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Good morning. Welcome to the fourth installment of the innovations of science and technology for inventory monitoring and assessment seminar series. My name is Carl Lucero. I will be the host for today's presentation timed the current presentation of e DNA for aquatic species and terrestrial species. Our speaker is Michael Schwartz, a research scientist and genetics team lead or the -- in missula, Montana, part of r&d rocky mountain research station. For you guys on the phone, we're recording this and we will be sending out a link so you will have a copy of Mike's powerpoint. Today's presentation is another one of a series of seminars to infuse new ideas into forest service thinking and how we might achieve our inventory monitoring objectives. With the increased expectations and what we're requesting to monitor and our -- requesting to monitor, we're striving to identify new and better ways of doing business. Initially, the seminar series was to serve the forest service inventory and monitoring assessment strategy, but the tools, techniques, and systems can be applied to other management needs such as the climate change scorecard and the watershed condition framework. So, we hope these sessions will broaden the application of the existing use of the tools or inspire new ideas. Before I formally introduce Mike, I would like to ask my colleague Michelle to say a few words about the strategy. Michelle?

Thank you, Carl. Hello, everyone. I'm Michelle [ Indiscernible ], I'm here representing the IMNA implementation team, currently consisting of Jamie Barber, the implementation team lead, and myself, an employee of the ecosystem management coordination resource information group. We're tasked with implementing the IMNA strategy, which was released in the letter from the chief in July of 2013. The strategy was the result of the work of a core team, including individualings from state and private forestry, research, and development. And national forest assistance staff and with input from the U.S. wildlife service, U.S. geological survey bureau of land management and national association of state Forresters. Currently, the forest service has a - IMNA to not allow us to answer questions, itingly at the regional and national levels. The strategy details the need for resource information integrated along the effective and efficience. Environmental threats and involving agency priorities like climate change vulnerability assessments, watershed and landscape restoration, new planning requirements for broad-scale monitoring and assessments, and interagency reporting requirements all call for improving our current IMNA system. So, Jaimie and I would like to thank r&d for including us in this seminar series, which challenges us to think outside of the box and discuss the most current resource and innovative techniques for inventory monitoring and assessment. Thanks.

