Intro:

You are listening to Making Waves, fresh ideas in fresh water science. Making Waves is a bimonthly podcast where we discuss new ideas in fresh water science and why they matter to you. Making Waves is brought to you with support by the Society for Freshwater Science, Arizona State University School of Life Sciences, and the University of Washington School of Aquatic and Fishery Sciences.

Stephen Elser:

Welcome to the Making Waves podcast brought to you by the Society for Freshwater Science. I'm your host, Stephen Elser. This month, we're joined by Stephen Cook, who is a PhD candidate at the Department of Biology at Baylor University. Thanks for joining us, Stephen.

Stephen Cook:

I appreciate it. It's good to talk to you, Stephen.

Stephen Elser:

First, we're going to just start things off with the easy question, how are Chip and Joanna doing?

Stephen Cook:

I got to tell, it's really weird for local Wacoans that Waco has become a tourist trap as it were since the Fixer Upper explosion or popularity. So I think they're doing great. Magnolia Market is a fantastic resource for downtown Waco. So yeah, I think they're doing really well.

Stephen Elser:

Okay, great. I'm happy to hear it. Okay. So yeah, you're a PhD candidate at Baylor, can you tell us a little bit about your general research interests?

Stephen Cook:

I am freshwater stream ecologist and I took kind of an odd path to academic research. I was not interested in ecology when I first read a book about it and first took a class on it, and then kind of on a whim took a class on aquatic biology that primarily dealt with benthic macroinvertebrates or aquatic insects primarily and was blown away by the amount of diversity and life and how interesting it was just underneath the water surface. And I've kind of been enthralled with that from that point on. So most of my research kind of centers around the stream community, primarily how macroinvertebrates are responding to certain anthropogenic stressors.

Stephen Cook:

My research kind of sits at the center of biodiversity research, but also introducing some temporal components and seasonal successional patterns and how biodiversity is affected by anthropogenic stressors.

Stephen Elser:

Wow, great! So you said that you're a big fan of aquatic insects. Do you have a favorite taxa?

Stephen Cook:

Gosh, that's a really good question. Yeah, I think caddisfly Moreilia I think might be my favorite taxa just because it can get some beautiful head patterns. It's just a really interesting taxa. So yeah, I think probably that.

Stephen Elser:

All right. Good choice. All right, great. So you recently published a paper entitled, Freshwater eutrophication drives sharp reductions in temporal beta diversity. Can you tell us a little bit about this paper? What your general goals were and then what you found?

Stephen Cook:

Sure. Absolutely. So that paper, I think it's important to mention up front that, that paper grew out of a much larger study that was being conducted by my advisor, Dr. Ryan King in the Illinois river in Oklahoma and Arkansas. So this is the Illinois river in Oklahoma and Arkansas, not the Illinois river in Illinois, which is a source of confusion when I try to tell my family about what I do.

Stephen Cook:

And the watershed that houses the Illinois river is special in a few different ways. And one of them is that it spans a pretty wide gradient of nutrient enrichment. There are some really pristine streams with very minimal human influence and there are some streams in that area that are, they're quite enriched, have elevated phosphorus concentrations due to human activities and everything in between. And Ryan was tasked with determining at what point or what concentration elevated phosphorus caused a shift in the algal species composition or algal biomass. And I was one of the graduate students assisting with that project.

Stephen Cook:

This paper came out of that. The larger study was a really fantastic opportunity for graduate students, like myself, to leverage that larger data set to answer questions of my own that I was interested in. Because the Illinois river watershed is really uniquely suited for conducting natural experiments to answer questions about how eutrophication is influencing freshwater communities. And we've kind of already alluded to it, but I love benthic macroinvertebrates, I think they're a really important part of the stream ecosystem and really interesting critters to study. So this paper grew out of, it was called the SRJS study, the Scenic Rivers Joint Phosphorus study. And this paper grew out of that and it primarily answers the question about how the benthic macroinvertebrate communities are being affected temporally by phosphorus enrichment.

