

Intro:

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Eric Moody:

Welcome to the Making Waves podcast. This week I'm joined by Dr. Amy Burgin, an Associate Professor at the University of Kansas in the Ecology and Evolutionary Biology and Environmental Studies departments, as well as an Associate Scientist at the Kansas Biological Survey.

Eric Moody:

So thanks for joining me, Amy.

Amy Burgin:

Happy to do so.

Eric Moody:

So the theme of this week's episode is eutrophication, and this is an issue we hear a lot about in terms of water quality and restoration and things of that sort. So I want to first start by asking you what exactly is eutrophication?

Amy Burgin:

So eutrophication is the buildup of biomass, of usually algae or cyanobacteria in lakes, is mostly how we refer to it, as a result of excess nutrients in the environment. So it's a particularly pressing issue in highly modified landscapes that have a lot of human activity in them, as we find in the Midwestern United States.

Eric Moody:

Right. So we, for example, we were just at the Great Plains Limnology Conference at the University of Kansas, and this is a big issue for people working in this region. Why is it so prevalent in the Central US?

Amy Burgin:

I think that's in large part because states like Iowa, for example, are some of the most modified landscapes in the US. Something like less than, I want to say it's less than 3% of the original landscape of Iowa, which was mostly prairie and forest remains, and most of it has been converted to human use of some kind, either urban or a large part of it is in agriculture.

Amy Burgin:

And with those activities comes great modifications to the biogeochemistry. You have a lot of changes in how plants and soils interact. Especially when you do things like tilling, that can increase the amount of sediment that is transported, if you don't have those native and intact plant communities. Sediment can wash off with rain events into streams and rivers, and then eventually into lakes and reservoirs, and buildup with that sediment comes a lot of phosphorous.

Amy Burgin:

We also have big modifications to the nitrogen cycle. Something like 10 times as much nitrogen is applied to fields as falls from the kind of natural deposition from the air to the soil, and so that additional nitrogen, in the form of fertilizer, also readily runs off when we have a lot of rain events, especially extreme precipitation events. And so all of this leads to modifications in the biogeochemistry that can impact the amount of nutrients in aquatic ecosystems.

Eric Moody:

You've done a lot of work lately on what you call the weather whiplash and how that's sort of making this problem worse in these agriculturally impacted watersheds.

Amy Burgin:

Right.

Eric Moody:

Could you talk about what the weather whiplash is and why it's a big problem?

Amy Burgin:

We started working on this when the Midwestern US was in an extreme drought in 2012. It was one of the most extreme droughts that we had on record. I remember driving in Western Nebraska out to the Niobrara River, which is a beautiful groundwater-fed river that has relatively stable hydrology, but in getting out there, we had to cross the Platte River. And at that point in September of 2012, the Platte River was completely dry. You can't look at what should be a river as an aquatic ecologist and think, "Well, the fact that there's no water there, that really has to be changing things." Not just for the food webs, but also for the transport and transformation of nutrients in the system.

Amy Burgin:

And so we got to thinking about how this complete drying of the Midwest in 2012 was going to impact how much nitrogen was moving into streams and rivers, and then eventually out into the Gulf of Mexico, where it's a factor in what we call this reoccurring issue of the dead zone in the mouth of the Mississippi River.

Amy Burgin:

So we had talked to a program officer at NSF and said we were really interested in this as a natural experiment, in that the modification of the landscape due to the drought was going to eventually bring a lot of nitrogen into the rivers on a scale that we could not possibly experimentally replicate. So we asked if we could have what's called a rapid grant to study this eventual mobilization of the nitrogen coming into the streams and rivers.

Amy Burgin:

That was funded, and indeed, the nitrogen did come into the streams and rivers in a way that we couldn't have predicted when we got the funding from the rapid grant. In fact, the spring of 2013 was one of the wettest in history. And so that extreme flip between that drought of 2012 and the extreme floods of 2013 was dubbed in the national news media as weather whiplash. The scientists that I was working with on that group, which included Terry Lucky, Diego Rivas, Adam Ward, Steve Thomas, we

kind of latched on to this idea and thought it was a really clever term, started wondering how we might quantify that.

Amy Burgin:

So we looked at it as a change in the precipitation between two different periods of time, as is described in the paper. So what we were able to show in this paper, was that weather whiplash has been increasing over time, and indeed, this is what's predicted for the area with increasing climate change. That we'll have more extremes in precipitation, that we'll have drier periods, mostly in the summer and into the fall, and wetter springs especially.

