Linda Chalker-Scott — Bat-Sheet Crazy

[00:00:12] **Jamie Vidich:** Hello and welcome to the ISA Conference Rewind video series. I'm Jamie Vidich, Director of Educational Products and Services at the International Society of Arboriculture. Today, ISA is proud to bring you a presentation by Dr. Linda Chalker-Scott on how sheet mulches damage soil and tree health. This presentation was originally given at the 2023 ISA Virtual Conference, and the views seen here are those of the presenter. So, if you are interested in learning about soil health and the importance of choosing the correct mulch for your trees, I expect you will find this presentation highly educational. Now, sit back and enjoy.

Linda Chalker-Scott: Hi, my name is Linda. For those of you that are familiar with me, you know I do a lot of research on mulch. So today, we're going to talk [00:01:00] specifically about the problems with sheet mulches, and then end up talking about what's a better choice. To give you just a brief overview of what we'll talk about, we'll start by talking about the unacceptable mulches—and you see I have POW! there. What POW! stands for is poor oxygen and water. Whenever I use POW or talk about sheet mulches, keep in mind that sheet mulches in general interfere with both water uptake into the soil from the atmosphere or water release—you have a way around—as well as oxygen and carbon dioxide exchange. And so that's the acronym POW.

We'll talk about various sheet mulches and some research that compares their relative effects on POW. Then we're going to focus on the benefits of arborist chip mulches. I always like to include this because rather than just shoot holes in everybody's pet project, I'd like to give some good guidance on what to do instead [00:02:00] and then the research behind that. Then I'll end up with just some brief management tips that have to do with using mulches in general, as well as how to keep soils and tree roots healthy.

So, some people—and not arborists, that's for sure—but a lot of your clients might say, "Why do I need to mulch?" There's lots of good reasons for that and lots of interesting choices to use for mulch, but the main reason is because you're going to protect the soil. This is through limiting disturbance to the soil and reducing compaction. Overall, it protects the soil environment by moderating temperature control and water moisture. It reduces weeds if it's used correctly and—as hopefully this picture shows you—it can be really a beautiful addition to a landscape. These are the types of things that you use to encourage your clients to consider a mulch, and then you move on to what's a good mulch and what's a bad mulch.

The unacceptable mulches I mentioned before include [00:03:00] the sheet mulches and they also include the synthetics. These are things like landscape fabrics and black plastic and rubber mulch. Regardless of what the packaging says on any of these materials, these will not control weeds permanently. There is no such thing as permanent weed control. There are good ways to control weeds, but it's not going to be something that is going to last without being replaced. Unfortunately for many of these materials, using them can damage both plant and soil health by introducing materials into the soil system that are not good materials—we'll talk about that—as well as just creating those conditions that reduce oxygen uptake into the soil and can interfere with water movement back and forth.

As I mentioned earlier, the sheet mulches (in this case, the fabrics and the plastics) are going to create those POW conditions. Rubber, on its own, besides having lots of other negative effects, is also flammable. And so especially if you're in an area where [00:04:00] forest fires are becoming more and

more regular as they are for me in the Pacific Northwest, the last thing you want is a highly flammable mulch. I also include organic sheet mulches under unacceptable mulches. This is where you may run into a little bit of pushback from clients, because organic is a good thing in general. But sheet mulches always are bad choices, and it's because they will create POW conditions. They will always interfere with oxygen and water movement just because of their physical nature. When they dry out—which they will on occasion; they become hydrophobic, and it takes a while for them to become hydrated again. So, when it rains and you've got some kind of dry sheet mulch, then the rain just runs right off.

They also serve as habitat for pests. So, you'll have people that will give you a push back on using a wood-based mulch, because they're afraid of termites, and for instance, termites actually love cardboard. They will actively search for it [00:05:00] to eat it, because it's something that they can digest easily. Sheet mulches also can give rats and other tunneling types of pests the opportunity to go underneath everything to reach various plants or other parts of the landscape. You can't really tunnel through a wood-chip mulch. It would collapse. So again, sheet mulches just have a lot of problems, not just in terms of their chemical and physical activities on the soil, but they can encourage pests rather than discourage them.

