USACE ERDC

Moderator: Julie Marcy
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Julie Marcy: This is Julie Marcy. I'm a Research Biologist and Professional Facilitator at the ERDC Environmental Lab in Vicksburg, Mississippi, and welcome to today's meeting on the Hydrologic Connectivity of Migratory Fauna in Puerto Rico by Dr. Kyle McKay and (Jessica Chappell).

This series of Web meetings on ecosystem restoration topics by ERDC and the Ecosystem Restoration Planning Center of Expertise is designed to address a variety of topics including training, lessons learned, research and development, and emerging issues. The Web meetings are recorded and archived files are posted on the Environment Gateway under the Learning tab. And you'll see that Web site listed on the title slide shown on your screen for those of you connected on the computer.

Just a few courtesy notes before we begin. Please place your phones on mute. When we begin in just a few moments, I will apply a listen only mode or a global mute to everyone.

During that time when our speakers are talking, if you need a question answered during the actual presentation you can still use the chat feature to ask a question or use the raise hand feature. I'll be monitoring that and then we'll take the majority of the questions at the end of the presentation. But if you need something clarified as they're speaking, we'll be happy to answer your questions at that time.

Once we get to the main Q&A session, I'll return everyone to interactive mode, but you may still need to press your mute button or do a star 6 on your phone to unmute yourself at that time. And then again you may either ask verbally or you can use the chat feature to ask your questions as you prefer.

If we can get a comprehensive list of attendees, that's very helpful to us. So if it's not already apparent from your login on the participant's list, if you could take just a moment to use the chat feature and give us your full name and organization. So for instance if we just have a first name, if you could use chat and just send me (Julie Marcy) a note with your full name and organization that would be very helpful to me. I'd appreciate that.

Also if you have more than one person attending if you can tell me that we have five people from Fort Worth District or whatever the case may be, that's helpful as well.

With that let's go ahead and get into our main presentation for today. Our first speaker Hydrologic Connectivity of Migratory Fauna in Puerto Rico is Dr. Kyle McKay who is a Research Civil Engineer in the ERDC Environmental Lab.

Since joining ERDC in 2007, Kyle's research has focused broadly on examining ecological effects of water resources infrastructure. Some of his projects have addressed quantifying environmental benefits of ecosystem restoration, fish passage improvement, environmental flow management, vegetation flow interaction, and the effects of woody vegetation on levee integrity.

Currently he's working on methods for quantifying hydrologic connectivity such as fish passage, sediment and sediment continuity, and assessing tradeoffs in flow management, such as environmental flows.

Kyle is stationed in Athens, Georgia to facilitate cooperative research between ERDC, the University of Georgia, and EPA's Ecosystem Research Division.

His co-presenter is Miss (Jessica Chappell). (Jessica) is a second-year graduate student in the Integrative Conservation and Ecology program at the University of Georgia. Since becoming a graduate student in 2013, her research has focused on examining the tradeoffs between water use by the public and aquatic organisms in Puerto Rico's El Yunque National Forest.

Due to her involvement in the ICON program which encourages students to complete a thesis involving both social and natural sciences, (Jessica) will be looking at how dams within the forest impact migrating aquatic fauna, but also at what services dams provide to the public including recreation and water use.

Additional information about Kyle and (Jessica) may be found in their bios posted on the Learning Exchange along with today's presentation. And that is also where we'll be posting the archived recorded meeting.

So Kyle and (Jessica), we're very happy to have you with us today and attendees, we're very happy to have you as well. And with that give me just a moment Kyle, and I'll give you presenter rights and then I'm going to apply that listen only feature. Just one moment and you'll hear the recording.

Woman: All participants are now in listen only mode.

Julie Marcy: And remember you may need to do the star 6.

Kyle McKay: Okay. Thanks Julie. Good afternoon everyone and good morning to the West Coasters. Thanks for attending.

My name's Kyle McKay and I work for the Environmental Laboratory in Athens, Georgia. Today I'm excited to present some ongoing work related to hydrologic connectivity and we're going to start with how we're approaching hydrologic connectivity in a broader project and then focus in on migratory critters in Puerto Rico.

This project is being developed in collaboration with the University of Georgia's Odum School of Ecology. So today I'm privileged to be joined by (Jessica Chappell) who will present a portion of today's presentation.

