Understanding Water Availability Across Landscapes in a Time of Increasing Drought

Ashley Fortune Isham: Good afternoon or good morning, depending on your time zone, from the U.S. Fish and Wildlife Service's National Conservation Training Center in Shepherdstown, West Virginia.

My name is Ashley Fortune Isham. I would like to welcome you to our webinar series that we hold in partnership with the U.S. Geological Survey's National Climate Change and Wildlife Science Center, or NCCWSC. They're located in Reston, Virginia.

The NCCWSC's Climate Change Science and Management Webinar Series highlights their sponsored science projects related to climate change impacts and adaptation, and aims to increase awareness and inform participants like you about potential and predicted climate change impacts on fish and wildlife.

I did just want to welcome Elda Varela Minder, who will be introducing today's speaker. She's a research associate. Welcome, Elda.

Elda Varela Minder: Hi. Yes. Welcome everyone. Thank you for joining us today. I just wanted to welcome our speaker, Jason Dunham. He is an aquatic ecologist with USGS Forest and Rangeland Ecosystem Science Center in Corvallis, Oregon.

For his graduate work in the early 1990s he studied fishes in the Sonoran and Great Basin Deserts, and since has expanded his work across the western US and internationally. His current research is focused on climate and land use change, species conservation, biological invasion, and development of tools to engage managers and stakeholders in science application. Thank you so much and welcome, Jason.

Jason Dunham: Thank you very much. Am I good to go?

Ashley: Yes.

Elda: You are good to go.

Jason: Thanks, folks, for signing up for the webinar today. It's a real pleasure for me to share this work. I hope you find it interesting and have some good questions for me at the end.

To begin with I'd like to thank the National Climate Change and Wildlife Science Center for supporting a good chunk of this work. Also for inviting me to serve on the SNAPP Ecological Drought Working Group. It's been a great experience. You'll also see here, on the marquise, logos from numerous organizations who have all played an important role in the work that I'm going to talk about today.

Hopefully I'll do a good job of acknowledging each and every one of them as I go through this.

Even if you're not from California you've probably heard about the California drought. It's been a big deal here out west where I work. I'm in the Forest and Rangeland Ecosystem Science Center in Corvallis, Oregon. As you can see here, from the drought monitor, even in normally wet and cloudy Oregon we have been experiencing a fairly dry conditions in the last several years, peaking in 2015.

This phenomenon is not unique to the west. If you take a look at the drought monitor, this is really a wonderful resource if you don't...it's interesting to see over time how things come and go nationally.

You can see in the southeast U.S. right now that it's starting to get into a drought situation. Across the U.S. things are abnormally dry in a lot of places. This is something that we're becoming increasingly aware of as the realization that climate change is probably the main driving force behind a lot of these cycles.

Here's the story from California. This is a nice summary of what's going on. It's from a paper by Noah Diffenbaugh published in "PNAS" last year. If you look at the left-hand graph, what you can see is a distribution of points over time, arrayed along two axes. One is a temperature anomaly. Warmer up top, cooler below. The precip anomaly, precipitation, again showing that same sort of gradient.

What you see historically is these points are arrayed more or less evenly across the four quadrants of that plot. If you look at a more recent time series from 1995 to 2014, and this is the modified Palmer Drought Severity Index, but just about any index would probably show this, what you see is an increasing prevalence of points in this quadrant here.

Let me get the green little pointer here to work. I'm trying to use my mouse. Sorry. Right here. That is indicating an increasing prevalence of drought conditions. It's mostly driven by increasingly warm temperatures.

Precipitation is all over the map, in terms of historical climates and climate projections. The one thing that we're pretty sure about is it's going to get warmer. That means increasing prevalence of drought. 2015 is basically a peak into what the future is going to look like on a more frequent basis for us.

This is how things have been playing out in California with the drought. One of my current master's students was a student at Fresno State University, studying Chinook salmon in this river, the San Joaquin. He decided to move to Oregon after 42 miles of the stream was dried up in the 2015 drought event.

It's a pretty big deal, and it seems to be moving around the country. Another thing that happens when things get hot and dry is wildfires, and this is just at the top of this slide here is a trace of large fires over time.

This is from a recent paper by Tony Westerling. The solid black line is temperature, and the red bars are frequency of large wildfires.

You can see that historically we've got a lot more, relative to the historical record, we've got a lot more large wildfires occurring now and temperatures are increasing as well.