Thank you, Michelle. Now, for the past 15 years, Dr. Schwartz focused on fields and population biology and landscape genetics conservation. His current work targets conserve vacation genetics, genetic of landscapes and ecology of endangered species and he combines field work and lab work. He received a doctorate in wildlife biology from the University of mondmont school of forestry in 2001, and he's the presidential early career award in science and engineering recipient, and a recipient of the rocky mountain research services station, visionary science award. So, Mike, the mic is yours.
Thank you very much. Thank you for the invitation to come here and speak and for allowing me to present the data in our lab and where we're going with environmental DNA sampling. I want to make sure I acknowledge my two co-authors on the talk, my two research partners in a lot of this work, Mike Young, who is here a few days ago talking about some diversity, quantifiable diversity surveys and Kevin McElvey. So, we want to think about monitoring. When we think about monitoring, we know monitoring is really affective when it's done at very large scales, but when some large scales to be assessed is even the very simple variables like thinking about stream variables, we can find it expensive. This is a map of all of the streams throughout the United States. You can imagine if we added new technology to this or want to change technology, just a few hundred dollars per site, and this would become expensive. As for a physical variable, as soon as we get to -- [Indiscernible] Biological variables, monitoring becomes more complicated. And it gets worse when we start thinking about mobile, elusive, or rare species and so while we want to monitor, we have a problem of trying to monitor wildlife and fish and that often are very expensive to monitor and very challenging to do so across the scale. One way that we recognize to reduce expenses in the past is using omnibus methods, where you use one method to tackle multiple species. One problem with multispecies methods is it often failed for rare species. So, fortunately, overtime we have been able to, within the rocky mountain research situation is look at new and develop new technologies that are allowing us to solve some of these issues. Okay. Here's paper from my lab on different technological items we came with overtime to help us be more efficient over time with common and rare species. So, technology that we're going to talk about today is the e DNA sampling and for those of you not familiar with this, eDNA is free-flying DNA found in lakes, rivers, soil, or air. Okay. And we want to take a more narrow view of it, the definition from the supreme court testimony from the scientist David March, DNA shed from an organism and present in the acreage environment presumably in microscopic tissue. That microscopic tissue might be rough skin -- the skin or gills of the organism. It can come from anywhere but not from the organism itself. It's sloughed DNA. The DNA in the environment. This is my recognition to be busy and sometimes we're only getting off for -- people's attention for five, 10 minutes. If you walk away with one message, I want to make sure you get this one message. This new eDNA technology I am talking about, the eDNA sampling is an approach that is applicable across big-broad scales. It can be scaled up or down and used, cross multiple problems and issues, it can be used in monitoring and research, and it's cheaper, faster, and more accurate than a lot of our current monitoring protocols. So, if you walk away with one message today, this is the message. You will hear this at the end of my talk. So, how does this work? How do we get to this? , how to wey get to this grand conclusion? We have a species in the water and for those of you here, you see the pointers, we have a fish species that might be sloughing cells at different points, it might be defecating in the water. We know that that, when food passes through the guts, it sloughs intestinal cells, and those cells floating in the water and each one of those cells has DNA. We use a simple approach. We filter the stream water. We take a pump and filter the stream water after, depending on the protocol we're quipping and different -- developing and different questions may require different protocols. After we filter one to three liters of water, picture you're bottles that you might take hiking with you. We pull the filter out and if you look close, it's dark and has lots of slough cells. Okay. And we bring the filters into the lab and this is a huge advantage. You don't need a specialized skill. My technicians even let me go out there and do this. This is meaning it's right for allowing people who may not have the formal training that need to do a survey extreme and
they might take formalized training and for safety issues and this is a simple approach. Anyone can do this. And you bring this into the lab and we analyze results. I will show you the steps we're using now. If you get a little bit -- and there are different poke folks on the -- folks on the call with different levels of expertise. I want to show you what is going on in our laboratory. A few minutes, if you're not interested in this, tune out for two minutes here. The slide is put together by one of our graduate students, Taylor Will Cox, and Taylor put together a nice demonstration of how it's going on in the lab and with the magic. What we have is two strands of DNA. We keep the DNA up and split them apart, we add the primers and this is a typical PCR reaction. We have been doing this for a decade. What is different with eDNA, we stick this here and -- with a reporter and winker, and -- and quencher and this unit will find our template and this is primer extension. We do a target extension and we have that primer extension, the first thing that it does is start to create DNA that mimicks this strand here. It hits the reporter and it flouresces and we can detect that with our machine. A simple approach. Okay? And it turns out the bonds can sometimes you get this report unit bonding with this strand here, even without a perfect match. If you have a non-target template and fortunately it's stronger than the bonds here. They get knocked off together and we never get the report or fluorescent with the non-target species. Again, what we get is flourescence, frontier, when we have our target species, we get no fluorescence with our non-target species. Okay, the basic principle of how it works. This is the innovation that is make eDNA a useful and poit shallly widespread application for our agency. Okay. And what does this look like what we have is that time and fluorescence. As we get more and more of them to break, we get a curb looking like this and we start to see an increase in fluorescence over time. And I know this slide is difficult to read. This is from one of our conversations -- publication, the kill Cox 2013. I put this up here to remind he to tell you that what we are detecting, we're linking the approach and the primers on to various specific targetcism lates, what -- target templates, what we're detects is levels, 2 1/2 copies of DNA per microliter of wire. If there is one cell in that water, we're able to detect it. Okay, and what you're looking at here are three different creeks that we looked at and this is a portion of success and we have one through most of this and on average, a half a copy per microliter and that is when we had less than 100% detection. Again, we're talking about incredibly sensitive methodology. Okay. Now the nice things they coulding in appeals is when we have different quantity -- quantities of DNA, we get different curves. If we have more DNA, we immediately start speaking of this fluorescence. Less DNA, it takes longer to pick up the fluorescence and this is appealing to us. Right now, we're comfortable saying we can detect exotic species or invasive species and we get to the details in a moment and one of the things we're working on is to clearly start to get at the question. When we detect the fluorescence here, are we going to be able to -- back with higher abundant efficiency streams, where we have lower abundant efficiency streams. We have done some of the tests and right now, one is -- the main projects about estimates conducted using traditional methods through the DNA approach to see how well abundance coordinates with the fluorescence. And this is how it works. We would have the standard curves with standard amounts of DNA and associated because of abundance and our research curve. We go extreme and run it, yes, species x, and the rare salmon was present in the water, and we have a high abundance of that species. How is it being used? Right now, we're using it to detect exotic species, we're using it to detect rare species, and we're using it to start to replace costly inventory and monitoring methods. A few examples, one of the things I like is to detect otters. We know that some places like the river in Missoula there is otter recolonization. We don't know where they are all of the time. It's expensive to survey for them. We had grad students spending their
