Post-fire Wind and Water Erosion in the Great Basin: Results and Management Implications

---

Eugénie MontBlanc: All right, I hope everyone can hear us. Good morning everyone. Thank you for joining us today. My name is Eugénie MontBlanc and I am the Great Basin Science Delivery Project coordinator. I would like to welcome you to our first webinar and I would also like to welcome our project PI, Mike Pellant, and our presenters, Matt Germino from Idaho State University and Jason Williams from USDA Agricultural Research Service at Boise, Idaho.

Since this is our project's first of many webinars to come, I wanted to give you some brief background information about our project before we begin the topic presentations.

So we're the Great Basin Science Delivery Project which is a member of the Joint Fire Science Program's Knowledge Exchange Consortia. That is a national network of regional consortia. It aims to bring managers and researchers together so that the best science is being conducted and that that the results of that gets shared with those who actually use it on the ground.

01:15 Our project was funded in September and is initially funded through September 2012 so for two years with the hope that if we're successful, we will be funded for the long term. We're governed by a six-member steering committee and advised by an eight-member advisory committee. Project partners include land management agencies, research agencies, land grant universities, regional research and management projects and collaborative organizations.

The goals of this project are to assist Great Basin land managers in identifying their technical means with respect to fire, fuels and post-fire vegetation management, then to develop the necessary information and tools to meet those needs and to provide the information and tools that are most preferred by the people who are actually going to use it, so field staff, field office managers and higher administrative levels.

02:10 A little bit of background about this project, we received a planning grant to conduct preliminary assessments that examine the technical needs and preferred modes of information delivery for Great Basin land managers. Some of the top technical needs were specific questions regarding fuels and fire management, monitoring, resilience and species conservation. Some of the top delivery modes were the capacity to contact experts, a web-based clearinghouse of information and cadres of managers and researchers and technical pocket guides.

We used the information from these needs assessments to develop a model for science delivery, and that model includes seven deliverables which are ongoing identification of needs, synthesis of scientific and agency information, web-based training, a web-based clearinghouse of information, field workshops including webinars and site visits by experts, networks of experts and program effectiveness assessments.

03:12 Where we are right now with each of those deliverables is we conducted the initial means assessments, as I mentioned earlier. Those were conducted from November of last year to the beginning of this year. We are working on collecting information syntheses and have a few posted on our website right now.

We are working with the University of Idaho to expand four of their online courses mentioned here and also to make those courses more applicable to the Great Basin. We have a web-based clearinghouse of information through the Great Basin research and management partnership and here is our website.

I'm going to skip ahead to that really quickly. I have a clip of our homepage so you can see we have upcoming science delivery activities, our few syntheses. We're working on lessons from case studies. We have online courses here, conferences and workshops and funding opportunities and a blog. I'm going to be spending the rest of this week before Thanksgiving updating those. I know there are some information that's a little bit old but I will update that this week.

04:19 Through the Great Basin research and management partnership, we have an expertise database, science locator, consortia database, meta data server and publications and links. We have about I think 4,000 publications. We have a few hundred in our expertise database and we're trying to populate our science locator right now, so if you're a researcher and you have some projects, it'll be great. This is a map where anyone can go on to the map of the Great Basin, highlight an area and see what projects are being done in that area. We'd appreciate your help populating that.

Also, I forgot to mention since this is our first webinar, this week we'll have somewhere around this header webinar links so that you can go see the recording of this webinar and also we'll have an agenda for upcoming webinars as well.

05:10 So back to our deliverables, we're also in the development of creating a network of experts for management and research agencies which we're calling our restoration cadre and there will be more about that to come. Field workshops, webinars and site visits, our first webinar is today, thank you for joining. Our first field workshop will be coming up May 24th and there'll be more information about that on the website.

I need to do some better advertising because one of the things this project has funding for is site visits by experts so if you're a land manager and you don’t know how to apply all the science that you're reading to your specific site and you wish that a manager could come and then give you their opinion and look at your field site then you can call us and we will set that up for you.

