What is Ecological Drought? Exploring its impacts on natural and cultural resources

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Webinar Transcript:

John Ossanna: Welcome, everyone, from the U.S. Fish and Wildlife Service's National Conservation Training Center in Shepherdstown, West Virginia. My name is John Ossanna and I would like to welcome you to our webinar series held in partnership with the U.S. Geological Survey's National Climate Change and Wildlife Science Center.

Today's webinar is titled "What is Ecological Drought?" We'll be exploring the impacts on natural and cultural resources. We're excited to have Shawn Carter and Laura Thompson with us, who are with the USGS National Climate Change and Wildlife Science Center, as well as Shelley Crausbay with us today.

Let's get started. To start things off, please join me in welcoming Emily Fort, who's with the USGS. She'll be introducing our speakers today. Emily?

Emily Fort: Hi, thanks, John. It's my pleasure to introduce Shawn Carter and Laura Thompson from the USGS National Climate Change and Wildlife Science Center in Reston, Virginia. Shawn is the senior scientist for our center and works with the USGS offices and the DOI Climate Science Centers. Laura is a research ecologist.

Shelley Crausbay is a postdoc for the National Center for ecological analysis and synthesis at the University of California Santa Barbara. There, she is part of the Science for Nature and People Partnership working program on ecological drought that was initiated by the National Climate Change and Wildlife Science Center.

She sits in Fort Collins, Colorado with the North Central Climate Science Center.

With that, I'm going to turn it over to Shawn.

Shawn Carter: Thanks, Emily. Good afternoon, everyone. Thanks for joining us today for our kickoff webinar on ecological drought. This is the first installment of a year-long series focused on the ecological consequences of drought across the country, within the context of climate change and other stressors.

The purpose of our talk today is to provide some initial context and framing of ecological drought, or ecodrought, as we call it. Some justification for calling it out as its own research initiative, which we've attempted to do, and also introduce some National Climate Change and Wildlife Science Center sponsored projects.

If you hear me say “nic-wisk”, I'm talking about NCCWSC. It's just the shorthand that we use. After my brief comments, I'll pass the baton to Shelley. She's one of our two postdoctoral researchers helping us lead in the ecological drought working group.

As Emily had mentioned, it's part of the Science for Nature and People Partnership, or SNAPP, based at NCEAS in Santa Barbara.

Shelley will outline our proposed conceptual framework for ecodrought, and describe some pilot work assessing vulnerability being conducted in the upper Missouri Headwaters region in Montana.

Next, Laura will talk about some relevant research projects to further illustrate the management implications of ecodrought. Some of which will be covered in more detail on future webinars.

Finally, I'll close out the webinar by covering some of our national synthesis, and science communication efforts, and then we'll open things up for questions.

To reiterate just a little bit, we're here today to talk about a subset of drought impacts. Those related to flora, fauna, and ecosystems, and both managed and unmanaged systems.

In fact, the genesis of this initiative was based on management need. Resource managers were being told that climate change will be increasingly impacting seasonal and annual, even decadal water availability, and we're struggling to form adaptation plans that could help them plan for the future.

How and when will ecosystems be transformed? Will conversions be temporary, or irreversible? How will other anthropogenic stressors interact with drought? How prepared are systems currently to adapt to climate change induced drought?

We started this initiative to begin answering some of these questions. As I mentioned, we hope to highlight how we're addressing these questions throughout this series, throughout the year.

To give a little bit more introduction to the concept, is Shelley Crausbay, and I'll just hand it over to Shelley.

Shelley Crausbay: Thank you, Shawn. I wanted to start briefly by telling you all a little bit about SNAPP, the Science for Nature and People Partnership.

SNAPP is the partnership among NCEAS, the Wildlife Conservation Society, and the Nature Conservancy. What SNAPP does, is they host working groups that really bring together scientists, practitioners, and policy makers, so that they can focus on questions, mostly questions that are really at the nexus of biodiversity conservation, human well-being, and economic development.

All of the work that I'm presenting today is a product of the ecological drought working group. This is our really diverse group of nearly 20 folks who are focused on this issue.

In particular, I want to acknowledge, and call out the core group, so the PIs, Shawn, who you just heard from, Molly Cross with WCS, Kim Hall with TNC, and also, especially, Aaron Ramirez, the other postdoc on this project.

Our group formed because ecosystems are more vulnerable to 21st century droughts, but risks to ecosystems are not always considered in drought planning and management.