entire career looking for otters. They can't pump water to determine if one is at the location. What is nice, and I don't want you jumping her -- [ Indiscernible ] The diversity assessment using the same sampling and filter and then I can look at what is the correlation, the positive presence of otters correlating with? Does it correlate with crate fish or native species or non-native species or invertebrae? We want to go here. What makes an otter reproduction successful? We're looking at this and we'll talk about this later on, but we're planning -- using the same approaches and with some boat trout are. I think it's a great job talking about this and noing general ideas where we think full trout are versus where they are and this is a way to validate the models and help improve the models. And use DNA for the detection of endangered species. The other things are invasive species, Brooke trout, depends on where you are. Where we are in Montana, they're an innovation species. Beaver-month-old New Zealand mud snails and all big invasive problems. If we can get the problems ahead of time. Imagine the water and get ahead of the that invasion, how much money we will save in the long run and check that one meter of water. Good, we don't have an invasion problem right now. If we do, we have to get on it right away before it's a problem that is too tough to deal with and light talk about exotic species in 2008 in front. We looked at bullfrogs and the first study, they threw bullfrogs in three meters of water and they sampled 15 milliliters. And we were able to detect bullfrogs and we went on to see if it worked in the wild. The traditional sampling and this is a nice comparison I like to study. Traditional sampling versus DNA sampling. The traditional sampling detected that 49% of the -- 14% of the streams have the bullfrogs, 7 out of 49 streams and bullfrogs. With the black stuff and where it was detected and 78% occupancy with eDNA and they're in many more places, the leading edge of the innovation and you can see three out of three positive in the left with the area that has upwards of inundated and -- [ Indiscernible ] If you are using traditional protocol and this is all with sampling 15 milliliters of water. And -- to get to the bottom line. Traditional sampling takes a training team and use call surveys from 10:00 a.m. to 2:00 p.m. and take a train out there and you can only survey, again, the right time of the year when the water is perfect and the environment is right. You have a narrow sampling window and have to go to which of these ponds are -- multiple visits and with some water into the laboratory and the samples can occur any time in any weather for this species. At the bottom line, it was greater than four hours per pond for traditional sampling and under two hours per pond at least in this study. They came to the conclusion, and this is a very conservative estimate, and again, partially because it was between 2008 and 2010, published in 2012, and eDNA was 2 1/2 times cheaper and drafier. And in our lab right now, the Schmidts and from other people cause it 10 times cheaper and 100 times faster. Given the way they're going, that may gun on oop end there, 10 or 100 times cheaper and more cost-effective. The cost estimates and from a famous study to date. The Chicago shipping canals, you know, they looked at the same question and this is a question, they're able to detect when the carp is invading the system. Amazing sensitivity and one of the -- [ Indiscernible ] Put on the list to detect it. 1,480 person-hours for electrofishing versus 400 person ours -- hours for eDNA approaches to detect the same level of carp. And they have had amazing results with this study where he they have gone out there and electrofished and not found anything, went out there and did the eDNA and found one fish, drain the portion of the canal and found that one fish. Pretty amazing. Okay, so how does this great technology, the great leap in technology that we have, how does it help our partners and the U.S. forest service? This is clearly -- I will go through a couple of these, not all of these. If I had more time, we can go through, but it's going to help us with our endangered species requirements, inventory, monitoring and assessment strategy, watershed condition framework. That goes without say, and enforce management
planning. It's going to play a big role. Okay, and -- [ Indiscernible ]'s few examples of inventory, monitoring, and assessment strategy: So, everyone here is familiar with this. I put it up first. I didn't know who was going to be on the phone call here. We implemented the monitoring -- inventory, monitoring, and assessment strategy has a three goals. Goal one, support effective decision-making by providing relevant and credible information. Ensure that all i M&A activities are inclusive and comprehensive and responsive and change. I think the eDNA will help in all of these because, well, if we look at the document strategies, inconsistently not well and integrated station blocking the quality of the needs and I think eDNA takes care of this, especially with one location in the forest and work with many partners. I have a genetic lab for 15 years and serving as the coordinating central role is essential in many of our efforts. And that is no different to these. If you look at the goal, under goal one, and that is talking go integration and DNA -- we can look at this at a project level and scale it up to a forest level or a national level. We ensure information is based in relevant science. There are published papers now impress -- in press. Two papers were free -- and other publishing papers show this is a robust current and defensible approach. Quality and consistency, I will show you something in a minute about that, and timing and -- timely and accessible, something, again, we can provide that information -- almost [ Indiscernible ] Something that everyone is concerned about. Should we be concerned about, the supreme court and district courts, so eDNA went through the supreme court and they looked at the data largely through the Chicago example and they independently evaluated the eDNA and they're getting by the E.P.A. and published in journal -- peer-reviewed journals, including three publications coming from our lab alone. And in terms of eDNA organizational boundaries, this is a map I put up of work that we're starting to do. We -- the red is what, at the end of last year, the red is the three projects we're working on. Three eDNA projects we're working on. Recently, our lab made the decision to invest and keep a coordinator. We let it be known we're going to start taking samples across a broader range. Within a month, we now have -- and I am not sure it's a full month, all of these groups in pilot groups this summer. Some are national forest systems, others state agency. A state agency that came to us that put together a proposal to get some work done on the endangered species down there. I'm going to skip this. I will say, and I will bring it up quickly, one of the ways we're hoping to be able to handle this massive increase in demand that we're seeing is to put together some work with other agencies who have come to us and we can talk about this initiative later. Okay. So that is -- and monitoring and assessment. We'll take a few more minutes to talk about the endangered species and the requirements and clearly it doesn't take much to see it can help us with the endangered species act. Any species that is in danger or extinction throughout all or significant portion of the range. And that -- about the geographic range of the species. As we think about habitat and critical habitat, should that be designated, eDNA is a way for us to develop rapidly, quickly, and cost-effectively, where we're -- [ Indiscernible ] Made and -- with some consultations levels and eDNA is very sensitive. It's a great tool for rarity. We don't have great monitoring tools for rarity and this is a case where it will help us re-enter and detect and recover. A couple of examples, the eastern hellbender and the giant salamander from Idaho. The Idaho giant Sala mandar and its detection in streams in Idaho and the hellbender endangered species in the south. There is another nice paper that came out last year, they're looking at eDNA to evaluate Chinook. It's threatened or endangered throughout much of the range in the northwest. I'm going to wrap it up here. I have kind of -- you on the edge for time?