06:02 Finally, our first evaluation will be in January. It will be a web evaluation through Survey Monkey so you'll see that coming if you're on our listserv. If you're not on our listserv. and would like to be, please email me.

Thank you very much. Again, this project is here to serve you so if you have any questions or comments, please call me or email me. Also, at the end of this webinar, we're going to have a discussion so you can type in questions for me and during the discussion after the presentation, I will answer those questions. Okay, thank you.

Now, I would like to let our project lead, Mike Pellant from the BLM say a few words.

06:44 **Mike Pellant:** Well, good morning or good afternoon to everyone. I will just echo what Eugénie said that we are very happy that you joined us. Just two quick things: 1) we'd really encourage your feedback on this webinar. We want to learn from it what can we do better. We would like to have a webinar each month as we move forward, and in that end, we would also appreciate if you have any needs that you would like addressed in the webinar to please let us know or if you have any potential speakers or presenters with information that would be applicable to the Great Basin and fire-related topics, please let us know about that.

Those are my two requests to you, and I think we'll go ahead and get started. So Eugénie, do you want to introduce our first speaker?

Eugénie MontBlanc: I will. So now I'd like to turn the webinar over to Matt Germino. Matt is an associate professor of plant ecology at Idaho State University. His current research includes

07:55 **Matt Germino:** Okay, hopefully everybody can see my PowerPoint now. The other part of my background is that we here at Idaho State University are learning a vigorous research program that aims to understand the causes, consequences and management implications of wind erosion in our western rangelands and in particular, the Great Basin.

Actually, our geographic emphasis is on the Snake River Plain which normally is comprised of mostly sage brushed up ecosystems that typically do not exhibit much in the way of wind erosion. Also, these very flat rangelands oftentimes are not particularly prone to water erosion. What we're observing in recent decades however is large pulses of extensive amounts of dust and other particles eroding from these sites.

08:52 My colleagues are Nancy Glenn, Joel Sankey and Amber Hoover, all of Idaho State University, and our funding has been provided by Bureau of Land Management and the Northwest Research Alliance, Department of Defense and we have leverage funding from National Science Foundation for the climate's logical aspects of this research.

This photo shows a dust storm that occurred west of Twin Falls in 2006, following the burning of several hundred thousand acres on the Clover Fire. Photos like this are reminiscent of the Dust Bowl Period. The Dust Bowl by the way was one of the most

significant environmental catastrophes to ever hit the lower 48. We know that the Dust Bowl did not result merely from draught but it was the interaction of drought and the condition of the land, both rangeland and agricultural crop fields. So land use is indeed an important part of vulnerability to wind erosion.

10:00 Lately, there's been a lot of increased attention to wind erosion and dust. Dust in the air affects the environment, for example, that influences the net radiation balance, sunlight penetration to the earth as well as thermal radiation balances. All those affect climate. Dust can actually inhibit the condensation of water to clouds and thereby can affect precipitation locally.

Epidemiologists have shown that dust recorded by the EPA correlates with records of asthma and other respiratory ailments and so there's an appreciable health issue

10:42 Traffic ability can be impacted by dust. Certainly, flying an aircraft through a dust cloud as shown in front of you here in an otherwise cloud day, it would be a frightening situation but increasingly, we're seeing on the news that there are traffic accidents attributed to dust. We're seeing an increase in the number of signs alongside highways and places like Southern Idaho have warned motorists not to pull over because this area is prone to low visibility attributed to dust. Oftentimes, you'll note that those signs are not always located downwind of crop fields but in fact they're adjacent to rangelands that have been impacted by fire or other types of degradation.

11:31 So most of what we know about wind erosion comes from studies on flat, simplified crop fields or dunes such as in coastal areas that tend to be very sandy or from warm deserts such as the American southwest or Africa. These silt systems have all experienced large amounts of wind erosion in our history and whether or not we can apply what's known about wind erosion from these sorts of scenarios to areas like the Snake River Plain which is a cold desert and which is experiencing these pulses of erosion that seem to be a novel occurrence of these with respect to recent decades to centuries or millennium, this is a major question. Probably the causes of consequences of dust in these systems that are newly experiencing wind erosion, they may differ from these other types of systems.

