S U N Y College of Environmental Science and Forestry Campus Conversations: The Podcast
Season 2, Episode 3
Dr. Greg Boyer, Professor Emeritus, Department of Chemistry
Dr. Stephen Shaw, Associate Professor, Department of Environmental Resources Engineering
4/21/22

Joanie Mahoney:	Hello. This is Joanie Mahoney. Lucky to be E S F’s current president. And I'm here on the podcast that we're calling Campus Conversations. And this season we're talking about research and we're talking to some of the faculty that do research in different subject matter areas, one of which that's big here at E S F is water. And so, I am joined here by Dr. Greg Boyer and Dr. Steve Shaw. And I'm hoping that maybe you can take a couple sentences and tell folks, you know, who you are, what department you are with, and what your general area of research is. Greg?
Greg Boyer:	Sure. I'll go first. So, I'm located in the Department of Chemistry here on campus. I'm a biochemist slash marine biologist by training, and I work on algae that live in either our lakes and oceans. And my interest is specifically in the toxins or things like that that they may produce that then turn around and impact ecosystem and human health. I have a dual role that I'm also the director of the Great Lakes Research Consortium. This is a consortium of 18 universities located across New York state with the goal of advancing research on a on a broader mission than just simply one, one area. We'll talk more about that later.
Joanie Mahoney:	Okay, good. And I know that your title includes the word emeritus, which implies some kind of retirement, but that didn't sound like you're very retired, Greg.
Greg Boyer:	Oh, yeah, no, I'm not very retired. I always think of the Merrill Lynch commercial when the archeologist, the young archeologist was asking the older archeologist what he wanted to do when he was retired. And his response is, I am retired and I am doing what I want to do. I'm having a great time working with lake associations and focusing on research and interacting with the students without necessarily all the other things that a professor is asked to do.
Joanie Mahoney:	You know, that is probably true of a lot of people that will listen to this podcast is what do you want to do in retirement? They would probably say they would love to be doing some of the work that you're doing that they probably never had an opportunity in their own careers to do so. I'm looking forward to telling them a little bit about that. How about you, Dr. Shaw?

Stephen Shaw: Sure. My name is Dr. Steve Shaw. I'm a faculty member in the Department of Environmental Resources Engineering. Environmental Resources Engineering is sort of a unique name, but it's basically a civil and environmental engineering department, which basically means it does engineering at the intersection of kind of human and natural systems. So, things like water supply and wastewater treatment and contaminant transport. My focus is mostly in water resources, so water supply, I'm looking at floods and droughts and more, how do we measure that sort of on the natural system side? So partially looking at how do streams carry water and what happens to water sort of during dry periods? And then also how do trees transpire and how much water they use at certain times of the year? Things like that.

Joanie Mahoney: So, in New York State, one of the things that we're well known for is our water. We're in the northeast and there's an impression that we have unlimited water. And maybe that's true because, Greg, the cycle that we're in with the Great Lakes, but that doesn't mean that we can manage it all at the same time or that it's available at the times that maybe the growing seasons need it. And Greg, I suppose for you it matters not that we have the water, but that we have clean water and that we don't have toxins in our drinking water and that kind of thing. So, let's start there with a really basic question. Is it true that we have unlimited clean water in the state of New York?

Stephen Shaw: Well, I guess I'll start with that one. So, the easy answer is no. We have pretty vast amounts of water. I was looking at a statistic the other day. The Great Lakes have 20% of the fresh water in the world, and we know we border hundreds of miles of the Great Lakes in New York. But the question is always, do you do you have enough where exactly you want it and when you want it? So, the issue is, do you have it in the summer or do you have it in sort of the town or the city where you work in or live in when you need it? And that becomes the issue of how do you get it to those places at the right time. So oftentimes we generally have enough water, but not always in the right time and place.

Joanie Mahoney: And is it our goal to build infrastructure or to undo the building and get to a natural way for irrigation to be happening?

