RETHINKING RIPARIAN and RIVERINE CONNECTIVITY

Moderator: Julie Marcy
February 24, 2015

Julie Marcy: Hello everyone, I'm Julie Marcy from the EDRC Environmental lab. Welcome to our webinar and our Ecosystem Restoration Series. Our program today is going to be on Rethinking Riverine and Riparian Connectivity by Jock Conyngham.

Our 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, such as training, lessons learned, research and development and emerging issues. We record and archive the web meetings and post those files on the Environment Gateway. You will see that URL listed on the introduction slide that should be appearing on the screen. - That's where you can access not only this presentation but all of our prior webinar archives.

Just a few notes before we begin. Please keep your phones on mute when you're not speaking, although I will be applying a global mute feature shortly. Then we'll reopen the lines when we get to our Q-and-A session at the end of Jock's presentation. If you have a question during the presentation when we're all on the global mute, you can use the chat feature to send a question to me, Julie Marcy, and I will ask it on your behalf.

We will be using the shared desktop feature in WebEx once Jock begins presenting. When we go to that feature, it's going to move your participants' list and the chat box to the top of your screen. You'll see a little green dot up there, all you'll need to do is click on that and it will enable you to enlarge the participant's box or your chat box while we're in that shared desktop mode.

So, you'll still have that accessible to you if you need to send in a question to ask during the presentation instead of waiting until the end to ask a question.

When we get to our main Q-and-A session, we'll address as many questions as we can, and if something comes up we're not able to answer this afternoon, we'll follow up and get back with you. I ask that if it's not apparent from your sign-in on the participants' list, if you would please take a moment to use chat to provide me with your full name and your office organization code.

You can use acronym initials or say St. Louis District. If you're calling in as a group you could Fort Worth District, five attendees. The full name or the number of folks if you're calling in a group, really helps us track participants in our sessions. So if you'd take just a moment to use the chat feature to add that if it's not apparent in your participant's log in, I'd appreciate that.

And with that, I'll give you a little more information about today's speaker, on Rethinking Riverine and Riparian Connectivity, Jock Conyngham. Jock is a research ecologist in the Environmental laboratory of the Engineer Research and Development Center, and he's stationed in Missoula, Montana.

His specialties include multi-scaled assessment, restoration, and monitoring of watersheds, streams and rivers, riparian zones, and aquatic population. Jock has provided technical support for dam removals, fish passage projects and restoration initiatives across North America.

Prior to joining ERDC in 2002, Jock was director of watershed assessment and geomorphic restoration for the national office of Trout Unlimited, where he worked for nine years. You can find additional information about Jock in his bio posted on the Learning Exchange, along with a PDF of today's presentation and where we'll be posting the archived meeting. So Jock, we're very pleased to have you with us today. And if you'll give me just a moment, I'm going to assign you presenter rights.

Operator: All participants are now in listen-only mode.

Jock Conyngham: Great, okay. Good afternoon everyone, and thank you for being here. I hope you in the east are enjoying the winter that we're not getting in Montana. It's been in the 50s and even 60s for much of the winter. I will be talking on new directions in conceptualizing, measuring and improving connectivity in riverine and riparian ecosystems.

The slide you see on the right are a couple of photographs from the Truckee Basin. That's a Lahontan cutthroat, the largest inland North American salmonid. This was a project that we did for Sacramento District that I'll talk about a little more later.

Now the Corps has been working on connectivity with its partner agencies for many years, but traditionally the focus has been on, and the way we think about connectivity has focused on, upstream fish passage for a listed species, most often salmonids and usually using linear site-by-site methods and tools for analysis.

And then starting several decades ago, downstream passage of post-spawn adults and downstream radiation of juveniles began to be considered, particularly in systems where a lot of water was withdrawn for hydroelectrical production, irrigation, municipal use, with a resulting risk of fish being lost to the system.

Then in the '60s or '70s there was increasing awareness of the importance of flood plain connectivity, usually in the sense of flood risk attenuation. But we all know that riverine ecosystems are a lot more complex than that, and that at a fundamental level, connectivity, when you're thinking about ecological integrity, refers to all flows of energy, materials, and organisms, usually as mediated by water flow.

