Abby Morrison: Hello and welcome to Feel Lab Earth, the podcast that's all about past and present advances in the fields of agronomic, crop, soil and environmental sciences. Today we'll be talking to Dr Dave Morris about tree harvesting and nutrient reserves in forest soils. What are the differences between different types of tree harvesting? How do they impact nutrient reserves in the soil? How does one conduct such long term large scale experiments to find out? Answers to all these and more coming right up. I'm your host, Abby Morrison. Let's talk about science.

Abby Morrison: Hi everyone. Welcome to the show. Today we are talking to Dr Dave Morris. Dr Morris received both his bachelor's and master's from Lakehead University and his PhD from the University of Guelph in environmental biology. Dave has been a research scientist with the Ontario Ministry of Natural Resources and Forestry since 1986 and is currently the stand ecology program leader at the Center for Northern Forest Ecosystem Research in Thunder Bay, Ontario. His research program focuses on nutrient cycling and boreal systems, with particular emphasis on evaluating the impacts of forest disturbance, including biomass harvesting systems, on stands structural development, stand nutrition and productivity. His research has been instrumental in the development of Ontario's forest management guidelines with respect to bio fiber harvest, with ongoing research efforts designed to evaluate the effectiveness of these guidelines within an adaptive management framework.

Abby Morrison: Dave also wants to thank the Canadian Forest Service for their long standing collaboration between Dave and the Ministry of Natural Resources, especially Rob Fleming and Paula Hazlett who have been instrumental to the success of this longterm project. Hi Dave, welcome to the show. How are you doing today?

Dave Morris: I'm doing really good. Thank you. Abby, how about yourself?

Abby Morrison: I'm doing super well. Welcome to the show. So just to give some background before we launch full on in here, you work really closely with this network called the North American Longterm Soil Productivity Network. Can you tell us a little bit about what that is, what it does, anything like that?

Dave Morris: Sure. So the Longterm Soil Productivity Program was really a grassroots proposal that grew into a national program for the USDA Forest Service, and it was really initiated by a small group of researchers led by Dr Bob Powers back in 1989, and it was really in response to the National Forest Management Act. That's the US act of 1976, which was legislation that required that forest management practices do not permanently impair the productivity of the land, and again, we have a very similar thing here in Ontario, Canada, again I'm up here in the north land, called the Crown Forest Sustainability Act and the same thing, we wanted to ensure the longterm health of Ontario's forest ecosystems, but as well as providing economic benefits to the people of Ontario through forest management.
Dave Morris: And during that time, that's like the late '80s, early '90s, so it was a real dramatic shift in how we did forestry and forestry operations. Instead of boots on the ground, you think of somebody out there cutting a tree with a chainsaw and then hauling that [inaudible 00:03:31] out to the roadside. We really were going to a very mechanized process with larger machines, higher utilization. And if you think about it, these big machines, you know, had the potential to compact the soil like heavier footprints and they were pulling the entire tree out to roadside. So increased nutrient removal. So there was a lot of concern around the sustainability of aura soils at that time.

Dave Morris: So since that time that program grew and multiple agencies like, and certainly us here up in Canada, Ontario and British Columbia in particular. So it grew to a multi-agency sort of program and and really, now we have about 100 installations across all of North America that generally have the same type of design, methodology and monitoring programs. So it's a really powerful network and one of the largest ones in the world.

Abby Morrison: That's super awesome. When you say installations, do you mean like a building where people are working? Do you mean like a stand of trees in the forest? What does this physically look like as a network?

Dave Morris: Yeah. So these are field experiment installations. Again a lot of the work in the past was really, in building of our guidelines, was really based on expert opinion, but there wasn't really any empirical evidence. In other words, experiments, longterm experiments that actually looked at changes in things like soil nutrients and nutrient supply and looking at tree growth. So these installations as we called them are our experimental designs, which have different series of treatments put on them in different forest conditions across North America. So different tree species, different soils, different climates. But again, the same design that was used, and in this real ocus areas around different levels of organic matter removal, different types of harvest removals in the experiment.

Abby Morrison: That's super amazing. I'm just so fascinated by this. So then there's a few other technical terms that we should probably cover before we get started. So the first of those is slash. Can you explain what that is?

