A partnership between the
National Climate Change and Wildlife Science Center (NCCWSC)
and the U.S. Fish and Wildlife Service's National Conservation Training Center (NCTC)

Webinar Transcript

Fish Habitat and Climate Change: Implications for the Desert Southwest, Midwestern Smallmouth Bass, and Eastern Brook Trout

Speakers:
Joanna Whittier, Research Assistant Professor, University of Missouri
Craig Paukert, Leader, Missouri Cooperative Fish and Wildlife Research Unit
Tyrell Deweber, Ph.D. Student, Penn State University

Recording Date:
Thursday, April 11, 2013

Webinar Video and Project Information:
https://nccwsc.usgs.gov/webinar/183

Ashley Fortune: Good afternoon, or good morning, from the U.S. Fish and Wildlife Service's National Conservation Training Center in Shepherdstown, West Virginia. My name is Ashley Fortune and I would like to welcome you to today's broadcast of the NCCWSC's Climate Change Science and Management Webinar Series.

This series is held in partnership with the U.S. Geological Survey's National Climate Change and Wildlife Science Center. Today's webinar will focus on the topic of "Fish Habitat and Climate Change, Implications for the Desert Southwest, Midwestern Smallmouth Bass, and Eastern Brook Trout".

Our speakers today are Craig Paukert, Tyrell Deweber, and Joanna Whittier. Dr. Shawn Carter, Senior Scientist at the USGS National Climate Change and Wildlife Science Center in Reston, Virginia will now introduce our speaker. Shawn, welcome.

Shawn Carter: Great, thank you, Ashley.

Thank you everyone for joining us for our webinar today. It's my pleasure to introduce a talk on managing the nation's fish habitat in multiple spatial scales in a rapidly changing climate. My understanding is this is going to be a joint effort.

I'm happy that we have Joanna Whittier, who is a Research Assistant Professor in the Fisheries and Wildlife Department at the University of Missouri. Her research focuses on factors leading to declines in species populations.

We also have Tyrell Deweber, a PhD candidate at Pennsylvania Cooperative Fisheries and Wildlife Research Unit at Penn State. He's currently investigating climate and land use change implications for river habitat and brook trout.

Then last, but not least, Craig Paukert, who is Leader of the Missouri Cooperative Fish and Wildlife Research Unit and also an Associate Professor at the University of Missouri. His research focuses on conservation and management of river and stream fishes, and the effects of climate change on aquatic systems.

Welcome, all of you. I'm happy to introduce you and look forward to your talks. You have the floor.

Craig Paukert: Thanks, Shawn. This is Craig Paukert, over at the Missouri Coop Unit. I'm going to start the talk today and spend about 15 minutes with some introduction, talking about smallmouth bass in the Midwest.

Then we'll switch it over to Tyrell to talk about eastern brook trout, and bring it back to Jodi Whittier to talk about some work in the Lower Colorado River Basin.

This is really the first part of a two-month talk, two one-hour talks, one today and one next month, on a pretty large project. As you can see from the PI list on the front of the slide there, this is a big project that collectively had about 17 investigators on it and really was using a lot of existing data, leveraged from all sorts of groups.

In particular, the National Fish Habitat Action Partnership, Aquatic Gap Analysis Program, also Federal Aid in Support Fish Restoration, Park Service, and other funding sources as well.

It is a big project. We're going to try to get through about half of it today and then the other half in about a month.

I just showed you the list of the PIs. They ranged from land use change modelers, climate change modelers and then fish folks. These are the people that are really doing the work. We have quite a few post-docs, PhD students, research and academic staff.

These are the on-the-ground folks. Several tech GIS and database type technicians helping out with the land use change modeling and just in general, GIS work, because there's quite a bit of that on this project.

You'll hear from Tyrell here in a little bit from Penn State to talk about the eastern brook trout work. I'm going to start off talking a little bit about the introduction here.

This is a big project. We're going at it from multiple directions in multiple different spatial scales and also going at it from individual species, all the way to fish community.

The first phase of our project really is talking about fish populations and in particular, smallmouth bass growth and consumption in the Midwest. That's what these four stars are, the native range of the smallmouth bass in the Midwest from Oklahoma all the way up to Minnesota.

Then we're actually going to expand out and go to looking at distributional changes of a key species in the east, the eastern brook trout, in the Eastern Brook Trout Joint Venture Range. Tyrell will talk about that.

Then we're actually going to head west. Jodi today will wrap up a big part of our talk on looking at native fish communities in the Lower Colorado River Basin. Next week, we'll actually continue that fish community at a regional scale, looking at Midwestern stream fishes. When I say Midwestern streams, that's going to be mainly Minnesota, Wisconsin and Michigan. We're also going to look at coldwater habitat in those Midwestern lakes as well.

Finally, we'll actually end with a national scale assessment, led primarily by Michigan State and looking at the entire United States. This is a more coarse-scale assessment. This is actually why we set it up this way. We knew at a national level, we wouldn't be able to get the detail that we may have at these more regional levels or even individual species or population levels.

Some of this work that we're doing is almost a feasibility study to show what we can and can't do from a nationwide scale all the way down to regions based on the different data available in each of the regions.

As I mentioned, today we're really going to focus on smallmouth bass, brook trout, and then the Lower Colorado River Basin. Next month, May 9th is the rest of the talk.

In the interests of time, unfortunately we're really not going to get into a lot of the details on the actual downscaled climate projections or the land use projections, but these were critical in our assessment, as you might imagine. These were the base for our assessments. We needed the downscaled climate projections so we could actually use this information to get, hopefully, air temperature and precipitation that we could link to stream temperature and stream flows.

We needed the projected land use, and this was mainly agriculture and urban land use, to link that to our landscape level metrics, which we've been using quite a bit in these assessments that are used as surrogates for fish habitat. These two critical pieces of information were input into the rest of our assessments that we're going to show you here in a couple minutes.

