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Tip Hudson: Welcome to the Art of Range, a podcast focused on rangelands, and the people who manage them. I'm your host, Tip Hudson, Range and Livestock Specialist, with Washington State University Extension. The goal of this podcast is education and conservation through conversation. Find us online at Art of Range dot com.

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Tip Hudson: This week, on the Art of Range, we have the first of a two-part episode with some individuals from University of Idaho, who have used microbial source tracking to identify various sources of fecal coliform contamination of a stream near Pocatello, Idaho. We will have present for both parts of the interview, Eric Winford, Jim Sprinkle, Jane Lucas, and Alan Kolock, and they will be introduced more fully in the first episode. The second episode will be a continuation of that interview. I think that this story is a really interesting combination of science and controversy, both science helping with the controversial problem, but also some science that has been questioned in some spheres. Controversy number one is that cattle are visible in a watershed, and they make a lot of manure, so it's commonly assumed that where there is E. coli contamination in a grazed watershed or a water catchment, as John Buckhouse would like to say, the E. coli must be from cows. At least the vast majority of it. So, we are going to talk about a really interesting story where some of that maybe has been solved. We have present for the interview Eric Winford, who is the Associate Director of the Idaho Rangeland Center, and someone that I've known for quite a while. Dr. Jim Sprinkle, who is the Extension Beef Specialist for the University of Idaho at the Nancy Cummings Research and Extension Center. Jane Lucas, who at the time of the study, was a post-doc at the U of I's Department of Soil and Water systems, and Alan Kolock, the Director of the Idaho Water Resources Research Institute. I think the first thing we'll do is introduce everyone, since we have more people participating in the interview than normal. And as you introduce yourself, say a bit about how you came to be doing this as a--in your career. Eric, why don't you start?

Eric Winford: Great, thanks Tip. So, as you mentioned, I'm the Associate Director of the University of Idaho Rangeland Center. And I have been in this position for nearly four years now. And my background is in Geography and natural resource management, broadly speaking, and I started focusing more on rangelands when we first met in Washington in Ellensburg. Maybe seven years ago now? And then really came into it quite heavily when I moved to Idaho and started working with the Rangeland Center, and with Karen Launchbaugh [assumed spelling], and the other faculty at the University of Idaho. And my role in this kind of organization as I see it is mainly to be a catalyst between land managers and researchers at the university and Extension specialists, so that we can do the research that land managers are needing to provide sound science and information for their management decisions.

Tip Hudson: Great, thank you. Jim?

Jim Sprinkle: Hi, Tip. It's great to be on this podcast with you, and I've very much enjoyed the podcast that I listened to on some of those long drives that we in extension have. I grew up on a livestock operation in southwestern Virginia. And then I went to junior college in horsemanship, stable management. I was a professional horse trainer for 10 years, and then I went back to school as a nontraditional student at the age of 33, and I went to Brigham Young University, and then Montana State University, and then I got my PhD at Texas A&M University in Animal Nutrition. And my research has all been involved with range/livestock nutrition. So I have a great love for rangelands. And I also enjoy seeing animals use those resources. When I finished up at Texas A&M, I was hired by the University of Arizona as an area extension agent in animal science, and then I had some other duties added later on, but I spent 20 years there, and I retired in 2015, and I was ready for a new challenge in life and not completely ready to retire. So I moved to the University of Idaho, and I've been working here, dealing with range livestock and looking at grazing behavior, and deal somewhat in rangelands as well, range monitoring and those things. And so this has been a very interesting career for me, and I've very much enjoyed it.

Tip Hudson: Great, thank you! Jane, why don't we go to you next?

Jane Lucas: Great, thank you! It's so great to be here, and getting to chat with everyone. I am a microbial ecologist, and I kind of got into the world of research and microbial ecology as an undergrad at a small school in Minnesota. I'm from Minneapolis, and really fell in love with working outside, and being on the lakes there, but I actually ended up doing a bunch of work down in Costa Rica and Panama, looking at microbial communities and ant colonies down there, and then moved up to do my PhD at the University of Oklahoma, where I continued on exploring microbial communities. I kind of was fortunate that there's so many new techniques that evolving these days in the molecular world, and so I was able to learn a lot of advanced tools, and also get exposed to molecular ecology and its kind of importance in the world. And eventually I moved myself up to the University of Idaho as a post-doc, working in the soil and water systems group, because I really loved the Palouse, and I loved the ability to work with farmers, and individuals in that area, and kind of understand our connection to our environment, and provide the molecular perspective. So, luckily, University of Idaho is a wonderfully collaborative institute, and because I had kind of this molecular toolkit, I was asked to join as one of the lab technicians on this project, and it was a really great opportunity to learn more about rangelands, and watersheds. And I've really enjoyed getting to be part of this process.