Dave Morris: Yeah, so slash or you also could call it logging debris or fresh residues. So again, when we go in and we harvest trees, even when we're doing, we'll have a term here shortly of full tree harvesting, but when we harvest the trees and take them off, I mean there's branches and the unwanted parts of the tree that aren't necessarily economically viable, they tend to be left behind. So when after you, let's say a clear cut harvest, if you look out over there, you'll see debris and some smaller trees maybe that aren't merchantable that would be left behind, that's considered slash.
Abby Morrison: Sure. And then like you said, there's a few different terms to describe the different ways that trees are harvested. Can you go over those three different ways?

Dave Morris: Sure. So more traditionally is, like I said, prior to the more mechanized harvesting practices, that was what we call stem only, or other parts of the world called tree langs. And in that case, that's where again, somebody maybe with a chainsaw would cut down a tree and then they would go and they would delimb, take all the branches off. Because again, that's not the merchantable piece of the tree and toss that. And then they would just pull out that boll or that the stem, you know, to bring it out to the roadside to put on trucks to take to the mills. So that's called stem only.

Dave Morris: And then we've moved to a more mechanized process called full tree harvesting. And again, other parts of the world call it whole tree harvesting where the entire above ground part of the tree, it's cut. But then we have larger machines that can take that entire tree, which includes all those live branches and foliage, that very nutrient rich foliage. It goes to roadside. And then there it's further processed with things like delimiters that take all the limbs off mechanically and then the boll is put on trucks and taken. But then in essence, all that crown material is left at the roadside and it's sort of taken away from the site.

Dave Morris: And then in our experiment we have a third treatment which is basically like the full tree harvest. But then we also went in and did an extreme treatment where we actually removed all the organic matter. So you think of that forest floor that we see, and all the litter and what not. We, we actually bladed that all off on our experimental sites to have an extreme treatment of a complete organic matter removal.

Abby Morrison: Okay. And when you say you bladed that off, I mean what does that look like? Are you scraping the tree down? Are you just cutting higher up on the tree? What does that actually look like in practice?

Dave Morris: No. So in this case we used a bulldozer, I mean some of the different sites use different approaches to taking off the organic matter. But for us we actually used a bulldozer and we bladed it off all the stomps, all that logging debris, slash, any understory plant material. And so what's basically left would be like your garden or like a freshly tilled farmer's field. You could just see the mineral soil that's left exposed, but that top, that organic cap was all taken off.

Abby Morrison: Oh Wow. So it's actually the ground itself rather than the tree?

Dave Morris: Yes.

Abby Morrison: Wow. That is extreme.
Dave Morris: It is. I mean, the beauty of that is, with those three treatments, it gives us a really nice full gradient of biomass removal or like forest biomass removal, that from an experimental perspective we can look at at things like response function or looking at, like whether it be follow up tree growth, we can look at it over the whole gradient as opposed to just those two sort of operational treatments.

Abby Morrison: Sure. And actually a really good transition into our next question here. So tree harvesters face a really unique problem in doing this work, which is maintaining the nutrient balance in the forest. Can you tell us more about that?

Dave Morris: Sure. And what I like to use is maybe an analogy with farming, or even for some of us that have that farmer gene and we like to grow vegetables or have our own little garden or small little garden plot. You think of those systems again, we plant our crops on an annual basis so they're fairly high productive systems. But normally we would add some manure or fertilizer to them, because obviously they need that nutrition or water holding capacity in the soil. We like to water our plants, so as we can get the production out of them. In forest we don't really have that luxury, they're generally remote locations and and for us, at least here in the North, it takes a long time for trees to mature from a small seedling to a harvestable product, maybe up to like 60 years. So when we go in and harvest, we want to make sure that we leave enough organic material that's going to turn over and release nutrients, kind of a slow nutrient release, like a slow fertilizer, for the trees to to be able to grow and maximize their growth production over a very long period of time.

Dave Morris: Again, another analogy would be like if we think of municipal law recycling areas, we do a lot of recycling now of all our materials. But or forest, they actually have their own sort of natural recycling program that is evolved over time. And we think of that with in the fall where we get the fall colors like in hardwoods, and it drops its leaves every year. But then there's all the microbes, there's the soil biota that then that's their food and they consume that, sort of to break down that material. And as a byproduct that's what releases the nutrients and then that's available for plant uptake the following year and then those plants use that to rebuild their factory, right? The magic of photosynthesis. So it's that sort of natural cycling process that's going on.

