. I do believe that spectral sensors mounted on aircraft will get better and more useful. I also am quite confident that satellite constellations of satellites orbiting the Earth with better resolution will become much more available.

So, why do I believe that? Because there's a new space race going on right now. There’re new commercial satellites going up all the time. The company Planit often puts up these small, little satellites that are only about this big that collect all kinds of data that have a return interval that can be a day or can be a week, and it's very promising. These launches are getting more and more common. This particular image here is one [00:19:00] that I took just a few miles south of my house here just a couple

days ago, before I recorded this presentation. This is a Starlink launch, and this far away is Vandenberg Air Force Base, and you can see the trail of the rocket. And here's the reusable, first stage of the rocket landing in the ocean, so they can use that again. And this allows more and more launches to go, and more and more satellites to go up to monitor the Earth's system. So, I'm very confident that we'll have a ton more data coming on board here real soon.

What else? Analysis? So, data analysis using machine learning will become almost routine. How do I know this? Data analysis using machine learning is happening right now. The details on this particular news item aren't important, but you can go back in later and read these if you wish. But this is a recent [00:20:00] article out of Alaska where a research vessel was in the Bering Sea collecting data and analyzing it on board using machine learning. Their analysis showed that there is a toxic algae bloom happening, and they were able to alter their course to collect more data to this threat. As soon as they got on shore, they alerted the relevant authorities, and they showed them all their data and they issued a toxic algae bloom alert, which is still going on now. It's this sort of thing that's going to get even more prevalent in the future.

Also, nearby my house in the Monterey Bay, there are both autonomous and fixed sensors out there now that collect DNA. So, we know what kind of creatures are swimming in the Monterey Bay and other parts of the California, Oregon, and Washington coast. [00:21:00] So, we'll send submersibles out there, collect DNA data, so we know what animals are out there. These sensors are also able to detect nitrates from fertilizer runoff. So, we know seasonality the flushes of nitrates into the Monterey Bay, and this is being done now, and so three- to five-year technological development will be, of course, even more advanced than that.

Data discovery, locating and acquiring data that's collected and put out in the world, will be aided by console design and machine learning routines, and we'll check on what that exactly is here in just a moment. Data analysis on the console that you choose will allow acquisition of all data and target areas that can be acquired. And we'll look at that here in just a second. And so these data will be collected by satellite. They'll be collected by aircraft. They'll be collected by survey elevation models. Anything that is labeled as [00:22:00] data that a computer can process and go out and find and collect off the internet will be able to be analyzed on a console.

So, what do I mean by that? What is a discovering analysis on a console? What is this guy talking about here? Well, console today is something where you input most commonly a computer language such as Python or R to perform tasks. So, here's an example of a commercial console. This is a company that offers this service that you can go out and get data and analyze this on their console. And you can use Python for that analysis.

Here's another one that you may be familiar with. This is Google Earth Engine, and you can see here in the center, these are the Python commands to perform this particular task that they're going to perform. And this particular set of tasks right here is called a script, [00:23:00] and it is quite common for people to write a script and then offer that script for others to use. It's a very useful function that people are doing right now. There are scripts out there everywhere to do all sorts of tasks. We'll look at that here in just a second. Here are practical examples of things that are being done. The Copernicus Consortium in the European Union is an organization that collects and makes data available to users. One of the consoles or hubs in that Consortium is called Sentinel, and so they have several hubs that they use to gather or disseminate data. They also have a number of contests that they use to write scripts to make it

easier for people to either upload or download [00:24:00] these data for others to use. It's a very nice community.

Here's an example of this hub and the data that is being used in the scripts that are written to perform these tasks. On the left-hand side right here is a set of user interface commands right here that are written, run in the background using scripts. So, you don't have to know Python to be able to run queries in this hub. You can just set some of these either collection platforms and what you want to look at right here. You can use this interface to do that. You don't even need to learn the language to perform basic queries, which is quite useful, and it's getting better every day. So, in the future there'll be development for user interface where you'll only need to use Python minimally. It won't be a big deal.