One of the reasons why I'm not going to go into the details of the land use and climate models is one, they're already available, and two, they're published. The climate models were done by Steve Hostetler and his team out at USGS and Oregon State. On the screen now, you can see the web link as well as the publications associated with the information that we're going to project here.

We used three GCMs at a spatial scale of 15 kilometers, so pretty fine-scale resolution. We also summarized this information, by day, but really used a five-year average. When we talk about 2060, that's the average over five years for a particular day around the year 2060.

We had 66 total variables that we received from Steve for this assessment, but the most logical ones that you'll see are things like air temperature and precipitation. Those are really used in our models for how that affects fish habitat and fishes.

The land use change is in a similar situation. Bryan Pijanowski is part of our team at Purdue University, and he's got a nice website. The link is up here. That shows the land use change in urban and ag land use in 10-year increments, using the 2001 National Land Cover as the base map. This was at the 30-kilometer scale.

For the urban land use, we projected out to 2100. For the agricultural land use, only to 2040. Brian wasn't very comfortable projecting agricultural land use out beyond that. Lots of variability and lots of uncertainty with the ag land use. Once again, this information's available, and there's the reference for the publication that just recently came out, using this information.

Unfortunately, that's really all I'm going to talk about with the climate and land use data, but as I mentioned, this was critical. Now what we needed to do is feed that information into our other assessments on fish and fish habitat.

The first one I'm going to talk about is at this individual scale. It's actually doing some individual-based modeling, bioenergetics modeling, to look at how climate change affects growth and consumption of smallmouth bass in the central U.S. here, where it's actually native. This isn't out in Washington or the Desert Southwest, where it's non-native and it's a problem, but it's actually generally considered a good thing in my neck of the woods here.

This was part of Allison Pease's post-doc work when she was with me here at the Missouri Coop unit.

For this particular project, we really wanted to look at the individual and population level impacts of climate change. As you'll see, if you're familiar with the climate change research and even some of the talks today, there was a lot of work on distributional changes in fishes, particularly recently on a lot of trout work in the Pacific Northwest in the western U.S.

But, we really wanted to focus on the population level and the individual level to show that just because a fish is there, doesn't necessarily mean that it's doing well.

We wanted to predict growth and consumption in these four populations of smallmouth bass. These are across a strong latitudinal gradient from Minnesota -- from the Mississippi River in Minnesota down to a smaller river in Oklahoma, the Glover River.

We chose these four populations for a couple reasons. First is because of the latitudinal gradient. We really had a range in temperatures, but also there was a fair amount of data available, both stream temperature data, air temperature nearby, and then fish data at these locations from various studies.

The first thing we wanted to do with this particular study is at these locations, these four locations, to relate air temperature and stream temperature. This is where it was really nice that we had temperature gauges nearby on these particular stream reaches.

We just used the last five years or so of data to compare air and stream temperature. We found actually a pretty good relationship just with that simple regression model. Depending on the site, the R-squares were 0.76 to 0.87. So, we felt pretty comfortable that we could predict stream temperature from air temperature.

Then, since we had that relationship, we were able to plug this in to the downscaled climate models with our air temperature data to predict, in the future, what the potential stream temperature would be at those particular sites. We did this with the three GCMs that I mentioned earlier. Just for the purposes of this talk and clarity, we're going to focus primarily on comparing present day to 2060.

When I say "present day," it's a little misleading. Because actually we used 1995 as present day for this particular study, and the main reason for that is that its about the time frame that a lot of the information on smallmouth bass was collected at these sites. It's not technically “present day”, but it's the time when growth rates and diets were collected on smallmouth bass.

We did use a bioenergetics model. The physiological parameters from this model came from a paper that Greg Whitledge did. This actually is from the Ozark population, which is one of our study sites. That was kind of an advantage that we're actually using some of the physiological parameters directly from the Missouri study site.

What we really wanted for this particular project was we needed diets from the fish - ideally, seasonal diets. Energy densities of prey, basically how many calories per gram of energy is in a particular prey item. And then growth rates of the smallmouth bass.

We actually had most of this information from literature, agency reports and peer-reviewed publications. And then some of it was just from other literature and databases that were available.

Just to keep things on a level playing field, we decided that we were just going to model a 300-gram smallmouth bass. Every system had the same start weight. We model it for 365 days, which is just nice round number to say what was the annual growth, annual consumption. We didn't assume reproduction in these particular scenarios, just really for simplicity.

Real quickly, some of the inputs from the different regions. You can see here that there's actually...We had two seasons of data for diets, and there was actually a fairly substantial difference in diets, particularly from the northern to the southern populations.

That fish really dominated the Iowa population, for example, particularly in fall, but crayfish was really a big part of the southern populations, the Missouri and Oklahoma populations. Where insects, particularly in spring were dominant in some of the northern populations, like Minnesota and Iowa. We did have differences in the diets throughout the two seasons.

Then the growth rates that we have here just show you as well that there's a fairly substantial difference in growth rates. The Missouri populations are growing pretty slow. They grow to about 250 mm at age four, where in comparison, the Iowa is pretty fast growing at a little over 300 mm. That's really about a two inch difference at age four, which is pretty substantial for a smallmouth bass.

This sets the stage to say that we can input the projected stream temperature in the future that I just mentioned previously, the diets from these studies on these four populations, and then growth rates as well, and feed that into the energetics model.

The first thing I want to talk about with this is just the general differences in the temperature. I'm not going to dwell on it a whole lot, but I want you to focus on the left side here, just the text. The white numbers there are just the average deviance in temperature from present day or that 1995 to 2060. What this means is that depending on the model -- remember we had three different models.

The models show that our average temperature even decreased by up to 1.0 degree or 0.9 degrees in Minnesota, but also other models showed that it increased up to about 1.7 degrees. Iowa, kind of the same thing, so we actually have one situation, one model, showing cooler water temperatures.