Abby Morrison: Yeah, I like that. Those are really useful analogies. So obviously you work with this nutrient imbalance a lot in your research. Can you tell me more about the hypothesis or theory that you wanted to test in this specific project?

Dave Morris: Yes. So what we sort of hypothesized is that, again, so, so we're going in there and when we harvest to stand, obviously we're taking nutrients away from the site to some extent. And with our different experimental treatments, different levels. But we expected to see in the soil, because of that removal we expected
to see a decline in soil carbon and nutrients, you know, shortly after harvesting and certainly between our stem only versus our full tree. Again with a stem only leaving a lot of that nutrient rich material on there. We expected to have a lot more of the slash between those two treatments. But because there still is breakage in a other material in the full tree harvest, over time we expected that generally the soil nutrient reserves would be very similar between those two treatments. And then over time that would rebuild back to its pre harvest levels.

Abby Morrison: So once you had pinned down this hypothesis, how did you go about testing it?

Dave Morris: One of the key things coming out of some of that early LTSB discussions was that inherently, nutrient poor sites in particular would be more sensitive to these types of increased nutrient removals. So part of our experimental design was to target those types of sites, and those that are very coarse textured sandy soils, that generally impoverished in terms of nutrients as well as very shallow soils, so over bedrock, which we have a lot of that up here in Canada because with the glaciers kind of moved all our soil down to the US and then they sort of went back. So we have a lot of a very shallow, so over bedrock soils up here. So they just have very inherently low nutrient holding capacities. So we focused on those types of sites, because we felt that they would be the most sensitive.

Dave Morris: And then we implemented on each one of those, sort of replicated those three treatments. So we have like 14 sites that had these three treatments replicated, across the landscape under slightly different soil and productivity levels. And then from there we've monitored on a regular basis, looking at soil. So the soil nutrients, soil carbon, on sort of five year measurement cycles. And as well, we replanted them with the dominant tree species for us is Jack Pine and Black Spruce. And we've tracked the growth of those trees over time as well. Taking those as sort of a biological integrator of the conditions that we generated as part of those experiments. And then we've been able to track them, now they're coming up to 25 years since they were established back in 1993 and '94.

Abby Morrison: That is just wild to me. I'm always so impressed when scientists, I mean obviously you were doing other things throughout this whole experiment, but I'm just so impressed when they are like committed to such longterm projects. I think that's really amazing. So thank you for doing that.

Abby Morrison: So basically you just kind of cut the forest down and have been kind of keeping an eye on the recovery process, right?

Dave Morris: That's correct.

Abby Morrison: So what's interesting to me about this then, well many things obviously, but this project obviously has just a huge scope, as far as just the scale of different sites that you were testing or the incredible length of it or the costs of going in to harvest all the trees. So how do you manage something like that, whether that's
just in designing your project or in maintaining it over the years, of making sure things are tested the same way each time? Like how do you manage that?

Dave Morris: Yeah, well this is again, it's certainly no easy feat and certainly has been through a wide set of partnerships both regionally. So again, because we have different nodes like for us in Ontario and then folks in California and then in the Southern US so you've got key PIs but they really have their own partnerships. We have a lot of partnerships with industry and academia, which bring different things to the table. So sometimes money and just in kind support and it's an ongoing challenge to sort of keep that momentum going. And full Kudos to Dr Bob Powers, who like I say for more than two decades was kind of the leader of the LTSB network and kept us together, and we had annual meetings and made sure we're on track.

Dave Morris: Unfortunately we did lose Bob back in 2013 to a battle of cancer. And that's pretty sad. But others are picking up the torch and carried that on and like I say, it certainly has been a challenge to keep it going. And like you said, to try to avoid things like natural disturbances. We had a fire that burned right past, just past the edge of one of our installations that could have easily been a fire control suddenly.

Abby Morrison: Yeah, I'm interested about that as well. I mean, what do you do if, for example, there's a wildfire or one of your partnerships changes and you can no longer use one of your sites. I mean, how do you handle that?