[00:25:00] Here's something a little bit closer to home for me. Data collection and analysis. Here's a different type of user interface that's run by scripts, that in the future, this will all be, you won't have to input any Python or R or COBOL or C or Fortran. Any of those languages. You won't need to know any of those languages to make these things work. Libraries already exist that streamline some analyses. And so there are some scripts that are run that you can go out to a library and get some scripts to pull data and to analyze those data. But again, I want to emphasize that plant health interpretation and analysis is best performed by us by arboriculture or forestry people that understand remote sensing analysis. And scripts can be written to pull the data, but it still has to be [00:26:00] interpreted by us. This is an opportunity for us to go forward to solve some of the problems that we need to address going forward in the future.

So, again, I want to just put this out in text, so you can see it and refer to it later. We're going to be essential for these automated analyses in the next few years. People that are writing these scripts to do these things need direction, and we are the people that provide this direction. So, here's an example of some scripts. They're available. This is GitHub, and these are some scripts for the Earth Engine that we were looking at earlier. These are just things that run that pull data for you, so these will be very common in the future. We'll download these and use these. And once they're downloaded and done, we'll do a little bit of tweaking and that'll be it.

[00:27:00] So, a way to look at big data is it's the new inventory for urban forestry. So, back in the 50s and 60s, everything was paper, and then, and in the 90s and the 2000s, all of a sudden, inventories came online. Well, big data is just the new inventory coming online. So, how will you access big data for your clients or for your public, right? If you're a consulting arborist, you're either going to find the data collection that works for you: a drone, aircraft, satellite, plus a console that you can use to analyze some of these things. Or you'll just go out and hire a data firm to do that for you. On the municipal arboriculture side, you'll either hire or develop staff or you'll contract a firm to do that. One or the other. But you're still going to need staff that can verify that the output that you contracted for is going to make sense for what your requirements were.

[00:28:00] So, preparing. Just to hammer on this again, I will never stop hammering on this as long as you see anything that I do or talk to me. Big data is going to need to be accessed by knowledgeable staff. There's going to need to be some data literacy by somebody to be able to use this data. It's either going to be you, your staff, or by contractors, but who is going to make the requirements? Who's going to guide the work? Who's going to say this makes sense? Who's going to say the output is usable for your clients, for your planning commission, for your city council, for your state senator, whoever, for your public, who is going to say that this stuff makes sense, right? Who's that going to be? Who's going to ask

those right questions? Who's going to write the requirements? How do we get those people up to speed with respect to data literacy to make these things happen? Is it going to be one nerd [00:29:00] or is it everybody in your organization that's going to be a nerd? We don't know.

That's going to be the key for us, and the next 3-, 5-, 7-, 10-year horizon is wrapping our minds around how to utilize all these data that are out there, to make that usable, to make our urban forests work for everybody. So, what does that mean? So, let's ask this a different way. Who will get you what you need, right? Who is going to do that for you? Do you need big data analyses often: once a week? Once a day? Or do you just need a few times a year? If you just needed a few times a year, again, who's going to ensure contractors are going to give you what you need. Looking at this in a different way again, restating this are different way. How will you find these folks to do this work? Where are the future [00:30:00] technical foresters going to come from? Are they going to develop themselves? Are you going to develop your staff? Are you going to give them incentives to make themselves better to do the things that you need to do or are universities or are technical colleges going to do that for us? We don't know that's up to us. That is our future to decide how we are going to access and use big data to make urban forest work for us.

So, what does that mean? Is it going to be a talent pool drawn from computer science? Or is this going to be a specialty in urban forestry? We don't know. This is our future to decide. One thing though, we're all going to have to have some level of data literacy from modern urban forestry courses, right? So, if we're going to have [00:31:00] urban forestry courses offered to students, we also have to make sure that those students, you know, have what they need to give us what we need, and so that is up to our educational institutions to ask us what we need, so we can give them our requirements and then they can develop those curricula for us.

