Transcript

Speaker 1: Hello and welcome to the graduates, a radio show dedicated to Berkeley graduate student research. My name is Stephanie Gerson, and I'll be your hostess for the show here on k a l. X. So today I'm talking to Christian Broderick, a Ph d student in the department of Earth and planetary science. So welcome Christian. Thank you. And we're going to be talking about stream, meandering and stream [00:00:30] restoration. So first, can you briefly introduce your work?

Speaker 2: My research is looking at what are the conditions necessary to create and maintain meandering gravel bed rivers. And the reason we're interested in this question is because rivers are currently being restored to try and improve aquatic habitat. Often these rivers, especially gravel bed rivers, are restored as meandering systems. So what we, what we're doing is we're trying to use experiments to figure out that the [00:01:00] key components are the ingredients that are necessary to have a river that meanders across its floodplain and a gravel.

Speaker 1: Okay. So let's rewind a little bit of what caused streams to change in the first place. And in what ways have they changed?

Speaker 2: And streams have been changed by a lot of things. Uh, the most obvious example is dams which have severely altered the amount of water and sediment that goes down streams. They trap all the sediment behind them [00:01:30] and they often reduce the high flows that occur. So you've got less sediment moving through and less ability for it to move because you have less discharge. The other thing that's severely impacted streams is land use. Things like the mining in the 19th century had a severe impact on how much sediment was in the rivers. Uh, logging has effect on both flow and sediment. Um, and then we've also taken a lot of rivers and put levees and revetment and rip rap along their banks so they don't migrate [00:02:00] anything.

Speaker 1: Uh Huh. Okay. And then when did the movement towards stream restoration begin and what inspired it?

Speaker 2: I think it was inspired by a general recognition that things were really bad in rivers and that a lot of rivers, um, we're losing their populations of endangered species like salmon. And I think it was really in the west coast, at least it was the salmon issue that really pushed stream restoration. And it probably began some time in the seventies or eighties, probably more than the eighties, but, um, [00:02:30] it really took off in the mid nineties and has been growing exponentially since then.

Speaker 1: And you say that $1 billion per year is spent in the u s to restore streams and improve aquatic habitat. So where does that money come from and what is it being spent on specifically?

Speaker 2: So the money generally comes from a federal agencies. They have a lot of money, um, and they're often involved in water policy in some way. Um, and also from, uh, every 30, 50 years, [00:03:00] a dams need to be relicensed. And as a part of that relicensing, there's often restoration now that gets included in what they have to do. Um, and what it's spent on really varies, uh, from anything from just putting up fences around rivers to keep cattle out to buying land, which is what the nature conservancy is doing a lot of in the Sacramento valley to actively changing what streams look like and getting in there with bulldozers and excavators and re configuring what the channel looks like and what the shape of it is.

Speaker 1: [00:03:30] As far as the streams that you research, what types of strings are you talking about? The types of streams I'm researching,

Speaker 2: um, are mostly Loland rivers. So s so in California they would be rivers that come into valleys, not that aren't constrained by bedrock, that are, that have flood plains and are moving back into,

Speaker 1: okay. And actually, because that's kind of a beautiful thing, can you explain what that means? That a stream moves back and forth across its flood plain

Speaker 2: things about rivers is that they're sort [00:04:00] of the author of their, of their environment. And one of the things that rivers do is they make their own valleys and they make it by meandering back and forth across their valleys.

Speaker 1: And so if you're a bird watching, you know, looking down on a stream over a long, long course of time, you're a very long living bird, then you would see it move across. It's flood plain. I mean, how wide is the, how, how far can it move, the ones that you work with?

Speaker 2: Well, the, the, it depends on the width of the valley. Um, the central valley is pretty wide [00:04:30] and the Sacramento River, um, which is probably a couple hundred meters wide in places the valley is, uh, kilometers wide so they can move back.

Speaker 1: Wow. But what timeframe are we talking about?

Speaker 2: Depends on the river again. Um, some river is, it takes thousands and thousands of years and some less.