Today we're going to talk about ongoing research. So there's not going to be a lot of data at this point about the outcomes of the work but instead an overview of how we're approaching it. And as such my goals for today are to give you a window into our current thinking on the subject of connectivity and what we're viewing as hot topics in this subject. And then I'm going to chart the path of our research on a particular case study and highlight how those results can be generalized beyond that case study.

And then finally my last goal is to receive any feedback you may have on our project and find out what connectivity issues are really capturing your attention and you feel like need the most focus.

Starting with an overview of hydrologic connectivity: when I talk about this concept I use a definition by Cathy Pringle, our collaborator here at the University of Georgia who suggests that it is water-mediated transfer of matter, energy and organisms within or between elements of the hydrologic cycle.

This is a pretty broad definition, but it has some teeth there. It's mediated by the flow of water between for instance a river and floodplain, upstream and downstream areas, or potentially vertically between benthic and hyporheic zones in the river. So these multiple dimensions of connectivity can be assessed in different ways. And each of those three dimensions can also vary in time. There's a sort dimension of connectivity which is temporal in nature.

I also really like this definition because it's broader than just animals. I think historically when we talked about connectivity and restoration thereof we talk about organisms. We talk about things like flyways for migratory birds or corridors for large mammal movement or watershed connectivity for fish like salmon. And those are absolutely critical ways of thinking about the problem but there are a lot of others as well.

For instance when she highlights matter and energy, energy could mean the flow of carbon between an upstream and downstream ecosystem. Or it could be the flow of matter like nutrients between the river and floodplain.

Here in the bottom left is just one example where you see the Amazon River plain. This is a giant carbon subsidy from the entire Amazon Basin to the near shore ecosystem. So, all of those upland nutrients and energy are being transferred directly into the near shore environment.

Today we're going to focus on longitudinal connectivity at the watershed scale and we're going to focus on organisms. But when we talk about the connectivity, we're generally talking about a much broader view of the subject.

As with most restoration or ecological issues the best place to start is what we've done to impact our ecosystem. So we have an incredible ability to disconnect ecosystems through thousands of mechanisms as a society. So let's start with the most dramatic.

So shown here on the left are dams in the state of Georgia from the National Inventory of Dams. And this database only contains dams greater than 2 meters. A recent study in one watershed in Georgia indicates that this could be as much as an underestimate by a factor of 20 within one particular study watershed. So by that logic there are 1000 dams in the National Inventory shown but there could be as many as 25,000.

We have a really amazing capacity to disconnect with infrastructure but it also comes in the form of road networks as well or the levee networks disconnecting rivers and floodplains.

While we often talk about physical barriers, and they're by far the most intuitive and easiest to point at, there are other forms of barriers for disconnection as well. So there can be water quality barriers. So for instance hot water coming out of a coal fired power plant. The cooling pipes in the coal fired power plant could disconnect an ecosystem for fish moving upstream.

Likewise here at the bottom is a recreational feature in Missoula, Montana and you can imagine that a feature designed explicitly to increase velocity could potentially induce a velocity barrier.

While we talk about physical barriers more than other forms of barriers, that's not say they're the only barriers.

What are we doing to address this problem of disconnection? It's hard to scope these analyses, and our research project is focused on informing that and how we assess connectivity and quantify it so that it can be traded off with other issues such as habitat quantity or nutrient uptake or other ecological processes of interest.

In our research project we're taking on four different research themes. The first is related to identifying some general principles for conceptualizing and quantifying connectivity and a series of guiding questions which structures an assessment of connectivity. Questions like what is the dimensionality of connectivity? Or are we talking about a biotic or an abiotic process? Or to what degree a different regime like a thermal regime or a flow regime might influence connectivity and how those may vary over time.

And then finally principles associated with whether we're assessing the structural connectivity or the functional connectivity of an ecosystem. For instance, today we're talking about watershed connectivity but we're talking about spatial metrics largely. We're not talking about the population connectivity that's deriving from that spatial connection.

After a general overview and some principles for assessing connectivity, we wanted to test these out. The remaining three tasks are really about applying recommendations from the first.

In task two we're focused on organism-centric case studies and we're trying to look at critters that folks haven't looked at a lot in the past. Today we're going to talk about a whole assemblage of stream migrants, including some invertebrates in Puerto Rico.

