Greg King: Effects of Residential Development on Growth of Mature Trees

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[00:00:00] In every country, you know, we can work together and learn one winning to meet the challenge.

Jamie Vidich: Hello and welcome to the Conference Rewind video series. I'm Jamie Vidich director of Educational Products and Services at the International Society of Arboriculture. Today, we are pleased to bring you a presentation by Dr. Greg King: The Effects of Residential Development on growth of Mature Trees. This presentation was originally given at the ISA 2021 Virtual Conference. And the views are those of the presenter. If you are interested in trees and development, I expect you will like this presentation. So sit back and enjoy.

Greg King: Okay. Good morning, everyone. My name is Dr. Greg King and I'm assistant professor of environmental science at the University of Alberta, Augustana. And this morning I'm gonna talk to you about the effects of residential development on the growth of mature trees.
This project utilizes the science of dendrochronology in an urban environment to assess unique long-term growth trends at an annual resolution. And what we're interested here is how those trees are impacted by the urban environment.

There are some challenges to consider in this work, but lots of potential. And this presentation is a small project investing in one aspect of this potential approach. So today I'm gonna work through some background around talk about our research question that drove this study look at our study site methods, and then share some results.

So what you see here is aerial view of the neighborhood of Arlington Woods, which is located in Ottawa, Canada. And we have a fantastic urban tree canopy here. And we know that, that urban tree canopy brings multitude of bene- benefits. Unfortunately, this project [00:02:00] was initiated based on the presence of a natural disaster that happened. In 2018, a tornado which is quite unusual for this area hit the neighborhood. And so this view of the neighborhood now looks more like this, or right afterwards, it looked like this. It's now been cleaned up a little bit.

But what happens here is that this devastation happened, obviously or thankfully, no loss of life. Significant damage to homes, which you can see. But residents were also mourning the loss of the trees. This neighborhood is rather unique, which we'll talk about, and especially the presence of that white pine that populated the neighborhood.

And this project kind of came out of happenstance because I heard about this tornado. I used to live in Ottawa, I don't anymore. So I knew about the neighborhood and the opportunity to go and look at trees that had been removed or were removed because of this event and compared to trees that were still standing and be able to do some coring around properties to kind of tell a little bit of a story about this unique urban environment.

And so the thing that happens, of course, is that loss of trees equals loss of benefits. We residents, are mourning a loss of that aesthetic value of those trees, but also we know about those tremendous other benefits. And I think that we talk about that benefits and then we say, okay, well, we can plant trees. But in this case, and in many cases where we remove mature trees, we actually are talking about this loss of canopy equals loss of benefits, and the amount of time that actually takes for that those benefits to re-accrue or regrow is tremendous.

So in this case, this graph is just from an example tree a white pine tree from this neighborhood. And we can say that it took many decades to reach tree size that would accrue [00:04:00] similar benefits. And so we're talking 50 or 60 years from now. Even if we were placed every single tree that was lost in the, as tornado we, we would have to wait many, many decades to, to have that.

And so this brings in the question of, can we retain those mature trees? Now, in the case of a natural disaster, we can't, but an equivalent kind of human disturbance is often with

development. We're facing this in many cities. As we move towards more compact and climate resilient cities this, this density is being encouraged. And that results in a conflict between this increasing urban density but extent tree canopy, which is often present in these inner city suburbs many more mature trees, larger lots that wouldn't be built today.

And so what we're seeing is infill and removal of mature trees as these houses get bigger increased footprint of houses on these lots, but we can also think about this in terms of greenfield development, which is more of the story for Arlington Woods, where we had existing trees and forests and agricultural land, and then we built suburbs onto top of those.

And so this, development process happens. And oftentimes we say, well, we have to remove these trees for this development, but is it possible to retain those trees? And if we retain those trees what is the impact of development on their growth? And this is where the science of dental and using annual ring widths and looking at how much growth there is per year, we can investigate that question.

And so what I wanna do right now is just kind of give you an idea of that neighborhood development. So Arlington Woods is a suburb located in the west end of Ottawa, and it's directly adjacent to Ottawa's Greenbelt. And so this is an air photo from 1934 before kind of development reached this area. And what we can see is this stand of white pine trees. [00:06:00] This is a creek here and the stand of white pine trees.

And what happens as we approach through the fifties is that there was a greenbelt that was proposed in 1950 to restrain urban growth in Ottawa. And it was proposed in 1950, but not completed until the mid-1960s. And basically it was involved buying land, agricultural land in these areas and creating this, this belt of green around the city.