Speaker 1: Yeah. Wow. Okay. So I understand that stream restoration increasingly involves rebuilding streams so that floodplains are inundated during high [00:05:00] flows. And so that sediment transport frequency is increased. So if you were a fish, why would you want floodplains inundated during high flows and higher sediment transport frequency? Will fish go on flood plans during high flows? The floodplains are where fish hanging out. Because if they were in the main channel, they'd get blasted out and blown downstream. So the floodplain habitat ends up being really important for fish. And if I'm a fish, I eat things and those things [00:05:30] sometimes fall off trees. So having a riparian system is really important. And sorry, I explained your terms here. I remember the first time someone said to me when I was in a geology class and it took me three days to figure out what they meant. And it's pretty fun. I would say that that riparian just means side, right? Parents, vegetation

Speaker 2: is vegetation that's next to a river. So [00:06:00] if you're, um, a fish, those, the vegetation next to the river is really important. It provides shade, which keeps, Oh, first person as a fish. Yes. Um, I think it's really important to have trees because they provide shade. Um, they've rough in the bank, so I can hide in the banks. And then the floodplain habitat is quite important during a high flows because you can imagine a couple inch long fish doesn't stand much of a chance during a flood. So they tend to go up onto the floodplains [00:06:30] and hide out there. And in larger river systems, the floodplains are where all the action is, the, the sediment, the sediment. So what happens to the sediment is that the bed Corsicans through time as the finer particles are winnowed away because there's, there's, it's not being transported as frequently because there's fewer high flows and there's also less sediment supply to replenish the particles that are moved away. So as the bed core suns, it becomes harder and harder to move, which is compounded by the lower flows. [00:07:00] It turns out that a lot of aquatic organisms live around rocks in the bed and a lot of bugs and things that fish eat or dependent on that. And then the other factor is that the, a fish spot, especially some onwards, spawn in gravel beds. And if the particles are too coarse and too hard to move, they can't spawn anymore.

Speaker 1: Hmm. Okay. So what happened when the dam was [inaudible]?

Speaker 2: Well, um, what happened to me, what happened [00:07:30] to me is that all of a sudden the frequency of high flows is less. And so I can't get up onto the floodplain. The channel has started to in size a little bit. Um, so that means that the banks, the difference between the bottom of the bed and the top of the banks is higher. So it takes more flow to get flood on water onto the flood plain. So the channel can contain when, when the dam does spill, the channel can contain a higher flow. So all of a sudden, the moment I'm in this bowling alley, yeah. Uh, with bowling balls running [inaudible]

Speaker 1: [00:08:00] for fish or fish. And so if you're going to, and you can be a fish for the rest of the interview if you want, that's awesome. If you're going to restore a stream, there are obviously many different design questions. One of them being the size and the shape of the stream, which you refer to as the morphology of the stream. But, uh, actually before we get into that, what other, what other design questions might there be? If you're going to restore a stream,

Speaker 2: [00:08:30] what other design questions might they be? What do you mean for vegetation? Okay. So when you're restoring, I see a lot of variables. Yeah. So when you're restoring a stream, you have to take a lot of things into account, um, one and, and you have to remember that rivers are an ecosystem where a lot of things interact and a lot of those interactions, we don't really understand all that well. So I would say that that you definitely need to take account the vegetation and often I'm getting native vegetation to grow along streams again is one of the primary objectives of restoration [00:09:00] or well, the secondary objective after having more fish like me and the, um, so you need to take that into account. You also need to take into account where you are, what the geology and topography is like around you. Um, what the, what the hydrology is like, what's the, what the patterns of high flows or like, uh, what the sediment supply is like where's the sources of sediment. Um, sometimes you can be down below a dam, but because you have tributaries that are bringing in sediment and because of land use, they might be [00:09:30] bringing in more than they had before. You need to, um, I just lost my train of thought. Thinking about breathing, I know, uh,

Speaker 1: user gills. So why don't we return to stream morphology? What different types of morphologies are there?