As you can see in the slide here, these events have fairly significant impacts on streams. The questions I have with respect to fires, droughts and other effects of climate are, "How does this influence availability of water across landscapes in streams like this?"

About 80 percent of our streams in stream networks are small streams. These are the circulatory systems of water delivery systems for our larger rivers and the landscape as a whole.

We're also interested in stream temperatures because what happens to stream temperature essentially parallels what happens with stream flow permanence.

To start off with, I want to discuss an example of a series of projects that we're working on in the Great Basin out West here. Then I will expand to a more regional perspective and ultimately to a national initiative that we're trying to launch now to look at these questions about flow permanence and thermal regimes in these smaller streams.

The Great Basin is a great place to do this work. It's characterized by indirect drainages. None of the rivers here flow to the sea. They're all kind of self-contained.

There's a lot of so called pluvial lake basins. A lot of these places had a lot of water in the pleistocene. There was a lake across this expanse here that was about the size of Lake Erie 15,000 years ago.

The topography is a horst and graben topography, or basin range, if you prefer. It's an easy place to work because it's about 80 percent or more public land, depending on where you're at on this geography,

A lot of the Great Basin is this snow driven hydrology, so it should be fairly climate sensitive. If you want to learn more about the Great Basin, I highly recommend this great book by Don Grayson in the lower left-hand portion of the slide. It's great background to the region.

I want to acknowledge a few specific individuals that are working with me out in the Great Basin. Folks in my lab, Mike Heck, Luke Schultz. David Hockman-Wert, Nate Chelgren playing key roles. Ivan Arismendi from Oregon State University, some folks from Trout Unlimited, Dan Dauwalter, Kurt Fesenmyer, Helen Neville, and Seth Wenger from the University of Georgia.

Also funding from a variety of groups there in the lower right-hand corner of the slide.

Why do we care about water in the desert? It's obvious. There are a lot of species that depend on water, a lot of species of conservation concern. In the upper left-hand corner of the shot there of the Greater Sage Grouse which is a major DOI species of concern as of late.

Other species though like mountain quail in the center top there was proposed for listing and another water dependent species, the pygmy rabbit in the upper right. North American beaver, a big species in terms of being an ecosystem engineer and the focus of a lot of restoration efforts out there including climate adaptation, Columbia spotted frogs, obviously dependent on water being an amphibian.

Then, of course, I'm a fish ecologist, and I always point towards the fish which don't always get as much attention, but they are the listed species in the Great Basin and by far the most in peril because they are completely dependent on water.

What do we know about water in the Great Basin? This is a picture of USGS's flow gauge network across the nation. Don't worry about the colors. That just shows you where they're at in terms of this discharge relative to historic record, but you can just see the concentration of points across the continental US, Alaska, and Hawaii, Puerto Rico, and a big concentration of gauges in the east.

Some along the West coast, and as you move further inland, you can see here in the state of Oregon, we get Western Oregon, a lot of gauges here. Once you move out into the Great Basin, hardly anything at all. When you take a look at the state of Nevada, which hosts a big portion of the Great Basin, you get a lot of gauges up here around Lake Tahoe.

Once you get out into the eastern portions of the deserts, very little in terms of gauges. Not a lot of information out there for us to tap into, in terms of understanding flow permanence, thermal regimes, and all that kind of stuff. The other challenge with gauges is, they're often put up in places where people have a strong interest in using the water.

They're often located on streams, or watersheds that are highly altered by human flow regulation, so it's really hard to pull that climate signal out of gauges. We know, from recent work by Tyrell Deweber and others, that gauges often don't represent streams in terms of conditions that you see across the landscape. They're a very selective sub-set of streams that are out there.

Gauges are a wonderful source of information, but we can't rely on gauges alone to understand climate change, to understand what's going on across the landscape. We could turn to looking at water temperature. A lot of folks are sampling water temperatures in streams across the nation.

This is a lot easier to do. All you need is one of these little instruments, like the one pictured here in the slide. That's a little TidBit made by Onset Corporation, but lots of companies making these things these days. It's pretty easy to program, and drop into the stream.

If you look at, this is just the Lahontan Basin here, in the Great Basin. Let me get my pointer moving here. It's a little challenge here, to use this. This is the outline of the Lahontan Basin. Again, Lake Tahoe over here. You can see all these little dark points, lots of water temperature sampling here, where all the people are, all the water is.

Once you get out to the eastern portion, just huge extents of the Great Basin where there's very little information at all, even for these very simple sensors. We can use contemporary spatial statistical models to prep for six hours in between some of the points that we used to create this model, so we're not sure, exactly, of how reliable these predictions are.

