Intro:

You're listening to Making Waves, fresh ideas in freshwater science. Making Waves is a bi-monthly podcast where we discuss new ideas in freshwater science and why they matter to you. Making Waves is brought to you with support by the Society for Freshwater Science.

Eric Moody:

This is Eric Moody with the Society for Freshwater Science, Making Waves podcast and joining me in this month's episode is Dr. Erin Hotchkiss, who is an Assistant Professor in the Department of Biological Sciences at Virginia Tech University of the famous Stream Team. Excellent place to do stream ecology. So thanks for joining me Erin.

Erin Hotchkiss:

Great, thanks. Happy to be here.

Eric Moody:

And, Erin is also the 2017 recipient of the Society of Professional Earth Sciences Hynes Award for New Investigators. Specifically, you received for your 2015 ecology paper, Hotchkiss and Hall, which will be linked to the page for this podcast. And so we'll talk about some of the work that that paper focused on and what sort of has happened since then. To the person who doesn't study freshwater systems, you may assume that most energy that supports food labs comes from the algae and the plants that are growing within those streams and lakes. But in fact, freshwater scientists have often focused more on terrestrial resources. Like, you have decided to really start looking at those aquatic resources and what happens to them. So why don't we think that those aquatic plants are more important or why traditionally have we not studied it?

Erin Hotchkiss:

And so, interesting question. Stream ecology has kind of had this long history of thinking about the importance of external or terrestrial dry material and fueling the food webs. I think, some of that has been somewhat of a bias of some of the ecosystems that we're studying. So if you go to small streams in like Hubbard Brook or Coweeta, you see there's basically no white, when leaf fall happens, you can't see the stream anymore and you see these really strong correlations between invertebrate bio-mass and leaf litter that's present in the stream. And so we know that in those ecosystems, and even in more open algal still ecosystems, we know that terrestrial dry material is really important.

Erin Hotchkiss:

But there seems to be some limits in terms of how much biomass in aquatic ecosystems can be supported by terrestrial dry material alone. And it seems like a lot of the consumers that we study require some proportion of algal material to build their bio mass and to reproduce. And so, just quite the importance of algal carbon in kind of these basal functions in streams and lakes, we don't really know a lot about where the carbon goes after the algae fixes it through photosynthesis.

Eric Moody:

Yeah. So you mentioned carbon specifically, so why should we care about what happens to carbon in aquatic ecosystems? Why is it so important?

Erin Hotchkiss:

Right. Definitely, I've had a carbon bias in my research. I want to put out a plug for those to think about other elements as well. I think stoichiometry is really important, but I focused on carbon for a lot of my research because it's really kind of the building block, as we learn early in biology, for a lot of those important functions. And so when I think about carbon, I think about, what is there in terms of both carbon dioxide and organic material, is really setting the stage for growth and reproduction of organisms in the stream, as well as a lot of bio geochemical functions that we're interested in. Whether it's linked to nutrient transformations or also focusing on carbon or methane emissions from the stream.

Erin Hotchkiss:

I think going beyond, just saying what's there and thinking about what happens is really important because if we were to just study concentrations, we would think that not much is happening, right? It looks pretty constant for a lot of nutrients and carbon, but by studying what happens or the transformation for carbon in streams, we're able to see what these energy or nutrient transformations are that are happening and are contributing to changes in water quality by mass emissions, all sorts of different things that we care about in fresh waters.

Eric Moody:

As a stream ecologist, I often think that if you don't find much of something in an ecosystem, that may actually be even more important. Would you say that it's sort of the same thing with carbon in the places you've been working?

Erin Hotchkiss:

It's kind of this tricky thing that we deal with in that, if we go to a site and we see a lot of one thing and basically nothing of something else, it could either mean that nothing of something else really isn't important or it could mean that it's taken up so quickly, right, that we have no chance of ever measuring it in the water column. And, I think it's that second case that I like to at least think is the true case for a lot of ecosystems. I think that's not always the case in terms of what we see as carbon, just because carbon is so much more complicated than a lot of the other elements that we study and that it's in all these different structures of organic molecules that span a range of simple sugars to really complex lignins.

Erin Hotchkiss:

For example, if you go to a boreal stream, the water is brown, there's a lot of carbon, but we still find some of these streams to be carbon limited. The carbon is not in a good form for things to use it, right? It's not in a very accessible form for microbes to take up. But along the same lines, if you go to oil streams and you measure nitrogen or phosphorous, it's super low and some people say, Oh that makes it not interesting. But I would argue that it makes it super interesting in that things are probably really struggling to make a living in some of those streams.