Stephen Shaw: Well, really, it's to build infrastructure. And I think we've been building infrastructure for hundreds of years, even in New York, that have sort of dramatically changed the way water is plumbed in the state. So, I think we often take for granted how different it would have looked if you were here 200 years ago. So. I like the easy example. A good one is New York City. They receive 60 to 70% of their water from the Catskill Mountains, which are 90 miles away. So, there's a deep bedrock tunnel and another surface aqueduct that carries that water 90 miles from the Catskills to New York City. But a lot of communities across the state have reservoir systems and pipelines and tunnels that are moving water pretty vast, different distances to get them to the places where they actually need that water.

Greg Boyer: I'd also say there's a local infrastructure question, too, on the individual property owner. You know, New York is blessed with some 10,000 plus lakes, and if you went back maybe 60 years ago, you would be lucky to have three or four, maybe 20 cabins along those lakes. Now, lakefront property is very exciting. And so, the lake that had 20 cabins now has 200 houses. And these are no longer cabins that are used just in the summer, but they're now year-round homes where people are there 12 months a year. So, the infrastructure we had 60 years ago with septic systems and things like that might have worked just fine if there was only 20 houses on the lake. But it's just not appropriate for when you have that much development along the lake. And we need to recognize that some of these changes need to happen in order to protect our lakes. So we continue to have good, clean water.

Joanie Mahoney: We talked about turning lawns into meadows. But, I would imagine now that we've built up that lake front, the water moves more quickly into the lake. So, we'll carry more sediment and maybe more herbicides or pesticides that have been applied on that land that's been developed. Is that something that contributes to that?

Greg Boyer: Oh, absolutely. And there is actually a really strong effort to do what we would call lakefront landscaping, where you no longer have your, for example, yard go all the way down to the edge of the water, which means the runoff from your lawn goes right straight into the lake, but you put in buffer strips where you have and these can be quite, you know, fancy buffer strips. Chautauqua Lake is an example where they've made a real contest out of it and they have, you know, a little sculptures and they have all sorts of native plants and everything else that are quite attractive. But at the same time, it can really decrease the individual runoff into the lake.

Joanie Mahoney: So, what are you seeing in terms of the algal blooms now compared to the beginning of your career? What has happened and what's your best scientific guess for why we're seeing what we're seeing now?

Greg Boyer: I think there is sort of a combination of three factors. First of all, we're simply way more aware of them and things that we would have passed off before we now have a heightened sensitivity. I always laugh. We did some work up on Payne Lake in 2019 in response to some animal livestock fatalities that happened from green water. And it was very interesting to go back and read the vet report from 1938, which talked about cattle fatalities that happened from green water. And so, in some ways, these have already, these have always been here. But our lakes have a lot more stress now due to more people, more intensive agriculture or animal feedlots. And so, we are actually seeing more blooms. And climate change is also becoming a factor in these blooms. And so, we actually do think it's not just a reporting issue. We actually do think that we are seeing more and more blooms happening in our lakes.

Joanie Mahoney: And how does climate change affect that? Is that the warmth of the water?

Greg Boyer: Most people would say it's the warmth of the water, but in fact, what's more important is probably the length of the growing seasons. Lakes stratify, and what happens is you get the algae growing in the upper, warmer waters and they will continue to grow into the fall until the lake turns over when these cold waters come back up into the upper waters. And that's usually what terminates most of the fall algal blooms. The problems is that with the increasing warming in the spring, these lakes are stratifying earlier and the staying warmer longer in the fall. These lakes are turning over later. And so, the estimates are for like Lake Erie, we're increasing the growing season by about 2 to 3 weeks per decade, which that's a really major impact on how long these organisms have to grow before they they naturally end.

Joanie Mahoney: So, when you first said the growing season, I'm picturing in my head agriculture and maybe runoff, but you're talking about the algae itself growing.

Greg Boyer: Yes.

Joanie Mahoney: The season for that to grow is lengthening by a couple of weeks every decade.

Greg Boyer: Yeah, that's exactly correct.

Joanie Mahoney: Will we then get to a place where it isn't turning over?

Greg Boyer: Well, that's a good possibility for some lakes. For some lakes, they're so big and they will always turn over. I doubt that we're going to have, you know, 70-degree climate here in Syracuse 12 months a year. So, we're still going to have a snow season and things are still going to turn over. But for some of the the shallower lakes, yes. That the period are the how often these lakes turn over is definitely changing.