I always like to call the geotextiles out (weed cloth) because they seem to come seated with weed seeds. They seem to appear as soon as you get the stuff down and that's because of course these little holes and things that are in the fabric (that the promotion materials tell you allow for air transfer), they quickly get filled up with soil and other particulate matter and then weed seeds blow in and germinate on top and then you just have not only [00:06:00] an ugly mess, but you have plants that are competing with the desirable plants for water, oxygen, and nutrients. So, what happens with the desirable plants of course is their roots have to grow out on top of whatever this mulch material is. In this case, you can see it's actually black plastic, and that's how they can get up to where they can put their fine roots down for water and nutrient uptake. But this causes a problem down the road, because eventually people always take these mulches out, because they're ugly, and they disintegrate, and they're just replaced by something better.

So, when you're ripping out fabrics and plastics, you will often find that you're also ripping out the roots of your desirable plants, so it's just a good idea not to use these materials in the first place. Unfortunately, the very favorite thing for lots and lots of community groups to use—and unfortunately a lot of municipalities to use too—are cardboard sheet mulches. This has come primarily from the [00:07:00] permaculture literature that really advises to use deep mulching with all kinds of material from newspapers to cardboard to old car woodchips are being used, a pet, and cardboard is thing that seems to have stuck. Even in restoration where s in this picture here, they still persistently put down cardboard beneath the woodchips. It's always because, as I've asked before why are you doing that, they said we're trying to smother the weeds. We'll come back to that reasoning in a little bit, but this is kind of overkill, because as we'll discuss and as you may already know, woodchips are a great mulch for weed control. Putting cardboard down there just interferes with all kinds of things going on in the soil.

They just don't regulate water well, and so when they get wet, they're really really wet, which means the soil under them is also really wet. Then when they dry out they're really really dry and water and other mulches for instance—in this picture where there's a slope—[00:08:00] you can see that everything's going to slide right off. The water ends up going downhill to where the weed seeds are, and they grow quite well. Meanwhile the plants (the desirable plants), that are surrounded by the sheet mulches aren't getting anything to their immediate root zone, because the cardboard is interfering with that. The most persistent and unfortunately rapidly growing method of doing, you know, getting rid of

weeds and putting in a native garden or getting rid of turf and putting in landscape plants and all the things that people like to do—and with good reason—is unfortunately being done by lasagna mulching. This is one of those things, because everyone thinks of lasagna and who doesn't love lasagna? So, we're taking that love of lasagna and we're putting it into a garden or landscape, because it's lasagna, number one. Number two. It's a do-it-yourself recipe, and it's very very emotionally appealing. People love this. [00:09:00] And as I mentioned before, this is something that's come out of the permaculture literature as being the best way to prepare a soil bit. So let's look at that a little bit.

The good thing, I will say, about the lasagna mulch philosophy is that it's a way of preparing soil without tillage. Tilling is the absolute worst thing you can do to soil. It doesn't seem to be something that we do regularly in landscape horticulture, but as you probably know, it's something that's come out of production agriculture. Even in production agriculture, farmers are getting away from tillage, because it does destroy soil structure. It releases carbon into atmosphere. It's much better to keep that soil structure intact and work around issues that might be lurking underneath. So that's the reason that lasagna mulch is used is so you don't have to till and that's a good thing. However, as I said, it's kind of this recipe driven thing where you have noodles and sauce, and the noodles being the cardboard and the sauce being compost or other types of loose organic material [00:10:00] and then just building this pie. In permaculture, you can actually read in some of the books, they'll say, you can go up to 12 or 18 inches. They recommended these really deep layers of sheet mulches plus all this organic matter in between. There's absolutely no science behind this. It's nothing ever been published in the peer-reviewed literature. It's just one of those anecdotal things that is highly appealing to people and very difficult to myth bust.