Eric Moody:

All right, so let's talk about the 2015 paper. So in this paper you looked at a particular stream in Wyoming and really tried to understand what happens to this carbon that's fixed by algae in the stream after doing some carbon additions. So I guess to start with, how did you actually determine what happens to algal carbon? Because it seems like you use some pretty interesting methods.

Erin Hotchkiss:

You know, a lot of the studies that we use to understand what happens to algal carbon are just based on net fluxes. We can measure rates of gross primary productions. We change the oxygen or carbon in the stream. But that doesn't really tell us where that primary production ends up, right? And, we can scrub rocks, but we don't really know how much of those rocks are actively photosynthesizing and we don't know how much of that algal carbon has already gone somewhere else before we struck the rock. So in order to try to get at this question of where is that CO2 that's fixed by algae ending up in the stream, we added a stable isotope tracer to essentially target what the algae would fix, which is CO2 during photosynthesis. So algae fixed CO2 during photosynthesis, they convert it into organic material and respire some of it. And by using a stable isotope tracer, we changed the ratio of 13 to 12 carbon in a way that we could identify the amount of that tracer that was fixed by the algae, as well as where that 13 C ended up after being fixed through photosynthesis.

Eric Moody:

You applied these methods to this reach in a stream in Wyoming and what exactly did you find happened to this algal carbon after it was fixed?

Erin Hotchkiss:

We were able to trace the carbon in a way that we couldn't just from ambient measurements and metabolism alone. And we found that about 30% was lost really, really rapidly in terms of after being fixed by algae during photosynthesis, a whole bunch was respired, so about 24% was respired within the matter of hours. But, a lot was actually leached out as dissolved organic carbon. So we know that this is something that algae do that we think is a really good food source for microbes. And so, there seems to be the short term either lost as respiration. So remember algae respired and, or lost as organic carbon, which we think is a really good food source for other microbes. So that's kind of the zero to three day time span of what was fixed. Beyond those three days, we found kind of a longer term space on the stream bottom.

Erin Hotchkiss:

And so, this is when we think higher consumers and hydrology played a key role in determining the fate or how long that carbon sticks around. So shortest residence time, the stream bottom carbon, in terms of how much and how long stuff stuck around after being respired or leaked out as DOC, Dissolved Organic Carbon, was 49 days and the longest stuff stuck around was 114 days. And that was in prime particulates, which is probably a lot of decaying algae that sits on the stream bottom until it's washed out with higher flows. So even though this is a longer term fate, it's still less than a year. So it kind of points to really rapid cycling of carbon after it's fixed and not a lot of time sitting around on the stream bottom for invertebrates and fish to consume it.

Eric Moody:

Yeah, that was the most surprising thing to me was really how fast everything seemed to disappear.

Erin Hotchkiss:

Yeah. Luckily the algae are always photosynthesizing, right?

Eric Moody:

Yeah.

Erin Hotchkiss:

So, rapid kind of fixation and loss cycle that's happening in the stream. And this is a stream, I should mention, that was pretty open canopy. And so we think that most of what's happening in that stream in terms of biological processes is really ruled by what's happening with algae.

Eric Moody:

Yeah. So continuing on that theme, you've done some more work across a broad range of streams, trying to understand how important this sort of algal carbon versus terrestrial carbon is and what kind of patterns did you find at a broader scale? Was this stream in Wyoming typical or did you find some other interesting patterns?

Erin Hotchkiss:

The stream in Wyoming is one of those types of streams that I think is relatively understudied in terms of how we think about what streams do in broader carbon cycling. So in the nature geo science paper, we used rates of metabolism to identify the role of streams in producing CO2 that was then emitted to the atmosphere. And so, it's actually kind of a disconnect from the ecology paper in that anything that the algae is doing, by definition, we would assume as kind of like a net zero in terms of carbon emissions, right? So algae fixed CO2, and we assume that most of that carbon that algae fixed will eventually be respired somewhere either by the algae themselves or by a consumer that eats the algae or by decomposers that are breaking down the consumers.

Erin Hotchkiss:

When we think about the role of streams in some of these broader carbon budgets, especially in terms of CO2 production, then that becomes mostly about the terrestrial derived carbon, right? So streams can only be net emitters of CO2 when they're breaking down and producing CO2 from external sources that weren't already fixed within the stream itself. So yeah, a big shift. And I think a lot of that came from, so, I was working in these open streams in Wyoming where it was all about the algae and thinking a lot about what happened downstream and how that may mitigate the amount of terrestrial material that the things consume. But then I moved to Sweden where the water was brown and started, there was no visible algae in any of the streams or rivers, and started thinking a lot more about when can streams contribute to these larger sea budgets? And I think a lot of that has to do with when they're doing stuff with terrestrial or external carbon.

Eric Moody:

So then what do you think is the next step in terms of what should we do to understand what's happening with carbon dynamics and streams?

