Erin Larson:

You are listening to Making Waves, fresh ideas in freshwater science. Making Waves is a bimonthly podcast where we discuss new ideas and freshwater science and why they matter to you. Making Waves is brought to you with support from the Society for Freshwater Science, Arizona State University's School Of Life Sciences, the University Of Washington School Of Aquatic And Fishery Sciences and Cornell University's Ecology And Evolutionary Biology Department.

Erin Larson:

Welcome to Making Waves. I'm your host, Erin Larson and today I'll be talking with Dr. Jonathan Tonkin. Jonathan is currently a postdoctoral scholar at Oregon State University and his research interests focus on figuring out how biodiversity is maintained at multiple scales, integrating both empirical and computational approaches. Welcome to the podcast, Jonathan.

Jonathan Tonkin:

Thanks. It's great to be here.

Erin Larson:

We're glad to have you here. So I wanted to start it out talking a little bit about some of your recent work and you have a bunch of interesting papers that have come out in the last year, but I'd like to specifically start by talking about your recent paper in Ecology titled Seasonality And Predictability Shaped Temporal Species Diversity. Temporal dynamics are often ignored or thought to be too difficult to incorporate into empirical work. And then as a result, we often use space for time substitutions or assume that in dynamic systems, a one onetime sampling can capture what's happening and in your paper you talk about how adiabatic predictability can shape temporal biodiversity. Can you tell us a little bit more about the goals of that project?

Jonathan Tonkin:

Yeah, sure. So we set out to sort of explore the way that seasonality can affect biodiversity in general, but with the additional idea that while the extinct of seasonality can vary, wherever you are on the planet. So ranging from really highly seasonal environments through your aseasonal environments. So can the predictability of the environment as well. So we essentially consider seasonality environmental predict abilities separate entities that shape and regulate biodiversity. So in the paper we focused in on temporal biodiversity or temporal species diversity. So this is essentially the turnover or the change in communities from one time point to another and we set up some hypotheses based on the environmental seasonality and predictability and it seems to be how it regulates temporal diversity.

Jonathan Tonkin:

Think for instance of a highly seasonal environment, if it's not predictable at seasonality, then organisms are not able to sort of evolve like history segregated niches out in time within a year to capitalize on those environments. If you have a highly seasonal and predictable environment then species are able to sort of diverge their niches in time and separate their niches in time to sort of form and focus in on different times of the year. So think for instance of a better training system, but you have a better training strain and there's been some really great work in California from Vince Garin and his colleagues.

Jonathan Tonkin:

There the seasonality is so predictable that enables species to diverge their niches between different times in the year. And so if you look at a historical hydrograph or a rainfall record, you can see this real strong cyclicality from one season to the next and it repeats from year to year. And so that enables these species to diverge their niches and you can actually see this with the macroinvertebrate communities and we have two distinct communities and time within a year in the exact same location.

Jonathan Tonkin:

So you have mayflies staying pleasant caddisflies dominating in winter where it's colder and the water's clearer and the river cooks down a strange cook down and get much warmer and sort of less clean I guess. And you have OCH or Odonates, Coleoptera, and some Hemipterans. And so that sort of suggests that highly predictable seasonality sort of promotes the greatest temporal species diversity. And we don't have the predictability. You have much lower. On the other hand, if you have high predictability of environment but it doesn't change throughout the year, then you might expect to have high alpha diversity and sort of a tropical system where you have a lot of species packing into a location. But if you go different times in the year, the community's going to be pretty similar. So you have high alpha diversity, but low typical beta diversity.

Jonathan Tonkin:

And at the very end of the spectrum, you have aseasonal unpredictable systems where you might expect low alpha diversity and also low variability in time. So we set up this framework to taste these hypotheses and we develop methods to sort of quantify and we use methods to quantify seasonality and predictability using cold wells wavelets methods that... I won't go into the detail on those. And so we use a bunch of data from around the world to sort of look at these seasonal and critical environmental aspects.