When you get down to Missouri and Oklahoma, all of them show positive increases of 1.5 to 3.0 degrees C. The peak is just the midsummer temperatures that the models predicted. What I want to show you here is, particularly in Missouri but even in Iowa, that we had some of our projected stream temperatures: 28 degrees, 27 degrees.

Depending on which study you look at, that's getting into a pretty high temperature for smallmouth bass preferences. Really teetering on a thermal preference or a thermal limit that after this 27, 28 degrees C, they may not be real happy in that water temperature any more.

Really the nuts and bolts of this particular portion of the talk is looking at the growth and consumption. This is actually the change in growth and the change in consumption over this one-year period that we modeled. You'll see that up in Minnesota and Iowa, we have pretty modest increases in growth, three to four percent but they needed to consume somewhere around 15 to 18 percent more food to achieve that growth.

When you head down south, in Missouri and Oklahoma, growth was quite a bit more - 10 to almost 20 percent -- but look at the consumption rates. The consumption rates were 48 to 63 percent more. So really the take home message with this is that all these populations do appear to grow in the future climate warming scenarios, but they're going to need -- particularly in the south -- to eat a heck of a lot more food to even have moderate growth rates.

This is assuming food availability or prey availability does not change. It's a big assumption, but it's something that we just have to deal with right now. I think the southern populations, in particular, cause some concern that they're really eating a lot of food, so maybe that means there could be limited carrying capacity issues, depending on food availability in the future.

Another way to look at the information I just presented to you and more in a general way, is that across all populations, in general, a one degree increase of water temperature meant about a seven percent increase in growth. But to achieve that growth, they needed about 27 percent increase in consumption. Once again, a relatively modest warming means yeah, they may grow a little bit, but they're actually going to be burning through a lot of food to achieve that growth.

That was a real quick background on some of the smallmouth bass work that we're doing. This really sums it up, that we really didn't see consistent patterns across latitudes, probably no great surprise there, that the southern populations or at least in the native range of smallmouth bass, that these fish do seem to be consuming a lot more as they start creeping up towards some maximum thermal temperatures that they would like.

To be honest, the reason why we looked at growth is because it was easy. Growth is a lot easier metric to measure than some of these other things, like food web dynamics.

We're certainly making the assumption that growth is a surrogate for fish health, that maybe it means other things, like does increased growth mean maybe increased fecundity or increase survival or other measures of that could be achieved at the population level to show that maybe it's a more healthy population with faster growth, for example.

Also, the increased climate warming may allow managers to consider how to maybe tweak their management regulations based on maybe harvest regulations like protecting spawning bass, for example, during the spring, which is something that comes up on occasion. If we have a change in phenology, if we're talking about fish spawning a little earlier, a little later, maybe that start-date for bass season may have to change.

Also growth rates, particularly in the south, are what really increased quite a bit. If you're protecting to a certain size range, maybe those fish will be one year...Maybe they're not age four, they're age three by the time they reach a harvestable size.

As I mentioned before, I think though, one thing that we got to keep in mind is that we'd love to figure out how this links into food web dynamics. We are assuming that there is the same food available in the year 2060 as there is now. Not sure that's really going to be the case, but that's really, I think...The next step in this is trying to get handle on say for example, crayfish abundance in these particular streams and how those with our climate change.

That was a quick overview of our smallmouth bass work. I think Ashley, we talked about maybe a little bit of time here for questions about these individual projects, but we will have a larger chunk of time at the end for overall questions. If anyone wants to ask any questions specific to the smallmouth bass work, we can answer them now or we can wait till the end.

That ends our smallmouth bass portion of the talk. That really demonstrated that we do see these potential individual effects of climate change. Now we're going to take it up to more the distributional level and head out east to the eastern brook trout, where Tyrell is going to talk more specifically about distributions in eastern brook trout related to, particularly, the stream temperatures in that system.

With that, we'll switch it over to Tyrell for about the next 15 minutes or so. He'll talk about brook trout.

Tyrell Deweber: Thank you, Craig, and thank you everyone for listening to our talk. Today, I'm going to talk about linking climate and land-use projections to stream temperature and then implications for brook trout in the eastern US, as was mentioned.

To start off, for folks, I'm sure all of us are familiar with brook trout. In the eastern U.S., throughout its native range, it's a culturally important species and considered a sentinel of pristine streams and rivers. There's a lot of focus on conservation of brook trout and they're culturally important and considered a game fish of importance throughout the region.

The habitat requirements are pretty stringent among fish. The water temperature is typically cold water; temperatures less than 22, around that ballpark, are considered suitable. They require clean water and clean gravel substrate for spawning, and also suitable flows for egg and larval development.

Today, I'm going to focus on the water temperature. I'll talk a little bit about temperature modeling and then relate that to brook trout.

As we know, or anyone familiar with the Eastern Brook Trout Joint Venture assessment, there's less than 30 percent of sub-watershed tab greater than 50 percent of original [audio cut] intact.

What about 80 years from now? Will climate and land use changes cause decline? Declines in populations and where they're found.

The basic outline of today's talk is air temperature and landscape attributes affect water temperature, and these in turn affect brook trout. The goal of this work is to develop a predictive water temperature model and then to link this to brook trout.

I do realize that landscape predictors can also be shown to directly be related to trout distribution, but we won't learn about that today. Then we're going to begin the climate and land use changes. Climate change is expected to increase air temperatures and land-use change results in landscape changes. This takes place throughout time, so from present day into the future.

To briefly go over the temperature model, the goal is to characterize thermal habitat throughout the region. We chose to predict mean daily water temperature for all stream reaches in the region.

This is the NHDPlus data set. We focused on those that are topologically correct, so there are some that are removed, but for the most part, this is the...It's around 190,000 stream reaches. It's a pretty big effort.

We chose to use neural networks because they're able to handle non-linear interactions and we don't have to know exactly all the processes and the effects of each predictor on water temperature.