Our charge was to synthesize all the best available science, and come up with a new conceptual framework that defines ecological drought, parses out the national and human drivers, and really helps us identify important trade-offs, and perhaps some mutually beneficial solutions so that we can help mitigate effects, and hopefully improve drought preparedness.

Our group started simply by trying to define ecological drought -- what is it? What I'm showing you here is a word cloud of all the definitions that were put forward by our working group members.

What we settled on was this definition here, which is, an episodic deficit in water availability that drives ecosystems beyond thresholds of vulnerability, impacts ecosystem services, and triggers feedbacks in natural and human systems.

To come up with a conceptual framework for ecological drought, we are using a vulnerability framework where one dimension really looks at each of those pieces of vulnerability, so exposure, sensitivity, and adaptive capacity, on through to impacts.

A really important second dimension really tries to highlight both natural and human processes that go into this.

Here's our framework for ecological drought, our conceptual framework, and you can see that we're looking at all the pieces of vulnerability from top to bottom. You see a box for exposure, for sensitivity and adaptive capacity, and then a box for impacts, then you can see also from left to right we're considering natural processes in yellow, and human processes in blue.

Don't worry about trying to digest this conceptual figure right now. I'm going to walk you through each piece of it as we go along. First, I want to start with the top piece, exposure. Looking on the yellow side, on the natural side, we think about meteorological drought.

Maybe this is the most easy thing for us to think about when we think about drought, and particularly how meteorological drought is propagated across the landscape via soils, the physiography, and landscape position, and things like that. But the human side of exposure is also really really important.

For example, it starts with anthropogenic climate change. Here, you see a map that's showing the percent change in current versus year 2100 drought levels, and this is assessed with a pretty common drought index called the PDSI. I just want to point out where, if you can see the black stipples in this map, that's showing you where there's really strong model agreement among all the CMIP5 models.

Climate change is adding heat to the climate system, and we know that heat is going into drying. While climate change may not necessarily manufacture droughts, it's certainly going to exacerbate them. Another feature of anthropogenic climate change is that climate change is increasing the risk of mega drought, so you can see on the left, we're looking at the Central Plains.

The Y axis is showing you the percent risk. From the last part of the past century, risk was fairly low in the Central Plains, and here we're looking at three drought indices -- PDSI and two soil moisture proxies. You look on the right side of that graph from 2050 to 2099 and you can see that that risk of a multi-decadal drought is really strong.

If you look at the map on the right side, you can see the spatial variability in that risk, and you can see that the western US and southern US is fairly at risk from mega drought in the future, but take a look at that map and you can see that this really is truly a global issue.

The other side of the human piece for exposure is human water use. Humans really add to the severity of drought. You can see in this graph, this is just a graph of water level in a particular basin, and you can see on the left, that's a totally climate-induced drought where water level declines.

In the middle, you can see an example of a totally human-induced drought where, let's say, water level declines solely because humans are pulling water out of the system through irrigation or what have you. In reality, what we have is on the right. It's a combination of these things.

For example, we can simulate a natural drought shown there in yellow, but the reality of what we see and what we observe is a combination of natural and human effects. In fact, in the future, human modifications are set to reduce water availability perhaps even more than climate change in some regions, for example the Colorado Basin where I live.

All those pieces sum up our exposure piece for ecological drought and we're calling that "ecologically available water," the idea that this is a combination of these atmospheric and terrestrial water availability as well as the natural and human processes that control that availability.

Moving further down our conceptual diagram, you can see we're thinking about sensitivity and adaptive capacity. These are just the ecological or evolutionary characteristics of a system that control how strongly it responds to the same level of exposure.

Of course on the blue side, the human side, natural resource management can certainly manipulate the ecological and evolutionary characteristics that go into sensitivity. For example, the graph on the left, I'm showing you a graph of predawn water potential for two different tree species in the Southwest.

You can see that pinyon pine up top in red had a much higher threshold by which once you cross that predawn water potential, you are more likely to die whereas the juniper below that had a much lower threshold. The pinyon pines experienced much more mortality than the junipers did.

On the right side, we're showing this natural resource management idea and how they can affect these ecological characteristics. For example, this graph is showing a time series of basal area, and the yellow box in the middle is a strong drought that this site experienced. You can see that the areas that rescind, that top dotted line graph, really recovered much more quickly.

Their basal area was much higher post drought than the other sites. Moving down our conceptual figure further, once you cross a threshold of vulnerability, you're going to get an ecological impact, so, widespread tree mortality, major fish kills, things like that.

In turn, that is going to cause losses perhaps in ecosystem services that we see on the right side there in blue, but panning out overall for our ecological drought conceptual framework, we think that the feedbacks are very important. This is represented by the arrows that you see on either side of the graph.