12:29 Note that many of the soil types in the Snake River Plain and other parts of the Great Basin are characterized as being dried up loess. In other words, the soils were deposited through Aeolian wind-driven processes. And for millennia perhaps, those sites have been accumulating dust but now the occurrence of fire is leading to a net loss soil from these sites.

Erosion and dust production from deserts can affect regional hydrology. Here for example is a photograph of mountains in Colorado. You can see the dust is darkening the snowfields. That's a major concern for water managers because the reduced albedo causes the snow to gain more heat from sunlight and to melt more rapidly, creating a flashier hydrograph which impacts the ecology streams but also reduces the amount of water stored in the mountains for late summer use in agricultural and municipal purposes.

13:35 This type of connectivity between deserts in our mountains is really important and it's going to change the way that we manage our semi-natural air ecosystems. Locally, redistribution of soils is known to affect the site fertility. Sujith Ravi, Jimmy Lee, Greg Okin, Dave Breshears, Belnap and others have created a large body of literature for warm deserts in the United States and revealed that wind erosions indeed have major impacts. Here, I'm going to focus on wind erosion as it affects cold deserts such as the Snake River Plain.

So fire reduces the protective cover that vegetation provides for stabilizing soils. Fire is changing considerably. The map on the left shows 30,000-acre fire that burned in 2008 and within it, you can see that made these patches of brown have actually burned repeatedly in the recent decades so fire frequencies have changed from being on the order of burning once every 50 to a couple of hundred years to they're now burning once every few years. That was true of the photo here on the right. Portions of this area that burned in the summer, this is occurring on the Idaho National Lab. Portions of this have burned once or more in the last decade or so.

15:05 This fire was 100,000 acres. You can see the charred areas where wind erosion has not impacted it so much and the blind areas are where the soil has been eroded away and if you look closely, you can see the dust is actually suspended in the air actually over the Greater Yellowstone ecosystem to the north. So the fires are increasing in their aerial extent and that enables wind to increase its momentum strength, basically the fetch for wind has increased in these large burn areas.

15:45 A larger fire had occurred after this Jefferson Fire west of Twin Falls. It burned something like 550,000 acres. This 100,000-acre fire was followed by the loss of about five inches of soil, I think, and I've heard that even more was lost from that fire that occurred west of Twin Falls a month later. This is an appreciable occurrence. We have been asking in our research program how extensive is post fire wind erosion, where and when is it occurring? I can tell you right now that fires that are a couple of thousand acres or larger are where we're seeing the wind erosion but not on smaller sites.

16:30 Why should we care about it? All of our sites have been in and around the Idaho National Lab; that's four different burn sites. This photo on the lower left reveals that if you don’t always need data and scientific studies to know that wind erosion is impacting a site, here you can roots of these so-called pedestal plants that are now exposed. This is following just a few weeks of wind erosion up the Jefferson Fire. The photo above it shows the Twin Buttes Fire for which we have a lot of data and you can see this rippling of soil that is now evident in the year following a wildfire.

Erosion impacts aren't always so obvious. This lower right-hand photo shows the site that we've recorded quite a bit of wind erosion on by using these passive sediment collectors as well as sensors that we record with the data log here which can record soil movement with a device that measures impacts to the particles and we can measure the corresponding wind speeds and relative humidity.

17:36 The processes by which soil moves are known as saltation. Those are bouncing particles that move meters, sometimes distances the length of a football field. This schematic is nice because it shows how saltating particle kicks off the movement of other particles, be it creep or larger particles might blow along the soil surface or smaller particles may get kicked off as dust and suspended for a long range of transport.

The other thing that I like about this schematic is it shows how erosion at any point in space is clearly impacted by erosion occurring upwind and one particle can kick off the movement of many more particles.