Stephen Cook:

There's only one thing that you need to know to, you know, for listeners that don't study benthic macroinvertebrates or don't know a lot about them. There's really only the one thing that you need to know to understand this study and that is under natural conditions, a benthic macroinvertebrates are really seasonally variable and a lot of these critters are specialized to make a living and be effective competitors at certain times of the year. And the paper in ecology demonstrates and outlines how when you increase total phosphorus concentrations, you get declines in the amount of natural seasonal variation present in these macroinvertebrate communities. So you get more homogenous communities or communities that are more similar in time as phosphorus concentrations increase, which is a really cool finding and one that I wasn't necessarily expecting because I was originally thinking of this study

system kind of as a spatial question and not necessarily a temporal one. So it was kind of neat to see that.

Stephen Elser:

Yeah. Great. Thank you. So you mentioned eutrophication as one of the aspects that you were studying here. Can you talk a little bit about eutrophication? Can you define it for us? What is eutrophication?

Stephen Cook:

Sure. So eutrophication, at its core is basically just what happens when too many nutrients get into a system. So aquatic systems fall on a continuum of productivity and the level of nutrients available to organisms for growth is one of the primary controls on that productivity. And when I say nutrients, I'm talking about the big two, I'm talking about nitrogen and phosphorus. And on one end of the spectrum, we have systems where nutrients are pretty scarce. These are the really pristine streams in the Illinois river drainage basin, and these are called oligotrophic systems.

Stephen Cook:

And on the other end of the spectrum, we have systems where nutrients are much, much higher and these are called eutrophic or hyper eutrophic systems. So eutrophication is when the levels of nutrients in the water get to this higher level that they're too high and they elicit really large increases in productivity.

Stephen Elser:

Awesome. Thank you. You also mentioned, the title of your paper, you mentioned temporal beta diversity and you talked a little bit about ... You sort of defined it early on, but could you more explicitly tell us what exactly is beta diversity?

Stephen Cook:

Yeah, that's a really good question and one that's been kind of hashed out in the literature in recent years. Beta diversity as a whole has kind of become this umbrella term to encompass a bunch of different things and cover a bunch of different nuance. And beta diversity can mean a bunch of different things to different people, depending on the type of question that you're trying to tackle. But at its core, beta diversity just describes the amount of variation, community to community or assemblage to assemblage.

Stephen Cook:

So you have spot measurements of diversity. Let's just take it at its simplest level, just species richness. You can have a spot level of species richness at a particular place, at a particular time. And that's called alpha diversity. But that only gives you information about one particular site. What is a lot more valuable is comparing two different sites. And beta diversity captures the dissimilarity or the uniqueness of those two different assemblages or communities from each other. So high values of beta diversity indicate very different, unique assemblages and low values of beta diversity indicate more homogenous community. So they're very similar.

Stephen Cook:

In our study, temporal beta diversity was a really good way of quantifying assemblage variation through time. So how different is a site or a community from itself at different time slices throughout a study? And that's what the question that I was very interested in, because naturally benthic macroinvertebrates display quite a bit of seasonally driven variation in assemblage structure. So any changes to that could highlight losses in biodiversity that you wouldn't necessarily detect just by taking spot measurements of diversity or solely looking at alpha diversity.

Stephen Elser:

Thank you. That was an excellent explanation. So we keep talking about it, diversity, diversity, diversity in these streams. But why is it important that there is a highly bio-diverse community of invertebrates in streams?

Stephen Cook:

Benthic macroinvertebrates occupy a pretty important place in the stream ecosystem, kind of taking the big picture view. They're basically just little organic matter processing machines and they occupy one of the key links between basal resources in the stream and higher trophic levels. So in some stressor is causing shifts in how these primarily insects are structured. The infects don't just stay compartmentalize to that little group of organisms, and it's pretty well established at this point that biodiversity and ecosystem functions are linked and that when biodiversity declines, that's going to impact other processes going on in the streams such as nutrient uptake in cycling, detrital processing, energy transfer is up the food web.