We're also developing a case study of oyster reef connectivity where we're looking at multiple reefs within an estuary and pros and cons of reconnecting them. One can imagine that a pro of connectivity would be transfer of juvenile oyster spat between reefs. And thus, increased population.

But there's also a possibility of introducing diseases or pest species, like boring sponge, which could move from reef to reef as well. So we're looking at tradeoffs between positive and negative influences of connectivity.

In the third task we are focused on matter and energy oriented case studies. The transport mediated processes. Chuck Theiling in Rock Island District is working on nutrient issues in Upper Mississippi River and how river floodplain connectivity and influence those. Sarah Miller in Environmental Lab is looking at how channel dynamics in riparian vegetation are all mediated by flow connectivity again between the river and floodplain. So we're trying to provide some case studies for how we can get these principles into action.

Finally, with respect to restoration we'll see today some examples of ways we can look at dam operation or dam removal to increase connectivity. But then there's another case study being developed by Larry Oliver and Wendy Gendron where they're looking at fish passage in the Narragansett Bay watersheds and how the sequence of dam removals can benefit the watershed over time.

Although today we're focused on Puerto Rico, this is a much larger research project looking at a number of different issues surrounding this topic.

So with that I'll pass it over to (Jessica Chappell) who's going to tell you a little bit about our case study here.

(Jessica Chappell): Okay. Thanks Kyle. You can see on the bottom left a picture of the island of Puerto Rico. It is in the Caribbean Sea and it's hard to tell from the picture but it's actually only 50 miles wide by 100 miles long. So it's a fairly small island, and El Yunque National Forest is located in the top right hand corner, where that circle is in the northeast section. As you can see, it's made up of several watersheds, which drain the water that falls within the forest and down to the ocean.

A lot of work has been done in this site. The U.S. Forest Service has its Institute of International Tropical Forestry located in Puerto Rico, and they do a lot of research in the forest that they apply to other tropical sites.

The National Science Foundation has a long term ecological research site that's been established there since 1988. They've also collected a lot of data. USGS has a presence on the island with rain gauges and stream gauges throughout the island.

One of the interesting things about the forest is that 20% of Puerto Rico's population receives water from this site. The largest city, San Juan, isn't that far away at all from El Yunque. It is also the only tropical forest managed by the U.S. Forest Service. But one of the interesting things I think Kyle and I liked about this forest is that there are a lot of cool migratory organisms found within the forest.

One of the organisms that has been studied the most is definitely the freshwater shrimp. They provide a lot of ecosystem services such as keeping the water clean of algae and also scraping algae off of rocks which provides a lot of habitat for other organisms.

Just to walk you through the lifecycle of one of these migratory organisms, there's the diagram on the left. You can see that looking at Letter A, the adult of the shrimp lives within the freshwater upstream area, and then in B1, they release their larvae and they float passively down to the ocean or the estuary, where they then develop for 50 to 100 days before becoming juveniles.

Once they're adults they have to find a source of fresh water, but not necessarily in a natal stream like salmon. They have to find any source of fresh water and then they begin to actually climb back up these streams and live out their lives in the headwaters. Some of these species have been found to live for up to ten years. Some of the other migratory organisms are listed: the sirajo goby which is a type of fish, mountain mullet and American eel.

As Kyle mentioned really what's important for these organisms is longitudinal connectivity. They really depend on this connection from headwaters to the ocean.

To give you a better picture of how these organisms are moving, on the top left, the juvenile shrimp climb along the stream. You can see them climbing along next to streams. On the bottom left, mountain mullet actually jump over barriers. Anything less than 5 meters they can jump over.

Then also the sirajo goby, they have a modified pelvic fin which you can see and they use it as kind of a suction cup, and they can climb over any barriers that are less than 32 meters. And then also snails, they seek out areas with low velocity. When we're talking about barriers we're talking about those waterfalls, which are natural in these systems, but also dams. They can also climb over those as well.

This is important because within the forest there are several low head dams built throughout the forest. There's actually 34. In that bottom right picture, you can see a lot of times with these lowhead dams, they're associated with water intakes, which is where these people are getting their source of water from the forest.