Also, a thing to think about is this is going to be a new track for the urban forestry profession, for the municipal arboriculture profession, for the tree care profession. So, we're going to get new blood coming in that are data literate, that are literate in computer science, or we can have some of our older folks who can't take the climbing anymore, don't want to take the climbing anymore, now have a family and they can't do that, they need more time and they want to work from home, this is a new path for them as well. It's not going to be for everybody. I don't expect everybody to be [00:32:00] data literate or to code in Python, or to do some of these other things, but it is track for folks to access urban forestry to make our urban forests work for everyone.

One thing to think about when we're going forward, if we want to train staff, if we want to do this ourselves, if we're consulting arborist, and we want to get in on some of these opportunities to expand our offering for clients, is that there are a number of courses available right now for us to get started to be literate in big data machine learning, or these courses can be used for us to look at contractors to see if they've got enough preparation for us, to be competent for the things that we need. Here's an example, just one example of the many courses that are out there, to be able to get literate to use Google Earth Engine, [00:33:00] to pull down data, to look at the urban forest in the data to see if we can use that to supplement some of the things that we're doing now. So, there are multiple courses out there for people to use for us to judge your competence.

How do we know that these things are relevant and useful going forward? Well, Google Earth Engine is already being used to assess Google Earth images to solve problems. And here's just an example of papers that are out there now, applying Google Earth imagery to solve urban forestry problems. And

there's more. Imagine what they'll be in five to ten years. Imagine how we have to look at some of our education curricula to modify [00:34:00] something like this to insert maybe a data literacy course or maybe a computer science course or something like that.

This is Stephen F. Austin right here, and so, you can see that they're focused on communication which is very important. They've chosen this particular curriculum here to add in addition to the plant knowledge and the forestry knowledge communication. So, you can communicate your ideas or understand what the client needs. So, we know that curriculum can be modified to serve a particular need. There's no reason to believe that any curriculum that is out there now can't be modified to fill a big data need as well. So, we know it can be done. It's being done now, and we can go forward in the future and do it again.

Alright? So just to recap, that was a lot of data. [00:35:00] Big data is expanding rapidly and driving progress forward, and many sectors, including urban forestry, are watching these changes happen today in many other sectors. There's no reason that it can't continue to happen and expand in urban forestry as well. Useful data collection isn't necessarily purposeful. We can find data anywhere and suit that to our own needs. We don't need to go out and collect the data ourselves. We can get that from somewhere else, from a library. And these analyses can either be human directed or they can be automated. It's possible but not easy to start utilizing big data tools today, but the tools and the programs are out there now. The educational programs exist today to get us started. So, we can start using these big data tools to expand our offerings for our needs for our clients.

These barriers to entry are falling daily, [00:36:00] and the computer language requirement that is needed now, it'll be overcome soon. So, what may be a daunting task today in just a couple years won't be a big deal at all. The need for more data and tools, of course, a seemingly never-ending. We've got problems, challenges, issues all over the place and they never seem to stop coming. Big data and data analysis is one way to wrap our minds around some of these challenges that we have going forward and address the needs of our clients and our publics in the shade of our urban forests. And again, arboriculture arborists, plant health people, we're the ones that analyze tree health. Hardly anybody else can do that. So, consulting arborists, municipal foresters, [00:37:00] we are the ones that can leverage these rapidly expanding technologies to offer more services, more products to our clients, or better services to our publics.

These barriers to entry that exist now, these can be overcome with education and with time for technological development. All these challenges that we think about and rediscuss all the time over a beer after work, these require creative solutions. These require ideas and direction, and big data and analysis is one way to help us wrap our mind around what's happening today and how we can go forward in the future, so we can continue to offer shade for our publics in urban areas. And last thing, of course, arboriculture is always adapted to new tools and [00:38:00] technology from the axe and the saw to the chain saw to inventories, and we'll do so again. It's just one more tool in the toolbox to assess and use to offer better tree care.

And with that, I'd like to thank everybody. And I'm happy to take anybody's questions either here online or shoot me an email. And I'd be happy to sit down and have a conversation and talk about what we need to do. Thank you very much.