Joanie Mahoney: So, Steve, I think you intersect with this conversation because as part of the Center of Excellence, you picked up the baton when the state government was asking for help with harmful algal blooms. What were they asking you and E S F and Clarkson to do?

Stephen Shaw: Well, the general idea was to come up with a kind of a mitigation device, which basically means if an algal bloom occurs, can you actually remove it? So, the typical measure so far, which generally makes sense, has been preventative measures. So, to try to understand why blooms are happening and then to implement measures to keep them from happening. But there's been more work to sort of acknowledge that blooms are going to happen. And are there ways to treat them once they do happen? So, oftentimes it's done sort of at the point of source. So, if you have a drinking water supply, there's sort of standard ways to basically filter that water and treat that water near a drinking water supply. The broader challenge has been to actually treat in a lake, which was sort of the work we were looking at, which the challenge always remains, sort of that the large volume of water there. So, I think a good analogy is always like a small a pretty small town, say 5,000 or 10,000 people might build a water treatment plant to treat their sewage, basically. And this is a rough number, but say they might need to treat 1 million gallons per day. That might cost a few million dollars to build that treatment plant. If you were to try to treat that amount of water in a lake, that would be somewhere around, I don't have the exact numbers in front of me, but a few acres of a lake, which isn't a very big lake and that's only a few feet deep. So people won't say it's unusual to spend $1,000,000 to treat 1 million gallons per day for sewage. But if you said you had to do that and you're going to treat the lake, well, it just doesn't it doesn't scale. So, there's definitely an interest there and there's definitely a need. But the question, the technology question is, can you do it at a cost where you can treat a lot of volume, which remains to be determined.

Joanie Mahoney: So, I know having had the opportunity to have conversations with you at the time that you were working on hydrodynamic cavitation, which I think is an interesting technology, is there a way you could put that in layman's terms for us a little?

Stephen Shaw: Sure. It basically just means you create small bubbles, you create a phase change. So, you get water to go from a liquid phase to a vapor phase and then to switch back really quickly. So, when it switches back, you take water, it's all water, but it goes from liquid to vapor bubbles. And then the vapor bubbles collapse. And when they collapse, they generate small, intense amounts of heat and pressure. So, if you kind of have that in the right place, it could potentially damage harmful algae cyanobacteria.

Joanie Mahoney: And then is there something about it dropping to the floor of the lake?

Stephen Shaw: Well, that was the idea. But one thing with cyanobacteria is they basically evolved. And Greg can talk about this a little better than I can, but one of their one of their main evolutionary traits is that they can move pretty efficiently, more so than other algae in the water column so that lets them outcompete. I don't know if you want to say anything, Greg. You want to jump in on that?

Greg Boyer: Yeah. So, a lot of the cyanobacteria or blue-green algae have a lot of very unique adaptations they've made that have allowed them to dominate in water columns. And one of them is they have these little life preservers that we call gas vessels that allow them to float to the surface in order to gather light. And if the light is too bright, they will sink back out of the water column to hide from the light. They will eventually go all the way down to the bottom and they'll come back up as the light gets to be the right level. And so they're constantly moving up and down in the light. And one of the ideas is that it's an old fashioned limnology experiment to put them in a jar and just pop the jar and pressurize the jar and you can break these gas vesicles, and then they will all sink. And the idea is, as Steve mentioned, is that if we can use hydrodynamic cavitation, we can break those gas vesicles and disrupt their ability to move up and down on the water column, and that should inhibit their ability to form blooms.

Joanie Mahoney: But then we're back to the cost of that and the scale of that, given the size of some of the water bodies we're talking about.

Stephen Shaw: Yeah. And it goes and that was sort of the idea of hydrodynamic cavitation was it's pretty simple. You really just need a pump. So, in terms of what you need mechanically, it's not it's not that complex. So, if anything, you could scale you could potentially scale that. But even that, it's probably not efficient enough to necessarily treat large water bodies.

Joanie Mahoney: So, then the goal, as you said, the best option so far is to prevent. So, I'm curious, what would you tell people who want to be helpful, what they should be doing on their own land that can help prevent these harmful algal blooms?