There are also a lot of larger dams throughout the island of Puerto Rico. The graph on the top right is showing large dams per area. And we consider large dams over 15 meters. You can see there's a very large density of large dams in Puerto Rico which is a really big problem for a lot of these migratory organisms.

Previous studies have been found looking at the water budget within El Yunque and it was found by (Kelly Crook) in 2007 that about 50% of freshwater is not reaching the ocean. It's actually being taken out of the system to use for human use. Also on the left you can see a picture of a low head dam. You can see they're fairly small. There's an intake area, and then on top of that intake, there are actually people recreating in there. So again it's a source both for water use and also for recreation.

As I mentioned, longitudinal connectivity is really important and as you can imagine when water's being taken up it's actually impacting connectivity. On the left you can see that when water is coming into this withdrawal site the larvae is mixed within that water that's being sucked up into the withdrawal. And then a lot of the larvae is probably getting proportionally sucked out along with the water. So if you have a withdrawal site, we know that you're losing larvae that actually could be affecting the shrimp population island-wise and definitely within El Yunque.

It's important again to remember these large dams, some of which don't have any connectivity to the ocean. They're taking out all the water, and without that connectivity you have shrimp that can't move down to the ocean and also the juveniles can't move back up. So that's really impacting connectivity and if you have a spillway that would be similar to a waterfall that it would allow connectivity, but some of these dams do not outside of the forest.

Kyle McKay: Yes so you can see how they're a very tight coupling between the hydrology of the system and the broader connectivity of the system. Where we're starting on this project and -- have started I should say -- is developing the hydrologic budget for the watershed and looking at things like precipitation, evaporation, and runoff relative to these withdrawals.

These water budgets have been conducted in 1994, 2004, and now in 2014. And they're giving us a picture of how withdrawals have changed over time and how connectivity is accordingly declined over time. This portion of the project is really focused on how this tight coupling between hydrology and movement for organisms happens at the very mechanistic level.

What we're doing is working with the College of Engineering here at University of Georgia and Dr. Jason Christian and Joel Martin. And they are developing this water budget for 2014. Currently they're estimating withdrawal rates using a number of different approaches so that we can see how different ways of assessing withdrawals may influence our outcomes of what we recommend for restoration.

In the future they're developing a predictive unit hydrograph model for estimating both hydrology within the system and associated withdrawal. And what this allows us to do is play out different future scenarios, things related to how we think land use, withdrawal, withdrawal rates, population, or climate might change into the future, and we can test different scenarios as they're developed.

Right now, this water budget's in its final stages of development, and we're hoping to get that turned into the Forest Service very soon and start working on the connectivity side of things.

Just as a quick reminder, with this hydrologic basis you can understand how we're estimating things like discharge at each of these locations and withdrawals and how those influence passage rates between upstream and downstream ecosystems.

How are we going to use all of that information? Well we can estimate passage for each structure under these variable hydrologic conditions. And then we can scale up to a watershed scale and look at the cumulative impact of many barriers in the watershed.

What might we need to know to assess connectivity at these large scales? The key variables we need are things related to passage rates which now we have based on our hydrologic models as well as habitat size and habitat quality which we can extract from different geospatial data layers, things like land cover information or national hydrography data set.

Let's walk through how we might take these bits of information and combine them into a connectivity index. So let's take a simple example of the small watershed with two barriers. If 50% of the shrimp can make it past barrier A and only 40% make it past barrier B then we know that cumulatively only 20% can reach the top of the watershed above barrier B.

What we can do is couple that with information on how much habitat's being accessed. If we have 5 miles of habitat upstream of B and 10 miles upstream of A we can multiply it by those cumulative passage rates. And that allows us to create a metric which we call accessible habitat. And then we can look at the ratio of accessible to total habitat, in this case 6 miles over 15 miles, and we get a connectivity index of .4. A watershed is 40% connected by this logic.

Then we can use those connectivity indices to play out different restoration scenarios and different potential actions we might take. Just looking at removal actions, we could start with the do nothing scenario, the future without project and again our metric is .4. But if we removed barrier A and reconnected all 10 miles in green, the metric would go up to the watershed being 80% connected as a whole. Conversely we could remove barrier B and it would be 50% connected.

By looking at this larger scale, we see that barrier A is clearly a preferred action. But if we had only looked at passage rate we may have said, "Well we're going to fix the quote/unquote worse barrier, the 40% passage rate at B." So we made the different decision by zooming out and looking at a larger spatial scale.