Dave Morris: I mean strength and replication for sure. You know, having multiple sites is really helpful because things do happen. I mean even for us up here, we have pesky little beavers and things like that that like to build ponds and so we can sometimes lose road access to some of our sites that make it really difficult to go back and do remeasurments. And like you say, you have, natural disturbances for us is definitely, wildfire is a threat. I mean we're lucky it's a really big land base and we've been really lucky that most of our sites have been maintained. Like you said, we had a couple of close calls in the past, but you do your best, but you also have insects that like to chew on foliage and leaves and things like that that come through. And I mean, we keep track of that. But again, that's the natural process of those forests and that's things that they have to tend with over time as well.

Abby Morrison: Yeah, I guess it's kind of, you're trying to do research about the forest, so trying to completely control things that would naturally in the forest would probably be a little counterintuitive to what you're trying to do overall, I suppose. So then I have some questions specifically about this network. So when you have experiments that are running for this long, how do you choose which experiments get to go where? Are they running multiple experiments on each installation? I mean, do you just lay dibs on something for the next 20 years? I mean, how does that all work?
Dave Morris: Again, some of this just sort of came together almost magically I would say. But with all the different regions ... And again, because this is was directed certainly in the US, through the USDA Forest Service and some of their experimental stations so they sort of put their installations in some the dominant forest types of that region and soil types. And those are different, when you're in California and Sierra Nevada's versus you get down on the the flood plains in Southern United States. Different forest grow there, there's different soils and they're in different climates.

Dave Morris: And that, that actually is a real strength of the network because you're able to look at your regional responses, what's going on with our Black Spruce and Jack Pine. And then in the lake states it's Aspen. But you can put that in the broader context of what's happening across a whole range of soil types and in climate regimes and tree species. So that's, that's a real strength and a real strength to our policy folks too when they look at what the results are coming out of our Ontario studies, but how that fits into what's happening elsewhere as well with that same design.

Abby Morrison: Gosh, I just love that. I think that's so cool. I'm always so fascinated when scientists has these collaborative networks. I just think it's like the coolest thing on the planets. So good for you guys for doing the work that you do. That's really cool.

Abby Morrison: Hey, science fans. I hope you're enjoying the show. Interested in learning more? Dave's article Effects Of Biomass Removal Levels On Soil Carbon And Nutrient Reserves In Conifer Dominated Coarse Textured Sites In Northern Ontario 20 Year Results, published in the Soil Science Society of America Journal as part of their North American Forest Soils Conference International Symposium on forest soils will be freely available for the next two weeks. You can find a link to it in our show notes.

Abby Morrison: We also wanted to give you a reminder that our listener survey will be ending July 27th, in just one week. It only takes five minutes to complete and will help us to improve and grow our show. To find the survey, please see our show notes, our Twitter at field lab earth or go to our website, fieldlabearth.libsyn.com. That's fieldlabearth.libsyn L-I-B-S-Y-N.com. Listeners who complete the survey and sign up for our newsletter list will get a free exclusive loyal listener sticker. Thank you for your participation. Let's get back to the show.

Abby Morrison: So you cut your trees and then you've been keeping an eye on them, hoping that there is no fires and beavers to get in your way. And obviously they have come through for almost 25 years. So what have you found? What were the results of this experiment?

Dave Morris: Right. Kind of interesting. So if we think about the soils and think about a carbon or, or some of the nutrients, you know, the main nutrients, you know, like if we
go and buy a bag of fertilizer, for example from the store, you see those three numbers on the bag that you're going to put on your lawn. And that's generally nitrogen, phosphorus and potassium, three of the main sort of macro nutrients that are really important to plant growth. So certainly, we track those. And so for our soil, carbon, nitrogen and potassium at least, we found we certainly did get a decline like as we expected after we harvested. But the declines were very similar between the stem only and full tree. And we've actually been tracking that through time and it's actually now out at 20 years has actually come back up and is equivalent to what it was pre harvest.

Dave Morris: And it's a combination of some inputs from atmosphere and some mineral weathering as well as the dropping of litter and the rebuilding of some of that forest floor and just incorporation of that logging debris into the soil. So that's really good to see. Phosphorus on the other hand, it also declined but it's kind of stayed at a below pre harvest levels. I mean the good news is that the stem only and full tree are largely the same of each other, but we haven't seen a recovery of the Phosphorus [inaudible 00:21:45], so we're certainly wanting to keep an eye on that. Some of the other elements like calcium and magnesium, interesting enough, we actually got a spike after we did it and I think that was again because we sort of exposed that mineral soil a little bit more and you got a lot of some of the base elements or whatever in the bedrock and [inaudible 00:22:03] material. We actually got an increase in weathering and got a bit of a short term pulse of calcium and magnesium about five or 10 years out and now about 20 years, again it's kind of settled back down but they're also at pre harvest levels. So that's the soil part.