Greg Boyer: Well, I'm always a fan of the Think Global, Act local. So, I mean, if you have a property. Right. Control or limit the amount of fertilizer you put on the property. If you have lakefront property, in my mind, there's absolutely no reason you should be putting fertilizer on your property. You could just stick a garden hose out in your lake and pump the water right directly out of the lake to use it to fertilize your lawn. And then your lawn would be acting as a filter and clean some of those nutrients up and you would, you know, benefit the lake. Right?

Joanie Mahoney: Yeah, that's very interesting. And no one has ever said that to me. So, things that probably seem obvious to the two of you are not obvious to everybody listening.

Greg Boyer: The other thing is, is to really be very cognizant on your lake in terms of sort of sediment runoff. You know, what's your lake shore area like? Are there is there dirt sediments that are all washing into the lake and stuff like that? Are there creeks on your property that are washing in sediments and things like that and try to control the amount of sediment. Because sediment is a very good carry of nutrients, try to control the amount of sediment that goes into your lake, around your individual property.

Joanie Mahoney: Is it true? Because it's interesting when these things happen, everyone seems to all of a sudden have a whole bunch of scientific information that's probably not based in science, but they see the patterns. And a creek runs hard after a really big rainstorm. And that's connected, I think, to the climate change because the storms are more intense. So, we have this deluge of water and then you see trees and mud and everything make its way into the lake. And at the end of the season, we see the harmful algal blooms. Are those things connected? Is it that runoff that happens in the late spring contributing to those blooms that we're seeing in August and September?

Greg Boyer: Absolutely. In fact, Lake Erie is probably one of our best understood systems. You can predict the harmful algal blooms that basically happen in June, July, August, September, purely on the runoff that occurred in January, February, March. So, most of the nutrients in that system are coming into the lake early in the season. The algae are feeding on them, they're storing them, and they're waiting for the conditions to be right for them to grow.

Joanie Mahoney: It's interesting to me that our mission is so specific here at E S F and we're all working on issues like you and Dr. Shaw, and it all connects. So, I'm thinking about the things that the Restoration Science Center is doing that they don't maybe explicitly say are for the reasons that affect the research that the two of you are doing. And then I'm thinking about the policies that need to be put in place at the government level to help some of these things. But you have to measure that. So, you know, ideally from a nature standpoint, we would want big building lots so that you wouldn't have that density and so much stress put on the lake. But that eliminates a whole sector of the population because you're making it too expensive and then those lakefront properties aren't accessible to everybody. So, we have environmental studies doing this environmental justice work and talking about how to bring equity to some of these policies. You know, we have the Restoration Science Center. I went out to Skaneateles and we worked on a restoration of a creek that feeds Skaneateles Lake and folks that were out there, we're making it meander rather than, you know, just be a straight shot. I don't know how with the lakefront as crowded as it is now, that you have a lot of room to put some meandering creek in there rather than what happens now, it just comes straight down and literally whole trees are coming down, you know, but it's interesting to me listening to you, how we all overlap. How about again, with the harmful algal blooms, the people who live in the city of Syracuse drink some of the water that comes from Skaneateles Lake. Lakefront properties, we're told you can't drink that water because of these harmful algal blooms. But then folks who live in the city were told that you can drink it because the length of time that you're able to treat it between the lake and the reservoir, is that…?

Greg Boyer: Yeah, no, this is it's absolutely true. So, in the case of Skaneateles Lake, they were talking about a particular type of toxin and that was a liver toxin. This toxin is destroyed by chlorine, but it actually takes time for that to occur. So, in this particular case, the water would come from Skaneateles Lake. It would get treated with chlorine in Skaneateles. But then it had to transfer through the pipe the whole distance until it got to Syracuse. And there was enough time during that transfer that the toxin could be degraded. So, if you were taking the water in Skaneateles directly from the pipe before it had time to treat, then it wasn't safe to drink. If you were waiting and giving it the time to travel 20 miles, then it was perfectly safe. Even worse is the people that took the water directly from the lake because they quite often were not chlorinating their water. They were just assuming that the water was safe, so they had no treatment at all.

Joanie Mahoney: There's a lot of that, I would imagine, in those 10,000 lakes all across the state. And that is something we're going to have from a public health standpoint to be really careful monitoring. And speaking of monitoring, that is a big part of what you are doing. And you were talking before we had the microphones on about this citizen science effort. So, what exactly are people doing that contribute to the data that you're able to gather?