The other factor in this part of the world is the issue of flow permanence. About 80 percent of the streams in the Great Basin are classified as intermittent, so they don't have water on the year-round basis. That makes it very challenging, as well, for predicting water temperature, because in fact that stream is more likely to be dry. We'll talk about that more in a second. One of the things that really drew me into this work, I might have mentioned I'm a fish ecologist by training, and by practice.

One of the things I came to realize, working in the Great Basin for over 20 years, is that we actually know more about fish than we know about water. We've got about 500 samples of water temperatures in the Lahontan Basin, for example, and we've got over 5,000 examples of fish, based on a recent publication of mine, but when I realized this, I got a little bit chagrined, and decided, "Wow, maybe we should start doing more work on water, and we'll get to the fish later."

Another interesting issue to bring up here, at this point, and give you a little background material is, a lot of you folks know this I'm preaching to the choir, I'm sure. Our stream classifications are often decades out of date. USGS did a wonderful job decades ago in mapping out streams using stereo photographs, and pen and paper. This is a great image that Kevin Roth, who was in charge of NHD, now retired, but still working with the NHD program, she sent this to me, just an old, historical map.

She reminded me that all of the digital NHD that we see these days, and we use in our conservation assessments, was digitized from maps like this, that oftentimes are quite old. We simply don't have the staff anymore to go out and look at these streams, and these classifications were created probably during a different climate regime than we're experiencing today. No wonder, when we go out in the field, we find that these are often incorrect. Folks have looked at this.

There's an interesting, recent paper by Ken Fritz, and a bunch of other folks from EPA. They actually did the work here in Oregon, looking at NHD, and actual patterns of flow permanence. What they found here in the state of Oregon is, NHD was about 50 percent off with respect to classifying perennial streams. Again, I'll talk more about that in a second, with the great basin, and what we found there.

What's the solution? The obvious solution is data. We simply need more data on patterns of flow permanence and thermal regimes in these streams. We need to get stuff in the water. We have three different types of sensors that we're deploying in streams to collect this data. The first is a temperature logger, an example here of the Onset Tidbit.

That can give us, we're putting them in for a full year, to get a full year thermal regime in, and working up some ways to statistically determine when that temperature is telling us when a stream went dry, versus when its got water in it. To back that up, in a lot of places we've got electrical resistors deployed in these stream channels.

These are modified thermistors. We basically pulled the wires out, disabled the thermistors, so this thing is measuring electrical impedence, the ability of the water to conduct electricity. That gives us basically an off/on signal of wet or dry.

Then, in a few places, we've got instruments like this deployed that can...they're pressure transducers and thermistors, so they can tell us water depth and temperature at the same time, so that's another way to look and tell if a stream has gone dry.

Finally, we pair these instruments up with air temperature sensors in the basin, the correlation between air and water can tell us if a stream has gone dry or not, based on that pattern of variability, and also give us an idea of how stream temperatures and flow permanence are responding to changes in atmospheric conditions, as indicated by air temperature patterns.

What we're trying to get at is annual regimes. We want to look at seasonal variability among years. We're trying to move away from the three stage classification of streams as ephemeral, intermittent, or perennial, and embrace this idea, like we have with flow regimes, of thinking about flow permanence and thermal regimes.

In terms of the frequency of events, their timings or phenology, if you will, the duration -- how long do they last -- and magnitudes. We know all of these are very important biologically, and give us much greater capability to look at the effects of climate on these systems.

We're doing that for thermal regimes, and you can see here. Here's some different descriptors of thermal regimes in terms of timing, the variability of magnitude. This is just a two-factor principal components plot, digesting all of these metrics into a couple of scores.

What you can tell from how these different descriptors are arrayed across this graph is that the timing, variability, and magnitude at least are telling us very different things about these streams. They're all useful descriptors of what's going on.

The same logic applies for stream flow permanence. This is an example published by Chris Jaeger a couple of years ago, again in PNAS. This is the Verde River Basin in central Arizona, and looking at the frequency of zero flow days, or events, and the duration of these events, trying to come up with a more regime-based approach of classifying flow permanence. This is where it's all going in the future.

What are we doing in the Great Basin? We've got two different types of instrumental networks deployed. At one extent, we're looking across entire large basins. This is the Eastern Lahontan Basin in northern Nevada, and this is the distribution of points that we're hoping to sample using an e-MAP and grids design, to look at regional sensitivity, flow permanence, and thermal regimes to climatic variability.