For example, on the yellow side, when an ecological impact happens, let's say widespread tree mortality, that's now going to feedback and change the ecological characteristics of that place, or it's going to change the landscape characteristics say from the perspective of a species that's now migrated to a new location.

Even through teleconnections, it can affect the probability of future drought in that area.

On the blue side, our idea is that once an ecosystem service impact is so strong, it's going to feedback and cause humans to really think about various institutions and how can we change our natural resource management practices or our water use institutions in order to reduce vulnerability to these ecological impacts in the future.

At this point, we're trying to take our conceptual framework and turn it into a really flexible framework for a vulnerability analysis.

To do this, we're borrowing ideas from the species and habitat distribution modeling community where essentially we're trying to look at an ecological response, say tree mortality, and create models that drive that response based on each aspect of our conceptual diagram.

We're trying to integrate each aspect of vulnerability and mostly we're trying to parse out which are the strongest drivers, these human or natural controls on these responses. In particular, we want to discover what those drivers are so that we can link them to particular strategies and outcomes that might reduce vulnerability to ecological drought in the future.

Essentially, this is what we're trying do. We're trying to come up with an equation for ecological drought. For example, I'm pulling the icon from our conceptual figure here.

You can see on the left, we're looking at some ecological response, say tree mortality as a function of a combination of meteorological drought, landscape characteristics, climate change, water use, these ecological and evolutionary characteristics, as well as resource management.

Ok so let's see. Thinking about trying to come up with a function to describe what drives a past ecological drought impact.

Let's say your model was driven solely, or really most importantly by soil moisture, or some aspect of the landscape characteristics, like I have highlighted here. That might tell you, "Hey! Mimicking beaver activity is a really good strategy to consider, and we need to really attempt to improve water retention on the landscape."

In contrast, you might have a system where your primary driver was something about water infrastructure. Let's say you're modeling a fish kill, and what you see is that it's really the timing, and amount of irrigation that was pulled out of the system that maybe drove that impact.

Then you might consider water markets as a strategy, and really your desired outcome would be to lower that water withdraw.

Another example might be a situation where you're looking at tree mortality, and you see that it was actually plant density that was a really strong driver of any kind of spatial variability in an ecological response. That might point to a strategy such as forest thinning, so that you can reduce competition for water in the future.

We're attempting to try and do this kind of analysis in such a way that it's an easy template that can be shopped around to different areas, different regions by using the same system.

We're really excited to use software developed by folks at the USGS Fort, and the USGS North Central Climate Science Center, and this is the VisTrails Software for Assisted Habitat Modeling. This is an open source management and workflow system. What's really great about it, is it builds ecological response models using a bunch of different techniques.

It's combining machine learning, and correlative niche modeling. We think this is a really great framework for us to do our analysis here, and hope that others can easily pick it up in the future.

To test this out, we're working with the National Drought Resilience Partnership, and they have a demonstration project in the upper Missouri Headwaters region, which you can see here in this map, in Southwestern Montana right along the Missouri River.

What we're attempting to do is look at tree mortality after an early 2000's really strong drought that was in this area, and essentially, just following along with the functions, we're trying to look at tree mortality as a function of rainfall, vapor pressure deficit, ecologically relevant landforms, and temperature, especially including maximum temperatures, irrigation levels, any kind of human influence on stream flow, as well as vegetation density, and identity.

Hopefully any kind of maps that we can pull together for resource management that has gone on in the area.

We're hoping that this lays the groundwork, and it really forms a template for other ecosystems and locations. We think that once we build these models, you can automatically have a predictive system that could perhaps be an early warning for ecological impacts.

Not an early warning for drought, but an early warning for those ecological impacts. The system could also allow you to test scenarios. So, for example, you could look at drought impacts during future climates, or perhaps, and this is something I'm most excited about, is how can we test the efficacy of different strategies.

If you really think beaver mimicry is a great idea, let's get some data layers developed for beaver activity, and we could put those into our models, and see, "Well, how would tree mortality...How much would it have decreased had we had this strategy on the landscape at the time?"

With that, I wanted to say that we're really excited about our new framework, and this template for analysis, and we're hopeful that this framework and template could be used in upcoming USGS drought projects. With that, I would like to pass the baton to Laura Thompson.

Laura Thompson: Thank you, Shelley. Now, I'm going to talk about some of the ecological drought projects that the NCCWSC is sponsoring. There's two different types of projects. We have a group of solicited projects, and then a group of directed projects.