And so this white pine forest actually straddled this green belt. And so this area over here is actually now a green belt area. And we see that developing, although we can see that there was logging or removal of trees between 1965 and 58. But this, Greenbelt area is also a, but this, this white pine forest continues and is actually part of the current residential neighborhood. And we'll see that here.

And so this neighborhood was developed by Robert Campo in 1968. The development happened in pieces more of the southern end was developed first. And then we had this part that was developed here. And you can see that these mature trees, these mature white pine trees were retained. We're still not sure exactly why if that was a developer decision or requested by the municipality after amalgamation on these records were, were lost or are not as readily available. So we're still investigating that question.

But this, this type of development at that time in the late-sixties, early-seventies focused on large lots custom-featured homes and it catered to an upper middle class market. And there's potential that the developer himself said, well, this is a pretty unique location to put a neighborhood, and we're gonna try to retain as many of these white pine trees as possible.

And so what we can see [00:08:00] from a more recent air photo, this is from 2014, is this is kind of zooming in on the neighborhood on the top. And it's a nice photo because it's taken just before leaf out for deciduous trees. So all of these trees that we see are the white behind trees and the remnant stands that exist from the creek on your screen right here, all the way across through the

neighborhood into our green belt here, which is starting here on the left and continues for several kilometers the other way.

And so what this study site looks like we are in Ottawa which is in Eastern Canada just kind of north of New York State and indicated by this red box here. And this is our actual study site. So we're zooming out a little bit from that last picture. And what we did was we went and we cord a number of trees. We spoke to residents. This was about... We went in May, 2019. So about six months after the tornado. Many trees got removed right away and we didn't have a chance to collect from them, but we did collect from stumps. We're able to cord from stumps.

And then we also cord some of the trees that were in this green space area.

So we split our two sites into a residential site, which is the yellow dots and a green space site. And we originally had a ravine and these other lands, but they responded so similarly that we kind of grouped them together into this green space. And we also looked at, we measured DBH of these trees. And I'll talk about, more about that in a second.

So what does this neighborhood it look like on the ground? This is basically kind of what it looks like from the front. Obviously, some of these have been planted since construction, but we can see some of these larger white pine individuals, especially towards the backs of some of these houses were retained during this construction and have continued to grow in the neighborhood.

And at this point, I should have provided a caveat to look away if you're in Western North America and think about fire smart planning. Because this is a neighborhood that certainly [00:10:00] did not have that thankfully in an area that was a little bit less in, in danger of fire. But we ended up with the loss of those trees from this tornado that happened in 2018.

And so we're focusing here on one species of tree. This is the eastern white pine or Pinus strobus. It is Ontario's provincial tree. So potentially that played into that decision making from the developer about should we retain these trees or not? Mature trees are very large, up to 30 meters or more tall, very large DBHs. In natural areas, they can commonly live for 200 years and have...

Samples have been found in Ontario from over 500 years old.

There generation is linked to wildfire. And so in this case, this stand of trees is linked to a fire that happened in the 1870s in the area. And this, this stand, gen- generated at that point.

And so looking at the ages we see that our trees were about between kind of 80 and 100 old, generally speaking some going back a little bit further. Although we were cording at breast height, so we didn't get true tree age in that sense.

So what were our methods? Basically we contacted residents of the neighborhood and the na- natural ca- National Capital Commission, which manages the greenbelt for access to that green space. And we collected tree cores, which you can see on the left or cross-sections. It's nice when you have arborist friends who live in the area and they can bring their chainsaws out and collect cross sections for you from these samples and these stumps.

And these were located throughout the neighborhood and the adjacent green space. And we did this in May, 2019. We brought them was back to our lab here in Alberta, and we did cross-dating and measurement through our microscope system and scanning of those images to do measurement as well.

One of the challenges for dendrochronology when the [00:12:00] principles underlying dendrochronology is you can assign a calendar year to each ring. To do that, you need to make sure that you're cross- dating between. So basically this boils down to pattern matching. Sometimes urban trees present a challenge in that sense, because ring widths are quite variable. And so it's not the only signal you should rely on. And so we try to incorporate some visual signals as well.