Then we've got data being collected now in a couple of focal basins. One here in Southeast Oregon, the other in North-Central Nevada. These are really densely instrumented networks, and because of that, we're able to drill down, and not only take a look at climate sensitivity, but ask questions about local land, and water management, and how that influences what's going on in the stream channel.

We're going to talk about these focal basin studies in the time I have today, because we have more data, and more information from that at this time. Here's a close-up of the basin we're studying in Southeast Oregon, it's the Willow Whitehorse Basin. It's the world's stronghold for this threatened species, Lahontan Cutthroat Trout, pictured here.

It's also a very important place for the Greater Sage Grouse and a variety of other species, and important for the local permittee, who grazes his cows up here. You can see the black dots in the stream network. That indicates where we have these sensors deployed.

We've got one about every kilometer in this basin. We've used a modified grids design, so things are fairly well spatially distributed in what were classified by NHD as perennial and intermittant the streams. You can see the red dotted line around this watershed. This is the perimeter of the 2012 Holloway fire, which burned extensively across here in August of 2012.

Of course, up here, the partners who have supported this work. Bureau of Land Management has provided much of the funding, and Trout Unlimited is a key partner here, as well. The Trout Creeks and the Willow Whitehorse Basin, the Trout Creek Mountains and the Willow Whitehorse Creeks are a pretty important place.

It's one of the first examples we have of ranchers working collaboratively with land managers and other partners in the region to get the grazing rights. I want to give credit to Doc and Connie Hatfield, who are the originals involved in the Trout Creek working group.

This involved the former Secretary of Interior, Bruce Babbitt, and all that back in the '90s. It's been a real success story. We've gone from a fairly overgrazed situation to really nice looking riparian zones, like this, in lower Willow Creek. It's a great example to be working in.

Unfortunately, the Holloway fire, which burned this area in 2012, really changed the story, at least temporarily. You can see the pre-fire condition as an example of what that riparian zone looked like pre-fire, and then post-fire. It's a pretty much clear picture of what happened. Everything got really burned quite severely.

The BLM is very interested in trying to understand the post-fire response of these systems. It turns out that we had temperature loggers in the stream before the fire, so we had the capability to look at pre and post-fire changes in the stream conditions.

They're interested in using this information for their grazing management, after a wildfire, and BLM can call a halt to grazing for a certain time period until upland vegetation recovers. They've never really been able to consider how streams recover, and what that appropriate recovery timeframe might be like, so that's what we're looking into in the study, in part.

Here's a picture of one of our temperature loggers, just to give you a sense of how hot that fire was, at least in some places. This logger was protected by a PVC shield. We actually got data from this thing, but I'm not sure I'm really going to trust it. I won't talk about it today, but it takes a lot of heat to burn PVC like that.

Here's a place where we got good data back before and after the fire. This is just a zoom in of the immediate effects of this wildfire on stream temperatures, which you see immediately before the Holloway fire, is that maximum temperatures here in the red, average and minimums are tracking each other fairly closely.

Right after the fire, the maximum temperatures really shot up several degrees. The mean, just a little bit, and the minimums pretty much stayed the same. We're interested, over time, of moving out along this X axis to understand how long it takes a system to recover.

This is a little bit more of a confusing plot here, and here's the vertical line indicating the date of the Holloway fire. Maximum temperatures in red, average in green, and minimums in blue. We're tracking these temperatures over several years, from 2012, up to 2016, trying to get a better understanding of what's happening, in terms of summer heating in the wake of this fire, and recovery of the riparian zone.

Winter cooling, that loss of riparian vegetation, you might see more radiated heat loss in the winter. Nobody has ever looked at that. We might see more freezing, which is a big deal. Sometimes I wonder if freezing is more important than warm summer temperatures in this part of the world, in this cold Great Basin desert.

Then also interested in the duration, the number of years of responses. We're right in the middle of that statistical analysis now, conducting a pre-coast fire comparison with an unburned reference site, the stream just a few kilometers down the road that has a very comparable time series. We're going to be publishing that, hopefully this next year.

That's what we're looking at in terms of temperature in the system, in part. We're also trying to diagnose stream drying. As I mentioned before, we have these resistors deployed in this stream network that are paired up with these temperature loggers, so we'll know exactly when the streams go dry, and how that's reflected in the temperature record.