Part of what I'm going to do today is try to give you that information, so when you're working with clients who kind of insist on doing this type of preparation, to think about it objectively and then figure out something that's going to be better for the soil and better for human and animal health too. So cardboard mulches in particular. Newspaper is thinner but cardboard is always corrugated cardboard. As you might suspect, [00:11:00] pizza would not be delivered a box that was going to be leaking liquids. Amazon would not be delivering its products in something that was going to fall apart if it got wet on someone's front porch. So when corrugated cardboard is manufactured there's all kinds of stabilizers and plasticizers and coverings and other chemicals that are used to prevent water from easily penetrating the box. Of course, it's going to break down, because it is organic and it's based on fiber, but it takes a while. That's deliberate because, as I said, things are being shipped or carried and they're trying to prevent them from falling apart too soon. So that's why it interferes so much with water or movement, because it's got all this material.

In comparison, newspapers wouldn't be as bad but even a sheet of newspaper is going to cause some issues. [00:12:00] This is a nice thing for using as an example. I use it a lot when I when I train Master Gardeners. I tell them to tell their clients, you know, imagining have a wet sheet of newspaper and you put it over your face. Think about can you breathe through that? And everyone's going to realize that now you have this wet thing over your face. It's going to make it difficult to breathe. Plus, it's going to get all warm under there, because you can't regulate heat either. It's a very uncomfortable feeling if you imagine it. So, think about a soil system. The soil is a living, breathing ecosystem. Oxygen has to come in. Carbon dioxide has to go out, because there's all these organisms from microbes to earthworms to moles to plant roots that are using the oxygen. Anything that interferes with that transfer is going to be harmful to health and life in the soil.

So, what we did, because as I said, no research using cardboard as a mulch at all until we did this and published it in 2019. And so we did a very simple experiment, [00:13:00] lab-based looking only at how mulch materials interfere with oxygen and carbon dioxide movement, not worrying about anything else in terms of plants, because this would make it too complicated. We're just trying to establish what mulches do. So, we set up these mesocosms which look like plastic buckets you might get from Home Depot. They're not. They're actually carefully constructed so that when the top is put on, they're completely gassed tight. Each of these buckets is filled with soil. This one is a control.

So, there's the bare-soil mesocosm. Some of them were covered with woodchips. Some were covered with other mulch materials like black plastic. The important thing in terms of making measurements, you can see we've got these sampling ports. One is in the head space above the mulch, and then if you'll see a little bit later on, there's also one that's underneath the mulch inside the soil. This measures the gas concentrations in the soil. Then you compare those two things, and you can figure out [00:14:00] how much interference and how rapidly gases could be transferred. This is the good establishing science, in terms of how different mulches will interfere or not interfere with gas movement. We had several treatments as I mentioned. We had bare soil. That was the control. I will say that a bare soil like this would never exist in nature, because it's fluffy and light and it's constructed to be a control. Everything else is compared to that, but you would never find this in nature. Even though the results will show you that the bare soil is best, that's only in a lab system that would never ever happen in nature.

We use a black plastic mulch. One sheet. We used arborist woodchips. Four inches deep. We used landscape fabric. Again, one piece of landscape fabric and went with the high quality ones available at big box stores. Landscape fabric plus chips on top, [00:15:00] because a lot of people do this just to hide the ugliness of the fabric. One sheet of cardboard—corrugated cardboard. Then cardboard plus the arborist chips. So, those are the combinations and materials that we used. Of course, there's lots of other things that could have been studied too, but you really have to know where to draw the line, because you get to the point where you have too many treatments that become impossible to actually do the experiment.

These were all set up in these mesocosms. As you can see over here on the right-hand side, there's a closed mesocosm. This is because we're now taking samples from it to get different criteria about what's going on at mesocosms. With the soil that was put into each bucket, it came from a combination of a good loamy soil from the Puyallup River Valley which is where my station is based. We mixed it with some compost to give it a good shot of microbes. Because you've got to have some soil life in there.