Speaker 2: Well, streams can have a lot of different forms. Um, if you, and they changed from as you [00:10:00] go from the headwaters out to the ocean. So in the headwaters you tend to have canyon streams and then as you go downstream you tend to get gravel, bed rivers that tend to be Brayden and that Braden, a braided river tends to have a lot of different paths. The water can flow down. There's, if you were to walk across the river, you would go up and down and up and down and up and down as you go across different bars, you can also get below braided rivers. You can get, um, an island bar morphology where you've got islands and then it'll have your channel that are usually vegetated. And [00:10:30] then below that you get to meandering rivers. And finally you get to a sort of a nasty moseying or deltaic systems where you've got lots of channel paths in the rivers, might use all of them or switch between different ones.

Speaker 1: Okay. And even if you've chosen a meandering morphology, there are still a lot of variables to think about, right? Where are you going to make the meanders, how big are they going to be, et cetera. But you take the approach of trying to understand what conditions [00:11:00] promote meandering in the first place. So can you talk a little bit about that?

Speaker 2: Well, one of the questions that's been raised by stream restoration and something that people have been wondering for a long time is where would you expect to find me entering and braided streams? And the simplest division would be that you would expect gravel bed rivers to be braided and sand bed rivers to be meandering. Um, because the sand bed rivers have low, they tend to be at lower slopes, which promotes meandering, but there are gravel, bed, meandering [00:11:30] rivers. They're um, they're located in different all over the world. Um, the most probably well known local example is the upper Sacramento near Chico is a gravel bed, meandering river. So our question was where do they, where do they occur? And, um, what things do these rivers have in common that allows them to be meandering where you would otherwise expect them to be braided. And so, uh, through delving in literature, uh, we found that, uh, one [00:12:00] common theme is bank strength.

Speaker 2: So they have something to provide strength to the banks. And that's typically either vegetation or cohesive material. A cohesive material is like, we can usually think in gravel bed rivers it's usually silt, but it's like a clay that's a little bit sticky when it gets wet. So it has some strength to it. And other characteristics are, are that they're close to the transition between a gravel and sand bed. Um, uh, kind of neat part about rivers is that the transition [00:12:30] from gravel to sand is very rapid. And so the, these tend to be on the lower edge of the gravel bed. Rivers. Other characteristics are, they tend to be in either humid places like England, has the British islands have girl bed, meandering river, just like there's no tomorrow. They're everywhere in the west. Um, which is definitely not a humid area. They tend to be in places dominated by snow melt hydrographs um, like the Sacramento River. Um, and they are also very common in smaller [00:13:00] Mettowee streams where, which have low slopes

Speaker 1: [inaudible] but the reason that you're interested in looking at the conditions is because those are the conditions that you're trying to create to restore a stream.

Speaker 2: Ah, yes. Um, so the reason we're interested in is because, um, in the spring restoration, they often create these gravel bed, meandering rivers, and that's because they have a diversity of habitats. They've got deep areas in shallow areas, places for fish to hide out and a spawn. Um, but they're the, a lot of these, there have been a lot of projects [00:13:30] that have been constructed that haven't worked. They've ended up becoming braided systems. And as we're building rivers faster than, than we're monitoring them or as we're restoring them faster than we're monitoring them. The, we're not really learning what's working and what's not working. And the, another problem that Matt conned off on campus raises is that we never monitor them anyway, so we don't really know if they're working or not. So we're spending millions, well, $1 billion. Yeah. In these reconstruction [00:14:00] projects, we're probably spending millions and millions of dollars each one. Uh, I think the median cost of a reconstruction project is over a hundred thousand dollars. And in each one, we really don't know what we need to do. And, and because we're not checking whether or not they work, uh, the mistakes in the past can be repeated and, uh, that there's something wasteful about that. And it's also not good publicity to have, you know, say, Hey, we're gonna restore these streams and spend tax tax [00:14:30] dollars on it and then for them to fail.