What we're trying to do here is develop some statistical filters to diagnose when a stream goes dry, based on temperature alone, so in the future, we only have to use one instrument to determine thermal regimes and drying at the same time.

Here's an example of what these data look like, for the first year of data from Willow and Whitehorse Creeks. The blue trace over time is water temperature. The red trace is the reading from the resistor. The resistor is essentially just indicating presence or absence of water.

What you see at this particular site is that it was dry until about February of this year, then it got wet. You can see an immediate change in the thermal regime, that's recorded by the sensor that's sitting in that stream channel, and of course an immediate response of the resistor, indicating that there is now electrical conductivity in that system.

Then it dries fairly abruptly in July. You can see the variance in the temperature increasing dramatically right after that transition from water to air. There's a few blips here in the resistor, and I think that's probably because there's some moisture inside the resistor.

Things aren't perfect when you put them in a stream for a full year. It's like what happened to my cell phone last year, when I dropped it in the river. It took forever to dry out, so that's probably what's going on here with this resistor. Anyhow, a pretty reliable indicator of stream drying.

We're also conducting some experiments. We have some experimental stream channels to the west of us here, the Oregon Hatchery Research Center and experimentally drying these channels to see what happens to the temperature under more controlled conditions. Here's one of our field assistants essentially watching a stream dry all day.

Not the most exciting thing, but it's something we've got to do to validate the use of this approach. Here's three sites for over time, in Willow Whitehorse Creeks, just giving you a picture of what months they were dry, and what months they were wet.

Anything that's green in this picture is probably dry. Question marks are based on some of the small wobbles in the resistor, but I'm pretty sure that means they were dry. The bottom line from these three sites, as you can see, that all three were wet in June of that year, which probably corresponds to runoff and snow melt.

Beyond that, these sites are completely different. The site up top was more dry during the winter than it was in the spring and summer. It was dry for the full months of December through April. The middle stream, you can see it was dry in the fall, but then what in the winter, almost the opposite, and then started to dry again in August of that year.

The site at the bottom was wet all year except for August, when it started to dry up a little bit for part of that month. Very different behaviors at these three sites, in the same stream network. Another interesting thing to look at with this data that we have...

[audio gap]

Jason: ...the capability of a super useful model. You can see the streamlines here for Willow Whitehorse Creeks, and the NorWeST predicted mean water temperatures from a data set that was collated from 1993 to 2011. This was just before the Holloway fire in 2012, so this is a really great baseline for us to compare or observe temperatures, too.

Here are the points that we sampled over the 2015 water year. We're looking at the observed August mean temperatures, and we've overlaid those on the NorWeST predicted August means. What you can see here, just from a quick visual inspection, is that oftentimes the colors of the dots and the lines are different.

That means that the observed August mean in 2015 is different from that 1993 to 2011 baseline -- different quite a bit at the time, actually. The other thing to notice here is, a lot of these sites are dry. The black diamonds indicate sites that we've found to be dry, and we went out and retrieved these loggers.

NorWeST itself, just by virtue of the statistical model that uses it, has to force streamlines through networks in order for the model to fit, so it'll give you a prediction of temperature, even when there is no water in the channel. We're just trying to add to what you can get out of NorWeST by understanding where you actually have water.

If we take a look at the observed minus predicted temperatures for this comparison that I just showed you, you can see here we've got just residuals between indicating the observed minus predicted. A positive means that our 2015 temperature was warmer than would be expected, based on the NorWeST baseline, and then a negative is colder than expected.

Remember, 2015 was a pretty strong drought year, as well as a post-fire year. Fire and drought tend to happen together in this country. When things get hot and dry, they also burn, as indicated in the background to this presentation. What you see in this particular data set is, of the total number of sites we have, about 35 of those had water temperatures that were warmer than the baseline for NorWeST.

Although a lot of these sites, the differences weren't that big, less than a degree difference, which I really don't consider to be that big of a deal. Interestingly enough, there were several sites actually that got colder during the drought, rather than warmer.

A very non-uniform response to the drought, that we never would have known, had we not had these instruments out there, cooking away in this intensive deployment. The other important thing to notice, about half the sites were dry.

If we look at these deviations, so it's the same scale on the Y axis on this graph as a function of elevation on the X axis, the horizontal axis, we can see that it appears to be a function of elevation. The higher up you get in the watershed, the more likely you are to see streams that get colder in the time of drought, versus warmer, which is more likely downstream.