Greg Boyer: I like to call it telemedicine for lakes. You know, you look out on your lake, and you let's say your lake is brown, or light green. The question is if that's pine pollen because it's that time of the season, that's one thing you don't worry about it. If it's a certain type of algal bloom called the diatom bloom. Okay, that's great for fish food. So, you don't really worry about it either. If it's a blue-green algal bloom, then you might want to be able to worry about it, but you can't really tell that just looking at the water. And so, we're working with a number of companies in Ohio and some companies in England that have made very, very high-quality microscopes that couple to your cell phone. Now, microscopes have been around for a long time, but quite honestly, they're not easy to use. And so, we finally found one that we think is easy enough that the average person can use, and now they can take very high-quality images, and through the wonders of email, just send them to an expert for review, and then we can turn back and give them some information about the status of the lake.

Joanie Mahoney: Where is that email going to? Are you receiving those emails?

Greg Boyer: Right now, they go to an email link here on campus, which is called Cyano Habs. And then either I look at them or a graduate student looks at them and sends a reply back.

Joanie Mahoney: And if somebody wants to do that, how should they start?

Greg Boyer: Probably send an email to Cyano Habs and say they would like to do that.

Joanie Mahoney: Okay, so it's just Cyano Habs?

Greg Boyer: CyanoHabs@E S F dot E D U. That'll go into the generic e-mailbox inbox.

Joanie Mahoney: And we're compiling that information so that if a data scientist comes along, they will have access to that data and can slice it and dice it and learn more things about it.

Greg Boyer: Some of that information, the images get posted on the New York State D E C website so that rather than them have to wait for a sample to come in and then take a microscopic image there in Albany, it just automatically goes up and they can jump the process several days and some of that information, we work with the

Lake Association to try to just really better understand what's happening on their lake and to give them a better appreciation of how things change over time.

Joanie Mahoney: Is there an app for a microscope that you can get on your phone?

Greg Boyer: You have to purchase the microscope. The one that we use is not particularly cheap, but in the realm of microscopes are not that expensive either. And then you just it's called the I O Light app and you just download that and put that on your phone and it works with either Android or cell phones or iPads or whatever.

Joanie Mahoney: That's incredible. That's very valuable information. I'm curious, Steve, about the work you're doing in the agriculture world. So, we have a lot of farmers. New York State is very dependent on the agriculture industry that we have, but things are changing. And I'm wondering what changes farmers are seeing and then what can people be doing who want to be helpful in the irrigation and agriculture world?

Stephen Shaw: Yeah. So, in terms of sort of farmers, it sort of partially depends on what they're growing, but in general, the main thing they might see is more intense storm events. So, they see, and this is becoming sort of more commonly accepted, but they see as air temperatures go up, that basically means the air can hold more moisture. So especially then for sort of short-term events like a thunderstorm or convective storm, that also means because the air is holding more moisture, they can drop more moisture rapidly. So, there's sort of this general statistic which is based on just basic physics and chemistry. The Clausius-Clapeyron relationship that says for every degree you go up Celsius, you should have 7% higher intensity rainfall. So, we've definitely seen more higher intensity events but at a shorter scale so like ours to sub-daily scale. But those are the types of things that would cause flooding and erosion on a field. Quite honestly, that's the thing farmers are probably most concerned about. So, over the decades and centuries, especially in a place like New York that doesn't have the most well-drained soils, they spend a lot of time putting in drainage so what they call tile drainage, and they're continuing to do that.

Joanie Mahoney: That's interesting because I would have guessed that they were concerned more about the droughts, but they're concerned more about the deluge of water all at once.

Stephen Shaw: That's the thing they're more concerned about, and I think that's what they have to address first. But sort of as they do that, because they kind of they put in this tile drainage and that's something, you know, once you do it, your field should be better drained. And then you kind of look at it as if you want to make additional investments in your land, what do you do next? And it's sort of becoming one of the options is to do irrigation. So, I think 30 years ago in New York City, if you kind of asked who was irrigating, it wasn't very many people at all. But now it's more people are considering that. Part of that was there is a pretty severe drought in 2016. I've been doing studies where we look at well-drilling records to see the number of wells that have been drilled and you saw a really substantial spike in 2016 and 2017. And really people made a shift in terms of deciding, you know, to go one year where a lot of their crop was wiped out, that they should invest in base irrigation and that was worthwhile drilling.