Then we wanted to assess predictive accuracy and get a good handle of, how is this actually going to perform at new sites throughout the region, so even non-random site based cross validation. I won't go into that anymore but the idea is just to ensure that our calculated root-mean-square error is actually representative of if we were to predict at a new temperature site or at a new stream reach.

Here's an overview, briefly, of the temperature data that I was able to collect. You can see that there's a pretty good latitude, no gradient, lots of data in Maine and in Maryland and also Connecticut and some down in Georgia and such.

There are big holes, but I'm very thankful if anyone found this call and gave me data and allowed me to use it. I was able to collect quite a bit. We had 1,059 sites after we screened them for effects of dams and problems with some of their records.

These range from 1980 to 2010. To go over, I'm not going to read off these landscape predictors, but we did select a range of landscape predictors, both at the network catchment and landscape...our local catchments that we expected to be related to water temperature in some way.

We also had empirical climate data from the National Climatic Data Center sites of air temperature from 1980 to 2010. At these sites, we calculated both current and seven-day prior air temperature and use these in the models.

To look at some of the results of temperature modeling, what we found was...It ended up getting what I would say is a pretty good fit for the model. I should say this is also the period...We're modeling between May and October, so it's mostly the warm season and not dealing with the winter when we have ice and different issues with the rivers. Most of the water temperature data is collected in that period.

The training root-means-square error was 1.98 and the validation was 1.81, but you can see it's a pretty good fit. It follows a linear trend, for the most part, but there is some over-prediction of low temperatures and under predictions of high temperatures. As you can see by looking up in this area, it's under-predicted a little and down here, it's over-predicted. We feel like this is a pretty good model for predicting water temperatures.

Then the [inaudible 26:38] water temperature model ise going to link it and Craig talked about this climate change data. The way I'm linking this to the temperature model is to attribute it to these empirical climate sites, so wherever one of these climate sites is found, it's given the air temperature above it from the climate model.

I'm using a Delta method to attribute the changes. If, for example, the GenMOM model predicts a two-degree Celsius increase between now and 2087, then we would add two degrees to the empirical data. That's a pretty standard way to do a climate change assessment.

There's also the land-use change data, and I wanted to show this for the region. In our case, there was a lot of agricultural build-out in the rest of the U.S., but in the eastern brook trout native range it is, I think, kind of expected. There's not a lot of agricultural build-out, but there is quite a bit of urban development, especially...

There are two [inaudible 27:39] centers in New York and DC and Pittsburg and other places that are [inaudible 27:44] , so there's a lot of developed land use. This can have definite effects on water temperature and on brook trout.

Just to show, I'm not going to focus on the predicted temperature increases themselves today because we want to talk about fish and brook trout populations. But, here is predicted water temperature, mean July water temperature in 1997 and here's an example of these different water temperature classes there on the left side.

In 2087, using the GenMOM model, this is the type of increases that we see, and this is the highest end around three or four degrees Celsius temperature increases, depending on where you are in the region.

How will we link this to brook trout? We defined suitable temperatures as being any mean July temperature less than 21 degrees Celsius. We consider that to be a suitable thermal temperature, or suitable thermal stream habitat for brook trout.

We identified this using trout occurrence. We lined it with predicted model temperatures. It includes about 98 percent of all the sites where we found brook trout, so we think it's a pretty good cutoff. There are certainly other options, but seems to be pretty good. This is what we end up with, if we predict brook trout suitability based on that.

So, that's our starting map. You'll see that there in a few seconds. I'm going to jump now, straight into the results. Plugging in the climate change data alone, we have...This is not including land-use changes, so it'll just be climate change alone and holding land use as it is now.

Here is for the GenMOM model. This is the lower end. The projected air temperature increases are quite a bit lower. Then in 1997, there's that map again. In 2042, around a six percent loss. You can see that it's mostly around these edges here, these lower elevation areas around the margins of the range, and then Pennsylvania, where the elevations are a little lower.

In 2087, around a 23 percent loss. Again, it's mostly around the margins. You do start to see some in this area, in the Vermont area, and also up in Maine.

Then for the next model, I'm just going to talk about the GenMOM and the ECHAM5. This is the higher end scenario of ours and then we had one other model, the GFDL, and I'm not going to present it because it's intermediate so you can just imagine that it's in-between these two. What we see is by 2042 around 10 percent habitat is lost and then by 2087, it's around 50 percent. This model really predicts big temperature changes around the second half of the century.

This is quite a lot of habitat loss, as you can imagine. It's significant. The areas you still have left are the really high elevation areas, the plateau in northern Pennsylvania and down here among the Smoky Mountain areas. Obviously, we don't have Rocky Mountains out here.

Then land use change, I'm not going to show maps for that because it's very localized and the effects were around nine percent habitat loss so it's hard to see on a map. It's really impossible unless using it on a specific area. What I will show is the additive versus the combined effects. I did the two scenarios with climate change separately and land use change separately.

If you add those together, you'll see over here on the left, I'll focus on the ECHAM5 for 2087. You get a combined predicted loss of 50.8 percent. If you put both climate and land use change in the temperature model at once and predict future losses, you get around 52 percent loss.

There are some streams that are being lost and in this adjustment, there are some synergisms between climate and land use effects, which everyone expects. It suggest around 1.2 to 1.4 percent additional loss that [inaudible 32:11].

Just to go over what I talked about. The temperature model is, I would say, an advance. It covers a large region with reasonable accuracy and can be used for a lot of other studies such as fresh water mussel conservation or other species of concern throughout the region. Then, also, the expected effects on brook trout from climate and land use changes, especially climate change stuff, there's been other studies done in the past.

Some of the first by Meisner was one of the first climate change studies for all species. It predicted similar effects of 50 percent, 23 to 50 percent predicted loss of the brook trout habitat depending on what the temperature changes were. This work is linked to individual stream reaches so it's quite an advance.