Jonathan Tonkin:

But also we use three study locations around the world to sort of explore the stream and vertebra communities as well. So we use some of the data from California and where it's highly predictable Mediterranean and we expected that these would have the highest level of temporal beta diversity. And then the other end of the spectrum, we chose data from New Zealand which is like an island-nation in the middle of the ocean and the Pacific ocean where it's sort of at the mercy of big frontal storms coming out the ocean on a regular basis. So while it's sort of seasonal, it's sort of more muted, that seasonality, we have warmer summers and colder winters and more rain fall in the winter than in the summer, but we can also have a big flood at anytime of the year because of the storms that come in.

Jonathan Tonkin:

And then in the middle we have Arizona streams, which sort of more seasonal and predictable but less than California. They had these two rainfall pulses throughout the year. They have a winter frontal storms and they have summer monsoons and so we expect that they will be intermediate in terms of the turn over and the New Zealand strains will have much lower turn over and it came out as we predicted. You had the highest level of variability of temporal species diversity in the California streams and the lowest in New Zealand. And looking at it from an ordination graft, if you're familiar with that sort of approach, you see that this real back and forth in the California systems between these two distinct communities and it repeats over and over again. Whereas in the New Zealand case it's much more variable, it's just this sort of scattered massive points.

Jonathan Tonkin:

So thinking about what it all means. I guess it's really important to have an understanding of all of the sort of environmental team play the equal streams that that's sitting in. If you have these really seasonal and predictable environments, like in the Mediterranean systems, you go and sample them at one point in time where it's for basic despicable for some sort of applied approach. Whether it be for blind monitoring, you could really undervalue biodiversity. If you go and sample once, then you're going to have potentially half of the actual biodiversity that's situated in this stream because the other half turns out later in the year. And if it's for a much more unpredictable system, like in New Zealand, the new streams could all be at a different stage of post flood recolonization. So it's really fundamental to have an understanding of what's going on.

Erin Larson:

Great. Yeah. So one question I had for you is, I was interested in the finding that you guys had that turnover rather than nestedness was what was driving some of those temporal diversity patterns. And I was wondering if you could describe a little bit more the difference between turnover and nested ness for folks and why that is a potentially important result.

Jonathan Tonkin:

Yeah, sure. So turnover is essentially replacements of communities and time. So you can have the biodiversity, which is variability between different communities, but it can be structured through, it's usually through turnover or through messiness. So turnover is replacements of species in time or in space and nested ness is species at one point in time or in one point in space or a subset of those found at different time or location.

Erin Larson:

But one of the things that you guys write in your papers that you hope that this paper will, and I'm quoting here, "spark renewed interest in the role of seasonality" and so you've mentioned already that folks should think about sort of when they're sampling and are there any other suggestions you might have for scientists who study dynamic systems like streams in terms of how they think about incorporating temporal scales into their work?

Jonathan Tonkin:

Yeah, that's a really tough question to answer because the easiest answer is to say that we really need to be incorporating typical dynamics in our sampling. But often that's really cost or time prohibitive. And so I think at a minimum it's really important to have a really strong grasp on the system that you are studying. And so like I said, if that's a Mediterranean system, then you need to realize that if you go at a particular time in the year, you're really getting half of the wide diversity that's there and like in a New Zealand stream or other sort of flashy system, you need to have a grasp on the antecedent flood conditions and the community's role potentially at different stages of recolonization following floods and students.

Erin Larson:

Very cool. And you mentioned a little bit some of the applied implications of this framework in terms of bio-monitoring and I was wondering if there are other ways that you think about this in terms of applications for management of systems. In terms of thinking about if a system has a certain level of seasonality or predictability, how do we think about managing that to maintain biodiversity?