This is kind of a noisy but sort of an elegant diagram from one of (Jeffrey Poole)'s papers. The large text refers to large spatial and temporal scales. Small text refers to finer spatial scales, or shorter time periods. The solid arrows refer to linkages that are driven primarily by physical processes. The dashed arrows are biochemical interactions, and then the dashed ovals, geomorphology, hydrology and hydrogeology, and ecology more or less depict somewhat overlapping or connected roles that various academic disciplines and practitioners tend to play and categorize themselves by.

We decided in this work unit to develop a somewhat simpler schematic or conceptual model based the idea that riverine and riparian ecosystems are determined primarily by abiotic regimes that you see over on the left: hydrology, sediment flows, a set of biogeochemical processes that structure and drive riverine ecosystems, and then some ancillary domains, like ice regime and large wood.

The idea is that these interact to form the abiotic environment, and the abiotic environment expresses its potential for biological support through this lens of life history needs. And this will make a little more sense as the talk goes on.

Whether at the species or the guild or the community level, depending on that specific suite of needs, these systems provide biological support at the individual and population and community level. And that is really what determines the number and distribution of populations in the biota that, in some large measure, we are tasked to protect or restore by various mandates and agreements.

Disconnections can occur within these initial interactions, where the potential for the abiotic drivers and their interactions to provide biological support gets reduced or significantly impacted. Or it may happen in a much more narrow spatial or temporal window, but because that window happens to be critical for life history needs, even a mildly impacted system, impacted in the sense of these abiotic drivers and regimes, can really function at a very low level of biological support.

Let's step back for a minute though and just talk about traditional fish passage, and fish passage activities. They are a big part of the Corps restoration mission, and I don't mean to say, I don't mean to imply by the rest of this talk, that it's unimportant or that it's relatively simple or easy or any of the above.

There are a suite of sometimes occasionally contradictory objectives, interacting target species, sometimes a few listed species, sometimes entire communities. Very wide ranges of site conditions and a much larger list of potential passage measures that we are used to working with complicate matters. And, a rigorous structured assessment of the interactions of those four big categories are what we need to work through to narrow down our alternative selection to a reasonable set of passage alternatives.

But the fact is we live in a country where our rivers are highly fragmented. Most sections of United States rivers, in terms of linear downstream-to-headwater connectivity, have been fragmented on the order of 90%-plus in terms of physical structures disrupting the ability of these organisms to move without trouble. If the only thing that the agency did was address connectivity at these spatial obstructions, we'd be doing a great deal in the restoration arena, and we have done a great deal to date.

Physical fragmentation for fish passage tends to focus on trunk channels. Again, this is a slide from that Truckee project, and what was probably the largest fish passage project in the country at that time. We were asked to look at 17 of 33 trunk channel obstructions to fish passage. The fact is that is a small subset of the number in the entire basin.

There are hundreds and hundreds of barriers on tributaries. I live near the Yellowstone River, which is widely celebrated as the nation’s largest unobstructed river. However, that refers again only to the trunk channel. There are hundreds of fish passage obstructions on Yellowstone tributaries.

So hydrology is the master variable, both of fish passage and these broader connectivity concerns I’m getting into here. And let’s talk a little bit about the way we think of hydrology as this driving variable for connectivity. And I imagine many of you have heard this, and these are well known parameters by which we characterize flow regime.

Magnitude of flows, frequency of flows at different magnitudes, the duration of those flows through time, when they occur during the year and the rate at which they change are the variables of concern. Of course, due to our water demands, flood risk mitigation activities, and hydro-generating capacity in this country, we have significantly manipulated each of those parameters in most rivers, most large rivers. And that has affected these intermediate values you see in water quality, energy in the ecosystem sense, physical habitat, biotic interactions and as they aggregate, ecological integrity in general.

Working towards these broader conceptual models of connectivity, we talk about three primary axes. One is longitudinal, and yes, there’s a directionality in water flow that affects many of the transfers and processes that we need to be concerned with, but that gets bi-directional in the case of fish as a transport mechanism. Fish are the one form of nutrient and energy that swim against the current. They swim in great numbers, and upstream migration actually is a large player in stream ecology at the basic energetic level. Dying fish in the headwaters, and their importation of marine-derived or lake-derived nutrients create a very strong influence on stream ecosystem energy flows broadly defined. So that is one type of longitudinal transfers.

There is a set of two-way lateral transfers, and we usually describe them as the interactions of active channels with their flood plains and low terrace areas, and the toes of upland areas in more narrow valley systems.

Then there are two way vertical exchanges. And those refer primarily to the effect of riverine flow on groundwater stage and interactions between groundwater and the channel.