Amy Burgin:

What we were also able to do in this paper, is show that that increase in weather whiplash, in areas of Iowa in particular, is linked to an increase in the amount of nitrogen coming into the streams and rivers. And so this is particularly bad in Iowa where there is a lot of nitrogen already and it presents a water quality issue, particularly on the drinking water side of things. So as we have increasing weather whiplash, we will have increase in the amount of nitrogen, which means that big cities like Des Moines, that already have to remove nitrogen to meet the drinking water standard, might have to pay more for drinking water as a result of changing climate and intensification in the landscape.

Eric Moody:

We already have plenty of nitrogen here.

Amy Burgin:

Yeah.

Eric Moody:

So we've talked about how changes in land use and changes in weather patterns can influence nutrient loading and eutrophication, but are there natural cases of waterways that we see being eutrophic or becoming eutrophic without these influences of humans?

Amy Burgin:

Yeah, there certainly some water bodies are more naturally eutrophic than others, absent the amount of human modification. There're some kinds of water bodies that just by their position in the landscape, as receivers of nutrients, are more eutrophic. But certainly, the human activities have exacerbated the problem, particularly in areas of the Midwestern US.

Eric Moody:

Change gears a little bit. As you've mentioned, eutrophication can have a lot of negative consequences for drinking water quality, for recreation, and fisheries, and things of that sort. And so it's costly and obviously something that resource managers would like to mitigate or prevent. But a lot of management techniques that have been used such as adding alum or trying to reduce phosphorous loading, don't actually tend to improve water quality or restore ecosystem function in these systems, and you've done work on several of these different problems.

Eric Moody:

So I'm curious, why do you think that they're so difficult to manage?

Amy Burgin:

I think they're so difficult to manage because we often lacked the political will to make very difficult decisions about about how to manage them. From a scientific perspective, we have a pretty decent understanding often, that if you control the sources coming into an aquatic ecosystem, you can help manage the issue. The problem is that most of these sources are what we call nonpoint source pollution. There are very, very limited tools to manage and regulate them. And so what it really comes down to, is a lot of voluntary efforts, and that's a very diffuse kind of thing to try to implement, to get a bunch of people on board in the same mission with relatively few regulatory tools around how to do that.

Amy Burgin:

So oftentimes, these kinds of situations we know what we can do, it's just really, really difficult to make the decision. And those decisions are often not made on science alone. As a scientist, I can come out and do a phosphorous budget for a lake or do some calculations about how adding alum might change the internal dynamics of phosphorus in a lake, but if we know it's still coming in from the watershed, anything that we do, like alum, that you mentioned, is really a bandaid. It's not addressing the root of the problem and that's a much stickier thing to try to solve. And science is only part of that conversation. You have to pull in policy and economics and a lot of politics usually in those kinds of conversations.

Eric Moody:

Yeah, I like that analogy because really, I feel like we're often just trying to treat the symptoms rather than the underlying cause when we do these types of management activities.

Amy Burgin:

Absolutely.

Eric Moody:

So what do you see is the future? Do you think that we can tackle these issues or is that too broad a question for you to answer right now?

Amy Burgin:

I hope so. I mean, I joke a little bit tongue in cheek that it's job security, right? We're going to keep having these kinds of problems, I think, into the future. I think it's promising when we see conservation efforts that are trying to go to farmers that have multiple [inaudible 00:10:22]. So Dr. Bonnie McGill, who is now a postdoc in my lab, is working on a Smith Conservation Fellowship, in part to try to understand this, how conservation, basically whether conservation can keep up with this changing water quality that we predict with changing climate. Whether we can basically implement conservation fast enough to help offset what we know will be a water quality problem with changing climate into the future.

Amy Burgin:

But these are really difficult things to study too. Some of the data, rightly so, around conservation practices is very closely guarded with regards to who is doing what on individual pieces of land, and that

can make it very difficult to study at the watershed scale. So we're trying to go after it with some remote sensing and some collaborations with USGS scientists that have different kinds of access to types of data.

Amy Burgin:

But also trying to understand humans as a piece of this is important too. Some of her work will focus on farmer behavior. A big piece of what we don't know is how farmers will respond to these wetter springs and drier summers, whether they'll change how much and when they apply nitrogen, and how that might interact with and feed into some of the problems we see. So it's not just getting implementation of conservation practices at the field scale, it's also trying to understand farmer behavior and how that is going to be effected and change us in response to changing climate.

Eric Moody:

These complex issues really need a sort of integrative, complex approach to solve them, I think.

Amy Burgin:

Yeah. Exactly.

Eric Moody:

You also do a lot of work just studying how these really eutrophic systems function.

Amy Burgin:

Right.

Eric Moody:

Your laboratory group focuses a lot on microbes in particular. Why do you think it's so important to study microbes to understand ecosystem function in these types of rivers and lakes?