Stephen Cook:

Biodiversity is important just by itself from that perspective. But as a scientist, they're an absolutely fantastic group of study organisms because within the macroinvertebrate group or the macroinvertebrate assemblage, there's a huge diversity even within that assemblage in the way that they feed and what types of materials they consume, what habitats they prefer, what time of the year that they're active and how they interact with each other. So it really makes them ideal when you're asking questions about how anthropogenic stressors are impacting biodiversity. It's a great group of organisms to look at.

Stephen Elser:

Great. Thank you. Finally, as we start talking about your paper, could you summarize your paper in the form of a haiku?

Stephen Cook:

Oh, goodness. Okay. Inverts partitioned time, add a little phosphorus, the partitions go away.

Stephen Elser:

Good enough. That's excellent. Thank you very much.

Stephen Cook:

Good enough? That was great.

Stephen Elser:

That was beautiful, improvised haiku.

Stephen Cook:

That was pretty bad.

Stephen Elser:

Very impressed. Okay, great. So you mentioned that your work in this paper was a part of a larger project called the Scenic River Joint Phosphorus study. Could you tell us a little bit about that? What's the history of the project and how it came to be?

Stephen Cook:

Absolutely. And this is a really interesting part of the story and it's going to take a little bit of a history lesson and a little bit of a law lesson. And I'm definitely not a lawyer, so bear with me. But the Scenic Rivers Joint Phosphorus study was put together by the Scenic Rivers Joint Study Commission, and its objective was to determine at what level of phosphorus enrichment do any of these statistically significant shifts in algal species composition or algal biomass occur that in turn results in undesirable aesthetic conditions in the designated scenic rivers. That's a mouthful. I totally understand that that's a mouthful, but it's important because Oklahoma has designated scenic rivers.

Stephen Cook:

And to kind of understand that, you need to understand a little bit about the structure of the watershed. So I mentioned that this was a river that spanned the border between Arkansas and Oklahoma. So the headwaters of this watershed originate in Arkansas. They flow across the border into Oklahoma. And once they do that, a lot of these waterways are Oklahoma designated scenic rivers, which affords them special protection under state statute.

Stephen Cook:

Another piece of this puzzle that you need to understand is that there are two main sources of phosphorus in this watershed. Northwest Arkansas houses, I think second only to Georgia, the largest density of poultry production in the United States and where you have lots of chickens, you have lots of chicken poop and it makes a really cheap fertilizer for people to spread on their fields in the pastures. But it's also very high in phosphorus, runs off, gets into the waterways. And that's one source of phosphorus loading to these systems.

Stephen Cook:

The other source of phosphorus in the Illinois river watershed is Arkansas. Northwest Arkansas is experiencing a pretty large population boom. You got three big cities up there, you've got a Springdale, Rogers, Fayetteville, and where you have a lot of people, you need a wastewater treatment plants. That's just kind of how it goes. And it just so happens that historically a lot of the, or quite a few of the wastewater treatment plants are placed on waterways like they normally are. But sometimes they've been very close to the border between Arkansas and Oklahoma, sometimes almost comically close to the border of Arkansas and Oklahoma. And that's not, you know, for many malice on Arkansas as part that's just where the population centers are located.

Stephen Cook:

So that's two big potential sources of phosphorus in this watershed. And all the way back to the 1970s, they started noticing algae blooms both in the Illinois river and in Lake Tenkiller, which is what the Illinois empties into. And Oklahoma didn't appreciate this. And this culminated in a Supreme Court decision. There was lots of litigation back and forth between Oklahoma and Arkansas. And this culminated in a Supreme court decision in 1992, where Oklahoma disagreed with the issuance of a permit, an EPA permit for a wastewater treatment plant facility that emptied into the Illinois river and sued and brought suit, and that went all the way to the Supreme Court. And the Supreme Court decided that the permit would stand like that was a valid permit. But the really important part of that Supreme Court decision is that it set the precedent that the EPA had wide latitude to interpret water quality standards and could take into account downstream water quality criteria in the issuance of their permits.