We can take these different connectivity methods and indices, and we can apply them to a single watershed through time. That's one of the real advantages of working with the long term data set, like the one in Puerto Rico. We can start to look at long-term trends; these are hypothetical results right now. We're working on populating them with real data but this is what we're working towards: our connectivity amount through time.

On the left you see naturally fluctuating conditions that take one watershed and you may have more connectivity in the wet season than the dry season, which makes sense if your passage rates are a function of hydrology. Or you may have between year connectivity where you have greater connectivity during the wet years than dry years.

The question is, "How variable is connectivity over time, what's the natural range of variability, and what are we doing to influence that with our restoration act?"

On the right we can think about things on a longer timescale and look at lost connectivity over time. Here, we can think of withdrawals increasing through time and accordingly our connectivity declines through time.

We can do this for each of the nine watersheds draining the El Yunque National Forest. This tells us which watersheds are the most vulnerable to connectivity or disconnection as well as which ones have the most restoration potential in terms of the most possible lift. So we're working towards the temporally varied view of connectivity.

Also when we talk about connectivity for fish passage or other applications we talked about it being a static quantity, but it's really much more dynamic complex than that, and that's what we're trying to emphasis with this analysis.

In our second analysis,we're focused on looking at many species at once. We can take one watershed; on the right you have an example of connectivity in one watershed and how it might differ for different species through time. So it may be that shrimp and goby are more resilient to disconnection because they're adapted to it. But shrimp and goby can climb these waterfalls. So they're adapted to climb dams if there's small amounts of disconnection.

Conversely, mullet or eel might be very vulnerable because they don't have the adaptation to migrate around natural barriers. They require swimming or jumping. We can look at how these different species compare and what we might do to restore the community as a whole. And it helps us move beyond this single species view of restoration and think more about a community improvement.

And then using those two pieces of information about multiple species and variation through time we can start to look at changes in connectivity under different restoration strategies. So the first strategy in Puerto Rico - because things are so tightly coupled to the hydrology and withdrawals - we may be able to operate these structures slightly different and increase connectivity at large.

It may be that timing matters for these migrations looking at seasonal timing but also maybe within a month. There's been some observational evidence that shrimp are migrating more as a function of what the moon phase is. And so we could include that variable in these types of models because they're temporally distributed and because we have a very mechanistic response.

These operational scenarios are analogous to environmental flows. We're talking about how do we operate infrastructure to have less impact on the environment? It's kind of turning the environmental flow problem on its head a little bit by approaching it through a connectivity lens rather than for instance a habitat provisioning lens.

Another way we can look at restoration or spatial planning is through looking at the arrangement of dams. Here, we can play out different restoration scenarios to see which dam removal might give us the biggest bang for our buck.

Alternatively, as population in Puerto Rico increases there may be increased water demand. We can use these tools to assess potential construction and permitting issues and look at different ways of permitting dams, different spatial that have less impact on the environment.

Here in the bottom right, you see a figure from The Nature Conservancy where they've proposed a similar framework of optimizing solutions that provide for both conservation and meeting municipal water needs.

Finally I want to point out that we can swap out the connectivity index that we're using. I've shown one particular connectivity index but there are a few different indices out there. We're going to try out a few of them and make sure that we're making the same decisions regardless of the index. This gives us greater confidence in our actions because we understand that we may or may not be making the same action under all different modeling scenarios.

What does this provide to the Corps at large? Well there are a few key outcomes of the Puerto Rico demonstration. The first is direct application. These are tools developed for tropical islands, and tropical islands typically have very similar assemblages of organisms, whether they're in the Caribbean like Puerto Rico or in the Pacific like Hawaii and Guam. We can use these tools to manage these ecosystems.

We're also looking at American eels which - the populations of American eel has been on the decline recently and more and more restoration seems geared towards American eel population status improvement. Both of these are directly applicable from our modeling.

We’re also developing and demonstrating a fleet of tools that we can apply elsewhere. One of the first items I think’s most important is moving beyond a fish only view of connectivity. We’re looking at a number of different organisms, all with different life history and all with different physiological capabilities. We’re using the same family of methods to look at each of them and how they vary through time.