Joanie Mahoney: So, you and I crossed paths because we worked on the Reimagine the Canals Taskforce, and one of your projects was chosen for funding. What was that project?

Stephen Shaw: So that project was to use the western part of the Erie Canal. So, basically the section between technically Lockport and Rochester to basically use that to convey water for irrigation. So that part of the canal is unique in that it's basically what we would say is above grade and that that part of the canal is always flowing above any other streams. So, there might be sort of hundreds of streams that it passes over in that part of New York. But all those streams are busy in pipes and tunnels that go underneath it. So, what it does and what the water comes from in that part of the canal is from Lake Erie. So you basically have a giant conduit to pass water from Lake Erie potentially over in that entire slice of western New York. And that's actually already that's what's been done for more than a century, but it's been done in the interest of maintaining water levels in the canal. So, the project was to explore the possibility of using it, not so much to maintain the water level in the canal for commercial transportation of goods, but instead to basically irrigate farm fields. And we should say farmers have actually been irrigating for probably over a century already, but just not in a very formalized way. So, the interest was to sort of explore the possibility of doing that in a more formalized way.

Joanie Mahoney: And I think we learned from some of the consultants that advised that task force that there is no commercial traffic moving goods on the Erie Canal, but we're still maintaining the water levels as if there are and there's maybe a better use of that water in 2022.

Stephen Shaw: Yeah, I think the state statutes basically say like this is what this is how the Canal Corporation who operates the canal is supposed to operate, but because there's no commercial traffic that needs to have water levels at a certain level. So, so yeah.

So, there's a reasonable way to go proceed forward to sort of explore other uses of how to manage the canal.

Greg Boyer: I should point out, though, is while there's limited commercial traffic, you still do see large windmill blades and things like that go down the canal. There's a very robust recreational industry on the canal and many of the canal-side towns have leveraged their canal opportunity. So, it's very exciting.

Joanie Mahoney: I think that was one of the goals of this task force and one was mitigating flooding and the other was mitigating the transfer of invasive species. And it was very interesting. I was fascinated by some of the consultants who came in. But as Steve said, there's also a terrific asset there when you look at it in terms of a water source available for farmers to have more of a predictable cycle of water for their growing season. So, Steve, I was reading a little bit about some of your work and I had never heard of beaver dam analogs, and I'm interested, if you want to explain to people what that is and what your research is.

Stephen Shaw: Sure. So, one project I'm working on, and this is really more for the Western U.S. I think in the eastern U.S. beaver, dams are still kind of a nuisance sometimes, but especially out West, they're being explored as ways to help retain water in streams. So, really out west beavers have been in large cases pretty much removed from the landscape and then, especially when people started ranching in. Remove vegetation, especially woody vegetation near the stream valley bottom. So then even if beavers could kind of make their way back, they wouldn't really have anything to build with. So, the project is basically been treating artificial beaver dams with the idea to basically raise the water level in streams. And then what that allows is it slows the water down and then you basically get accumulation of sediment behind that and it helps to account for erosion that's happened over centuries and at the same time, it helps retain water in the streams. And what actually happens is the water will flow back into the stream banks. So, you get what's called stream bank storage. So, you can think of the volume is filling in the stream itself. But then that because the water level comes up, it will push water into the stream banks. So, then you sort of have several times over just the water you actually see in the stream itself. So then when you have drier periods and especially out west, there's these are mostly snowmelt-dominated streams. So, you're talking about later summer can kind of prolong the amount of water in the stream for longer periods of time. So, we're sort of exploring the degree that that happens. So, in the past, when people looked at one of these called beaver dam analogs, they've often built two or three. But we're working on a site where there is over 45. So, you actually have sort of a large assortment of them, which is actually more closer to what would naturally be there if you had beavers naturally in the environment.