And again, I will get into the significance of that in slides to come. So here's just another way of breaking it down, longitudinal transfers, latitudinal transfers and how they express in different valley morphologies, and then this vertical dimension. You're seeing some long words here and I apologize for that.

This is not my diagram, but particularly in the "c" area here, the parapotamon structures really refer to connected side arms, such as secondary and tertiary channels, and though they are not shown on these images, what are called plesiopotamon structures and paleopotamon features refer to increasingly disconnected channels remnants, wetlands and so forth that we are tasked with protecting and restoring. Water stage in these wind up being controlled by water stage in the active channel, and we will get into some of the significance of that as the talk evolves.

Now, some points about this three-dimension conceptual model. All of those axes are important, but the priority of importance really depends on specific project objectives. If your only concern is getting diadromous fish up and down a channel, you don't really need to worry very much or as much about vertical connectivity or a lateral connectivity. If you are tasked with restoring or protecting a fish species that's a floodplain spawner, then clearly lateral and vertical connectivity become far more important.

In terms of some of the things we think about in both passive and active restoration, let's say we're looking at sediment starvation below a reservoir. The reservoir has created a discontinuity in sediment supply in the downstream direction. At that point, your lateral connectivity becomes critically important--that's the only way that a channel is going to rebuild its sediment supply, and that's important for habitat features--in the absence of active routing of sediment through the reservoir or even sediment augmentation that we do use and other agencies use on some projects, but at great expense and some disturbance. And finally in referring again to life history needs and specific biological needs, the degree of connectivity that is desirable is often pretty tightly bounded and a classic display of that are vernal pools. I'm smiling, but these include plesiopotamon and paleopotamon structures.

The depth of those vernal pools and their duration, their temporal duration in the year, has to conform with the breeding behavior of the herptile amphibious species that use those vernal pools, that are obligate to, the vernal pool dynamics. And if they dry up too quickly, that's a catastrophe. You lose whole age classes. However, too much connectivity can be equally damaging because they then fill with fish predators that will, that can prey on virtually

100% of the eggs and larva of species that we may be tasked at protecting or restoring.

Similarly, we work in a lot of riverine systems and riparian systems that are full of invasive species. Some are quite damaging, many are not, but the ones where invasives really displace native species, then the fact is that discontinuities and lack of connectivity unfortunately can be a good thing.

Then there is a further temporal dimension that overlays those three more spatial axes that I have referred to. In terms of the longitudinal axis, drying of intermittent and even ephemeral channels can disrupt really critical fish movement or fish utilization. A lot of those secondary and tertiary channels are very important for spawning and nursery habitat. For lateral connectivity, we talk a great deal in this part of the country about the need for time-appropriate lateral connectivity because it’s so critical to cottonwood germination on western rivers. Cottonwoods only germinate when their seed material is deposited on fresh alluvium that has been deposited on riverbanks by shallow overbank flows…flows that happen in a connected system, oh every two years or every five years or more.

Unfortunately we’re seeing, we’ve been experiencing alterations of the timing of a lot of our high flows related to weather and climate shifts. And we’re getting those overbank depositional flows before cottonwoods have really put out their seeds and there’s been a temporal break in that connectivity need, that connectivity process, that is really holding back a very important colonization role.

And similarly, as we lean on a lot of rivers more and more for water supply or for irrigation supply, there are some very rapid drawdowns, and they have created shifts in timing by which rivers shift from being a losing river at high flow that charges local groundwater tables, creates a lot of bank storage, to very rapid drops in to kind of a gaining reach, and they drain the floodplains rapidly and that can have very severe effects on things like vernal pool duration, survival of young seedlings, movement of minerals through the soil profile, and a whole set of response processes that structure a number of ecosystem values.

So let's continue to break it down a little bit and get into some of the scalar issues. I'm sure many of you have seen this, a common diagram of first Bartonian stream order. Two first-order tributaries need to join to create a second-order tributary, two second-order tributaries join to become a third-order tributary and so on. That is a schematic of course, that doesn't mean much in terms of diversity of habitats or biodiversity. This, though, is a well-known graphic from Montgomery and Buffington's famous paper on a classification of mountain streams. And it begins to show how not just habitat forms change as streams get larger and slopes drop, but some of the driving geomorphic processes that create habitat forms at various scales also change.