We had a couple of ways of measuring gas. [00:16:00] We used a LI-COR analyzer, and that measures carbon dioxide concentrations. We also had a gas analyzer for oxygen and so both of these things would get samples from each of the mesocosms during the testing. As you can see here again, the mesocosm is capped. It's now not transferring any gas to the outside atmosphere. So, we're going to get a good stable reading for both a head space above the mulch and for the gas below mulch. You can see here the two ports now, one of them being above and one of them being below. Here that is close up, and you can see this is how we would take the aliquots, taking a syringe and pulling the gas through here, and then injecting it into these meters to find out how much carbon dioxide was in each of these areas as well as how much oxygen. As you can see, it's not really very fun for a plant person like myself because there were no plants involved in this. These were all soil scientists that were doing this work.

[00:17:00] reason was to establish some credible rules or increase data that would be able to be used to make recommendations about mulches. From the article, I made a graph, and it's kind of a complicated

one. I'll spend a little bit of time with this. This is looking specifically at carbon dioxide movement, and it's establishing a diffusion coefficient. The nice thing about diffusion coefficients is you can use them to compare to each other, because it's only a measure of the mulch materials' ability to interfere with carbon dioxide movement. This number does not change in terms of the mulches' characteristics. I mean if you have wind blowing or it's raining or it's hot or whatever, that's going to change gas movements too. But it has nothing to do with the mulch material itself.

The Y axis is actually an exponential axis and each of those tick marks is a factor of 10. [00:18:00] Just like pH scale or earthquakes, you know, it's a factor of ten between a tick marks. The bare soil had the highest diffusion coefficient. That means it was easiest for carbon dioxide to move through it. Again, this is not compacted. It was a nice fluffy soil and that was our standard to measure against. The woodchips, the four inches of woodchips, was about roughly 10 times more interfering with gas movement, because there's something there. It's not completely open as a bare soil is, but of all the mulches, it was obviously the best choice. One sheet of cardboard was ten times worse than four inches of woodchips. When you're thinking about this and think about lasagna mulching, and all those sheets of cardboard you're using along with all the stuff in between, you're really talking about a lot of interference with natural gas transfer between the atmosphere and the soil. Fabric was a hundred times worse than the cardboard, and the black plastic [00:19:00] was about 10 times worse than the fabric. Working backwards, we can say that, a single sheet of black plastic is going to reduce gas movement (in this case carbon dioxide) by 10 times more than the woodchips.

Having these type of data are really helpful when you're trying to convince clients to get away from using the sheet mulches that are going to cause all kinds of problems below ground that we can't see and instead use a coarse, three-dimensional, chunky mulch where there's plenty of space for gases to move through. As I said, in the article we published, this chart is not there. I derived the chart from the data actually in the article. If you're interested in reading the article, it's here. It is published in 2019, and I was just one of many authors. I was the plant person, and actually, this is my experiment, and I got funding [00:20:00] for my colleagues to do this. But I needed to have people that really knew soil physics to do this, because it certainly isn't my area of expertise. When you read it, you'll see it's mostly calculations, a lot of calculus. No pictures of anything that would be helpful to you when you're working with clients, but in the abstract, it does say that among the mulches tested, "woodchips are a preferred method of mulching in terms of providing best gas permeability, particularly in landscape conditions." And this was really interesting because my colleagues I work with—and I just said all of them are soil scientists—a lot of them were using landscape fabrics in their yards. They were surprised by the results, and I'm hoping that they all decided to remove that landscape fabric, but it just goes to show you that even people who are studying applied plant and soil sciences as their career may not make the connection [00:21:00] between what they're doing in the home, garden, or landscape and what actually is happening with good solid research.

That's part of the information you can use to encourage people not to use sheet mulches and to consider other alternatives. More recently, there was a really kind of scary study that came out, looking at various materials and the chemicals they contain that are really things we want to avoid. Cardboard contains, among other things, PFAs, and you've probably heard of those before. Those are for floral... I can't even remember. It's too early in the morning, but they're chemicals that a lot of people call forever chemicals. So, we're just going to go with that. They're forever chemicals. This looked specifically at all the contaminants that were in a lot of different materials used for bedding from poultry.