So the key concept is that wind erosion involves processes that act like avalanching cascades. It's something to keep in mind.

0:18:25 Here's a photo of Joel Sankey and Nancy Glenn collecting the soils from our sediment traps. We periodically collect dry and wavy soils, fit the masses to this equation and we can get an estimate of sediment discharge. In this case, it's for five replicate towers located on a burned area and another five collectors on an adjacent unburned area. You could see in the unburned area we very rarely see much in the way of any sediment discharge but here, the horizontal flux of sediment is near 10 kilograms per linear meter per day. That's a large amount of sediment. You can try to envision several gallons of soil being transported per linear meter per day.

This erosion is sustained following fall or late summer wildfire over many months. Snow covers the site during the wintertime and stabilizes then. Upon snowmelt the site still has not had any green up and we can see a post snowmelt dust storm. What surprised us was that the site greened up to just about 10% fully recover, we observed that the wind erosion was considerably reduced to unburned site levels.

0:19:46 These high amounts of wind erosion are impacted by increase of wind speeds at the ground, erosivity shown here. Wind strength is shown by these horizontal arrows. How loose the soil is which is erodibility and how much of that loose mass there is or supply of erodible mass, we're finding that each of these varies in how well they can explain the high amounts of erosion that we're seeing via wind after a wildfire. After a fire you lose protective vegetation, wind speeds increase in strength and they begin to entrain soil particles creating that avalanching cascade of soil particles but whether or not you have appreciable erosion is dependent on whether or not this site will continue to supply the erodible mass. It turns out that that matter of supply is important as I'll demonstrate.

0:20:40 So first, we've evaluated erosivity by using remote sensing techniques. We can use laser altimetry collected from airplanes to look at surface elevations. We can get many laser returns within a five-meter by five-meter pixel. That's about a 16x16 foot area. The blue areas here are sites that have a lot of roughness attributed mainly to vegetation. Moderately burned areas have a few unburned shrubs and perhaps some charred skeletons of sagebrush remaining. I didn’t show an intensely burned area

which would be completely slipped off and totally green in this map.

So these are data that Nancy Glenn collected and Joel Sankey worked up for his dissertation, a really interesting manuscript that is sort of ground breaking for linking LiDAR to wind erosion.

0:21:33 We collected this LiDAR data soon after the fire and then a year later and Joel calculated the elevation change of surfaces. He corroborated these data by the way with direct measurements in the field of surface elevations made relative to rebar posts. Those are called erosion bridges. The rough unburned landscapes actually gained soil during the year after wildfire. The severely burned microsites lost several millimeters to up some meters of soil.

I want you to note that the moderately burned areas in here had almost no surface change in them. I'll come back to that.

0:22:11 Erodibility we can know by measuring the natural occurrence of soil redistribution by using devices like this that record the microvoltage every time a soil particle had set. If we locate an anemometer, a wind sensor next to this, we can create a plot that looks something like this. So within a day, these are hours, you can see wind speed picking up. As wind speed increases about 10 meters per second, you see the soil particles moving. We can use a statistical approach to determine the critical wind speed required to move those soil particles.

Here you can see it ranges from about nine to 11 meters per second and it varies in time. In the next slide, I'll try to give explanations for why it's varying in time. We're interested in those sorts of patterns because ultimately we want to create predictive models for where and when erosion might be expected.

0:23:07 Notice also in the unburned areas we never did observe saltation sufficient enough to calculate a critical threshold wind speed. In these sites, we've got to come up with a way to increase wind speeds to the point where the soil moves and that can be accomplished with wind tunnels.

So high amounts of variability and erodibility, that variability is occurring even during extended high pressure systems where we're not seeing rain events or other things that might affect the erodibility of soil. So the high amount of erodibility could be still nevertheless attributed to variability in surface moisture, due to evaporation or perhaps dew fall or it could be due to crusts forming and weakening or to variations in the supply of erodible sediment.