The goal of both of these different studies is essentially to fill key knowledge gaps with regards to ecological drought, and then also to gain insight on future research that needs to come about of the results of these knowledge gaps.

In 2015, the NCCWSC put out a call for research funding proposals. We ended up funding four different projects, including drought related to forest management, drought and the impacts on migratory water birds, and the impacts of drought on stream drying, as well as dryland ecosystems in the Western US that include a lot of grassland areas.

Just to go into a little bit of depth on some of the findings on some of these projects, a recent study by Munson and Long…the goal of the project was to better understand the resilience of grasslands under future climate conditions.

Grasslands are really important for providing ecosystem services for a large portion of the US. The actual goal of the study was to determine the capacity of grass species to shift phenology in response to climate over the last century.

The approach that the authors took was to use ovarian samples from approximately the last 100 years from several different regions in the Western US. The colored areas are different eco regions, the dots represent species locations, and the different colors represent different species.

They were able to relate flowering times with different climate variables. Just to give you an example, this graph shows, on the left, two graphs show a species in relation to flowering date related to temperatures through time, and temperature through space.

Particularly on the bottom left graph, you notice that species tend to either increase, advance their flowering date with relation to temperature, or their flowering date becomes later as a result of temperature.

When those are broken up by different photosynthetic pathways and functional traits, we notice that C3 grasses, which are grasses that essentially do better in cooler, wetter environment, tend to advance their flowering date in relation to increases in temperature.

Where C4 grasses that respond better to warmer, dryer temperatures actually have later flowering date. The authors actually went a little further, and these graphs just show individual species.

Indian rice grass in the two left graphs, and blue grama in the two right graphs. They found that the Indian rice grass is a C3 grass, and will actually advance its flowering date if it's more pronounced in more Northern eco regions.

The further North you go, you may see a stronger phenological response. The key findings from this study is that, in the past, many grassland species have been responsive, phenologically, to climate, which suggestw that that could continue in the future.

Some of these systems may be fairly resilient to climate change. It's not all doom and gloom, which is always a good thing.

To highlight some of our directed projects, we have a number of studies on ungulates, including a couple of projects on bighorn sheep, mule deer phenology, tracking how mule deer track green up throughout the season, and a remote sensing project that is closely related to that, through EROS.

Also, we have some fish projects and aquatic projects in various places in the country. To highlight one of these studies in the Southwest, the pronghorn is a species found in the Central North America, the interior Western US.

The goal of this study was to better steer conservation, sustainable conservation for ungulate species under climate change, and then disentangle some of these relationships between climate, population dynamics, and project them across time.

This map shows the number of populations that were included in this study. There were population surveys. This is 18 different populations in the Southwest, and these population surveys go back to the '60s.

They were able to relate population growth with climate variables, and the authors found a pretty strong relationship between precipitation for the majority of the population as well as temperature.

The precipitation in particular had a strong seasonal response, which suggests that precipitation was particularly important during the lactation period for these animals.

They wanted to be able to determine how these animals might persist in the future given future climate scenarios. They were able to model using two different climate scenarios from CMIP5, a less conservative or somewhat high scenario as far as greater climate change impacts and more conservative estimates of slower climate change impacts.

The black is the high scenario, and the gray line is the low scenario. They essentially found that approximately half the population will go extinct by the year 2090 in these different regions. In a few areas some of the populations might actually be able to persist where precipitation may potentially increase. I mentioned we had some fish projects as well.

One is in the southwestern US on the cutthroat trout which is the most southern of the cutthroat species. There's several expectations with regards to potential impacts of climate change, and very little monitoring has occurred for this species. The goal was to examine potential drought risks for these vulnerable populations.

I apologize the picture is covering it up, but you have a pretty picture of a trout, and you can see the orange cutthroat on the front.

The approach was to empirically access the effects of seasonal stream temperatures and discharge in Rio Grande cutthroat trout that may be potentially at risk for drought conditions, and then model drought effects on the persistence of populations including modeling stream discharge, intermittency, and temperature in these different streams where they exist.

Finally evaluate how drought conditions will alter population model rates.

We have a study that's just starting up in Hawai'i. Drought doesn't just occur in the southwest. We actually do have island drought as well. The need for this particular study is due to the fact that there's limited incorporation of climate change into stream management. There is a desire to better understand future conditions.

The goal of this project is to identify critical conservation areas with climate change using stream flow. The approach is to simulate stream flow, both windward and leeward watersheds and access the impact of changes in climate on native species; describe current habitat usage and project future distribution of these species and then build an assessment framework called "ridge to reef" framework for prioritizing aquatic conservation efforts.