Five or some minutes.
Five or some minutes. Okay. I will put this up, following up some of the things that -- and what we talked about last week. We see this as being cost-effective, we take on surveys unprecedented in size and need to be done. We talked about the thermal scape, excellent work, again, this is taking the monitoring data and -- seeing how well it applies and where they are -- [ Indiscernible ] And what kind of thermal features are required. Again, this is a map extreme to identify what they call patches and -- grants we submitted in Idaho across the network and looking at up to 4,000 Gene patches and think about that. We said we would accomplish this and, again, getting it funded or not and to be able to couple climate change data with the detection of DNA and giving us monitoring and research products. To understand how they -- change. Okay. The last concept, talking to you about the approach about detecting one species at a time and detections endangered and invasive species. I want to mention the last two, about two or three slides, what we're starting to do and look at in our lab are ways to go beyond the one species at a time approach. We're using genomics. Genomics is a fancy way of getting to say that we're new using the entire sequencers that get us a lot of data at once. And what we're able to do with this is to go to the stream. We have the same filter and all will sampling protocols and instead of using the PCR reaction I showed you before, we're using different chemical reactions saying can we detect many spaces at one time on this filter. -- species at one time on this filter and in Europe, there are all of these rare species, and they are able to detect, and had high detection rates of the rare species and using one sample of eDNA. A better way to look at this, you look at the different approaches and everything from -- [ Indiscernible ] Other types, snorkeling, Charlie, night snorkeling and eDNA and this is the number of species they're able to detect right here. And this -- 15 minutes of sampling per site. This is where the ecology is and not only can we get the monitoring data, yes, but species you care about is at this site. Who knows, detect other species that we may have been concerned about that and -- to generalize the panel. This is where we need to be going. I think we're six months to a year out from having this well-developed in our lab. Again, we'll come back to this take-home message. You have seen this already. Environmental dneigh -- DNA sampling applicable across regions and problems. You can realize this approach is cheaper, faster, and more accurate than the current monitoring protocols. I will leave you with that.