Greg Boyer: I would just add that that same type of approach whILE being, you know, studied out West is also being proposed for many of the farmers here in the East. So if you happen to have property along, for example, the Finger Lakes, it has a fairly good slope. And so, you get a lot of erosion because of the water running down there. The one of the current best-managed practices is to build a whole bunch of small beaver dam like analogs along that creek so that it's constantly going from pool, to pool to pool to pool. This is allows both the water to soak into the fields and so you get more beneficial use. But it also slows the water down.

Joanie Mahoney: So that reduces the sediment run, makes it swimming off. Interesting. These are exactly the kind of things I was hoping that you would talk about, because those are things that people can relate to on their own property. You know, when we talk about big picture, the environment and the climate and the changes that we're seeing worldwide, it's hard to get your head around it. But when you talk about the research you're doing and how it applies to things that I can see and touch and know about, then it's better for people because we're educating them. But also it's better because you'll have citizen scientists, you'll have people who will use some of those best practices on their own property. And that cumulative effect, I would hope, is going to make it better for all of us. When you talk about the beavers being gone, I can't imagine how many plants and animals over time have been considered a nuisance that we've eradicated and then have had to deal with the after-effects. Everything has a purpose and we have to be really careful that we keep it all in balance.

Greg Boyer: Yeah, it's sort of the law of unintended consequences that you think you're going to get rid of wolves because they're a pest, but then you realize that they also have a very important part controlling other animal populations in the ecosystem.

Joanie Mahoney: And then you have the deer that there are so many of that are carrying the ticks. And we have this explosion of Lyme disease. And as I said, right, it all goes together. So how about the sap flow sensors that you're working on? I'm curious why it's important to know how much sap is flowing and why it's important to know how much water is coming out of a tree.

Stephen Shaw: Sure. And a first thing is sort of I wouldn't say it's a misnomer, but often when we say sap, we kind of think sap for maple syrup. So, kind of early season or spring sap, but we're really not interested in that phase. And really, it's more once the leaves are out, which is when you want to use this, it's really the water the tree is moving, more for transpiration to cool itself. So, sort of different time of the season. So, what we're primarily interested in is basically measuring water use of a tree. So, basically, from when the leaves emerge to when the leaves fall off at the end of the season. And what that's basically telling us in in a place like New York State is probably 70% of what we call evapotranspiration. So, basically water that that does a phase change from a liquid phase through a gas phase where that's going and how much of that is happening. So, I should step back one more step. So, if we think about sort of the simple hydrologic cycle, you basically have rain falling in the system, you have snow melting in the system. And that water can primarily go to places. It can either flow out of the system as streamflow or river flow, and it could go into a lake or the other way it can leave the system is it can leave by evaporation. So, what we're trying to do is basically better understand sort of that final component of the hydrologic cycle, which is how much evapotranspiration do you have?

Joanie Mahoney: And why is that important?

Stephen Shaw: Well, it's really it's traditionally been the least measured part of the hydrologic cycle because with rainfall, you can basically put out a bucket in the simplest way and you can measure how much rain you have. And for streamflow, you can pretty much go out and just measure how fast your stream moving and the basic dimensions of your stream. And you have a pretty good sense of streamflow. But evapotranspiration has traditionally not been that easy to measure. So, the idea of the research we're doing, so people have tried different things for a long time, and what we're doing that makes it different is to basically have sensors that are less expensive but also use lower power. So, even when people have measured sap flow in the past, they've often had to take car batteries out of the woods. So, you can kind of imagine you want to go measure sat on a tree in a remote location, which is what you often have to do. And then you basically have to carry a bunch of car batteries, say, a mile into the woods to basically power your instruments. Because the way these work, it basically applies a small heat pulse. And then you have two sensors that basically measure sort of the intensity of that heat pulse away from where you applied it. So you can measure how fast is water sap moving in the tree by basically how fast is that heat pulse moving. But so, you need batteries to generate that heat pulse.

Joanie Mahoney: Again, as I said all of the research kind of intersects with each other. But for folks here to hear that we're carrying car batteries out into the woods, right, to do this kind of work, I imagine that they will get their wheels spinning about how better to do that.