Speaker 1: That's true. So for those of you who are just joining us, I'm talking to Christian Broderick about stream, meandering and restoration. Okay. So the way that you try to understand what conditions promote meandering is by doing actual experiments, which you refer to a little bit, but can you in a little more detail what kinds of experiments you do [inaudible]

Speaker 2: yeah. Uh, so I do um, uh, what we call phlegm [00:15:00] experiments, which are experiments in, and I have a six meter by 17 meter sandbox, which is at the Richmond field station, which you've never, if you've never been there as a lovely place, uh, right on the bay. [inaudible] so what I do in these experiments is I can control how much water and sediment goes in and I start with an initial channel that has one Bennett and then is otherwise straight. And then I generate meanders and ah, uh, by turning the water on, I turn on the water in the sediment and let the channel build meanders. [00:15:30] [inaudible] the key components that we do in these experiments are that we add bang strength using Alfalfa sprouts and Alfalfa sprouts are cool because they grow pretty quickly. It takes about a week for them to go from seed to something that can provide bank strength. And then we also add fine sediment. Um, we use a lightweight plastic as a model sand the sand scale. It's difficult to scale sand because an odd thing happens in with sediment, which is that if you get down below [00:16:00] particle sizes less than sand, they actually become harder to move as they get smaller because there's less particle exposed to the flow. So we use these, this lightweight plastic as a model sand.

Speaker 1: Uh Huh. And you mentioned that the only experiment that has been successful besides the ones that you're doing is one that someone did in the garage.

Speaker 2: Yeah, in the mid to late nineties, a guy named Charles Smith who was a software engineer in his garage in his garage garage in San Jose. Um, he was, he [00:16:30] used a bunch of, uh, cohesive, cohesive materials. Uh, I think he use Kale anite clay and uh, diatomaceous earth and he made, was able to make meandering streams. And uh, until those experiments people had sort of given up on our ability to make them in labs. Huh.

Speaker 1: And you're the only people you know of besides him that have been successful doing this?

Speaker 2: Well there've been some other people who've been, um, who've bought an awfully close, um, how long

Speaker 1: does it have to survive [00:17:00] for it to be considered a success?

Speaker 2: Well, that's an interesting question. Um, it seems like a lot of people are able and what we were able to do in our preliminary experiments is you're able to generate some initial curvature but eventually the channel will straighten and once then once it straightens you're not able to regenerate it. So, um, we think that you need to get past that point of it straightening and then regenerating curves and channels straightened by what's called cutoffs, which is when, uh, a bend, uh, essentially gets cut off as the river shortens [00:17:30] its course through the back of the band. And so what we will like to see our experiments do is cut off and then regenerate curvature again. And our experiments have done, have been maintained a meandering morphology for something like a 138 hours of high flows, which scaled. Yeah, there's

Speaker 3: two years of my life, which is scaled to the field is, is is something like

Speaker 2: many years of high flows, like five to 10.

Speaker 1: And so are these, are these types [00:18:00] of experiments widely done and just not usually successful or are they not very widely done because people are running simulations or using other methodologies?

Speaker 2: Um, I would say that they're not very widely done, partially because there aren't a lot of places that can do though. Yeah. There are the places like the Richmond field station where you have that sort of space and big pumps and people know how to fix them are pretty rare.

Speaker 1: See A, those huge sandboxes all over the place.

Speaker 2: No, unfortunately don't see huge sandbox as long as the place. And when [00:18:30] you do see them, there are kids with [inaudible]

Speaker 3: pails or cats. Um, and so, um, but people are scared of cats. Fish are scared of cats. Rightfully so mean they don't have salmon flavor meow mix for nothing. Um, okay, so, so stream, so I think people are using, no, that's okay. Keep going. So I think, uh,

Speaker 2: people have historically approached the questions of meandering [00:19:00] from either numerical models or from doing field studies and field studies have the advantage of, you're actually out in the field measuring things and in a real scale that they actually happen at, but you getting the timing right so that you're there during floods, it's really difficult and it can be difficult to make measurements in floods.

Speaker 1: And on your website there is a time lapse video where you can actually see a stream with one initial meander kind of create me Anders [00:19:30] through time. That's right. So is that the 137 hours?

Speaker 2: Yeah, I think on the website right now it's, it's the first 60 something hours of the experiment. And, um, since you've reminded me that I haven't updated my website since the fall, I'll probably go and add the rest of it.

Speaker 1: Yeah. So what did you learn about the conditions conducive to meandering from this experiment?