We can see where there's actually going to be lose rather than using an elevation or an air temperature gradient as was done in the past.

The caveat is that not all of these affected areas that I showed here currently have trout. Some of them, a lot of them actually, brook trout aren't found there anymore so that needs to be kept in mind. Another assumption of these results is that there's no adaptation and no refugia so the brook trout aren't able to find ways to escape these water temperature changes or to find cold water refugia where they can hang out, which we know they do and they are able to find them sometimes.

Also, how should we interpret these results? It leaves one wondering. I think they should be combined with additional information. They probably shouldn't be taken on their own, that a given stream is going to be lost, because there's a lot on this broad, coarse scale modeling that I don't know. I'm not the manager on the ground.

If one takes this information and looks at the stream and it seems like a reasonable assumption, there's not a lot of ground water, importance isn't so great in that stream and it seems like it could warm by that much then I think it could be used to prioritize conservation efforts. The additional information is key.

It can also be used to maintain flexibility and by that I mean to examine [inaudible 34:24] trout and they get special protection. If those are lost, if the brook trout populations fall below a certain density or such, that has implications for future water quality problems and conservation efforts because they will no longer receive the same level of protection unless something has changed in the current system.

A future effort that I'm focusing on is the role of riparian forests. In the temperature model, it does include a riparian forest scenario, riparian forest as a predictor. I'm just looking at that and looking at different scenarios to see how that might affect water temperatures in light of climate and land use change.

Conclusions: Brook trout could lose up to 50 percent of their thermally suitable habitat due to climate change and it acts broadly across the whole region whereas land change acts locally. It's minimal habitat loses from land use change, but a lot of these streams are on the edge of cities or maybe they're really culturally influenced because their populations are where many people are fishing.

There's also related fisheries and water quality implications from this land use change, primarily developed land and urbanization.

These projected changes can certainly help guide future decisions, especially when combined with additional information. With that, I'll take any burning questions if we have them. I'll also take some at the end, but if there are any that are out there...

Ashley: We do have a question from Monty Schmitt. It says could this modeling effort inform or even map where stream restoration could mitigate long-term climate change impacts?

Tyrell: It can depending on what the stream restoration efforts are because the limitations are broad coarse scope predictors such as land use throughout a local catchment or also riparian forest which is just defined by the national land cover data set at 30 meters on either side of the stream. My preliminary results that I had before, it was a little different temperature model but it's pretty similar.

They suggested that the climate change impacts were around 10 percent less in some cases, especially for the higher end temperature increases. There was a significant effect of riparian forests on maintaining stream habitat. I don't know if that answers the question. That's probably the limit.

Ashley: Do you have anything else?

Tyrell: No.

Ashley: We have another question from Than Hitt. It says can you talk more about how air temperatures influence the stream temperature projections. For example, did the Delta model assume a one to one relation between air and stream temps?

Tyrell: For that, we did not assume any relationship between air temperatures and stream temperatures and how they're related. The neural network model was basically used to do that. I did some diagnostic plots and it's very similar to the Mossini plot, if you've seen this. It probably depends on which stream you're in, but around a 0.8 degree, I would say, increase in stream temperature for every one degree increase in air temperature.

You also see that flatten out as you get warmer. We let the model decide what that relationship was.

The Delta method, on the other hand, was just for the air temperatures. I was hoping that wouldn't confuse anyone. Basically, for the Delta method, you have a given climate site and because the empirical climate data and the model climate data don't overlap, one may say that in May 24, 2013 that the empirical data says it's 26 degrees and, of course, the model data says it's 22.

That's not what we're really interested in. We're interested in what did the model say was the temperature increase? You add the expected increase to the empirical data and ignore what the model said the temperature was at your baseline.

If it says in the future it's going to be 29 degrees and now it's 26 then you would add three degrees increase.

Ashley: Thank you. We'll take one more question and then we'll hold the others until the end. This one is from Anne Timm. It says what is the main difference between the ECHAM5 model to the other models?

Tyrell: I'm going to have to divert this question. [laughs]

Yeah, it's probably more of a climate modeler's question. I call it ECHAM5. I know it predicts higher temperatures in the end. The scenarios are all the same, I can say that. The scenario as far as how much carbon is going into the atmosphere is similar between all models so it's what are the forcing factors.

Ashley: Thank you. We're going to switch it back over to Jodi (Joanna) and then we'll take the other two questions at the end.

Tyrell: Alright. Thank you.

Ashley: Thank you very much.

Craig: This is Craig and I'm just going to provide a brief transition. Basically, we've seen now so far that at the individual level, climate change may affect small mouth bass. We've also seen at the distribution level how it will affect brook trout. Now, we're going to do something completely different and head over to the desert southwest and talk about fish communities, particularly native fish communities.

I think in the next few minutes you'll realize why we went out here that we're going to see some pretty drastic differences and challenges related to water in the southwest.

Jodi: To give a little bit of background on this area, as Craig mentioned, we did select this area because it is topographically, environmentally, and climatic-wise quite different from our other regions in this project. We were curious to see what we might be able to do in terms of changes in stream habitat and the fishes that live there.

Our primary objective was looking at the potential changes in stream habitat based on shifts in land use and climate. We were looking to identify streams and watersheds that would be vulnerable to those changes. As many of you know, the lower Colorado River Basin is primarily a desert system. It's very xeric with very little rainfall.

There is also a very high number of endemic fish species and, unfortunately, an even higher number of fish species that have been introduced.

At this point, there are estimates of nearly 90 species being introduced and, of those, about two-thirds have actually become established. It's also a region that has incredibly high urban growth rates in the Vegas and Phoenix areas which, of course, then leads to additional demands for water. Water is being used for urban uses as well as a high proportion of agriculture.