Stephen Cook:

And this was a big deal, like it acknowledged the interconnectedness of waterways and really acknowledged that, so if I have a stream going through my backyard and it originates in your backyard, Stephen, what goes on or what you do in your backyard has a direct influence on me and the part of the water going through my backyard. So it was really an acknowledgement of that. And it was really important for case law in the United States because if they hadn't found that water quality criteria in the United States, it would always be set by the lowest common denominator. And water always flows downhill. It's one of the big fixtures of life, you know, death, taxes, and water flows downhill. So it was a really important decision.

Stephen Cook:

And since that time, the two states have really been working together to reduce phosphorus loads, and this culminated in, it's called the Statement of Joint Principles. It's basically both states getting together and going, you know, like we need to stop the litigation back and forth. Let's both work together to reduce phosphorus loads to this watershed. We both care about the quality of the water, both states do. And they got together and appointed a joint study committee. So this was three experts appointed by the governor of Oklahoma and three experts appointed by the governor of Arkansas. And these experts got together and appointed an out-of-state third party. And my advisor, Ryan King, put together a great study and was selected to conduct the study. It was definitely to my benefit because I learned a lot from this and was able to collect some amazing data. I realize that's a pretty long history lesson, but it really has been going on since the 1970s, and has some really cool milestones along the way and it's culminated in this project.

Stephen Elser:

Yeah. Thank you. That was an excellent history lesson. I think you did a really good job introducing it. So you mentioned in sort of like the mission statement of this project was to determine at what point elevated phosphorus concentrations resulted in undesirable aesthetic conditions brought in by algae blooms. So could you talk about what's so undesirable about these algae blooms? Can you talk just about what it looked like when these blooms occurred?

Stephen Cook:

Yeah, absolutely. So the primary tax of concern in these waterways is a nuisance green algae called cladophora. It's a filamentous algae and it can really, really explode and bloom and proliferate at high levels of total phosphorus, and it will absolutely carpet the bottom of stream beds and you'll get these

huge long streamers of cladophora, sometimes feet and feet long that completely transform even like the physical structure of the benthos when clad really takes off. And when it gets grazed down, like it gets like these very thick mat, like these carpets of clad that look almost like shag carpet-ish. So the nuisance algae blooms can really, really result in some undesirable, I might even border on kind of gross aesthetic qualities and certainly affects a life that's living in the stream and the benthic macroinvertebrates, which are near and dear to my heart.

Stephen Elser:

Yeah, right. And also at this point, I'm going to say full disclosure, I was a technician on this project and I work alongside Mr. Cook here. And I remember in addition to, yeah, obviously having this big impact on macroinvertebrates and it being really nasty looking to speak more on that. Like we would regularly see folks floating down the river near some of our sampling locations. And like I could very much see how these big blooms could negatively impact recreational ecosystem services that the streams provide.

Stephen Cook:

Yeah, absolutely. This is ... I can't impress upon your listeners enough how beautiful of a watershed this is and how special this area of the country is. It's absolutely gorgeous. And like Oklahoma designated these state scenic rivers for a reason, they are a resource that is worthy of protection and preservation. So anything that negatively influences both wildlife conservation or outdoor recreational value is a concern. I was really glad that I could be a part of this project because I think two different entities or two different states getting together and saying, this is something that we want to address and we're going to do it in a scientifically defensible manner and we're going to listen to the recommendations that the team puts forth. I think it's a really a special thing that hasn't really happened a lot or at least to my knowledge hasn't really happened a lot in the past.

Stephen Elser:

Yeah, I agree. That is something that was really special about this project. Can you talk a little bit more about that in terms of how it felt for you to be a graduate student working on a project that you knew would have potential policy implications for the state?

Stephen Cook:

Sure. Yeah. It was kind of a sobering experience to be completely honest with you. I've been involved in research in the past that has effect on me. But contributing to a project that is directly going to influence public policy and nutrient criteria. I was very conscious of that. My advisor, Ryan King, did a very good job of one, designing and implementing the study, but two, involving his graduate students in this project but also insulating us enough from the greater study enough that we could concentrate on doing good science without necessarily having to worry about stakeholder meetings and standing up in front of those people. I think Ryan balanced those two needs very, very well. Like, hey, this is part of a larger project, but you also have the latitude to go out and do good science, ask interesting questions. So I was really lucky in that regard.