Here's a different depiction in which the headwaters act the source areas for sediments, then you get down into third-, fourth-order channels and they become kind of a sediment transfer, a conduit zone in which there's neither long-term gain nor loss of sediment. It is an area of sediment continuity. Then you get down into depositional zones on larger rivers. And that creates a lot of alluvial processes and coastal and esturine processes that have received a great deal of attention both in restoration and coastal storm energy attenuation.

And I'm running a little tight on time, but this bottom graph here explains how that happens as stream power, which is a product of slope and normally energy or discharge in a given cross-section winds up determining that, and becomes a useful tool for a whole range of applications, operating hydrology at reservoirs, planning for dredging, stream restoration.

The channel continuum concept is one of the classic models of stream and river ecology. It came out of that earlier work I just presented, but it shows shifts in the downstream direction of biotic, abiotic, biotic and chemical shifts. I urge you to spend time with it; it’s a powerful model. And the point, the take-home point is that many aquatic populations have really developed these movement needs as a response, as a way to utilize diverse habitats.

I’m going to kind of bounce through this quickly. It’s just the point that, that same kind of habitat diversity occurs at even fairly fine spatial scales. And those spatial scales are important to many organisms that actually shift their habitat utilization diurnally on a daily basis, seasonally or with life stage. And again, manipulation of hydrographs can really alter or truncate availability of, particularly some of the lower-velocity habitats.

This is a slide that just illustrates some of the biodiversity in macro invertebrates. They have evolved very specific niche partitioning that utilizes distinct habitats. And I’m sorry, I got ahead of my point, which is that this biodiversity allows and supports some of the bio-monitoring protocols we use.

Getting down to the fundamental level of biogeochemistry, there are, there is, a whole movement that I am a fan of and a proponent of. There’s the thought that the community of stream restoration and stream protection, and I’m not just talking about the Corps here, I’m talking about the community broadly defined, has really under-considered biochemistry.

The National River Restoration Science Synthesis, if you’ve heard of that and you should have if you haven’t because it’s kind of a compelling piece of work in the last ten years that documented to a large measure the ineffectiveness of a lot of the stream restoration efforts and techniques to date. And part of the current thinking that lack of documented success is because those efforts and techniques really don't incorporate biochemistry to an adequate degree.

Chemistry is important; reactive solutes like nitrogen and phosphorous are really how streams set up their entire metabolism at the level of primary and secondary productivity. They govern it, and the rate of passage of these solutes through a stream is governed by abiotic and biotic uptake and release. It's referred to as the nutrient spiral. A terrestrial ecosystem will put in nutrients in the form of leaves and debris, as a dominant source in many ecosystems. Decomposition and respiration release solutes, but then they are bound up again and released, and there's this spiraling as they come down through the stream bed. Both abiotic and biotic uptake in release mechanisms depend on exchange at sediment surfaces, and intereactions between the channel and the streambed. Those interactions, those exchanges are governed by channel roughness, and by the complexity of the bed. I'll point out at several scales, that forms at interstitial spaces between individual gravel elements, connectivity, surface water and shallow groundwater and surface water, the hyporheic zone that you may be familiar with are all important in this sense. And that hyporheic zone needs to be renewed by periodic large bed entrainment flows before the bed seals off. Here is another graphic of that solute spiraling in the longitudinal direction.

There has been a lot of recent attention and talk about (it's a historically missing element, and we've got some active research at the lab on) large wood. One of my main work projects for the last several years has been producing a book on the role of wood in riverine ecosystems, and utilization of wood in stream restoration. We're producing that with the Bureau of

Reclamation. All the draft chapters we've just finished this week, and we're hoping to have a final draft out by mid to late summer, so stay tuned for that.

But wood, the supply of wood has been dramatically altered relative to normative historical levels by land use changes, by the construction of reservoirs, stream crossings that don't pass wood. But it is one and arguably a dominant form in many systems of that hydraulic roughness as a source of flood plain connectivity, the lateral connectivity I referred to. Here's kind of an extreme example (but it gives you an idea of what normative wood loading was like in some systems), the Great Raft of the Red River. At its peak length it was 165 miles long, and totally impeded navigation at a time that was important for settlement, nation-building. The Corps removed it in its entirety, that took nearly 30 years. However, as soon as that initial raft was removed, there was so much supply coming from upstream that a second raft was formed, and that raft was removed. And at that point, they'd taken care of the main background load and, in conjunction with related snagging efforts, it removed so much wood that it drove the capture of the Mississippi River by the Atchafalaya, and created the need for the old river control structure that we continue to spend money on.