Our initial approach was for the regional projects, we were going to try to predict potential changes to stream habitat conditions by developing stream temperature and flow models. From there, we were hoping to use that to project the shifts in habitat conditions, as I mentioned, from land use and climate change. Then we were hoping to be able to link that to, in our case, fish communities and in some of the other regional projects, they were going to look at individual species, such as Tyrell did.

We were also thinking that we might be able to use the fish traits to tie into those changes. Unfortunately, for the lower Colorado we had to change our plans on that. When we started exploring the data sets that were available, we contacted federal and state agencies, universities, NGOs, and other groups and individuals, but we just did not find enough data to develop year-round temperature models or flow models.

This figure just shows you where we found some continuous stream temperature data sets, but then when we filtered for trying to get year-round data; it really limited what was available and the total distribution of that. We did explore trying to use the method for the national assessment, which will be discussed in detail next month, with our thought being that the additional fish data that we had might help us refine their method for the lower Colorado.

Unfortunately, we also ran into another roadblock here because a very few number of sites met the requirements that were needed to conduct the method based on the national assessment.

Once we determined that the methods proposed for both the regional scale and the national scale were not going to be possible or did not add much additional insight for the lower Colorado, we took a different tactic.

Previously, we had developed species distribution models for fishes in the lower Colorado that included proportion of ag and urban land use and also variation in spring and winter precip and average annual temperature. The details of that method can be found in Strecker et al. 2012 "Ecological Applications."

One modification we made to this method is previously we had conducted community models. But in this case, we wanted to detect the differences in how species were responding to climate and land use so we ran individual models. These initial models had been developed using 30-year climate data so that's what's indicated here. We used a current, a 2040, and a 2085 time step.

This figure here shows the temporal coverage of the climate models we used just briefly. We ended up, for the lower Colorado, using the ECHAM5 and the GenMOM, which was primarily indicated earlier. This is a high change and low change with GFDL being the moderate.

As you can see, we didn't have enough temporal coverage with this model to be able to conduct these three time steps. Today, I'm just going to be talking about the more conservative model, the GenMOM.

This is a list of the species that we were able to model. Because we ended up shifting to the individual models, the number of species that we modeled dropped slightly and we ended up with 16 native. You'll notice from this table, a lot of these are endemic to the lower Colorado and only one is found elsewhere outside the Colorado system.

I've highlighted the humpback, pikeminnow, loach minnow, and razorback just to point out the sample size, which I think will come into play as I discuss some further slides. All modeled species had significant response for at least two of the climate or land use metrics that we were varying in our future models. All species except for the razorback showed a significant response to urban land use. The next most influential variables were various spring precip and average annual temperature.

This figure shows the directional change in distribution based on the difference in the number of stream segments that qualify as occupied using the conservative threshold of a 0.6 probability. Between the current condition and the 2085 time step, seven species increase their distribution by more than 25 percent and four of those by more than 100 percent. However, keep in mind, percentages can be a bit deceiving.

The distribution of pikeminnow appears to skyrocket, but this was really on a shift from about 10 stream segments to 100 and was restricted to primarily the Verde and Salt River system.

As I indicated previously, there can be other factors going on that we were not able to capture in our species distribution models. At the other end of the spectrum, it looks like five species have decreased by about 25 percent and three of these are endangered and one is threatened.

I want to highlight a couple of these species just to discuss the strengths and caveats of our results and how managers might apply this information. With the Humpback Chub, this species is really restricted to the Colorado Mainstem and the lower end of the Little Colorado. Although it appears that it is decreasing by about 50 percent of its range, one thing to keep in mind is the scale of the data that went into these landscape models and how species with these very restricted distributions, we may not be capturing enough of the climatic influence because these climate models are at such a coarse scale.

Where it appears the Humpback seems to be losing habitat, this actually is not terribly good habitat for this species in the first place so this shift from a current existing in 33 stream segments in the Little Colorado down to 16 stream segments may seem like a lot but, in reality, the scale of this information may be causing some problems.

However, on the other side, with the distribution of the Loach Minnow, this already occurs across several watersheds and in different systems. At this point, the current restriction on this species range shows it existing below 2,200 meters.

But, with these projections, we actually see it's moving up in elevation to about 3,000. This could be actually a real response to changes in climate as well as land use. We wanted to see how this fit in with the Desert Fish Habitat Partnership rankings. Thinking that, we'd see how well the response to climate might be already captured in this.

Unfortunately, really, it doesn't look like there is a strong correlation, but keep in mind that one of the components they incorporated was the level of management available.

Some of these species with low rankings swayed what might have been a correlation.

For the Colorado River basin, we had hoped to be able to follow the protocol that our group developed for the regional assessments. However, due to data limitations, we had to explore alternative approaches.

We first evaluated whether we could refine the results produced using the national approach given that we had access to additional stream temperature and fish records, but found that we were still data limited.

Ultimately, we used a coarser approach than the other regional projects where we incorporated downscaled climate metrics for air temperature and precipitation to model changes in species distribution as a surrogate for changes in habitat condition.

Based on our models, there does not appear to be any correlation between the Desert Fish Habitat Partnership rank and our projected changes in habitat conditions or distributions. I know they've been discussing possibilities of trying to incorporate some climate metrics into their projections. And so, this may be further justification for trying to build some of the influences of climate and land use change into their rank levels.

One caveat to keep in mind on the way we approach this was that we're assuming that percent occurrence by stream segment is actually reflecting changes in the habitat suitability for these fishes. And that the air temperature, precip, and land use influences are somehow linked together with other environmental factors to actual changes in habitat conditions.

We do believe that the extreme changes are likely more informative than the slight subtle changes, either on the positive or negative side. However, we really did also find that species with very restricted distributions are much more challenging to address, because of the landscape scale and coarse scale of a lot of the data sets that we have available.

We do feel that the information from these models can be used in more large picture management plans, more large scale management plans as well as also looking at potential future directions for research, in particular, trying to get to the mechanisms that could be driving these shifts in habitat conditions.