And then also compile stream conditions and information on species distribution.

This provides a bit of an overview of some of our solicited and directed research projects. Most of these I should point going back to Shelley's framework tend to focus more on the ecological impacts that certainly have implications for natural resources management and ecosystem services.

I'm going to hand it back to Shawn Carter.

Shawn: Thanks, Laura. As Laura alluded to there is socioeconomic component to some of this work that we're not addressing given time constraints today but will be dealt with in future webinars as part of the SNAPP initiative.

Finally, I would like to close today's presentation by mentioning two other activities that are meant to summarize our understanding of eco drought and the implications for research management and broader public understanding.

First in cooperation with the Integration and Application Network team at the University of Maryland, we're holding a series of regional workshops to conceptualize ecological drought impacts around the country. These are the impacts encountered by each of our eight Department of Interior Climate Science Centers. They're shown here on the map.

Our goal is to engage scientists and managers in discussions about how future droughts might play out within the respective geographies. So far we've completed five of the eight CSCs with each producing its own summary newsletter which are shown here. Additional materials can be found using the links that I'm going to provide at the end of this talk.

Finally, we hope to integrate all of these activities that we've just touched on in this webinar today.

Our proposed framework for using ecologically available water and integrating some of those feedbacks that Shelley mentioned, our SNAPP pilots in the upper Missouri, working with our partners in the National Drought Resilience Partnership, our sponsored research from around the country and then our regional conceptualizations of ecological drought from these workshops at our Climate Science Centers.

We hope to incorporate all of these into a comprehensive synthesis over the summer, a national synthesis of ecological drought. Stay tuned for a more national scale summary of these projects in the future. With that, I'll conclude our presentation today.

Listed here are a few sources for more information and also some acknowledgement of the valuable contributions from our partners who we've mentioned. I'd like to thank you all very much for your time today. I apologize in advance that we won't be able to accommodate everybody that wanted to join. We'll entertain your questions. Thanks.

John: Thank you all for your presentations.

First off, let's start with Evan Albert. Could this be part of a historical cyclical phenomenon? I read somewhere that analysis of tree rings suggest the western states have had many droughts of two decades or longer including two mega droughts lasting longer than 100 years.

Do you know what that was in reference to? I'm sorry about that.

Shelley: I think Evan's question is about megadrought. I'm going to guess. Evan, this is a really active area of research right now. There's a lot of really cool stuff going, and it's true there were lots of mega droughts in the past particularly in the southwest and particularly during the medieval climate anomaly, so around 1,000 years ago right before the little ice age.

There's a lot of thought around whether those higher temperatures during that time period drove those mega droughts, but it's a really complex picture. There's a lot involved with sea surface temperatures, with various oscillations like the Pacific decadal oscillation or the AMO, things like that, internal atmospheric feedbacks are really important.

One thing I'd say is that maybe there isn't a whole lot of really strong consensus right now, but it's a really active area of research where a lot of people are doing great work to try and figure out what really drove megadroughts in the past, and what are we likely to see in the future.

John: Would it be possible for all citations and papers used for these presentations to be summarized for us? Certainly. If the presenters are willing to come up with something, I could certainly pass that along to everyone that would be interested. Shelley or Shawn or Laura, would any of you be interested in that?

Shelley: Yeah, absolutely. Happy to do that.

John: Whenever they get it to me I'd be happy to forward that on to everyone else.

Shelley: Thanks, John.

John: Roger Sayre. I'm hoping I say that right. Will the Hawaii work and ecological stream classification that NCCWSC has reported as a stratification device?

Shawn: I'm looking at the person who might be responsible in our office for that. We don't have an answer for Roger at this moment, but that is an active area of research as well that we have a couple of investigators working on right now. Stay tuned.

Actually, I'll just add that is one of the Climate Science Centers that has not had their drought workshop yet, and we'll be holding that in about four to six weeks from now. That will also be discussed at that workshop.

John: Doug Beard. The Hawai'i work is Ralph Tingley's work. Uncertain how it'd be used yet. OK. Thank you for adding onto that as well, Doug.

Monica Ketcham is uploading some links on ecological drought from NCCWSC and SNAPP. Thank you, Monica.

Feel free to take advantage of those anyone who is attending. I would like to thank Shawn and Laura and Shelley and Kate and Elda and everyone that put this together. It was quite a few people in this presentation. I would like to thank all of you for your presentation. I'd like to thank everyone who attended for your participation in this.

Shawn: Thank you.

Shelley: Thanks.

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