Jonathan Tonkin:

Yeah, that's tricky. I guess the key is to know what you're valuing. Like I said, if you're sampling at a particular point in time and you're quantifying newer streams and the health of your stream, if you go in summer, often you might get lower monitoring scores or the other aspects of your bimonthly system because the communities to those have sort of adapted to live in really hot water conditions or really harsh conditions compared to if you went in winter. And so having a good understanding of all the actual seasonality and environmental variability is really crucial for being able to sort of valued and first of all. And so you might not be able to pick out the land you [inaudible 00:10:59] or discharge it takes in some streams that have stochastic environment compared to some that are much more predictable and stable through time, for instance.

Erin Larson:

Awesome. Yeah, and another thing I was interested in is at the end of the paper you guys talk a little bit about applying this to other types of systems besides stream systems as well. And I was wondering if you could talk through how you think about applying this framework to other types of systems that have seasonality and predictability, really shaping communities.

Jonathan Tonkin:

Yeah, that was really interesting to get into. There's a lot of other systems that are- I mean seasonality is at the heart of environmental gradients around the world. And so there's a lot of things that are affected by seasonality, but the combination of seasonality and predictability and you think about... We use a case study of waterfowl migrations that capitalize on predictable seasonality. And so this is a clear explanation for this secondary peak in in latitude and species richness for these waterfowl is because these clear locations. They're predictable. The seasonality is really predictable and there's a lot of literature on coexistence and the storage of it from sort of arid annual plant systems. You have these two rainfall peaks that allow these two distinct communities to sort of pop out at different times of the year and I think that's really fascinating. And they say the other systems ahead of these species of seasonality that are open for exploring with this framework as well.

Erin Larson:

That's great. Speaking of other systems, I wanted to transition to talk about another recent paper that you have out where you guys were modeling riparian plant dynamics under different hydrologic regimes. And that was a paper that was headed up by Dave Lytle and I was wondering if you could just give us a brief summary of that project as well.

Jonathan Tonkin:

Yeah, sure. So this is the first product out of a large collaborative project that part of. So the PIs on the project are Dave Lytle and Julian Olden and Dave Merritt, and it's also Lindsey Reynolds and Jane Rogosch on the project as well. And so we're developing methods for forecasting aquatic populations and dynamic systems. And we're really focusing in on the arid Southwest. And so we're basing these approaches on the idea that the flow regime is the master variable in the streams and rivers. So we're using this flood regime as sort of the main predictor of populations of riparian plants and fish and beta births and using a variety of approaches. But this paper in particular developed a method for coupled stochastic population models. So we're combining really detailed stage specific vital rates of riparian plants with specific attributes of the flow regime.

Jonathan Tonkin:

So the vital rates are things like how the plants relate to the flow regimes, specifically to floods and suitability to droughts and so on. But we don't include anything to do with biotic interactions in this model. And so it's a really cool approach. And what's so cool about is that we're able to really recover, no one population trends of key plant guilds from on the ground measurements through vital rates and flow regimes on their own. And so I think this is a really cool mechanistic way of modeling communities and populations that can be really useful for managers that are operating and managing flow regimes and operating dams. Releasing water to key in on specific aspects of the community they want to promote with a prescribed or environment of flow regimes or individual aspects of key populations, whether it be sort of managing the promoting cottonwoods over Tamarisk for instance.

Jonathan Tonkin:

So we show that in that case, bringing a flood 10 days earlier in the year, really benefits Cottonwood over Tamarisks. So the invasive species is getting sort of pushed out. If you push it back later by a few days, then you'd start to enable Tamarisk to take over. So these are really key little changes in the way that you can operate a river flow regime can have massive implications on what's downstream.

Erin Larson:

Awesome. That's really cool. And so what are some of the future directions that you guys are hoping to take this work?

Jonathan Tonkin:

Yeah. So one of the really exciting things that we got out of that paper and we're sort of employing it in a followup paper that's in revision at the moment, is that we've developed a way of sort of quantifying and merging interactions between guilds and stage classes and the model that we didn't specify at the outset. So many things these plants require is space on the landscape. So this is a finite space. It's a specially implicit model. And so what we did was develop this method of sensitivity analysis to quantify these emergent interactions. So sensitivity analysis is a way to test if the model is working properly.