With that, I'm going to turn this back over to Craig.

Craig: I'm just going to quickly wrap up a few slides here, but really over the last hour or so, what we wanted to demonstrate on this project is that what we have learned is that the individual and population level, such as smallmouth bass in the Midwest, that they may need to actually eat or consume quite a bit more food -- up to 27 percent more food -- for a relatively moderate increase in growth rate of about seven percent.

Now if we go to the Northeast and talk about brook trout distributions in the Northeast, based on some of the climate projections and the work that Tyrell has been doing, brook trout could lose up to 50 percent of their suitable thermal habitat.

And then, if we go to a completely different basin, in the lower Colorado River, where it's a very arid system, we actually found that several warm water native fishes would increase by even over a 100 percent or double, where a couple of them would actually decline. One of the challenges here is we have many species with restricted distributions. They're in a relatively small area where they live.

For example, the humpback chub is only found within the Grand Canyon reach of the Colorado River and some of its lower tributaries.

Using these downscaled climate models and these broad scale analyses to address some of the issues of distribution for a relatively restricted species may be challenging. So that's where, as Jodi mentioned, going to the larger spatial scale, larger analysis, big picture is probably more appropriate given the uncertainty in these climate models. We're taking global models and downscaling them to a local level.

One thing that I want you to keep in mind is, when we started this project, particularly these regional projects like eastern brook trout in the Lower Colorado River Basin and what you'll see in the Upper Midwest next month. The idea was to try to keep these methods as similar as possible because that was the whole idea, to try to keep these consistent.

We couldn't, and Jodi just mentioned it, one of the reasons why we can't. In the Lower Colorado River Basin, when you're talking about just very few sites, relatively speaking, with stream temperature and flow, and particularly when you link those up to ones that have fish, it became less than eight percent of the sites.

The brook trout data that Tyrell was talking about actually had quite a few sites, over a thousand sites with temperature. What you'll see in the Upper Midwest, which is Michigan, Minnesota and Wisconsin, next month is that we're going to be looking at about 1,700 sites.

When you just take a simple calculation of the percentage of actual stream reaches in the region that have temperature, the Lower Colorado River Basin had just 0.2 percent of those. That's actually rounding up. I was trying to be conservative.

Even though the Upper Midwest is only a little over one percent, it's still substantially more than the Desert Southwest and even the eastern brook trout. For folks that have been linked up to the Fish Habitat Partnerships, this is no great surprise. One of the big issues with trying to get at some of the data we need is we need more stream gauges out there.

We need more flow information. We need more temperature information. This is no great surprise on that end.

As I mentioned, the approach that we took was dictated by the data. The Desert Southwest was a good example of that. We would have much rather tried to link stream temperatures and flows to fish. We just couldn't, given the data we have. In the eastern brook trout range, they could.

We're really hoping to provide a framework and recommendation. Given the data you have, what can you do with this information? Trying to put a positive slant on it, other than everything's doom and gloom. Given the information, what can we do?

Next month, you'll see the next half of this webinar. That's actually going to expand out. We're going to focus mainly on the Midwest from a lake component in the cold water lakes in the Upper Midwest, as well as Midwestern streams. Then we'll also talk about doing this very coarse scale national assessment as well.

So, you just kind of got a taste of the half of this project, and the other half will be coming May 9th. That's really it.

Obviously, you can imagine we had a lot of help on these projects, particularly with the existing data and leveraging existing funds from NFHAP and Aquatic GAP and some folks that I mentioned before. The Climate Change and Wildlife Science Center and USGS funded the work.

From the individual projects, we listed a lot of people here that offered data from the brook trout and the Lower Colorado River Basin as well. At that point, I think that's it. We can open it up to questions specifically to Lower Colorado River or just in general across the whole talk.

Ashley: We do have a general question about the funding. Genevieve Johnson asked, "Is there funding to help get more stream temperature data for the Southwest? I know managers who are willing to pay for the temperature gauges but can't fund the data collection."

Craig: Not coming to us, at least. I know that's been talked about. I'm not sure if there are any ongoing efforts with that. If there are, it would be great, but as far as I know, there's not. At least not directly related to this project.

Woman 1: Stephanie Coleman mentioned that she's got...Stephanie, I don't know if you're still on the line. It says you've got some funding for data collection?

Stephanie Coleman: Hi, this is Stephanie Coleman. What we're doing currently...I work for Forest Service on the Apache-Sitgreaves National Forests. Right now, I'm using Forest Service general program funding to fund data collection. Now at this point, it's only enough for a few loggers, but I'm trying to press at least to the region that this should become part of our general management.

I don't know how far I'll get. I'm also interested in other avenues for acquiring funding for data collection.

Craig: This is Craig again. I can say that atleast in the state of Missouri, so not the desert southwest, but we actually have a state funded project to develop stream temperature and flow models throughout the state.

We're throwing out, Jodi what is it, about 80 sites right now throughout the state? Putting them in there, putting loggers in there for at least three years. That's the Missouri Department of Conservation funding that work, so no federal funding.

Jodi: The Park Service has also agreed to help do it under about 12 sites.

Ashley: Jodi, I think you answered this somewhat. Stephanie also writes that the Apache-Sitgreaves National Forest is working towards getting a stream temp monitor network set up on the forest.

How many years of the stream temp data are needed to run the models? Can the models be used at a smaller forest scale? Did you guys cover that?

Jodi: I would say we should try for at least a full continuous summer to make a first stab at it. Preferably, if it could be multiple years and year round.

Particularly out where you guys are, because you're kind of in a similar situation that we are here. Where the changes in the winter, particularly in the lower elevation areas, might be really important too as we see the winter temperatures start to increase.

And, how that might influence how the aquatic communities are going to respond. The more continuous data we can get, the better chances are we can do some models, get some robust models off of those.

We found just from looking at literature that you don't need to be doing 15-minute records in order to keep the temperature loggers out there longer and lasting. Hourly seems to work pretty good.