Dave Morris: From the tree part, the tree side of things, in terms of growth, again, the stem only and full tree, the trees are largely tracking similar to each other in terms of growth rates, but it is that extreme treatment that we do see declines in productivity. And again, it's probably likely what we would have expected, but it does indicate that there may be some level of threshold, level of organic matter retention that we do want to look at. And now when we're turning more to things like biomass for energy harvest, where we might want higher utilization, there may be some threshold that might be greater than that full tree harvest that we did. So that's something that we've got to think about into the future.

Abby Morrison: Yeah, that's super fascinating. So what do you do with these results? I mean, do you talk to harvesting companies? Are you developing guidelines or policies? What are you doing with your results?

Dave Morris: Yeah, kind of a combination. I mean generally what we're finding, again these were deemed to be very sensitive sites or potentially the more sensitive sites and we're not seeing that that level of sensitivity. There's, actually quite a bit of resilience in these forest soils, which is really a good thing, so that that's a positive. But we have developed some what we call best management practices. So again, trying to maximize the amount of material that is left even in a full tree harvest operation. I think just simple things, maybe like winter harvest.
up here again, things are really cold and frozen and so when you cut a tree and it falls down, you tend to get a lot more breakage. Branches just snap off cause they're so brittle during the winter. And in terms of the protecting the soil, you know it's got kind of a snow layer. So when you're dragging the trees out and stuff, that organic layer is sort of, has a greater level of protection. So just simple things like that.

Dave Morris: From a policy perspective, I mean at this point in time on these sites, we don't see any need for any increased restrictions, from a full tree harvest perspective. But again, we do caution at any more higher use utilization, like some of that under sized material that might go for biomass for energy, where they might grind it up to to make pellets or something like that. In all likelihood, these would not be the site types that we would want to sort of push that envelope in terms of taking off more porous biomass and what we do for traditional wood products.

Abby Morrison: Yeah, I like this because it's a very positive, it's a very positive research project of just like the forest is really good at taking care of itself and recovering, and that just is, it just makes me really happy. It's good job forest. But there's also more work to be done obviously, besides just continuing to develop these guidelines and give recommendations. So can you tell me more about what the next steps are for research in these areas?

Dave Morris: Sure. Again, when we think of our sites, we're up here in the north and we have very large tracks of Boreal forest. So all of these installations or 14 sites, they were all mature fire origin stands. They've never been harvested before, it was the first time that we've been in there putting roads in and harvesting in some of those locations. So these natural forests, these very old forest, so some of them were 100 years old. They have what's termed as biological legacy. I mean you have these very deep forest floors that have developed over time, over 100 years. There's lots of deadwood because the trees of the forest of self thinned, so there was a lot of material on the forest floor at the time. So this is like almost a buffering effect, we call it a biological legacy, but it potentially is, it is buffered against the treatments that we actually imposed on them.

Dave Morris: So the question now is, well, what about, secondary for us and even tertiary for us, like in terms of the second rotation, rotation being the second time we go in and harvest. So like these plantations, you know we've planted them and they've grown up so far to 25 years, but maybe in 50 years we're going to want to harvest those. And so we want to look at that over time, in terms of a next rotation. So that's our second generation LTSP. We've gone in and we've got some older plantations that maybe are 50 years old. And so we've gone in and basically done the same set of treatments in a second rotation where they don't have that deep forest floor, that big soil nutrient reserve to start with. So the potential that we might drive those systems down a little bit more. So we're just looking into multiple rotations into the future I think is something that we want to do beyond just modeling that.
Abby Morrison: Sure. And then there was another thing that you mentioned in our back and forth before the show, bio diversity indices. Can you tell me a little bit more about that?