Thanks, Mike. This is some cool science stuff. I think there is a lot of questions the audience may have. What I would like to do is go into this Q&A session and start out in the room if they have questions for Mike. As you ask the question, state your name and -- [ Indiscernible ] On the -- to know who you are.

And this is [ Indiscernible ], national wildlife ecologist in D.C. You showed the patterns of fluorescence based on the frequency of occurrence in the stream. If you sample at the headwater,

going to have a rare sample. As you move to the bottom, you're going to pick up more individuals for the species. The pattern will shift. Have you looked into that?

I appreciate you bringing this up and there are a lot of people doing eDNA sampling or priming it for their species of interest the. The university jumped on this and I think it's great. To go from gee whiz we can find something and a sampling protocol to use on the town, it was a lot of blood, sweat, and tears between those, well, a lot of tears. It's difficult to make it into a sampling
protocol and this is what we're dedicated to do. We're dedicated to not just, and this is how we
defect bull trout. Can I move on and our life is simpler and ho you do we make this into a
protocol to hand to every national forest and rammer district. This is what you do when it's in
this condition or this condition in the head waters in a pond and because of, that we have under
why taken numerous studies asking the question about the DNA degradation. One of the studies,
the one on the verge of being published, and we worked with colleagues and put fish in a stream
and he said okay, this is different numbers of fish in a came in a stream and what does that did,
neigh profile look like down the street? It turns out that there is a degradation process, and -- this
work, where they have gone into the stream and looked at how DNA degrades. You put
something in the stream, how long do you acquire the signal and pull it out. How long do I do
that. We are thinking about those things and trying to guide our sampling, the headwater and that
is a good question. We're seeing degradation, 250-meters. And that is some degradation of one
fish in a came.

Great. Thanks a lot, one followup question. You mentioned sampling air.

Sampling air, to me that is the untapped potential. Right? No one has done it. If I was a botanist,
I would be all over this and, for example, pollen and a rare -- especially in a tropical system. This
would be the way to go. We haven't charted for the species, put a big filter at the end of the
Helena national forest. We haven't gone there and the crazier it sounds, the more likely it's going
to be a cool innovation in the future.

Thank you, Mike. Other questions in the room? Yes, sir.