We're not sure exactly why this is. It probably has something to do with groundwater. The groundwater temperatures are related to mean annual air temperatures, so that's certainly a contributor. The other thing that's a possibility is, when you have more streams wet in the case of a condition that's not a drought, there's more of that flow path that's exposed to the sun, and could potentially heat up.

A little bit counter-intuitive, but results like this make us think harder about what's really going on in issuing networks, in response to drought. The bottom line is, a very common theme in a lot of the climate change work that I've done in my career, local variability is really playing an important role here.

In terms of stream classifications, just a few examples. Our results were very similar to the work by Ken Fritz, about 50 percent off. Here's a few streams that were classified as perennial in this network, and constantly bone dry at the time of our sampling in August.

Here's a few intermittent streams, these look more, to me, like ephemeral streams. Ones that barely have water, except when it's really raining hard. Some of these look like they've never had water. These are also portions of the NorWeST stream temperature network.

They have a predicted August mean water temperature of 14 to 16 degrees, but of course there's no water at all. The classification table here, just giving you a summary of how our observations comported with the NHD classification. What you can see here is, we're pretty far off.

It's not a big surprise, and I'm not trashing NHD. It's a great program, it's just we can't do all the work to get out there and find these streams, and accurately classify them. We're off about a third of the time, in this particular system, a third to half of the time in terms of accurately classifying streams as perennial. A lot of times they're actually dry, in reality.

For intermittent streams, during this time of the year, most of the streams are dry. Very few are wet, and in fact those might be perennial streams, I'm not sure. That was a result, from 2014, basically the same result from 2015. In terms of the trout distribution, I mentioned before that this watershed is the world's stronghold for this species, threatened Lahontan Cutthroat Trout.

You can see in the stream network, the heavy lines indicate places where trout are known to occur. The thinner lines are places where trout are absent. During that drought of 2015, most of the watershed was too hot for the species, if you go with the EPA criterion for this fish, which is less than 20 degrees.

Only the dark blue dots here conform with that criteria, and all the rest of them are too warm. Just a few places in the tippity-tops of the stream network were cold enough for the species during the drought, and you can also see, even in some of these cold places, that there was no water. It dried up.

A real dramatic response of this watershed to drought, very climate sensitive, and this is consistent with some of our past research on the species. They can look good now, but when things change, like in the case of this drought, very sensitive.

What's next? We've got a lot of work to do in terms of continuing to deploy these instruments in streams in as many places as we can put them, for as many years as we can sustain this effort. Again, it's really remarkable to me that we know more about fish than we know about water. I'm hoping in about 10 years that we'll know more about water. It's important for everything out there in the Great Basin.

After we write up the initial results of what I showed you today, the next step is to take a more detailed look at how these in-stream responses are changing in response to the riparian zone. We've been working closely with Trout Unlimited. They've been able to interpret nape imagery to classify riparian zones.

You can see an example here, in the upper left hand corner of this slide. Let me get my pointer here. I can't get my pointer to work, but in the upper left-hand corner, you can see a shot from 1991 in this particular stream, where it's a very thin riparian zone, very under-developed.

After improving the grazing management on this particular allotment in 2013, you can see a much more well-developed riparian zone. There's my arrow, it was in the riparian zone, I couldn't find it. You can see a much more developed riparian, and actually if you look closely here, there is a little discontinuity in the water.

These are actually beaver dams, beavers that have formed extensive wetlands in these systems, which is really neat to see. There's a close-up of what I'm talking about here, 1991 versus 2013, pretty obvious change. How's that translating into what's happening in the stream channel, in terms of thermal regimes and flow permanence? That's what we're going to be able to look at next in all of these data that we've been collecting.

Here's the picture of what it looks like on the ground, I've showed this to you before. This place was basically a sagebrush plane before grazing management improvements, and now beaver have come in here, and this place has become a giant wetland. That's a good deal, it looks nice, but we have questions about how these beaver dams, beaver structures are contributing to late season low flows in these systems, as well as, temperatures.

It could be the case that temperatures might cool down because of increased connectivity with subsurface hyper react or groundwater. In a lot of cases, beaver dams warm up streams. It may not be that good if the climate is warming, or if we're going to be experiencing more droughts.

A lot of questions, a lot of uncertainties. We'll be able to address those with this data, for the first time, in a network context. I get the question from managers in this region, "What are we going to do with this data?" I've been working with them to identify the uses.

The main question is, "What are they not useful for?" They're totally useful for evaluating beaver and riparian restoration, water and wildlife, lots of species like sage grouse and many others are absolutely dependent on access to water.