So, there's a study about poultry, and you might think that doesn't really have much [00:22:00] relevance to your work as an arborist, but the fact is, they're looking at materials that people also use in their landscapes. That's why it's really important. I've given you the reference there. You can go in. It's open access, and anybody can read it. I wanted to just share this with you because it really is important. And in particular, there's a table. It's table 3.1. This is the whole thing. We're look at just part of it up close, but this is looking at all these contaminants in various types of bedding used for poultry. There's just many things that are available for poultry in terms of giving them something to walk on that is not going to be wet. We're going to focus on the control material, which is here [the green], which is wood shavings, and then shredded cardboard, which is recycled material number one.

I'm going to go to a different chart now, just to show you those two, because, as I said, it's kind of hard. I probably should try to [00:23:00] reconstruct these tables myself, but these are just taken out of the article and they're a little bit blurry, and I'm sorry for that. This is the shredded cardboard, and I'm going to talk real briefly about what's here over on top of the chart. We've got TEQ, and that's a toxic equivalent. We'll get back to that in a minute. You can see they measured PCBs, and you might remember, polychlorinated biphenyls, which were made illegal in 1976 in the US. So, it's been almost 50 years and they're still around because they're some of these forever chemicals. These two here, the PBDEs and HBCDD, which have nice long chemical names, are both for flame retardant. So, you'd find them in clothing and carpet and everything else. The PFOS and PFOA, these ones are part of the PFAS. [00:24:00] So, that over here is the combined amount of those chemicals. These are all chemicals that are persistent in the environment. They're easily taken up by plants and people, and so these are something to really be concerned about if you're using cardboard.

Now this cardboard is shredded, and it's available commercially for people that are raising poultry, but it's you know, it's corrugated cardboard. In comparison, the wood shavings is just untreated wood. You'll see with all these materials, and the materials are what's across the top of each of these boxes. So, the cardboard contains this amount of those materials and of those chemicals, and then the wood shavings numbers are here. Even though this is unused, untreated wood, you can see they still contain these chemicals. That's because lots of things will take these up and they're there forever. But it is a low contaminant in these materials. [00:25:00] This is why wood shavings are used as control. It's the lowest thing that they could find in terms of having these contaminants. But look at the difference in the toxic equivalent between shredded cardboard and the wood shavings. Then you can get into the article and you can read all about these things, and you'll see that shredded cardboard is a really toxic material, because all these things that are used in just the production of cardboard and, in particular, like the pfas themselves, are used to resist water. So, you know when they make things for shipping, whether it's pizza or whether it's from Amazon, there is these PFAs in there that make the cardboard water-resistant. Doesn't mean they're not going to break down, but they stay intact for a while.

So, think about this. The people that are using cardboard, whether it's just as a [00:26:00] single layer underneath some woodchips, or whether they're constructing this giant lasagna garden, all that material is going to break down. It's going to go into the soil. It's going to stay in the soil until it's taken up by plants or people are you know, kids are playing in the soil and they put their hands in their mouth. That's how you get them. I mean, these things are nothing to ignore and there is a lot of concern about these materials. All of them that are listed up here are things that are either not legal like the PCBs in terms of their manufacture, or they're restricted or you know in the process of being regulated. But once they're out there, they're out. They just don't break down. The more you're exposed to them, the more problems you're going to have with potential uptake. So not going to get into details about what these chemicals do. You can read all about it in this paper, but the point is that cardboard is not a [00:27:00]

nice natural material to put on top of your soil. It's full of all kinds of chemicals and they should be chemicals that were not putting into the soil. So, the best thing to do with cardboard after you're done with it is to recycle it and use other things like wood material that has not been treated.

Getting back to why people use cardboard in the first place. I think they always say so I can smother the weeds. The verb smothers is not a great one to use when you're talking about a living soil system. Mulch should protect soil life. As I mentioned earlier, your good mulch protects soil life. Cardboard is not doing that. It's interfering with gas movement as all sheet mulches do. It's restricting oxygen getting in. It's restricting the ability of water to you back from a wet soil or to get into a dry soil. Not only is it this gas transfer issue, but it's also this water transfer as well. The thing that is most important if you're trying to [00:28:00] eliminate weeds from a landscape is to use something that eliminates sunlight, because that's the one thing that the soil system doesn't need. Things that live in the soil don't need sunlight. Plants need sunlight and so they have to have some material above ground to get that sunlight. If you're able to put a barrier that is a permeable barrier in terms of gas and water movement but will keep light from being able to get to seeds or to crowns of perennial weeds, that's going to control weeds.