Jonathan Tonkin:

So you modify a vital rate in really minute increments and you see if that individual guild or their stage class responds in a way that it should be. So we modify Cottonwood, the adult stage of Cottonwood for instance. If we modify its sustainability value, then it should very quickly decline linearly in terms of its population abundance if we run it through the model. And so we did that. And when we did that we thought if its abundance is declining in response to those changes, then it's opening up space for other species to come in and take over. And so then we thought we'd actually put this guild in space and have a look at it and we can see that other species are responding positively to changes in another guild. And so we thought, well actually if we do this for all guilds and all stage classes, then we can sort of quantify these potential interactions between individual spaces that are like an emergent interaction and they represent competition for space.

Jonathan Tonkin:

So we formed these into networks of interactions from the digital interactions and we're able to show that in the follow up paper, without giving away completely, is that the natural flow regime is really fundamental. Maintaining aspects of the natural flow regime is fundamental for maintaining the complexity of these ecological networks. As we move away from the natural flow regime, and in particular as we reduce the amount of floods, whether it be through drought and increases in drought, or through climate change or whether it be through removing floods from a dam management scenario where you have a stable base flow, you have a real collapse in the complexity of these networks and actually adding floods doesn't have so much of an effect. So because these species are so adapted to capitalize on flow regime to see it seed and so on, it's really fundamental to maintain the floods in particular. So it's maintaining its robustness.

Erin Larson:

Awesome. That's super interesting. One question I had as someone who works more empirically was what are some of the challenges that are associated when you do big modeling projects like this? I know in the previous paper that we were talking about, you mentioned that some of the vital rates for some of the riparian plant guilds had to be estimated to then surround empirical values. Is lack of empirical data sometimes the limiting factor or are there other challenges that arise when you're doing a more modeling approach to these types of questions?

Jonathan Tonkin:

Yeah, so I mean in terms of the vital rates, we were lucky to have a real expert on riparian plant dude on the team. So Dave Merritt has natural history knowledge of riparian plants in the Southwest is incredible. It was key to have him on board and enable to learn a lot of the information. And I think that's what's really exciting about this approach is that we sort of coupling really detailed natural history information with more computational approaches. But in terms of the challenges of computational approach, I guess the main one is making sure you get access to a high performance computing cluster. Some of the stuff that I did for the follow up paper, it took 500 days of computing time. And so without access to that, you couldn't do it on your desktop or if you did, you'd have really good holidays every year. You could run a model and they go away for a year and come back. So I think that's probably one of the keys is to have access to something like that. Sure.

Erin Larson:

Cool. And I guess another question I had for you, kind of stemming off of that, I know you've sort of made a shift from primarily empirical work to incorporating more computational approaches. And first of all, for folks who might not be familiar with the phrase computational ecology, I was wondering if you could just tell us a little bit about, quickly, what computational ecology is and why it's such a big growing field right now.

Jonathan Tonkin:

Yeah, sure. So I mean I think of the computational ecology is not really being independent from other forms of ecology, but it's essentially the same thing in that you're asking questions, important and complex ecological questions. But maybe the difference is that you are focusing more on really large scale data sets, imperial data suits or relying on more advanced computational approaches and mathematical and statistical models. Key examples might be exploring ecological risks because they involve a lot of complex information. It might be using machine learning techniques, or AI, to sort of advance predictive ability or even sort of simulation based approaches to test key hypotheses. And I think that's one of the key aspects. These computer models allow us to rapidly test ecological ideas through simulation. They provide us that ability to sort of ask "what if" questions that we wouldn't be able to do otherwise.