I'm Jim Allegria with [ Indiscernible ] Management in Washington office. My question is -- what
is my question? I had it. I'll get back to you.

Okay. Jim, while you're trying to remember your question, Jamie, do you have a question?

Vo a couple of questions. You answered the first one and join the first party, I had the idea you
what you were looking for. And genomics, I got the sense you were saying you don't, or that
you're trying to figure out how to not. What exactly is the status of going out and filtering
something and coming back and saying this is -- [ Indiscernible ]

And three different approaches. Approach number one, you know what you're going after and
that sensitivity is amazing. I have never seen how expensive it is S. I go out there and the I want
all the DNA that I find and this is a filter. And -- what are those species? You need that -- the
data bases of what is out there. And I dedicate it to -- the DNA for a long period of time. Those
are the extremes. I think we're going to end up in the middle. Where we say we're going to use
the genomic technology and here's a panel of 20 to 50 cc what we're interested in and we're
going to take those 20 to 50 species and do something for the species, and do what they call next
generation and then we won't have the confrontational problem with the back end. So, we know
that we can do that. The difference of the question that we have now, that we need to test is do --
sensitivity when we go to this sequencers and use the next generation compared to the approach
that I just showed you when we have the fluorescence and have one cell. I don't, the one person
who has done some of this work in Canada is compared -- to see it all. I had a meeting with him
in Sweden three weeks ago, and he said there is no loss. And this is in the DNA sequencer technology made to be more sensitive. If that is the case, when you see everything, you have the case -- [Indiscernible] We get the sensitivity we want and many species at once. I think we'll get one -- I don't want to test it ourselves or trust it to one person. I am hoping not to -- the next six months.

My other question was how aware parts of the specialist so far? Something we're not aware of at this point.

That is a good question. I know -- when I hired the coordinator, we instantly had people coming to us. -- with the phone calls and all and the next thing you know, the phone was ringing off of the hook with people interested in us, you know, and right now, all we want to tackle is highlight projects for different reasons and there is -- to point him. We have the approach with a couple of species, full trout and we're working on him for a few other species. But, for each time we want to tackle a species, it's small r&d component. We have done this before. And right now, we're working on over 40, well, over 60 species now with the aquatic stuff. And for every one of those species overtime. This is nothing new to us. There is going to be that step that will take place. The demand, I mean, I am, I am afraid of the demand right now.

Remember your question?

Yes, I do. Really a followup of what Jamie was asking. How much does -- to develop a primer for a species. Because to be used, I am thinking, you know, the pollen type of a screening and I am assuming that has been betweened a thousand of species and what does it Costa, April to do?

I want to think about that a little bit. That number, you want to know something about -- one of the papers that we published, what happens when we have a species in the same area and -- [Indiscernible] To test it exactly. And one of the things they're working on right now is coming up -- [Indiscernible] The data base sun and essentially that is out there and one of the first ones to go to someone else. And -- [Indiscernible] The problem with this, testing it and you want to test it with an ecosystem where the problem is at. So much with the number, I don't believe it's expensive. $100,000, not beyond the species. That is -- you have to handle this.

Thanks. Why don't I go to the phones now and open up -- [Indiscernible]

One point to.

Shaking the head.

Let me see if Christy is online. Carlos, can you open up the lines and, Christy --

And Christy, are you online?

Yes, I am.

Can you give us --.
morning?

The perspective on this?

Yes, I would be happy to. Here in Missoula, the original task of the lab was to help us determine where Canada links occur in our national forest. So, that was hugely helpful to us. As Mike's talked about, the samples were from here species, from a non-invasive approach and we didn't have to am the animals, which helps us with cost and also just harm or injury to the animal. And so eDNA was an aquatic version of what we're doing for terrestrial wildlife and what we have been doing. Our national forest sent in hundreds if not thousands of samples to Mike's lab every year to be analyzed and, for instance, the fisher, we didn't know for sure in this region where they were distributed and so we deployed 5,000 boxes with base and went back in to look for hair samples and sent those in for analysis and determined that they were more widely contributed than we thought. So, we just really feel like this is an amazing planning and these documentation tools as well because we need to have documents that are defensible, accurate and for species on the ground and it's nationally and internationally, and I am certain they're going to be wildly successful with this. They have a great specific foundation for the work -- scientistic foundation for the work and Mike is great to deal with. I am excited to be a part of the process and that worked well for us here.