All seeds that are small are generally photodormant. In other words, they have to have sunlight before they break dormancy. They're there and if you have several inches of mulch on top, they're not going to germinate there. They'll just stay dormant until there's enough sunlight. The perennial weeds also need light to start growing again after the winter or whenever, you know, they've stopped growing, and if they don't get light, they have a limited number of [00:29:00] resources in their crown and roots to try to get above a thick mulch layer. Soil organisms don't need light, so you can just not worry about them. If you're using a good mulch, it's going to enhance soil organisms and not harm them. What this all tells you is that if you have a deep course mulch, you're going to restrict light, you're going to control weeds, but it doesn't have much effect on top in terms of water movement, in terms of oxygen and carbon dioxide exchange. So, even though our research showed that woodchips were worse than bare soil—bare soil like we had in our lab experiment does not exist in real life because in real life, a bare soil is heavily compacted; it's eroded. It could have a crusty layer on top of it that interferes with almost everything.

So, woodchips are absolutely the best thing to put on top of a soil as our research suggested, and it's in the abstract, and what I would suggest to you and your clients. [00:30:00] So, instead of lasagna, people like recipes, so I kind of tried to use recipe terms. You're going to mow the weeds or lawn or whatever it is you're trying to get rid of to the ground. You're going to scalp it to the ground. Now in my part of the country where we have dry summers, it's best to do it in summer. If you live someplace where your winters are really cold—like I used to live in Buffalo, so I know this—the lawns go dormant in the winter. You might do this in the winter. Summer's better just because it's warmer. The soil system is moister, and so the microbial action you need to have going on during this is higher than is in the winter. And so that's why I still recommend summer and then you just add a thick layer of woodchips. I recommend 12 inches, because that pretty much keeps anything from being able to grow through it. Then you let it cook. I use the verb cook, because it's warm in there. It's not hot. It's not going to burn anything, but it's warm because you have all this microbial activity, [00:31:00] breaking down that the turf grass that is going to die. Because it doesn't have any light, and it will it will die.

So, that is a no-till method of preparing a garden bed, a landscape bed, whatever it is you're trying to do to get rid of all of you know, the plant material you don't want anymore. This is actually from our little, tiny landscape when we lived in Seattle where we could not keep the lawn looking good in the summer anyway. We decided just to get rid of it all. And you'll actually see a picture of that a little bit later on

how that turned out. We've now burst the bubble hopefully for your clients who want to use some kind of sheet mulch. So, I recommend all kinds of fun things instead. There's good living mulches. In agricultural, there's our cover crops. In ornamental horticulture, there's ground covers. There's lots of different types of inorganic matter to use. [00:32:00] Some of those can be for walking on, and those might just be decorative. You can kind of go wild with different types of inorganic mulch. Then there's all kinds of course organic mulches. Some of them are good and some of them are not so good. I'm not going to go into details about you know, the benefits of each one, because I really just want to focus on the woodchips today.

I have lots of colleagues who do the same thing I do, and we're all in agreement that course wood chips are the very, very best mulch you can use if you have trees. They're going to provide nutrients and organic matter on a slow and sustainable means. It's not fast food. It's what we call slow food. All you have to do is add more mulch on a yearly basis or however often needed to get back up to the level it should be. It's going to protect and enhance the soil ecosystem [00:33:00] by protecting it in the ways mulch is due as well as providing these nutrients and organic matter. It will restrict light at the soil surface if it's deep enough. That's going to keep the weeds from competing with plants and being an eyesore.