Interestingly there was a study that was done in 2011 on white pine in the [Château] Hills, which is basically 25 kilometers north of where we were working across the Ottawa River into Quebec. And what they were looking at were inter-annual density fluctuations, or basically false rings. So this happens when a tree is stressed late in the growing season and basically begins to shut down, but that stress is overcome, you know drought is averted or you know, more precipitation is really received. And so then the tree continues to grow for a little bit more.

And the study in 2011 found prominent inter-annual de- density fluctuations in 1955 and 1959. We were able to use those to actually anchor our tree rings to know that they were dated properly, because many of our tree rings also showed this 1959, especially false ring here. And so this is a zoomed in, this is a, a, a white pine core dated back to 1918. And you can see this 1950 ring. And this is a, a false ring. So this is not an actual year, but rather a stress response and then growth that happens after that. And so this just provides an, an idea of that cross-dating and what we have to do to ensure that we have calendar dates assigned to each ring.

So into our results here. Let's talk about our general characteristics. Basically, this shows a, a, a [00:14:00] single-line graph for every single tree that we cord. We have green space in our blue on the top and our residential trees in yellow on the bottom. And the mean curve is represented in that thick black line. And this is basically just raw ring width.

So what we can see is and, and, and a couple of details for you. So in our green space, we had 28 trees. And in our residential, we ended up with 20 trees. The average ages were a little bit older in the green space, about 94 years versus residential was about 84 years. However, what that means is that all of the trees were older than development that we cord. And so that's key because as we wanted to look at what is the response of this neighborhood development on this tree growth?

One thing we did was we moved beyond ring width and we looked at basil area increment to look at these overall growth patterns. And basil area increment we used that because it provides a more complete quantification of total wood of production. Rather than just the width of a ring. it looks at the total area of, of wood that's deposited in a given year. And we convert from wing widths to d- BAI using our diameter breast height or DBH

We also then conducted a numerous stista- statistical tests between groups before and after develop to look at what was showing up in terms of their response. And just a quick primer on BAI. So this is a zoom in on that. Core, we saw earlier from 1918. And you can see the annual rings. And basically if you were counting ring widths, you'd measure perpendicular to those rings over time. BAI is a little bit different in that from the pith, you'd have your rings going outwards. These are concentric circles. We know that tree growth isn't exactly concentric, but that's the model that's used.

And what BAI would to do is take this, for example, this green ring, [00:16:00] and represent the area of that ring over time. And so with that model, we get a sense of how much wood is actually deposited

overall. And what's interesting is that we can actually use and develop a BAI ratio where we, look for example, at a 10-year average basil area increment, and then divide that by the average total basil area increment over the entire record to look at how that 10 years responds. Is it above one, which would mean that it's growing more than the average, or is it below run and maybe is growing less than the average?

And so here is what our annual growth comparisons revealed. BAI is on the left hand side and that's measured in millimeter squared. It's the area of any given year, amount of wood that's put down. And our dotted line there, vertical dotted line, represents the year 1970. So although the development in this neighborhood started in 1968, we have some house dates that are also from 1972. So we set the development year as 1970, especially in that area with the retained white pine. That seems to be about when construction would've started for some of the houses. Although they were done individually.

And what we can see here is we can see differences between the two chronologies. Green space represents those tree that are separate from development and residential, those trees that are right in the middle of the neighborhoods. There's actually good synchrony on high resolution or year-to-year basis. But you can see that there's a increase in our residential chronology starting just after 1940 here. And starts to increase over time. And that those green space trees also increase over that period of time, but there's a difference in that growth. And that difference seems to intensify after development, where you see that our basal area increment actually starts to exceed [00:18:00] in of that, of green space in our residential trees.

And you have to recall that these chronologies are approximately the same age. They likely all initiated in the same post-fire period. And so there's two really interesting periods that jump out here. On the bottom of those dots black dots represents years that had a significant difference based on a, a two-sample T test. And so what we see is one period ranging from about 1955 until about 1972, so just pre-development and, and just a little bit post-development where there's a significant difference. And the other centered around the year 2000.

The first is likely driven by a shift in that green space chronology, and potentially as a management growth release signal. So there was some clearing of the green space, the green space trees kind of respond to that by jumping up in their growth for a certain period of time. And then the second one is probably related to an extreme climate event. And I'll come back to that a little bit later in my presentation.