Tip Hudson: Great! Thank you. Alan?

Alan Kolock: Yeah, hi Tip! Again, thanks for assembling us all today to talk to you about this project. I think I can speak for everybody else on the panel, we really appreciate this. So we appreciate your giving us this opportunity. I am, as you've already said, I am the director of the Idaho Water Resources Research Institute. I've been in that position now for a little over four years. I came out of the University of Nebraska system, where I had appointments at the University of Nebraska, Lincoln, which is the land grant university--go Corn Huskers! The land grant university within the State of Nebraska. I also had a position with the College of Public Health at the University of Nebraska Medical Center. So, kind of like Jane, I come from a background where we were really interested in looking at public health issues through the lens of agriculture and livestock management. So, kind of looking at the interdigitation between agricultural practices and public health. Also, relative to that, we were interested in using modern molecular techniques to address those types of questions. So, given that introduction, I think you could see how it was a natural fit. When I came here to Idaho, this project that Eric and Jim introduced me to was of real interest to me, because it really hit on those topics, the topics of rangeland, cattle management, and then also potential public health concerns. And hopefully, over the course of the next few minutes, during this conversation, we can talk about that in a little bit more detail.

Tip Hudson: Yeah, that'd be great. This is a really diverse group, and it seems that those often produce the most effective and fun teams to be part of. I am reminded of a keynote address that Temple Grandon gave, with the Society for Range Management's meeting back in 2015? At--in Sacramento. This was right after the Fukushima reactor meltdown in Japan. And she was talking about different ways of thinking, different ways that people process information and then she is a visual thinker, and makes associations between images in her head. And she was saying that if there had been anybody that had been part of the design team for that reactor that was not a linear engineering style thinker, this isn't a land that is, you know, characterized by the tsunami, like that is a cultural symbol. Anybody who was not a linear engineering thinker would have seen in their mind's eye, the water rushing in, into the room that held the back-up systems for this reactor, because they were below sea level, and it's just crazy that nobody thought that was a concern in a place that's known for tsunamis. And I've since experienced the benefits of having diverse teams, where people have different sets of knowledge, different presuppositions, different skillsets, and different ways of thinking. So I'm pretty excited to have a discussion about this. I saw the article on the Idaho Rangeland Center's website, which I probably got in an email, describing this conflict in Mink Creek, in Idaho, near Pocatello, where there were a lot of--it's a classical multiple use scenario, and also a classic situation where you have some surface water impairment for fecal coliforms. So, can somebody give a little bit more of the background story of what was going on that led this group to try to figure out who is pooping in the forest, and why anybody would care?

Jim Sprinkle: Maybe I'll start off Tip. This is Jim Sprinkle. Because I was probably the first one contacted about this. The DEQ did their water sampling in 2017, and they found the exceedance of the safe level--I think that's 126, what is it--parts? Equal parts, for--

Tip Hudson: It used to be colony-forming units, but I think I saw in the paper a different metric now.