Speaker 2: So we learned a couple things. The first was that, that as people have suspected that you need bank strength, um, and that, [00:20:00] um, the Alfalfa sprouts worked for that. Um, it's not clear to me how the sprouts scale to the field because there are some morphological difference between sprouts and trees. Um, but that means that vegetation might be really important. The second thing we learned was that you need fine sediment. You need sand. And in stream restoration the sand is often seen as poison because sand can infiltrate into the bed and make it more difficult for fish to spawn. But one of the cool things about meanders and one of the reasons [00:20:30] that people build meandering streams is gives me underwritten rivers because they bend sort their sediments. So you tend to get the course material in one place, in the finer material on another. And we found that in order to, to keep that meandering, you need that fine sediment, which then promotes the growth of more vegetation.

Speaker 1: And are these things that you've learned, were they things that you didn't know before? Did you learn anything that you didn't know before about the conditioner?

Speaker 2: Yeah, so we've, we've um, I think mostly what they do is they, they verified what people had suspected [00:21:00] and not quantified before. Um, the, the fine sediment thing hadn't really been talked about by people before. Um, and we found that without it, we had just had real problems. The other thing we learned was that we did a couple of tests with real high flows where we had our floods go well over bank, um, not to the level of what's happening right now in the Midwest, but they were high, much higher flows than the typical floods we ran. And during those high flows, the channel just widened, which is not good for me entering because wider channels [00:21:30] tend to be braided. So it's, it seems to indicate that that, uh, you need to have flows that aren't, don't get that high. And so that's why meandering channels may be more common in wider valleys. And it's also might be why they, you don't see a lot of meandering rivers and flashy systems.

Speaker 1: Okay. So you're saying that if these conditions are satisfied, alright. Thanks. Strength from vegetation, fun sediment and flows that are not so high. They create conditions conducive [00:22:00] to stream mandering at least to a degree of certainty.

Speaker 2: Yeah. So, so, so, um, where we're at with the study right now is that we, we've, we've shown that we can create these manners with these ingredients and the next steps are to try and take one or two of those ingredients and say, so, uh, how much, what's the critical point? Yeah. How much of what, what thing is important. And so the, the thing we're tackling next is the importance of sediment supply. [00:22:30] [inaudible] people have seen noticed anecdotally that in places where you get high sediments supply, the meanders tend to migrate faster.

Speaker 1: That's cool. Yeah. Actually, because this is something I'm kind of fascinated by. Can you talk a little bit about what hungry water is and what it does?

Speaker 2: So, uh, the, the hungry hungry water is a concept that if you have a lot of water and not a lot of sediment, that the channel will erode, that the channel will change. It's slow, we'll [00:23:00] adjust it slope, uh, either lower slope, which can be hard to do, um, over long areas or it will just incise into its channel. And essentially what you're doing is that you think of sediment and water is being imbalanced in a natural system over a longer timescale. But hunger 100 water means that there is more water than there is sediment. And so

Speaker 1: yeah, so hungry water makes fish hungry too.

Speaker 2: It can makes for some hungry fish. Yeah, with the water. And the fish are in line though.

Speaker 1: Yeah. Okay. So [00:23:30] we will be right back on next week's show. I'll be talking to Jason Blaylock from the School of journalism about his documentary called my brother the Christian, which is about spending a week in Florida with his family. So please join me for the graduates every Monday from 12 to 1230 on Calex. Welcome back. Today I'm talking to Christian Broderick from Earth and planetary science about [00:24:00] stream meandering and restoration. So you're trying to restore streams to bring back their natural behavior. And I assume this is behavior from right before the dam was built or when natural behavior.

Speaker 2: Well, I think stream restoration, although people say that what they want to do is bring back stream behavior from before the dams. In many cases, we don't know what that behavior was. And also, [00:24:30] um, in many cases we can't get it back because there just isn't the water and sediment to do it. So I think a more reasonable goal is to try and restore streams as they act more like a natural ecosystem and, and at least behave in ways similar to what the way they did before.