Preserving microbial life, we're finding, is even more important, especially with trees. This picture here is actually an oak seedling I pulled up out of our landscape, because we have Garry oak trees, and acorns, of course, get buried by the squirrels. We have all kinds of seedlings every year. However, I wanted to include this, because you can see around its expanding root tips. And this is all this real fine cotton material. Those are all mycorrhizal hyphae. So, we've got to have mycorrhizae with our trees, and I think most of us know that already. It enhances water and nutrient uptake of the plant, and it protects the roots from pathogens. What we also know now is that not only are woodchips [00:34:00] good for enhancing soil conditions and benefiting desirable plants.

They're also, these woodchips are also needed by mycorrhizal fungi, because it's a source of nutrition for them. So, to have optimal mycorrhizal activity, you have to have a decomposing woody material for it to access. The easiest way to do that is with a wood-chip mulch. A lot of your clients might have concerns about woodchips. There's two particular ones. They're worried that these woodchips will cause a nitrogen deficiency, and they're worried it may have a diseased tree that's chipped up and made into chips. It's going to pass on disease to all other landscape plants. Fortunately, there's lots of research to show that this isn't a concern. For instance, this is some data that we generated from one of our tests that you'll actually see a little bit later on, but we wanted to make sure to [00:35:00] characterize both a pH in the carbon nitrogen ratio of our plots to look at later on. So, you can see we've got, before we started, we have the control which has no mulch, and then in the treatments, they have mulches. We don't need to worry about all those details, but I want you to see that both with pH and, more importantly for this discussion, carbon-nitrogen ratio, they're not really that different from each other. In fact, if you run statistics on it, there are no significant differences between any of these. They're all basically the same. The reason for that is of course, the soil system is a vast system, both horizontally and vertically, and putting a little thin layer of chips on top is not going to change that. In a container it might change things, but that certainly doesn't change it in a landscape.

We can see this for ourselves. We can see in restoration like in this picture here on the left. There's an oak seedling. That's a volunteer coming through, and it's not chlorotic. We could see this with ornamentals. [00:36:00] They'll come through woodchips, and they're not chlorotic. So obviously, there's enough nitrogen in the soil that plants can grow in abnormally. Even though the mulch itself has

a very high carbon nitrogen ratio. If you mix the material into the soil, as in this experiment we did here where we amended the soil with woodchips, then you absolutely will get nitrogen deficiency showing up on the plant. So you never want to amend soil. This is also a good argument not to do stump grinding because you're going to create this well of woodchips mixed in with soil, and that's going to be deaf to anything you try to plant there, because it's going to have so little nitrogen available for a number of months if not years.

The fungal communities and woodchips are also pretty benign in terms of the things they're going to do in the soil or to your plants. And active things you find in decaying wood are decomposers. Big surprise. Many of those decomposers are also mycorrhizal. [00:37:00] So that's an important thing to realize. If you have a woodchip mulch that is full of decomposers and otherwise, you know benign types of microbes, they're going to out-compete other fungi for space. And this is both on the roots and within the mulch itself. Because oxygen is environment, it's going to be easier for aerobic microbes to grow and they don't tend to be pathogens. Pathogens are things that do better in anaerobic environments. Poorly drained, compacted soils, those tend to have active *Armillaria*, *Phytophthora*, *Phytobacteria*, any of those things that will cause rots. If you have a well-oxygenated soil with a decent mulch on top, like woodchips, you're going to have healthy plants and you're not going to have these fungal problems. So, here's a photo of some of our research where we generated the pH and the carbon-nitrogen ratio material. [00:38:00] You can see we were testing all kinds of things from no mulch and different levels of mulch (4 inches, 8 inches, 12 inches), different types of materials (recycled woodchips as well as arborist woodchips), and then different textures (finely textured versus coarse textured).

What I want to focus on here is just weed control. So, this is up in Mount Vernon, which is again, you know a river valley area with really nice soil with great carbon-nitrogen ratios. When we start this, of course, we mow all weeds, and then we lay our materials on top and start our experiment. In the middle of each of these plots, you can see that hole. That's where there's a tree planted. Three months after we did that, this is what the plots look like. So, you can still kind of see the trees in the middle of some of these plots, but the weeds are coming back with a vengeance. We're not going to treat them, because that's not what we're doing in this experiment. We're looking to see how well the chips will repel weeds. [00:39:00] A year after, it looked like this, and so you can see some of the plots are completely covered with weeds, especially ones that had no mulch. The ones with thin layers of mulch also were invaded but there is zero weeds in any of the plots that had 12 inches. So you can see there's one of those there, and there's another one back there. No weeds at all in those plots. Along the edges: absolutely. The nice thing is that a year after, while these trees are establishing their roots, you know, extending out into the soil, they have no competition from weeds on top of the soil surface. All of the water and nutrients in these chips are going down and they are feeding the roots of the establishing trees without interference from the weeds.