Jonathan Tonkin:

I think, I guess the growth, the most obvious reason for the growth of that field is the advancements in computing power and access to high performance computing facilities. But I think the other is openness in science. And I think whether the openness be sort of paper sheer in data sets or code or methods. I think that's a real key to advancing the speed of ecology and science in general and our ability to expand revenues and new ideas. I think for instance about, R, the programing language. It really has sort of exploded over the last few years and it's so easy now to be able to reproduce someone else's results and use the methods that they employed to sort of ask or expand into questions of your own. Much more easy than previously when people were using Excel and drop down box stats programs for example.

Erin Larson:

Cool. I just have a couple more questions in this vein of questioning about... If you're someone who's thinking about making that type of transition, whether you're an early career researcher or someone who's deciding to steer in to computational ecology more as an approach, do you have any thoughts or recommendations for folks who are sort of looking to make that transition?

Jonathan Tonkin:

Yeah, I guess for an early career, I guess it would be to start programming early. Learn a language and preferably for an ecologist it would be R, because it's what 90% of us use. I think about it in terms of it's a big investment up front and it feels like a waste of time when you start, when you're learning. But every line of code you write and notate saves you a lot of stress and anxiety and time for the analog. And there's a quote from a software cabinetry course, I think, where it's says, "Your primary collaborator is yourself six months from now and your past self doesn't answer emails." And I think that's a really fascinating way to put it. And we've all been there where we've had those moments where either we're going through the girth of our paper and we have to reproduce that graph or reproduce some results and we just cannot figure out what we did to get there.

Jonathan Tonkin:

And back in the day of using Excel and other stats programs. If we had to change one value in it, the original data bottle and you had to go through like 50 procedures to get to the final point. If you have your code scripted, in either a single script file or in multiple files with a maker file and you have a fully script based approach, then you can just avoid this entirely. You can have just one click, one click can reproduce everything and that's a huge stress reliever I think, even though it does take an investment up front. So I like to think of coding and reproducible makers as a stress management tool.

Erin Larson:

I like that. That's a good thought. And so the other question, the sort of final question I had was... You mentioned folks like Dave Merritt as being awesome collaborators because they just have this wealth of natural history knowledge and are just amazing in that regard. And I was wondering if you also had advice for folks who are empiricists or natural historians, but who are interested in entering into more computational ecology collaboration. So maybe aren't interested in doing all the coding, et cetera, but are interested in supporting and being part of projects that use computational approaches. If there are thoughts you have as one of the more computationally focused people. What skills they can bring to the table? Yeah, advice or recommendations you might have for folks like that.

Jonathan Tonkin:

Yeah, sure. I mean I guess the best case scenario is to learn a bit of script. And preferably R because it does help you understand what's going on if you have a basic working knowledge of it. And I think another one would be to learn Git. So Git is like a version control system and it's a really good way to collaborate as well between people if you learn Git. And then you can work through Git hub, which is the central repository. So people can still do code and data flows on near and then you can sort of collaborate with people back and forth through that environment. Other than that, I'm not really sure. I think that would probably be my two main pieces of advice.

Erin Larson:

Yeah. And for them to remember that having empiricist and having natural historians is a huge important component of doing these types of projects.

Jonathan Tonkin:

Yeah.

Erin Larson:

It's not just computational oncologists working alone in a silo.

Jonathan Tonkin:

Exactly. I think that's fundamentally important. People are... We're losing natural historians and at a record rate because the jobs that it's harder to get money, but people would do that sort of thing. So I think you go to keep going with natural history. It's a fundamentally important aspect of what we do.

Erin Larson:

Great. I agree. Well, awesome. Thank you so much for taking the time to talk with us today Jonathan. I wanted to give you an opportunity if there's anything else you'd like to add to wrap up or if you're feeling good.

Jonathan Tonkin:

I think I'm feeling good. Yeah, thanks very much. I really appreciate it. It's been great.

Erin Larson:

Yeah. Awesome. Great.

Erin Larson:

You've been listening to the making waves podcast brought to you with support by the Society for Freshwater Science. For more info on the speaker, the Making Waves podcast or the society in general, please visit us on the web at the Society for Freshwater Science webpage. Tune in next time for another fresh idea in freshwater science.