I'm making the point here that even in systems that retain high longitudinal connectivity in the trunk channel, they may have experienced, for whatever reason, significant changes in connectivity to tertiary and secondary channels. And that has had tremendous effects on aquatic biodiversity and resilience to stress, and unfortunately for some of the listed species that we're tasked with protecting.

I want to talk for just a minute about dynamism. There's several forms of dynamism in American rivers, and we have altered the rates and types of dynamism as we've altered riverine flows. The left is the Nyack River basin near me here in Montana. It's a system in which lateral connectivity, really this shifting around of river, of the primary channel, occurs by avulsion movements, by sudden movements, and that is caused by ice dynamics and large wood dynamics. Very interesting, very resilient river and that kind of avulsive movement has dramatic and positive implications for hyporheic activity, for the presence of early successional areas of riparian plants, and there are a range of effects here that I can't really get into in a talk this short. And similarly, these, this more incremental meander extension that you see on the right, that keeps part of the riparian in early successional vegetation communities with important implications for habitat provision.

Julie Marcy: And Jock, this is Julie. Just a time check for you that it's about a quarter to the hour.

Jock Conyngham: Looking at it, yeah, yeah, I'm going to bang through here. This is available on site again, some of the, the biotic, the ecological importance of connectivity, this is available in the stored file that you can go back to. So again, I just want to make the point that these disconnections tend to happen in two places in this particular conceptual model, and we have tended to given most focus to these abiotic driving regimes and their interactions, and rightly so, but we need to, particularly with listed species restoration, the field needs to start paying more attention and supplying more tools that address life histories.

Different authors and different groups define functional connectivity in slightly different or complementary ways. In our work unit we're defining functional connectivity as connectivity that recognizes those life history needs and creates a biotic signal to our efforts, as opposed to purely structural connectivity. And I'm making the point here that different organisms have different capabilities for movement, different levels of specificity. Some are quite obligate in their habitat needs, some are much more generalist.

But they will react or they will benefit from changes in structural connectivity at very different rates, and if you're working in projects that are targeting guilds or larger communities, you need to be aware of this.

There are complicating factors as we get into biotically informed connectivity. I talked about cottonwood colonization and survival. There are different ways of parsing or combining life history needs, and the tools for characterization and aggregation those life history needs are only just becoming available. Here are a few; with the exception of the stream hierarchy model, they're really in very early stages of development, and none of these are really for prime time, so we're working towards that.

So this is really the most important slide, and I think the next to last slide. There have been different analyses of the effectiveness of various restoration techniques, and Phil Roni at NOAA has authored several of them with his team. And in every one of those meta-analyses that I have seen from Phil and from other authors, connectivity restoration had the highest likelihood of achieving restoration success, and usually at the lowest level of risk of an undesired effect or a structural failure.

And so connectivity restoration's important, and while we're working towards these more elegant tools, we still need to address it. So here's some basic questions that we developed in this work unit on how to think about it. What is the problem? What is the dimensionality, whether that is spatial or temporal or thematic or biotic or chemical connectivity that you need to think about? What are the drivers that influence it, abiotically? What either contributes to it or results from connectivity alteration or restoration? What is the role of temporal variability or temporal sensitivity in our connectivity work? How do we look at, characterize, parse, and aggregate life history needs, and how do they potentially constrain benefits or reconnection of something that's going to create that biotic signal.

And then how do all the above, how do they interact with your project constraints and project objectives? There is our contact information for (Kyle McKay) and myself. This is a mistake, it's more a technical note than a report, but it will be a long note. The principles for assessing connectivity in both system assessment and project planning is in a late stage of preparation. Then there's a set of organismically focused case studies and transport mediating case studies that we're working on. And with that, I'll take any questions.

Julie Marcy: Thank you, Jock. This is Julie, give me just a moment and I'll return everyone to interactive mode.

Operator: All participants are now in interactive talk mode.

Julie Marcy: You should be able to speak, but if you used the mute button, you may still need to depress that or hit a *6 on your phone so we can hear you. You can either ask questions of Jock verbally or using the chat feature at this time.

Julie Marcy: If you want to use the chat feature, you can also use that to submit a question and I'll ask it on your behalf.

Woman: (Unintelligible).

Julie Marcy: Okay, I can just barely hear you. I can hear someone just softly speaking.

Woman: I just wanted to say thanks and I think we have (unintelligible).