Jim Sprinkle: Yeah--

Tip Hudson: Most probable number per--

Jim Sprinkle: Yeah, most probable number of E. coli organisms per 100 ml, and so they had exceedances on this watershed. And so immediately, as you had mentioned previously in your introduction, is that it was pointed to livestock, and there were livestock present, and grazed that watershed. But there is also a high number of recreation days, because this is very close to Pocatello, and it's very easy for people to access it, and recreate there. And so, I had a permitee on the forest contact me as well as a forest service employee. And they asked for my input on this. So, I provided some input. I did some literature search, and tried to see what had been found in other areas, and so when I looked at some of the studies in British Columbia, and also in California, then it raised the question, well, really, are livestock a major contributor? And so, I shared with both the Forest Service, and with the permitees, that you know, we really ought to look at what the main source is. And so we went about a year, and so in September of 2018, the Forest Service, Rob Mickelson, he convened a meeting of the permitees on that grazing association at Mink Creek, and the city of Pocatello, Department of Environment Quality, and Forest Service employees, and then myself, and Eric Winford, from the Rangeland Center, and by this time, Eric and I had been communicating, and we had shared some insights that we had found in looking over some of the studies that had been done. And so, when this topic was introduced at that meeting, then I made a suggestion well, perhaps we should find out who the major contributors are to the problem, and we could probably use some DNA technology to assist this. And so, there was some push-back on that, from some of the folks that, well, they wondered if it's even possible, and then Eric Winford had been in communication with folks, I assume Alan, and he thought that the University of Idaho could provide some expertise with this. And so we had to find money to do this. So we spent some time doing that. We made four attempts and we finally got the $25,000 we needed to do the study from region 4, the Forest Service, and so we are grateful for that. And then you know, just to kind of wrap up my intro to this, is I think we have a lot of appreciation for the way the Forest Service approached this. They just didn't use a regulatory hammer, and just said, well, we agreed, livestock are the problem. They wanted to discover the answers, and then work with management and try to look at what could be done. So there, I think maybe Eric would have some things he'd want to add to this.

Eric Winford: Great intro. What I would add, a little bit, is just to think about how this is really a collaborative project, and it's a perfect fit for what the Rangeland Center, or what Extension, or what University of Idaho is trying to do is just give information for managers, so that they can make their management decisions. And as Jim mentioned, we came out to that meeting in September 2018, with ranchers and DEQ, and the City of Pocatello, and the Forest Service, and really just talked about what the issues were. We had a lot of great discussions about different ideas, about where the E. coli were coming from. But it was clear that there wasn't a consensus in that the Forest Service didn't have--really didn't feel like it knew enough about the source of the E. coli to really recommend appropriate practice to reduce the levels of the E. coli. Before the meeting, I had reached out to Alan Kolock, who I had known for about a year at that point, and discussed how we could maybe provide some information. And so he was the one that suggested microbial source tracking as a tool that could help us understand the source of the E. coli bacteria.

Tip Hudson: Yeah, that is a really interesting introduction. There are a couple of asides that I'd like to pursue for just a minute before we get back on the trail of that story. One of them is that I suspect a lot of people who may be listening don't know a lot about the regulatory framework here, both who is responsible, and also what the water quality regulations look like for what I would call wildland streams. I feel like I only barely have a handle on this, and I've been working with it quite a bit over the last 10 or 15 years. So the first question is, the Clean Water Act is primarily administered by the EPA, Environmental Protection Agency, but they delegate the authority within various states for enforcement of the clean water act, to state agencies sometimes. And in Washington State, that delegated authority goes to the Department of Ecology. I thought I had understood that the EPA still retained some of their authority in Idaho, but the Department of Environmental Quality is the one who is mostly doing this testing and enforcement, is that correct? Maybe it's a question for Alan?

Eric Winford: Yeah, that is correct, that DEQ is the primary purveyor of that information in Idaho, yeah.

Tip Hudson: Okay. And with regard to water quality regulations, E. coli as I understand it and fecal coliforms in general, are mostly used as an indicator for the presence of fecal material, which might have other pathogens associated with it. Because the E. coli is usually benign in terms of human health, with the exception of the notorious ones, like was it 015787? But what's--those bacteria are being used as an indicator for the potential presence of stuff that can cause dangerous infections, like cryptosporidium, and giardia, salmonella, campylobacter. So, what are the--how do the regulations work for wildland streams when they test? What numbers are they looking for? And what levels are bad? And are there different levels of bacteria that are acceptable for different kinds of surface water?

Eric Winford: Jim, you addressed that earlier on, relative to the numbers, and I don't have our manuscript in front of us. So could you take that relative to the regulatory numbers that you were talking about before?

Jim Sprinkle: Well, uh--so the 126, most probable number of E. coli per 100 ml is the trigger for the regulatory limits, and then there's a secondary limit, Alan, is that--it's 500-something? What is that exactly?