Thanks, Christy. What I would like to do now is open up the line for folks online to ask the questions. If anyone has a question, please state your name and affiliation and ask away.

Hi, this is Brian Dykstra from region 3, the wildlife program leader here. My question is: If you go back to the bullfrog example in France, if they were able to extricate that species from a pond or a series of pond, how long would the DNA persist there and how long would you expect a false-positive result?

That is a good question. Thank you. I have a few slides. One of those presenter anxiety moments. I fear going back through, and going through. I think when I first gave you guys this powerpoint, there was something like 140 slides. I think someone got nervous and most of those are back up slides to answer questions. Part of me is tempted to go look for the exact slide that answers your question. I think instead of doing that, I can only post it online or send it to you, basically, there is a few stud you -- studies that looked at how long DNA is in the environment. And for Salamanders or -- [ Indiscernible ] And most have found degradation and I want to be careful I'm trying to separate the ones from moving water and from ponds and -- I'm sorry, ponds and lakes and most of them -- .

Somebody's typing, can you mute your own phone.

And the answer is probably within 24 hours or up to a few days. And I think there was one study that showed the DNA could persist in the environment for a week, but I think that is on the outside edge. I think we're only talking about most studies being hours, if not days and before you would have to go back and resample or have to resample and not get a false positive.
Thanks, Mike, thanks, Brian, for your question. Do we have another person online with a question?

Hi there. This is Becky [Indiscernible] With the Pacific northwest research station. I have two questions. I wrote them in a question-and-answer online. I will ask them now, anyway. The if of the one was that, I heard contamination of samples with a methodology that exists sensitivity can be problematic. I wonder what are your experiences of that and how have you been able to work with the sensitivity of contamination. My second question was that this is a great method for present absence. Have you been able to look at possibly a way of getting abundance as well as present absence for population recovery monitoring that abundant pieces is pretty important.

Great questions. Sensitivity has its own issues. I'm not worried about the contamination from the protocols. We're spending a lot of time on developing protocols that are efficient in the field, and we want to get the weight of equipment down to minimal weight. If we're going to send out field crews across entire regions of Idaho or Montana, you know, and entire multistate regions, that things need to be fairly lightweight and inexpensive. And they need to be disposable or critical elements being disposable to avoid contamination. This is what we have dealt with over a decade with non-invasive genetic sampling and we have been worry about that, the one hair showing up in our carnivore survey got contaminated from one place to another. One, we have been able to make sure, again, that the methodologies we use, from everything when you pull the filter out of the filter holder, how exactly you put the gloves on and we have checks, double checks and triple checks and all sorts of things in our protocol to avoid the contamination. The other thing we do, it depends on the survey. Everyone is different. If you're looking for an endangered species, you can put it in your protocol. When we detect endangered species the first time, we're not going to claim we have it until we go back and survey with another method or go back and do additional eDNA surveys. You can put in your protocols, your interpretation protocols what a detection means for you and what actions you take from the detection. Again, everything from the field protocol where we eliminate 99% and if not more, to the interpretation. Like I said, we worked on this with endangered species for a long time. We're used to that and trying to build it into the protocol to be used across agencies. It's a great question and something you need to be concerned about and the second component is abundance. The correlation of abundance and not too bad of a coordination. We need to look at it not being a one-size-fits-all effort with different correlations of abundance and different habitats, obviously, the stream in the east. You might see higher levels of stream degradation and a shady stream in the west. And to the sun with higher levels of degradation and one that is not exposed and that is turning out slope and topography that will influence how long the tenures of DNA is in the system. Right now, that is what we're doing and I can tell you there is a great correlation between the amount of eDNA and abundance. That is there but we want to refine that by understanding how the covariats influence the relationship.