Julie Marcy: Your volume's still really low. You think it might be the volume on your actual phone, that you might be able to raise the volume?

Woman: Not working, I'll just put it in chat.

Julie Marcy: Can you do the stop sharing Jock? We had a question requesting posting of the citations for the references in the presentation.

Jock Conyngham: I will do that.

Jock Conyngham: They are from that technical publication that I referred to but I will strip them out and put them in the presentation.

Julie Marcy: If you can send that to me then we will post them in the archive.

Jock Conyngham: Terrific. Good.

Julie Marcy: Any other questions that anyone has?

(Jeff Trulick): Hey Jock, this is (Jeff Trulick).

Jock Conyngham: Hey, Jeff.

(Jeff Trulick): How are you?

Jock Conyngham: Fine, how are you today?

(Jeff Trulick): I'm good. Hey, I got a question, in the context of where Civil Works planning studies are nowadays with this three years, $3 million for a feasibility study, is there a possibility that you all could envision a type of study that would be done for under $3 million, whether that's length of river or complexity of river, versus something that would fall in the category of automatically over that, and probably not be able to be done for under $3 million. I'm talking about modeling demands, kind of dated demands or is that not something that can be distilled out of some of this research that you're doing?

Jock Conyngham: Well, I think what we work towards in this principles paper is some flexibility; part of it is building a hierarchy of data demands by the connectivity issue. Clearly if you've got a problem with solute spiraling and you're just not getting any primary production or you're getting too much primary production, that is a different data need than say, you know, removing a dam for anadromous or catadromous fish, where the benefits are quite clear.

So that's the way we've gone after that. I think that whereas our limits are fairly absolute, some of the things I've talked about indicate needs that have to be addressed by partners, whether that is NOAA or state partner or tribal partner in terms of say, documenting important refugia that exist somewhere in the channel network, and the fish have to get to as a response to lowered flows or higher stream temperatures or whatever it is.

I would argue that often this kind of, these points I'm making here really don't argue necessarily for more data, they just argue for the right kinds of data. I know lots and lots of projects--and you do, too--where there were plenty of data gathered, they just weren't gathered in a way that really informed the alternatives analysis.

Jock Conyngham: And again, I'm not just talking about the Corps there.

Julie Marcy: Jock, this is Julie, had a question that came in on chat. “Are there any certified models with system connectivity parameters that you could recommend in the interim other than HSI models?”

Jock Conyngham: I think we have, there’s some very simple flow-length models that I think are in certification right now that are, that should be about out. And I need to check on that. In terms of these biotically informed models that I referred to, no. I am not aware of any that have gone through certification.

Julie Marcy: Okay. And that was another question that had come up in the chat was whether or not the models you refer to are certified and how that could be an issue.

Jock Conyngham: You know the fact is that the standard technique--and again, I don’t mean to criticize the importance of simple techniques—have measures for flow length or connected habitat through aerial assessments and so forth. They are inherent in an HSI.

Man: Yeah, I do know that.

Jock Conyngham: Yeah. They’re inherent in QHEI, which is approved and I think that we will be working towards these more biotic landformed ones in the next set of models that we’re developing and submitting.

Julie Marcy: Any additional questions or comments that anyone has for Jock? Remember you might need to unmute your phone.

Jock Conyngham: I’m in the universal address book of course, and I’ve put my phone number and e-mail address at the end of the presentation, if you want to get a hold of me or Kyle.

Julie Marcy: Well, if not, we'll go ahead and wrap up. As I mentioned, we will be posting the recording of this presentation, a PDF of the Power Point is already posted there, along with Jock's bio. We'll also have the transcript of the narrative that goes with the recording that we'll be posting there, and those will be accessible for you to use at your discretion.

If you have any trouble accessing any of the files, just let me know, Julie Marcy at ERDC Environmental Lab, and I'll be happy to help you access them. Jock is going to send me a follow-up message with information on citations for references used in the presentation and we'll post those in the archives as well.

I thank everyone for joining us. We had a great turnout today and we're glad to see that, especially with the winter weather impacting so many, including here in Vicksburg, Mississippi, where the frozen north decided to head south this week. I hope everyone stays safe and warm, and stayed tuned for Outlook announcements on our next ecosystem restoration webinars. Jock, thank you again for an excellent presentation, and everyone stay safe. That will conclude our presentation.

Jock Conyngham: Thanks, everybody. So long.

END