Alan Kolock: Five hundred and seventy-six organisms per milliliter. That would be the trigger. The one-time trigger for additional monitoring, and 126 MPM per 100 ml is just regulatory standard. And that would be the standard for both primary contact streams, for streams that you would swim in, and secondary contact streams, that--so streams that you would just wade in, or maybe fish in. Mink Creek is a secondary contact stream per the IDQ.

And Tip, as you were talking about, earlier on, when you initiated this part of the conversation, all of the regulation is based upon public health concerns. So the reason why the number, this most probable number changes as both Eric and Jim just elucidated, the reason that it changes is how close the exposure is to the person. So, for example, if you're drinking the water, not that you would drink Mink Creek water, but if you were drinking municipal water, then the acceptable standard is zero coliform counts per 100 ml. If you were as Eric said, if you were swimming in it, then you have another standard, which is higher, because your exposure is less, and then if you're wading in it, it's even higher, because your exposure is even less. So it's all based upon relative risk. Based upon public health concerns.

Tip Hudson: Right, rather than ecological function.

Alan Kolock: Exactly.

Tip Hudson: So that a little bit of E. coli, or maybe even, you know, 500 CFUs, or 500 MPM wouldn't necessarily be an indicator of ecological dysfunction or an impaired riparian area, it means there are living things in the water, or near the water, that are leaving stuff in the water. I want to mention, just before we move on from here, we had Dr. Ken Tate from U.C. Davis up here a few years ago to do some training with conservation districts, and agency range cons, and our regulatory community, mostly for the Department of Ecology and one of the things he was pointing out were the gigantic numbers of microorganisms that are being shed by most warm-blooded organisms all the time. And the numbers are absolutely gigantic. So, the fact that we can test a water body and find, you know, something in the ballpark of 125 MPM per 100 ml, is really really fascinating. There's a whole lot going on at the microbial level. There's all these interactions going on that are making it such that there aren't numbers in the millions. The numbers are rather usually in the 100s, and this would be maybe a fun question for Jane later, because I suspect she knows way more about this than I do, but he pointed out that the main source of mortality for those microorganisms is predation by other microorganisms, rather than say exposure to sunlight that just makes them die. But these organisms are feeding on each other, and kind of managing the population so that it doesn't--we don't have huge, huge numbers of fecal coliforms running around in the streams. I think we can go back to the story now, and then maybe that will be a conversation we can try to remember to have later, once Jane comes on. I think one of my next questions was, why does it matter what is the source of E. coli, if--if there's impairment, meaning that what's being tested in the stream is consistently above that standard for primary contact waters. Why does it matter where the E. coli is coming from? It may seem like an obvious question, but I think it's worth saying out loud.

Alan Kolock: Yeah, and this is Alan again. I'd be happy to address that. And just at first blush, I'd like to talk about that relative to--well, from two perspectives. The first perspective again is getting back to the public health perspective. And that is as you, Tip, already mentioned. There are very serious public health concerns relative to drinking water. So we're not really talking about Mink Creek now, but relative to drinking water, there are very serious public health concerns, relative to the transmission of pathogenic organisms from humans through the wastewater stream into other humans. If you were to go back 100 years, back to the early 1900s, of the top five sources of mortality, both in the United States, and worldwide, two on that list would be cholera and typhoid. Now, those are transmitted, exactly as what we were just talking about, which is you have a patient that has the disease, they have an effluent stream, they have their waste. Someone downstream, unfortunately drinks water that was contaminated by those wastes, and picks up the disease. So it's really important if there's human effluent, or human coliforms, that's a huge public health signal. Cattle obviously--coliforms from cattle aren't going to be anywhere near the public health concern relative to humans that human waste would be. So that's number one. The second part of it, and much more germane to our conversation today, although I still think the public health point should not be glossed over, but relative to today, if we're going to remediate a stream, so to get it below exceedance, so it meets regulatory standards for either a state or the U.S. EPA, a state agency, or the EPA, if we're going to do that, we have to know where they're coming from. Because in Mink Creek, as a perfect example, we didn't know whether they were coming from the human source, or from the cattle source, and you can imagine, if you're going to remediate that stream, remediation based upon a human source would be fundamentally different than remediation based up on a cattle source. So, rather than go out and spend a whole bunch of money fencing off the stream so the cattle can't access it, or taking out privies that humans use, so that humans can't, you know, directly contribute, or do whatever else. We need to know first who the culprit is, right? Where are these bacteria coming from? And fortunately, with source tracking, we can address that question, which is exactly what we did.