Dave Morris: Yeah, so our first LTSB, we really focused again on like the results they showed in terms of soil of nutrients and about tree productivity. But as you know, there's a lot of other things I live in the forest and so there is a lot of interest in terms of all the critters that ... And even in the soil, there's soil Biota, right? There's different levels. There's microbial communities, which are really, really important in terms of breaking down that organic matter. There's fungi and bacteria and then there's what we call Meza Fano, but there's soil Meza Fano, which are a little bit bigger critters that you can maybe see with a microscope, like fungivores. So they eat the fungi, that's their food source and bacteria. And then there's things like spiders and beetles and things that crawl around on the forest floor that we see and they're eating those other critters as well. So again, you think of sort of these trophic levels or food webs, but all of those combined is what's turning over the organic matter and releasing nutrients, and so making sure that we have well functioning, healthy biotic systems in the soil, that those biological properties is also really, really important as well as opposed to just physical or chemical properties.

Abby Morrison: So at this stage are you just kind of taking inventory of what's there or are you researching how these systems interact with the nutrients?

Dave Morris: Yeah, so that's, so we're really looking at the interactions of all of these, and we're using things like metagenomics in terms of looking at community structures and function of all these different taxa. Again, so just trying to look at when we harvest, how do those communities shift and how do they ... They also recover. As the forest starts to grow up, that they come back, to the same sort of community structure that they had after a natural fire.

Abby Morrison: Yeah. That is all some super great work. Everything about this is wonderful. So I have three questions left for you. The first one is where can listeners go to learn more about this topic?

Dave Morris: Yeah, I mean, I just even did it again this morning. I just quickly just Googled, longterm soil productivity. You might get LTSB I don't know but if you did that, quite a number of things come up on the screen. Again, a lot of it you can go to like the a USDA Forest Service, regional experimental stations, because again, a lot of those are are points for the LTSB and so you can get a lot of regional results. And as well we have doing some synthesis products right? And trying to combine all the results from around North America into those and those are sort of posted online as well. So I think that's a really good source. Medial for example, like the Rocky Mountain Research Station Yard, our new LTSB leader there, Debbie Dimauro's page is there and she'd be happy to connect with folks if they want to get ahold of her and talk about the LTSB any further.
Abby Morrison: Sure. We'll include some links for those in the show notes. So then if a listener wants to maybe get involved in some of these efforts, what can they do to do that?

Dave Morris: And again, I can probably use, I'll use the Ontario example. I mean sure there's probably something analogous in US and elsewhere. But for us here, as part of our forest management planning for example, we have local citizens committees, which are actually involved in forest management planning. Local citizens can be involved and they're part of the planning process. And they come and they talk about maybe some of their issues, but also hear about some of the new and emerging science that's being used in the planning process. So it's a really good opportunity to actually be kind of hardwired right into that whole process.

Abby Morrison: That's super cool. That sounds really fun. Final question for you. What is one fun fact about you that listeners wouldn't know if all they had was your research?

Dave Morris: Well, one of the things, and hopefully this being a Friday that I'm hoping to go out and do a round of golf. I'm quite an avid golfer, and I do sort of carry my passion for forests and soils with me in that, because I find myself in the forest chasing my golf ball quite a bit, or hitting the golf ball out of the soil, in this case, it's sand traps, on a regular basis and maybe more often than I'd like to.

Abby Morrison: That does sound fun. I hope you get to get out there. I hope it's a good day for it. That's all the questions I have for you today, but it has been such a pleasure to have you on. Thank you so much for sharing your expertise. We really appreciate it. So yeah, thanks for being on the show.

Dave Morris: Okay, well thanks Abby. It's been fun.

Abby Morrison: Wonderful.

Abby Morrison: Thank you for listening to Field Lab Earth. You'll find a link to today's paper and other resources for this episode in our show notes or on our website. If you have any questions, comments, or recommendations for show topics, please contact us at podcast@sciencesocieties.org or on Twitter at Field Lab Earth. If you'd like to hear more content like this, please subscribe and don't forget to rate and review us on iTunes or anywhere else you find your podcasts, if you like our show. This podcast is a joint production of the tri societies, the American Society of Agronomy, Crop Science Society of America and Soil Science Society of America. Special thanks to Lobo Loco for the use of their song Spoof Castle on the intro and outro of our show. Opinions and conclusions expressed by authors are their own and are not considered as those of the American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, its staff, its members or its advertisers.