Stephen Elser:

Yeah. So you mentioned stakeholder meetings. Were there any other sort of outreach or communication efforts that the research team as a whole, or maybe Ryan more specifically took part in as a part of this project?

Stephen Cook:

Sure. You might have to have Ryan back on to get a really good detailed answer to that question. But just for my side of things, just talking to members of the community and kind of injected into that situation at the beginning, having some knowledge of it but not really like having a gut understanding of how long these issues have been discussed in that watershed. Everybody knows about these issues if you live in that watershed. So talking to people who live there and land owners, you know, streams go through land. And occasionally, we would encounter landowners who had a varying a degree of curiosity about the project. But talking to them and seeing just how important water quality was and how important the streams and the rivers in this region were to them was a very good experience, was a very neat experience. And communicating what we were doing, why we were collecting this data, how the benthic macroinvertebrate community could tell us things about the stream ecosystem as a whole. That was a very good learning experience for me.

Stephen Elser:

Yeah. This seems like this was a very impactful and large scale project. Did you encounter any challenges along the way, in field work or any other notable events that were a challenge that you had to overcome?

Stephen Cook:

Sure. I would say the one, like the paper that we were discussing earlier was concerned with the benthic macroinvertebrates assemblage. I would say the first challenge is not really understanding how large of an undertaking that was going to be when I first started. We had 35 sites in this watershed and we sampled every other month for two years, and those Hess samples add up really quick. And I can't remember, like you had mentioned that you were a technician on the project and really integral to processing these samples. I don't know at what sampling event we got a little bit behind, but the first challenge was just getting through and counting and identifying these samples in a timely manner. And I can't emphasize enough how much of a team effort that was.

Stephen Cook:

I wasn't the only graduate student working on the project. Lauren Housley also worked on the invert samples. You, Katherine Hooker and Morgan Vecher were awesome technicians. And if we didn't have you guys, I would literally at this moment still be sitting in front of a microscope picking and identifying benthic macroinvertebrates, So thank you so much. And that was kind of the first hurdle that we had to reach. And I can't think of any other like huge, giant hurdles that we had to cross and that's all credit to Ryan for really designing and doing some amazing site selection to answer the questions that we were interested in. Everything kind of goes smooth, everything is more smooth. The more work that you do before the study actually starts. So credit to Ryan for that.

Stephen Cook:

We did have a large 500-year flood towards the end of the study, which really just completely moved some of the streams in their path. This was kind of a unique experience for my career because it's the first time that I've gotten to go back and go to the same sites again and again and again and see just how variable stream ecosystems are. So the 500-year flood was a hurdle, but also a really good opportunity to see how these communities respond to semi catastrophic scouring event and how the successional patterns afterwards.

Stephen Elser:

Yeah, great. It really was cool me visiting those same again and again throughout the years and seeing how during some sampling events the stream would be down to a trickle, barely any water at all. And then two months later, it'd be huge. It would be like 30 or 40 meters across and roaring. So I think that was a really cool part of the project, to see how much influx the stream ecosystems really are.

Stephen Cook:

Yeah, absolutely. And a lot of these since the paper, we were talking ... My paper deals with the temporal component. Any temporal change that we saw was a really interesting part of the story of that ecosystem for me. And these are, most of these streams have perennial, they have base flow year-round. But you're right, the changes in hydrology season to season and the changes in the community I think are a really interesting and understudied part of what's happening in these streams' ecosystems.

Stephen Elser:

Okay, great. That's all that I have for you right now. Is there anything else that you'd like to say about stream eutrophication and how it impacts macroinvertebrate diversity or anything else about the project that you want people to know about?

Stephen Cook:

No, I think those were excellent questions and I really appreciate the opportunity to talk to you about it.

Stephen Elser:

Yeah, anytime. Thanks for joining us.

Stephen Cook:

Thank you, Stephen.

Outro:

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