If that kind of gets to your question? The more data that we have, the better. But, there's also a trade-off of funds and time.

Craig: One issue that when we brainstormed all this with Steve Hostetler that obviously makes a lot of sense intuitively, that it depends on the year, too. If you have a really high water year or a really low water year, flows may really affect temperature as well.

Getting, say, one continuous year or a summer of stream temperature data is useful, but only if that's truly representative of what's happening over a broader time scale. Certainly, as you look in the northern climates where the focus is more the summer maximum temperature, they're not caring a whole lot about what's going on in January.

Ashley: In regards to funding again, Genevieve Johnson had written possible Landscape Conservation Cooperative funding as a source as well.

Craig: And probably for the folks that are listening, when we talk about stream temperature modeling, most people are probably aware of Dan Isaak out of the Forest Service in Boise. He's got a blog and all sorts of temperature data.

He's kind of the go-to-guy I think now when it comes to stream temperature and fish relationships. Other folks around the country are also leaning on him to try to integrate stream temperature data throughout at least the northeastern U.S., and link it also to the western US where he's at.

Ashley: If anybody's interested, we do have a webinar that is archived of Dan's. You can send me an email and I will send you the link. We have a question from Doug Beard, Director of the National Climate Change and Wildlife Science Center. Doug?

Doug Beard: Craig, I apologize. I've got laryngitis, but it's getting better. I'm going to ask you the question Dr. Carter was so afraid to ask. You had a nice description of how these projects link together.

Could you expand on some of the challenges of trying to do this multi-scale analysis, and some of the things that we could learn from what you've found and could apply to other approaches? That really is the holy grail - trying to figure out how to put together projects that fit questions at multiple scales.

Craig: Probably the first thing that I can think of offhand goes back to the downscaled climate modeling. This project was funded I believe in '09, if I remember right.

There was a lot of downscaled modeling going on at that point, and a lot of concurrent modeling going on. We would hear about other models, other modeling efforts that were going on, and really didn't know a whole lot about them.

One thing that I think would be useful is just getting more communication around the US about what actual climate models are being done, and the pros and cons of those. Particularly being fish folks, like most of us are in this group, that we're relying on your climate modeler, Steve Hostetler, to tell us what works and what doesn't.

Unfortunately, these things just take a heck of a lot of time to process. That was a challenge too was that we'd be waiting for an additional model to finish before we could continue. Knowing what scales different models are using, maybe there's some modeling being done in another region that means that we don't have to do any modeling say for our particular project.

So, I think that would be one advantage is trying to put all the modeling pieces together. The second one is just that data availability is probably the biggest issue that we saw. You can see that in the Colorado River basin.

Unfortunately, it's something that we keep harping on. Most of us don't have a whole lot of control about getting more gauges out there. The idea that what we're trying to do with this project is trying to create a threshold. At what level of data can we actually say something?

How much data do we need to actually make some sort of meaningful analysis? You're going to see from the upper Midwest and Tyrell's work, where there's thousands of data points out there for temperature, that's really useful.

There's a gradient in the lower Colorado River where it's not useful because we have so few. But, somewhere, there's got to be a happy medium somewhere in between that we create a threshold where we have enough data to actually make some meaningful analyses.

Hopefully, that's a start at answering your questions.

Doug: Yeah, thanks Craig. That does illustrate some of the good challenges. Clearly, one of the things we ought to think about doing when you guys are done and after the next one, is have sort of a, I don't know what you call it, but a deconstruction or lessons learned sort of thing so it can help us when we try to do another one of these projects of this scale.

Craig: Yeah, I think that's a great idea. I think a lessons learned is...There's a lot of them. One of the reasons why we chose these different regions of the country is because we figured we'd have different lessons based on the different regions. That's exactly what happened.

Ashley: Thanks, Craig.

We have another text chat question from Sally Valdes. Any assessments on climate effects on fish in coastal and/or marine environments?

Craig: Not on this project. I suspect there are some going on, but not specifically for this project. We actually talked about it because one of our bases was really the National Fish Habitat Action Partnership. But just because of the limitations that we had as far as...This is as big a project as we wanted to handle, just looking at actually interior systems.

In fact, I can take that a step further. We had just one lake project. That's our lake project that you'll hear about next week in the upper Midwest. Another one that we've been ignoring is really lakes in other parts of the US and reservoirs, as well. This is 80 percent stream based. And so, not only are we missing coastal environments, but we're missing the reservoirs and lakes outside the upper Midwest.

Ashley: Thank you. And then, there's some great conversation going on between Stephanie and Leslie.

And then, also, Yin-Phan posted, for those interested in the temperature data, the Northeast Climate Science Center founded an extreme temperature inventory mapper and data portal. The mapper and portal is in progress. Thank you very much.

Craig: You'll hear more from Yin-Phan next month because she's part of this project, looking up the national assessment.

Ashley: Excellent. And then, I did just want to point out that Tyrell did answer Jennifer's and Dan's questions to his presentation. If you guys want to just take a look at that in the chat box and if you need any clarification, please just let us know.

While we're waiting, Craig, do you have any closing remarks?

Craig: No, other than thanks for everyone participating. It looked like we were somewhere up in the 70s range, so glad to see that. I'm glad to see some NFHAP faces or names on there and some folks from all regions of the country. We appreciate the interest.

Jodi: Definitely anyone who wants to, feel free to contact us directly if you have any other questions or any other thoughts down the road.

Craig: I have the beginning slide up and down towards the bottom at the center is our website.

Ashley: Thank you very much. Holly, do you have any closing remarks at all?

Holly: No, I don't think so. Thank you so much. It was educational and excellent. Thank you.

Craig: Glad to do it.

Ashley: I'd like to thank all our presenters again. A very, very good presentation. Thank you. A thank you to all our participants. I hope that you enjoyed it.

Transcription by CastingWords