Keep this in mind if you use deep layers of woody mulch. They're going to be the best for suppressing weeds and enhancing desirable plants. If they are low in slow nutrient sources, you don't have to really worry about overdoing in terms of phosphate and some of these other [00:40:00] nutrients that tend to be way too high in landscapes. Then you can always use them elsewhere. If you're using them to prepare a site, then you can clear them off and plant. If you don't put it back on for some reason, you can put them someplace else. They're a wonderful mulch, and they're worth their weight in gold. Keep in mind, absolutely before you add any nutrients, to look at your soil test. That's a whole other topic I won't get into, but if you have soil tests where your nutrients are optimum, don't add any more. You don't need to even if they're a little bit low. Don't add it unless you can see there's a deficiency. Once it

gets to very low, then that's a deficiency. If they're all above optimum, don't add anything, because it's already gotten more than you need.

Think about what roots need, and a lot of your clients are going to think about this. They'll remember water, and they'll remember nutrients. They usually don't think about oxygen, and roots need oxygen. They don't get oxygen from the crown. [00:41:00] The crown is releasing oxygen to the environment plus using it in the crown. They don't. Unless it's a wetland species, it doesn't have a way of transferring that oxygen down to the roots, since the roots have to get their oxygen from the soil as do their microbial partners. You know the beneficial bacteria as well as the mycorrhizae.

So, there's four things that tree roots have to have to survive, and we always forget about the last two. You want to choose appropriate mulch. You don't have to use the same one. This is actually what our landscape looked like after we got rid of all the lawn. You can see we did lots of stuff. We used a living mulch, ground cover, when we didn't have limited water. This area, we didn't have an issue with water. We used inorganic mulches, flagstones for... We wanted people to walk. Then we use woodchips to cover up anything that was bare. [00:42:00] The one exception for this was if it was underneath some of these trees and shrubs where it grows quite shady, we left the soil quite open because there are ground-nesting bees and other beneficial insects that do need open ground. And that was the easiest place to have them. Also, you would step on a nest if they were out and in the open.

If you're interested in the research behind this, especially woodchip mulches or just mulches in general, these three things are articles that I wrote in various stages of my career. And they're all very useful in terms of providing that peer-reviewed information that you may need if you've got some concerns or some clients that really need to have that extra help. I have my Horticultural Myths online, which you may be familiar with. And these are all free, downloadable white papers on a variety of topics. I have all of my peer-reviewed things collected [00:43:00] on ResearchGate which is something that you can, doesn't cost a thing, and then you can access not just my information, but any researcher who's a member of this will have their materials there for you to look at. We have our blog site and you can see that I was tackling once again sheet mulching on this one, and we'll be writing a new one, especially with the PFAS issue and these other forever chemicals and cardboard.

We have a Facebook page which is kind of a clearinghouse for a lot of interesting information. And we have our blog discussion group which really is a great space for having active discussions. You don't have to wait for someone to get back to email you. It's a live discussion. We've got over 27,000 members all over the world. A lot of people on this are experts in the field. And if you join it, you're going to have to answer a few questions, so we know you're not a bot, but there's a lot of arborists [00:44:00] on here as well. So we have lots of feedback as well as questions from arborist, and it's some place where you can not only ask questions, but you can lurk and learn new things. I'm always learning new things there, and because it's been there for 12 years now, there's a wonderful archive where you can just search the discussion board and look for discussions on all sorts of topics.

So, I hope you found this interesting and useful. There is a handout for this that somehow will be attached so that you can download it, and I hope to see you in a meeting in the near future. Thank you.