Tip Hudson: So you're saying traditional sampling methods are just testing for the presence of a particular species of bacteria, and that in and of itself does not say anything about the source.

Alan Kolock: It both is--and Jay may be able to elucidate here, a little bit more clearly than I can. But when we're doing coliform testing, coliforms are an aggregate of many different species of bacteria that are all within the coliform family if you will. And we don't know if we're doing just standard counts, these most probable numbers, we don't know who--what intestine those bacteria are from. Are they from the intestine of a cow? Are they from the intestine of a coyote? Are they from the intestine of a great-horned owl? Or are they from the intestine of a human? We don't know. We just know that they're coliform bacteria. So source tracking allows us to differentiate from one species to the next, relative to the warm-blooded animal that those bacteria were residing in the intestines of prior, before they got to the stream.

Tip Hudson: Yeah, I suspect that most of you are aware of the significance of this, but again, I'm reminded of some data I saw from a survey that U.C. Davis did sometime ago, I think Lesley Roche was involved in authoring the survey, and all this was published. But they were asking, they were essentially asking ranchers what are some of the things that keep you awake at night? Problems or conflicts, within the world of your business, that feel like they're existential threats, meaning if it goes wrong, it could be the end of your business and your livelihood? And one of the things that topped that list, and that certainly would be the case if a similar survey was run in the northwest, was environmental regulations. Because there are some real teeth in some of these. Either in terms of costs, for management actions imposed on landowners and ranchers, that would not be--were it not, you know, for this violation of environmental laws. Or, just the loss of say a permitted or leased range area, because of real or perceived environmental harms. So, I do think this is a really big deal, and at least in Washington State, there has been an awful lot of talk and controversy and litigation over livestock being the assumed primary contributor in nearly every single situation where there is fecal contamination of a water body. So I think what we're talking about is a pretty big deal, and I think this microbial source tracking has the potential to really help solve some of those problems. Because if a leaking septic system or a whole watershed full of leaking septic systems is the culprit, but what is most visible on the land surface are livestock, livestock are almost always targeted. I think probably because it's an easier target. It's easier to push ranchers around than it is a group of homeowners. And I am pretty excited about hearing that microbial source tracking may have matured enough that it could be pretty useful. So, I would like to ask, you know, from your respective views inside your geographic area and social sphere, what are the potential regulatory actions that can be taken against livestock producers or landowners in situations where livestock are suspected of being a persistent source of fecal coliforms that cause exceedance of those standards over a long period of time?

Alan Kolock: Tip, this is Alan Kolock again. And before we get to that question, which I think is a really great one, I'd like to just embellish upon what you just said. Because it's interesting because it has a lot of similarities to crime. So, and what I mean by that is, imagine that you're in a neighborhood that you've never been in before, and somebody steals your wallet, right? Now, when you--somebody steals your wallet, you may think to yourself, okay it's someone who lives in this neighborhood. So, in a way, what you're doing is you are neighborhood profiling. Right? You're saying, I'm in a neighborhood that I don't know, and that there is someone in this neighborhood that stole my wallet. That's kind of what you just said, where, you know, if you're in a cattle-intensive grazing area, and there is a regulatory violation, then people are going to look at the cattle and say hey, we're in the neighborhood of cattle grazing, it's the cattle, right? I'm not saying that's right, I'm saying that's profile. And that's a problem. Now what the beauty, and again, this is true for human crime, as well as environmental regulation, the beauty is using microbial source tracking, whether you're tracking the DNA of a crime suspect, or whether you're tracking the DNA of a species of animal in the field, it allows you to say, okay, someone in this neighborhood stole my wallet. But is it Jim Smith? Well, let's take a DNA sample from Jim Smith. And nope! He's innocent. He didn't do it. And right, whether we watch Jerry Springer, and you know, is this child yours or not? We see this in crime all the time, right? And we are very accustomed to dealing with that. I mean, we're very, you know, we just accept that as science doing its job. Well, science can do the same job, relative to this agricultural or livestock-oriented input, right? It's not that we're a priori saying it's the cattle. In fact, it's exactly the opposite. What we're saying is let's get away from species profiling, and let's look molecularly for the perpetrator, right? The species perpetrator that is primarily involved. And like in Mink Creek, sometimes that perpetrator may be us, human beings, homo sapiens. And that's fine. Because that's what we need to find out.