Speaker 1: Okay. But is this a situation in which there are many solutions to the same problem? I mean, how wide can the window be for you know what? Well yeah, what can we enter? What can provide [00:25:00] habitat?

Speaker 2: Well, the wide for what can provide hat the window for what can provide habitat is quite wide. I think. Um, I think people are probably overly committed to me entering rivers in stream restoration. And part of what our research I think is going to show is that you can't have a meandering river wherever you want. And it shows that already. And so I think that other rivers fashion with meandering rivers, I wonder, well there's, there's some people whose theories are people that people are obsessed with meandering rivers because [00:25:30] that's what they think of river should look like. And so when you go out and you see a beautiful river that's got floodplains and nice vegetation, the next to it and deep pools that you can swim in and bars you can skip rocks off of, that's what a river should look like. Um, but also the braided rivers too, and especially the island bar channels can provide a lot of habitat. Braided rivers are somewhat problematic because they don't have deep pools typically where fish can hang out and hide.

Speaker 1: You refer to transitions between me and during and [00:26:00] braided streams. And I understand that these transitions occur both in space goes through different morphologies as a coast from its headwaters out to the ocean. And also through time that, so even if, uh, even if we restore streams to some kind of morphology that's not meandering is a possible that it will become meandering at some point or can you, can you, can you restore it in such a way that it will lead to,

Speaker 2: um, [00:26:30] in theory you could probably do that. I don't know that anyone's demonstrated that you can do that. Um, but you could certainly restore streams. Um, I mean, part of some of what people do in stream restoration is just sort of by land on each side of the river and let the river move around and do it at once. And, um, that certainly provides habitat and value. And what kinds of timeframes are we looking at? Usually peoples, we'll design it to try and withstand a five year flood because that's just something that we can imagine. And it's got a relatively [00:27:00] high likelihood of happening in the near future.

Speaker 1: And since you mentioned a lack of monitoring, can you give a general sense of whether you think this $1 billion is being spent successfully? Do you think it should be spent differently?

Speaker 2: Well, I definitely feel like more more of it should be spent on monitoring. And it's not clear to me that we know how successful it's been. It's been so much of that because it's growing exponentially. Uh, we ha we have a lot of the rivers that we've restored haven't really been tested yet, [00:27:30] so I don't know that what percentage of the streams are being restored in a proper way. We're just not monitoring it. People tend to want to use all the money they can to try and make something better rather than to try and help out another product somewhere else, which might use the same design. The thing about restoration is that that it's hard to define what, what constitutes stream restoration. It ranges from things like putting up fences to buying land, to buying water to actively changing what the channel looks like. And in some places to rebuilding [00:28:00] levies. And a lot of people wouldn't think of building levees as, as restoring the stream. But if you're changing where they're located or how they're performing, that that can go into the stream restoration and you can then get to $1 billion right? Easily.

Speaker 1: Ah, so there's, so the billion dollars that are spent on stream restoration, somewhat broadly interpreted,

Speaker 2: it's pretty broadly interpreted. And if you think about, I'm trying to put a value on like that. They've recently done some tests in the Grand Canyon where they released these high flows. Um, the value of that water is tremendous. [00:28:30] So once you start putting money at monetary value on water stream restoration can get quite expensive. And then obviously the largest percentage is spent on research like yours. Actually the smallest percentage, unfortunately it's the smallest percentage is on basic research. The second smallest percentage is probably on monitoring. So the types of things we can learn from or we always get the short shrift. Yeah.

Speaker 1: Okay. Well thank you Christian. It's been a pleasure talking to you. Thank you. And if you'd [00:29:00] like to keep up with Christian's work and check out that time lapse movie, you can visit his website at e p s.berkeley.edu/tilda x I a n slash site slash research dot html. Wow thing links is so awkward. If you could just click on my voice, that would be infinitely easier. You've been listening to the graduates or radio show dedicated to graduate student [00:29:30] research on k a l ex Berkeley. My name is Stephanie Garson and I'm looking for new producers for the show. So if you're interested, please visit the Facebook page that's the graduates collects in quotes on facebook.com you can download our podcasts from iTunes university and join me next Monday from 12 to 1230.