Stream classifications, updating the ephemeral, intermittent, perennial classification, coming up with new classifications all are absolutely critical in terms of determining what sorts of land management are appropriate. For example, where you can drop fire retardants, apply pesticides, where the Clean Water Act is implemented, what are the waters of the nation.

All that depends on your stream classification. Then, grazing is an important use, and how that interacts with wildfire, like I talked about, is a major management issue. Of course, fish and amphibians are absolutely dependent on water.

Outside of the Great Basin, I just wanted to mention a couple of other things that are in the works, and giving you a preview of this, so you have a chance to give us some feedback before we do the work, rather than me coming in at the end, and showing you what we did, with no chance to change it.

We recently got funding from the Northwest Climate Science Center, here in Oregon, to develop a regional model of intermittency. Not just the great basin, but east side, west side, all forest types across the region. This is a collaboration between multiple USGS centers, water centers, and FRESC in this region as well as Trout Unlimited, and Dan and I are partially funded by NASA to do this work.

This is just a preliminary distribution of points in the three states, where we're going to focus our efforts. We basically have been getting data from anyone who's been out sampling streams, and is keeping tabs on whether the stream was found to be wet or dry at the time of the sampling.

This real concentration of points down here in Southeast Oregon as part of a Redband Trout survey, where they kept track of flow permanence, so it's super useful for us. A variety of other efforts, thousands of points that we're putting together across the region. Take a look at flow permanence.

One of the main things we're interested in is following up on this paper, by Roy Sando and Kyle Blasch. They published a paper last year, looking at predicting headwater stream intermittency in Alpine streams in Western Montana, and what they found was flow permanence was strongly a function of snowpack persistence.

If you had a snowpack that lasted late into the spring, into early summer, those were the streams that were more likely to be found perennial, flowing throughout the year. Geology and some other factors had an important influence as well, but snow was the big driver, and knowing how sensitive that's going to be to climate change can be a big focus here in the region.

Zooming out a little bit further, this project is not yet funded, but we're going to keep working on it until it is. We're writing a proposal right now to develop some citizen science applications focusing in national parks, because they're all about visitors. They do a wonderful job with that, and we're trying to develop some smart phone-based applications for visitors to parks, to track patterns of flow permanence.

The motivation behind this, number one, parks are great with working with visitors. Number two, they're potentially good bellwethers for tracking the effects of climate change, because they're relatively unaltered, at least many of them are relatively well protected landscapes, so we can factor out that human influence that's such a problem, like for gauges, for example.

The other thing is, we simply don't have the human power to do this work. It's very expensive to hire crews to purchase instruments, and to deal with all of those data for projects like we're doing in the Great Basin. The reason we're doing more of a scientist forward approach in the Great Basin is, there are no citizens in the Great Basin.

There aren't that many people out there. There aren't enough folks to drive the bus, but parks are pretty amazing. They have only 22,000 employees nationwide, but they have over 220,000 volunteers that work in our parks, and over 300 million visitors in 2015. There's quite a workforce there, as long as we give them the tools to contribute to understanding flow permanence.

Here's some of the applications that we're looking at, some of these smartphone apps. One is iNaturalist, which the parks have already formally adopted. They're using that quite extensively during their centennial year. The map at the bottom of the slide is just a global distribution of iNaturalist observations.

There's about two million across the globe, so far. Then there are some more specific applications, like this one called Creek Watch, which is geared towards taking a photograph of a stream, and responding to a very simple survey, which is then downloaded to a geo database online, automatically, to give you a sense of what's going on.

We're going to look at some sort of applications in between iNaturalist and Creek Watch to get this work done, with the visitors to these parks. I will say, I used iNaturalist myself, the other day. I found a rare species here, locally, in Corvallis. The sharp-tailed snake, I've never seen one in my whole life.

I was able to download the application, take a picture of the snake, and see my observation on iNaturalist in the space of about 10 minutes. Very easy to use, and really optimistic about applying this to documenting what's happening in streams and parks.

Here's another example of what's going on in the parks right now, with iNaturalist. This is sponsored, in part, by National Geographic. This map is just showing you the park properties in which they've hosted what they call a BioBlitz. This is basically a whole bunch of people they go out with their cameras, and use iNaturalist to document what kinds of species they see in parks.

A lot of times, they're finding things that have never been documented in the park itself. It's a pretty cool application. It seems like a real logical extension to apply something like this to water, and we've proposed, not calling these BioBlitzes, but “Drought-Blitzes”. This is named after the “Trout-Blitz” program in Trout Unlimited, so I'll give Helen Neville credit for coming up with that name.