I also think it’s really important that we’re looking at an approach that couples connectivity and hydrology. We know hydrology influences connectivity but it often goes under-emphasized in our analyses.

Finally, we’re looking at how operational strategies could affect connectivity. Moving beyond dam removal and fish passage structures to think of this as an operational problem in addition to being a structural one.

And then finally you may say, “well does connectivity matter at all?” Well as an agency, we’ve decided it matters a lot. It’s one of seven budget criteria we use for project ranking. We need a fleet of methods for objectively quantifying and informing these ranking. We feel like this project and these examples from Puerto Rico go towards quantifying and informing those methods and developing those techniques.

There are some other potential applications of these methods however beyond restoration. Corps projects could be operated or adaptively managed for connectivity benefits. In the same way that we release water from reservoirs for habitat benefits, we could release them for river/floodplain connection issues.

We could also take the technology we're developing here in the planning community and transfer it to a regulatory decision making process where we're talking about multiple interacting mitigation projects within a particular basin. So we feel like these methods are moving this discussion of connectivity forward in a few key ways.

If you only listen to one thing today, I hope it's this slide. If you take nothing else away, we want you to know that hydrologic connectivity is much larger than fish passage, that this is a broad scale problem addressing many species and ecological end points, and that our projects focused on generalizable tools and techniques.

Each assessment of connectivity probably varies through time. In some cases it may be a good assumption to focus on just one average condition but in others it may affect your outcome, for instance in our case study.

Finally we're moving forward towards a more assemblage or community view of connectivity and we hope that this example helps contribute to that.

So with that I'd like to thank (Jessica) for joining us today as well as the team at the University of Georgia: Drs. Cathy Pringle and Jason Christian and Joel Martin, as well as the Ecosystem Management and Restoration Research Program which is funding part of this work.

So thank you all for your time and I'd be happy to take any questions.

Julie Marcy: Okay and Kyle if you can do the stop sharing feature I'll open up to interactive mode again. Just one moment.

Woman: All participants are now in interactive talk mode.

Julie Marcy: And remember you may still need to touch the mute button or do a star 6 on your phone so we can hear you if you have a question. You may also use the chat feature to ask a question, as you choose. We'll open the floor to questions or comments now.

Don't be shy. I'm going to go ahead and advance back down to your last slide that has your summary information.

Okay any questions or comments or perhaps possible applications for this that you foresee? We had one question come in on chat Kyle and (Jessica). Is there a potential for a generic connectivity model?

Kyle McKay: Okay. I think in some ways yes and in some ways no. I think it's possible that we can think of connectivity at a watershed scale as developing tools that are completely generic. But when we talk about a tool that could address watershed connectivity relative to river/floodplain connectivity I don't think that's necessarily a reasonable end point. But they're just really different processes, really different mechanisms.

I think there are opportunities to create reusable tools and in fact we're working towards that with our fish passage tool. We've been working on this connectivity problem for fish passage issues. Now we're transferring many of the methods to this problem for shrimp and snails and other fishes in Puerto Rico.

We're also working with Colorado State University in developing an interactive web portal which will allow some of these connectivity indices to be built into the model so that the user could go on, click their watershed, and parameterize to their particular species of interest. So to a certain extent we are developing towards those generic tools.

Julie Marcy: Okay great. Any other questions or comments that you may have? Now remember you may need to take yourself off of mute on your personal phone. Okay I don't see any others on chat right now.

I see a few brave souls from the Northeast that have dialed in with us today so it's good to hear y'all are still faring well despite the challenging weather that many of you are facing.

Kyle McKay: Well if any questions come up in the next few weeks feel free to contact me. I'd be happy to talk to you more about it and learn about how y'all are approaching this problem. So if you're working on connectivity in your own restoration programs please let me know how y'all are doing it. We only learn by talking to each other so please stay in touch and thank you for your time.

Julie Marcy: All right. Well if there are no further questions thank you everyone for joining us today and Kyle and (Jessica), thank you so much for giving us that preview of your work, your ongoing research and giving us an idea of where it's headed and how it's going to be able to benefit us.

And thank you everyone for tuning in. Be watching your email for future meeting announcements. That will conclude our Webinar presentation. Have a good afternoon.

Kyle McKay: Thank you Julie.

Julie Marcy: You're welcome. Thank you.