Thanks, Mike. Does that answer your question, Becky?

It does. Thank you very much.

Great. Do we have anyone else?
This is John Roethlisberger. I am in the eastern region. I have a couple of questions. The first one, what is the fastest do you think you can turn around a sample? Is this a Randa sessment tool that would let us know if we need to treat fire-fighting tanks for invasive species, for example?

I think -- I'm just trying to think of some of our other technologies, we have been able to deal with issues, twoooer-hour turnaround. I am sure this can be a 24-hour turnaround or less and I don't know that I can get it down to eight. There is one step that mean eight and there are a couple of technological developments that we're investigating now that could get it down to under that six hours, six or five hours. 24 hours is a safe bit and that -- safe bet. Doesn't mean that people are on the line and sending the apples in mass qualities and we would send it back in 24 hours. That would be a misstatement. My lab technicians would kill me. In large surveys, thousands of samples can take, which I suspect -- and may be a month to look at. For the emergency cases, we could turn and rapidly. As we build our facility and grow, it will be a fast turnaround.

And that leads into the other question. What do you think long-term sample process. There could be thousands upon thousands of samples that people want to have tested. What are going to happen to these?

That is great. That is what we're hoping for, to be honest with you. And this is a need that we want to be prepared for. And this is a need we want to be prepared for. We want to be prepared to be able to handle samples from the research side of our agency to ask questions across broad scales and we want to be able to address the needs of people on different forests. We said we would open up pilot studies and I can't believe how quickly people were coming to us and ask us to take their forest on as a pilot. I agree that we're looking to find ways to be efficient and to expand rapidly with the demand.

And -- thanks.

R&d in the Washington office and that is a great question as we come to the end of the hour. The purpose of the series of innovations and inventory monitoring and assessment -- to identify those things that we are developing with technology, new knowledge and a look at where we get the biggest benefit in applications for the agency. We all know we have a significant need and we'll see an increasing need to do inventory monitoring and assessment from invasive to rare species, and [ Indiscernible ] Species and opportunities forgetting the biggest bang for a buck when we do restoration. Watch the applications. We need as an agency corporation here, to identify those technologies that we want to advance and how to make that happen across the agencies. So, when we see an increase in management and cost benefit as an organization can do that and one of the things we're going to follow up on will be seminars. Identifiable technologies and we move that and take it to the three areas to say how can we move this now? We're prepared to invest and develop a significant catastrophe to take this on. We look at who should be doing this. Is it a forest service? The university system? Usds. We have to look at what our need is and with the significant amount of public management that we have to manage when we look and see all of the state's agencies. We have to deal with this that we have programs that work, we probably are the agencies who step out and develop a -- [ Indiscernible ] If you have an interest and you see that this is an investment potential, please send your inquiries and your interest in seeing this.
That would help us make those types of investment decisions. You can send that to me. The chief of r&d, Cynthia West or into Jim Pena, and let us know. Let us hear about that. Thank you.

Great, thanks, Cindy. So, we have gone a little over our time. This is the end of the series, but I have a couple of closing comments to make. First, I want to thank Mike for coming here and sharing his time with us and his expertise and for Christy for giving her perspective on this innovative new topic. The two comments I have are, first of all, for those of you who want to stick around, we set aside the in, hour for a real deep dive into a discussion with Mike, but I'm going to need you to hang up and call back. The number is the same, but just the system works better if you guys hang up and call back. The same for you folks here in the room, just stick around and we'll get into the deep dive. The second thing is we have another seminar session set up for next week, May 6th, where one of our research scientists Mike Russo will be coming in at 11:00 a.m. to talk about roadway inventory for monitoring and watershed improvement W. that, I hope to see you next week and thanks for participating. With, that we're done. Talk to you later.

[Event concluded]