The main questions we have in this project, obviously we've got to get parks and citizens to participate, so that's part of the study. What affects where people record data, and when we get those data, what is the quality of those relative to the instrumental record?

There's a comparative component here, to validate QA/QC and the information that we get. Because we are applying to NASA for this particular funding, we do this anyway. Even if it wasn't NASA, we want to link these responses that we're observing in parks to satellite projects like land surface temperature or snow.

I showed you on the Sando and Blasch paper that snow is a real big driver of flow permanence, so we want to keep tabs on that, with the data that we're getting from citizens, and look at the value of that for modeling climate sensitivity. Essentially, taking what I call the hydrologic pulse of national parks.

That's all I've got to say. Again, I want to really express my gratitude to the many partners who have joined us in contributing to this effort. Particularly in the great basin, it's not easy work collecting these data. Here's one of our main partners, Todd with the BLM.

I hiked into this canyon with him, to drop off a couple of temperature loggers, and we literally hiked from the stream bed, up to that ridgetop, to get this done. It's not easy and I really appreciate the effort. I'm not going to conclude with the end, you guys are really in on the beginning of this work. I'm really looking forward to your questions and feedback. Thank you for listening.

Ashley: Thank you very much, Jason. Excellent presentation. Thank you. All right, we have a few minutes for questions. Yes, Matt?

Matt: Jason, Matt Obradovich. I was noticing on some of your maps, where you were in the Willow and Whitehorse drainages, you had your resistors out there, measuring wet or dry. In any of those, did you have any observations? In between where you had dry points, were there still small areas of flowing water? With your picture here, you're showing standing water, anyway, to a certain point, and then it disappears.

A lot of our streams in this part of the Great Basin, may run for a distance, and then disappear underground, pop up someplace else. Did you try to correlate where you had your resistors with some of those that were permanent flow, dry, so that you were capturing some of that in the data?

Jason: We take field notes on that, but it's a real tough issue with field sampling. We debated that a lot at the beginning of this particular project. The picture you see here on the screen is a great example of that. If you move your instrument just a few inches you're going to get a completely different reading on flow permanence.

What we decided to do was send our crews to a specific geocoordinate in a stream network. Then they're asked to walk a random offset, in terms of meters up or downstream to locate that point. It’s a random sample. It's a point sample.

That's giving us more of a probabilistic sample of the whole network. We're not going to be able to pick up these little details. We could, for example, in the Park Service work where there's a lot more folks, maybe volunteers, who are willing to walk the entire stream and map it out. It's a tough thing to do. That's a good question. [laughs]

Matt: I was just wondering, like you said, we have a lot more data on where fish are. In some of these streams, where you lose reaches, you may have fish still upstream from where it goes underground. You may have fish down below where it resurfaces. Just wondering if you were trying to correlate any of that with your temperature and wet and dry.

Jason: We will. Just to keep it short, with fish it's super important in that wetting and drying of the network. How does that link to what fish are doing in the stream? Are fish you see in the summer, when the flows are fairly low, is there abundance or body size...? Is that more of a product of what happened in the spring, in terms of how that water was spread across the landscape, versus the time that you're out there sampling?

What are the implications of that spatial temporal flow permanence for the ability of these fish to move around and persist in the face of climate change? We've got a post-doc working on that with some individual based models now as part of another NASA study we have going on.

Matt: All right. Thanks.

Ashley: Thank you. We have about two minutes and two more questions right now. From Wade he says, "Thank you very much for presenting. It's my understanding that the CreekWatch App is no longer supported. So, would your efforts with the National Park Service re-start the CreekWatch App?"

Jason: Yes. It would be something like CreekWatch. CreekWatch was only available for iPhones, I believe. We'd have somebody put something together for a variety of platforms, Androids, Windows phones, iPhones, that kind of thing. Yes.

Ashley: Thank you. Then Jim asks, "The additional ground water to a stream will definitely affect the stream temperature. Does this show up as a stabilizing effect?"

Jason: Absolutely. That's an awesome question. That's a technical detail I skipped over. [laughs] Yes. Looking at patterns of gaining and losing in the network, and how that's dampening the dirunal variation could be a really important diagnostic for ground water. Thanks for bringing that up.

Ashley: Thank you very much again for a wonderful presentation. Thank you.

Jason: Thanks, Ashley. Thanks, everybody. Cheers.

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