Erin Hotchkiss:

There are so many things, which is why I haven't let go of carbon yet.

Eric Moody:

That's a good answer.

Erin Hotchkiss:

It's still a really exciting field of research. I think, some of the biggest advances that are going to come beyond just looking at different types of systems that are relatively under studied is really thinking beyond the system boundaries and beyond anaerobic processes and also accounting for temporal dynamics. Those are kind of three things that I'd like to briefly talk about. One is, beyond ecosystem boundaries. So we're able to say we were able to account for basically 100% of the 13 C that we added in this mountain stream, which was pretty surprising. But, a lot of that included downstream export, right? And so we didn't really know what happened to it beyond the boundaries of our study reach. And I think that's the case for a lot of the stream research that we do and even a lot of the lake research that people do, right?

Erin Hotchkiss:

So you have an ecosystem that you set the boundaries and you know how much is coming in and what happens when nutrients and carbon come in and you can account for biological processes within those boundaries that you're studying, but you don't really think about what happens when things leave those boundaries and what the implications are. So I think kind of going up in scale, I'm thinking about upstream, downstream linkages as well as flood plain channel linkages. You know, we talked about this for many years, right? From river continuum to flood polls, but I still don't think we're doing a very good job with that at the ecosystem scale in terms of carbon cycling. So thinking about, what needs to enter the headwaters to support river processes, I still don't think we can really articulate that in terms of numbers or mechanisms. Most of our metabolism data is from oxygen, which means we've totally ignored any anaerobic processes.

Erin Hotchkiss:

We know that streams are sources of methane and we don't really account for that in most of our studies. And a lot of our studies are from single seasons or single periods still. And so, if we're really going to link ecosystems and study things at a network scale, you have to account for how things change over time and how water moves differently during high flow and low flow periods and what those temporal dynamics mean for the types of carbon that are coming in and the fate of that carbon. And, I can keep on going on and on.

Eric Moody:

Yeah.

Erin Hotchkiss:

There are lots of, lots of things to think about, but I really think going beyond our reaches, thinking about anaerobic processes and acknowledging that things change over time are really critical for moving the field forward. One thing that I'm excited about now that's coming up in the near future is, so you know, I'm still working a lot with carbon. I have some undergrads and grad students who are rebelling by thinking about nitrogen. So, I'm excited about that avenue of research as well.

Erin Hotchkiss:

But, I'm starting a project, it's already started, but the experimental component won't start for another year or so, where we're looking at predicted effects of climate change on organic matters, cycling and streams. And so, I think the more experimental design that we can come up with that allow us to test how some of these basic functions will change either in a warming environment or a more hydrologically unpredictable environment, I think are going to be really, really important next steps as well. So we're experimentally warming a tiny stream in Coweeta with John Benstead, Amy Rosemond, Ashley Helton, Vlad Gulis and hoping to be able to identify how that changes the residence time of this terrestrial organic matter. And so, kind of going back to the importance of terrestrial dominated carbon and how that means shift in a warming world.

Eric Moody:

It sounds like there will be many exciting products coming out of the Hotchkiss lab for years to come?

Erin Hotchkiss:

Yeah. Hopefully other labs too. We can't do it alone. Yeah, no, it's been a lot of fun to think about what's next.

Eric Moody:

I did want to ask you, studying carbon and streams seems like a pretty specific thing to focus on. How exactly did you get interested in this topic in the first place?

Erin Hotchkiss:

I don't really know when the switch happened. I mean, as many stream ecologists will tell you, I've always liked hanging out by streams. I've always liked water. I pursued those interests as a research tech for Jen Tank's lab as well as Cathy Pringle's lab when I was an undergraduate. But the work that I did with both of those groups was largely nutrient focused. So in Jen Tank's lab, they were working on some of the links projects and thinking a lot about de-nitrification and nitrification. And when I worked with Cathy Pringle's group as an RAU and more specifically with Marcelo Ardon, where we're doing a lot of nitrogen and phosphorous work in Costa Rica.

Erin Hotchkiss:

So I think something that kept on coming up from those nutrient specific studies is that, organic carbon mattered, right? In terms of the rates of those nutrient transformations. But despite that, when I looked back a while ago at my old grad application letter to work with Bob Hall at Wyoming, I think I still wrote like I am interested in doing nitrogen work and I knew I was interested in working with Bob because he was good at thinking about what streams do with elements, right, in terms of biological processes. And learning more about that, metabolism just became this really interesting thing to study from my perspective in terms of thinking about how we can use this ecosystem scale measurement to understand energy transformations in streams. And so, carbon became kind of a centric metric from that perspective.

Eric Moody:

Thanks a lot for taking the time to talk with us today.

Erin Hotchkiss:

Sure. Thank you.

Outro:

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