Stephen Shaw: Yeah. And what was so where we kind of had our device base, he uses just small rechargeable double A batteries, but the reason we could do that and not use car batteries was to be subject to some basic sort of somewhat basic off the shelf electronics that instead of our heater that generates this pulse, basically always being on this just to have a go on basically every half hour and then only to flip on for a few seconds, then to go back off. So, the traditional way to do it was basically to always have this heater probe heated just 24 seven. And that's what we've avoided doing.

Joanie Mahoney: And I think that's great. But I never really stopped to think about how you would measure the water that's coming out of the tree.

Stephen Shaw: Now, most people don't, right. And and the other alternative is what's called the Eddy Covariance Tower. And some of our faculty is E S F also, actually. So you buy these sensors and you have to instrument them usually on the top of a tall tower. And what it basically does is it can measure the moisture in the air and they can also measure the velocity there and kind of multiply those things together and you can tell you how much moisture is moving away from a tree. Those are great. And they can actually measure over sort of a larger area, not just one tree, but they cost tens of thousands of dollars. So, our device basically costs about $100. So, there's sort of this trade-off. You know, it's not the only way to do it, but basically trying to develop new ways to do things.

Joanie Mahoney: So that's where the engineering and the environmental science are colliding.

Stephen Shaw: Exactly. And a lot of this, too, is the kind of thing it's we're ordering parts, you know, from… They're manufacturing these thermistors and different sensors and microcomputers and they could be used for anything. Lots of hobbyists are using them. But really, in the last ten years, they become much less expensive and then just kind of opened a bunch of doors in terms of now building your own specialized sensors were ten years ago or 15 years ago, you might have to pay thousands of dollars to buy these.

Joanie Mahoney: Excellent work. How is the work that you are doing benefiting the people who live here in New York?

Greg Boyer: Well, I think you can approach that from two ways, both from what I would call a theoretical science way. And the tree sap sensors are an excellent example of a theoretical science way. One, if we are going to protect the system, it doesn't matter whether it's a lake system or forest or a desert. You actually have to understand how that system works. I mean, you have to understand who's pushing the buttons, what are the drivers, what are the responses, how much comes in, how much comes out? That's what I would call almost a theoretical basic what we would call basic science. And we have some excellent, very basic scientists here who are looking at basic science questions. But you also need applied scientists, people who take that basic science information and say, okay, we have this much water leaving the watershed as streamflow. That's too much. So how do we reduce that? How can we change the landscape? How can we plant certain plants, for example, that might retain the thing? How can we build artificial beaver dams that might retain the water? How can we just change when we water? Does it make a difference whether we water during the day or water at night? You know, simple things like that that have basic applied consequences that really can be important in actually protecting the environment. And E S F’s a nice place that way because it has a really strong mixture of both. There's there's recognition that both areas are important.

Joanie Mahoney: And you know, it's nice to know that there are people doing this kind of work informing the policies that we have in the state. I was starting out by talking about how we sort of have a reputation as being heavily regulated in New York. And even still, we're seeing water quality issues and some of the agriculture issues that you've seen, Steve. And thank goodness there is good science that's informing some of the policies that we have here. You have reacted to my suggestion that we're regulated. I'm curious what you're thinking.

Greg Boyer: I'm not really certain what I'm thinking. We are a heavily regulated state. There is absolutely no question about that. We're also a very populated state and we're also a state that takes its water quality and lands are very important. We are blessed with having the Adirondack region, the largest state park in North America, and some people would say, well, it's too overregulated, but other people would say no, the fact that it is declared forever wild is why it exists and why we still have it. And I think both Steve and I, as we travel out West to see areas that are less well regulated, some of these B L M lands that we've worked on, you sort of sit down and you say maybe taking a bulldozer to drill, to build a road through the middle of this area so that they could get to a new uranium mine and then having no plan what to do with the mine tails. Maybe that's not such a great idea and I should have regulated it a little bit more in the beginning.

Joanie Mahoney: I think that's very well said. And there's a difference between having a reputation for being very regulated and being overly regulated. And I think you're suggesting that there's a real benefit to the caution that we have in New York to protect our land and our water. And you two, as some of them, esteemed faculty at SUNY, E S F, are doing the work that's informing that. So, thank you very much, and thank you for taking time out of your busy days to talk to us about the work that you're doing.

Stephen Shaw: Sure. It's great talking to you, Joanie.

Greg Boyer: Thank you very much.