Amy Burgin:

They're the engines that drive most of the transformations that we study and call biogeochemistry. They're responsible for a lot of removal processes that we're trying to understand that can help mitigate some of the issues related to high nitrogen loads. They're also the receivers of all of this.

Amy Burgin:

So many hyper-eutrophic systems are dominated by cyanobacteria, another microbe that grows, and so understanding how they thrive in these rich systems, how they make their living, and how they modify that landscape, that lake or that stream, is also important because that's going to affect how humans can use it, how humans can interact with it.

Eric Moody:

One of the really interesting things that you're working on now is this study in the Kansas River. What's the site called again?

Amy Burgin:

It's the Farmland site. It's a former fertilizer plant. Yeah, so this was a great example of serendipity in science. I remember when I was an REU student, I was an REU student in 2000, at what was then called the Institute of Ecosystem Studies, is now the Cary Institute, and I did my REU at Hubbard Brook and we had a tour of Mirror Lake by Dr. Gene Likens. I was really young, I was a sophomore, caught between my sophomore and junior years, and I just remember him telling us about the role of serendipity and science, and being very befuddled by this because the science seemed very logic-based and like you move on a natural progression. So this idea that serendipity played into it was, I don't know, confusing to me at first.

Amy Burgin:

But getting back to your original question about farmland, now as a scientist, I totally see how sometimes experiments and opportunities arise that you couldn't possibly predict. So this past, about a year ago, fall, I got a text from the river keeper, the Kansas River keeper saying that the city was going to start releasing a lot of nitrogen into the Kansas River, a lot of high nitrogen water, and did I know anything about it? No, I had no idea. It turns out that the city of Lawrence had acquired this former fertilizer plant property that had operated for about 50 years and they were developing it into a venture park.

Amy Burgin:

So they basically acquired this land for very little money and were using it because it was a piece of prime real estate between Lawrence and Kansas City. It just so happened it came with a bunch of high nitrogen water on it, about 30 million gallons of water that contained about, on average, 600 milligram per liter nitrate and 300 milligram per liter ammonium. How they were storing this was in danger of running off or breaking or having an uncontrolled flow. And so they had petitioned the State of Kansas to be able to do a controlled release to basically get rid of it in a way that would help open up some of their reserves.

Amy Burgin:

So I saw this and got to thinking about it as a really unique opportunity. In the Kansas River, they were going to release a bunch of nitrogen at a scale at which I, again, could not experimentally replicate, but they were also releasing unique microbial signatures into the water. These ponds that were holding the high nitrogen water had basically been enrichment cultures for high nitrogen loving bacteria for for decades.

Amy Burgin:

So I collaborated and partnered with my colleague Lydia Zeglin over at K State, who's more of a microbial ecologist, and we thought this just presented a really unique opportunity to study not only what happens to the nitrogen cycle, what happens to that nitrogen as it's released into a large river, but also how changing the microbial community of the river might also help understand the processing of that nitrogen as it moved downstream.

Amy Burgin:

So again, we went to NSF with a rapid proposal, arguing that this was a unique event that we couldn't possibly replicate experimentally. And indeed it was. We spent a lot of the spring and winter out doing fieldwork when I'm not accustomed to doing fieldwork. Much of that conducted by my graduate student, Michelle Kelly, and a technician at K State, Janaye Hanschu. They floated down the river every

other week and collected samples. We did a bunch of nitrogen cycling process assays. We did a 24-hour experiment at a couple of points along the river to try to get at full river de-nitrification. So really trying to come at this question using a variety of methods and taking advantage of this unique opportunity to do a big scale river experiment.

Eric Moody:

Yeah. So it seems like you've been really good at taking advantage of these types of opportunities as they come up, like with the weather whiplash.

Amy Burgin:

Yeah, serendipity.

Eric Moody:

All right, so is it just being in the right place at the right time or how would you advise a young scientist to take advantage of these sort of opportunities?

Amy Burgin:

That's a great question. I think that's some of it. I think knowing the field and knowing where there are gaps, and then being able to see an opportunity as a way to fill a gap is a key skill in science. For both of these, I feel like we were able to go to NSF in part because we had that context for where the field was and how this potential event could help fill an important gap in ecosystem science. For both of them, I also felt comfortable going to a program officer and talking to them about the idea, either I did or Lydia did, to get these kinds of proposals rolling.

Amy Burgin:

I think that's another key message for early investigators, is that program officers, in my impression and experience, like to talk to people about these kinds of things. So you shouldn't feel like you're bothering them when you have an idea like this. It's appropriate to write up a short email, attach a one pager explanation of what you think this thing could be, and just start that conversation. That's how you get these balls rolling.

Eric Moody:

Thanks again for talking to me.

Amy Burgin:

Sure. Happy to.

Outro:

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