Tip Hudson: Yeah, and I'd like to clarify, maybe this is a question for Jane, what I think I heard you saying earlier was that there's a much greater likelihood of having the dangerous pathogenic microorganisms associated with human fecal material than livestock, is that correct?

>> Yeah, I mean, I'd be happy to jump in. I think yes, if your model is what's more dangerous to humans, then probably human contamination will be, because, you know, it makes sense that it's [overlapping speakers]--is going to also affect other people so that's why it's more dangerous. And just to give kind of a brief overview of why this is a great technique and why we can kind of become clear who the potential perpetrator or source of this contamination is, is that I think we're all very familiar now with this idea that we have a really vibrant gut microbiome, and what's really interesting is that a human microbiome versus a cow, versus a dog, or any type of animal, has some similarities there. There are certain genre of bacteria that we share, but what's really interesting is that over time, these different types of bacteria have become specialized to a cow gut, or they've become specialized to a human's digestive system. And so what's really nice is I don't need to go and take a DNA sample of every single cow on someone's rangeland. I can just look at the DNA in these coliforms, and I can pick up some of the specific DNA that I know, okay, well, this bacteria could only exist in a cow gut. It's just the only place where it's prime to live. Or it only exists in human systems. And so it's really nice because instead of having even more intensively, like with human crime, having to know the specific DNA of your suspect, here we don't even really need to know the DNA of our specific suspects, because you know, the gut system is highly specialized for different organisms.

Tip Hudson: Yeah, that's a good segue way. So, what is that, what does that procedure look like, identifying what, maybe what class of animals is responsible for a particular set of bacteria?

>> Yeah, so there's a lot of steps to it, and you know, the first thing is to go out into the field, and actually sample the coliform, and get that back to the lab, and I wasn't part of that particular component, but I think Eric, or Jim might be able to tell you it can sometimes be a little bit more of an effort, because you have to hopefully get that sample cold, and keep it preserved, because if you keep it in a warm cozy environment, that bacteria is going to start to change, and we want to just kind of take it out of the water, and freeze it in time, so that we can quickly look at what was there in the field. And then we bring it back to the lab, and we do these kind of fancy techniques, where we break open all of the cells, to allow the DNA to be kind of accessible, and then what's been really great is, you know, this is really an example of how science has built on lots of other people's work, but people have gone through and found, oh, this specific gene target is what's present in cattle. And this is present in humans. And this is present in cows, and--or dogs and wolves, so, we can use an advanced technique called Q-PCR, or quantitative polymerase chain reaction. That actually replicates the DNA, but it only replicates our targets. And so if we put it on a big machine, and it comes up positive, that means that in our DNA sample, our target gene was present, and therefore, cattle was the contaminant, or therefore, a human was the contaminant.

Tip Hudson: And what are the various kinds of animals that you could get that answer for? For example, in the study, you know, you have some that register as human, and some that register as canine, and bovine, and then there's other unknown. Is it the case, sort of like, like with Ancestry.com, you know, where over time, the DNA pool gets bigger, so that there are more and more matches over time? What does that look like with this, and then for what classes of animal do we not have an answer?

>> That's a really good question. So with this specific technique that we're using, we pre-chose the potential sources. So we chose that, you know, we think that cattle might be a source. We think humans might be a source. So we chose those specific targets. Now, there is another kind of similar, related technique, where we could have just sequenced all of the DNA, and looked for what was present, and that you kind of--we're only limited by whether or not somebody studied it before, so we could have potentially picked up a fox. We could have picked up a wolf, you know, bears, there's tons and tons of information out there, and I actually do a lot of this type of technique with insects, so I could tell you all these different types of insects, not so much fecal contamination of them, but just whether or not they're present. So, it's kind of, the opportunities are limitless, and we are only limited by whether or not somebody has done it before. And so you know, we focused on cattle, and humans, and some other potential indicators for this study. [Distant music begins] You know, it would be unlikely that we have elephant contamination, so we chose not to include that in this study, but technically, we could have if we wanted to.

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