So what are potential construction impacts on trees? This is an example, not from Ottawa, but just an example of house construction that's going on. And what we can see is potential bark damage to trunks or damage to the trunk themselves, root impacts from compaction, of course. We might remove some trees that are close to where our new house is gonna go in. So this can lead to a thinning response. But that thinning response can be negative initially, but also means that there's more access for those remaining trees to space, light, water. And so although that thinning show contemporarily slow growth, it can actually increase later.

And then what we have after construction is that we have residents. And residents actually change that environment. They may water trees. They may remove lower branches. And that watering can also happen indirectly with runoff from our houses where we will like to direct water away from our structures, but that can actually [00:20:00] lead to more water availability for trees outside.

Right? So there's a both positive and negative impacts that can happen from construction if trees are retained.

And so here what we did was we looked at everything, the basal area increment response after development. So post-1970. And so what we see for our residential trees is that we see a larger bump in basal area increment after development than we do for our green space trees. And that likely means that there is that you know, response by clearing out some of the trees or positive growth from more space, more water, more light. But what we notice is actually that difference is not significantly different from the green space trees themselves, which have not experienced that, that increase in, in thinning. And so... Or, or release from suppression or anything like that.

And so what we see here is that there's, there's actually not that much difference, but one thing that a treeing scientist can do is pretend we're assessing the tree shortly after the neighborhood development and, and kind of look at a time machine perspective and say, okay, well, if we could go back to 1975, how would the tree response or basal area increment look at that point? And so what we've done here is kind of split those up. So green space still on your left, still looking at a, a, a ratio of basal area increment from five years, 10 years, 15 years and 20 years after construction compared to that overall period.

And what you see that jumps out here is this residential response. In the five years, post- development, reminder, that's 1970, we see that residential trees have a BAI ratio that's below one, which indicates that that growth is less than the long-term average. But we also see that, that as you [00:22:00] follow that, time over the next 10 to 15 years, we actually reach that average BAI probably around 15 years after development. And then we actually start it about 20 years after development.

So we do see that initial shock of construction, maybe removal, but then we actually see this recovery. And we should also note that there is slight differences in our green space trees, and that could represent different climatic conditions maybe some removal of of certain trees in there for pathway development or recreational use, but not very much difference at all. And it's basically statistically constant. And so here what we're seeing is that this initial response can be negative, but if allowed to respond, that these trees will reach and oftentimes exceed some of those natural areas.

So what does this show in terms of a climate response though? So here, we're gonna go back to our ring wits and we actually de-trend the, the ring width series to remove non-climatic signals. So what we were looking at before had everything in it. And by doing that, we can actually identify the major of climatic rivers using correlation analysis. And then we can compare those climate responses. So were trees responding to different climate drivers before development or after development? And we can look and visualize those shifts.

And so what we see here again, similar graph to before, except this is now ring with indices. And so an average of one. And we see that points where growth is exceeding or falling below that level. And there's actually pretty good synchrony here. We do shorten our chronology so that they cover the same common period as as each other and as our climate [00:24:00] data, which goes back to about 1924.

And what our analysis reveals is there's some significant differences when we do our, our T tests. Again, these black dots show those years that have significant differences. But really, it's kind of spread over time. There's not any more before-development than there after-development based on our dotted line that, that acts as that. And what our analysis revealed was that it was really about a drought indice, so both a combination of temperature and precipitation that these trees were responding to. And that if we had drought in late-summer, it was consistently showing a negative response.

And that makes sense in the context of those inter-annual density fluctuations we talked about earlier, those false rings that these white pine are having a stress response later in the season. And that could potentially lead to less ring, oh, less tree growth over ti- in those, in those periods. And we actually had extremely similar responses to climate drivers before and after development, so I've kind of omitted those graphs, that there was really no differences between our our, our green space trees and our residential. Meaning that there wasn't a change in the responses based on development. So we don't see more of a drought response or more response precipitation that they're still responding very similarly to those trees that were avoided development. But then that's kind of the average conditions.

So one thing we wanted to look at was these, were these extreme events. And so we can identify extreme years looking at the ring with indices, so extreme drops that happen, but we can also look at the climate data and say, were there extreme years? And here we were focusing on this drought response, because that seemed to be the major driver for ring width variability. And we identified several candidate years before and after development. And what we looked at was this idea of tree growth resilience. And so that's a ratio between [00:26:00] three years of growth before a drought event, and three years after a drought event. And you can also weight that measure by severity.

And so what we see again, green spaces in the blue and red residential trees are in the yellow. And so we have three events that exist here prior to development, in 1930, 1941, and 1955, and three events that exist after development, 1975, 1991, and 1999. And really there's a lot of variability here. But there's not really a trend in terms of one tree one group of trees is responding very differently, either before or after. There's really no significant differences between any of these events.

We potentially do see maybe a little bit more resilience after development, where we have in 1975 a much more responsive group of residential trees and also in 1999 in response to that drought. And if we actually weight these events by the significance of them, so our more recent droughts have been much stronger. And this is one of the reasons we would look at this, is to say we're expecting stronger, more severe droughts. Does residential development have an impact on how trees might respond. And maybe there's a, a little bit more resilience, actually in these trees in the more recent droughts. But really, again, not much of a significant difference between these two.

One specific event that's not a drought that came up though was a 1998 ice storm that happened both in Eastern Ontario and, and Quebec and also Eastern United States. And this is in 1998, in January, 1998, and basically 67.6 millimeters of freezing rain were recorded in Ottawa. There was no melting. And most of that [00:28:00] fell within the first 24 hours. So there's extreme amount of ice buildup on trees. And we can see a couple of examples here from different green spaces and urban areas around town where you can see the damage on those trees.

And so what we wanted to look at here was what was the response of our two different sets of trees to this ice storm event. And just in case you needed a reminder, again, this is coming back from earlier. This is our basal area increment. We're going back to basal area increment, and we're looking at this over time. And what you can see is that climatic event that I referenced earlier wo- is actually, here and visible. And it seems that there is a difference in response based

on our, our statistical tests between these two groups. In that the green space trees actually seem to response more negatively than the residential trees.

And when we look into those ratios of BAI five years after the storm, 10 years after the storm, and 20 years after the storm, this actually plays out. And so again, our green spaces are on the left here and our residential trees are on the right. And you can see that five years after the storm, those green space trees are much lower than, than one. Or the median is much lower than one about 10 years after they've recovered. And then 20 years after they've actually started to exceed that longer term response. And so that's 20 years after that 1998 event. Whereas the residential trees, they stay kind of above that 1.0 ratio, throughout.

So there wasn't really that much of a response. And the question almost is, well, what would lead to that? And there is the potential that maybe there's a warmer micro climate in that residential area. You know heat loss from buildings, meaning it's just slightly warmer, less, less ice buildup maybe because of branch pruning and things like that, there's less ice buildup on those [00:30:00] residential trees, especially on lower branches and things than, than in this green space area.

But this could also be a response, you know, five or 10 years afterwards, that there's a longer growing season slightly urban area. And maybe by retaining these mature trees in these residential areas, we actually say that, over time, they've responded to this initial stress of development, and now they actually have greater resilience to some of these climate events simply because they are in a residential area. And so that by retaining them, we can actually accrue more of those ecosystem benefits that, especially at urban heat island or, um, offsetting that urban heat island by having these huge canopies and existing that over time.

And so my conclusions here are that you know, oftentimes we hear that retention and mature trees is, is not possible and that, you know, you'll see just a decline over time. Well, what our data here shows from this one case study is that, yes, you see a decline initially, but that increases over time that responses is overcome. And we actually see greater resilience, two extreme events in our trees that experience residential development. We have very s- similar responses in high-frequency growth and extremely synchronous responses to climate drivers before and after. So there's no real change in that sense. And the extreme drought events seem to not really have much resilience either.

So overall, I think this leads to the potential of saying that, yes, we should retain mature trees, and yes, we can retain mature trees. How we do that is maybe a different, question. But in this example, I think it was probably staged because you didn't have clearing out of a large area, but instead, lot-by-lot development. So there was an opportunity to kind of work around the trees, remove a few, but retain most of them. And that, because all of that development didn't happen at once it was staged, we could retain and have that [00:32:00] resilience of those trees to that development response.

And so I think this speaks to the need to maybe apply dendrochronology to more locations, more species. This is a single species in terms of a carnivorous white pine. It would be great to look at some de deciduous species. So if you have examples that are similar to this, where we can take advantage of mature trees that were retained during development, I'd love to partner on more research to look at this question further. And to use that that research method of dendrochronology to look back in time and learn what can the past tell us about how these trees will respond in the future.

And I'd like to acknowledge some help from the Neighborhood Association and folks who came out and helped me with with field work and connecting with those residents. Thank you very much. And I look forward to discussing in questions.

Music: Traditional skills and modern techniques, whatever language you speak, you world to offer every day climb with the ISA.