Here we used soil and water content sensors that measured soil volumes of around a pint or so, definitely not the surface, and we can explain some but not a satisfactory amount of the variability in erodibility measured as threshold wind speeds.

0:24:17 We're now working on new techniques to measure surface moisture to improve these correlations and on this site, I also want to point out that we're working with the US

Forest Service RMRS, Rocky Mountain Research Station. Natalie Wagenbrenner is using our field-based data in her predictive models of wind erosion and she is looking at computational fluid dynamics as a way to measure the wind fields here. That's I think research that will be highly effective for developing predictive models.

So the wind tunnels that we use to measure erodibility aren't the huge kind that you usually see in the basement of engineering departments but rather this tiny little portable unit that has a fan inside it that blows air down upon the soil and then we measure the dust produced. We can fit this device into the different kinds of microsites that occur in burned and unburned landscapes. Those tend to be under shrub versus interspace microsites.

0:25:17 We measured these types of microsites in burned and unburned areas across this gradient along the Snake River Plain this summer. Joel Sankey led this research. That device by the way is called the PI-SWIRL. Vic Etymezian of the Desert Research Institute led the development of it.

Well, this graph shows the amount of dust produced on these microsites as particulate matter of 10 microns or less in size, burning huge increase in the amount of erosion especially on the shrubs. That's a significant finding as shrub abundances are something that is affected by land management. Long-term grazing for example is known to increase the abundances of shrubs. That was seen to expose a site to being more easily eroded after a fire.

0:26:05 We however found that there was no real difference in erodibility, the wind speed required to dislodge soil from these sites which is kind of surprising. Instead, it appears that these burned and especially under-shrub burn microsites are sites that will produce a high supply or erodible mass.

So erosion is very large after a wildfire in part because erosivity increases and also it appears that the supply of erodible mass is important especially under shrubs. Remember from the LiDAR data microsites are sites that look like this that were only moderate burned actually didn’t appear to have much loss of soil. Possibly this residual vegetation and even charged stems is important for reducing erosivity.

0:26:53 Sujith Ravi and others have opposed that fire should homogenize this shrub island coppice and bare soil interspace heterogeneity. We've asked questions like does this also occur in sagebrush steppe and we see this sort of homogenization. It's an important question because this heterogeneity is an important attribute of where these ecosystems were.

Amber Hoover just finished master's degree at Idaho State University where she revealed that this interspace coppice morphology is actually highly resistant to the redistribution of soils after a wildfire, which was kind of surprising to us actually because you'd think that moving soils around in this landscape would obliterate this heterogeneity. Moreover, she showed that it's important because these microsite types actually support unique different plant communities and so their presence in some

ways contributes to diversity on these landscapes.

The mechanism underlying persistence appears to be the ability of these crusts to reform persistently following wildfires and in turn, she showed that that persistent crust reformation is linked to low organic matter in surface soils.

0:28:12 We've seen more consequences in site fertility. If we measure carbon and nitrogen in the sediment that's eroding offsite, we can see 20 grams of nitrogen per linear meter per day, hundreds of grams of carbon. These are large amounts of soil being redistributed in air compared to the amount of nutrients that are actually stored in the plants or the soil beneath the air. As you might expect, a site that's been burned and then heavily wind eroded has therefore less carbon and nitrogen in it, at least in the near surface, the top centimeter compared to unburned sites so about 26% less organic carbon, about 20% less total nitrogen.

This is important not only as these nutrients directly affect plants but organic carbon especially effects water retention, infiltration, availability of phosphorous and other nutrients. If you compare the nutritional content of soils that are captured from air where the soils are on the ground you can see a high enrichment. Wind erosion is clearly stripping out of the most nutrient-rich particles from these sites. When you look a little more closely at the eroded material and ask why, it turns out there's a lot of organic matter, both un-decomposed, partially decomposed to fulvic and humic acids that carried a lot of nutrients.

0:29:33 So to summarize, soil and nutrients have a low resistance to wind erosion on large fire sites in places like the Snake River Plain but surprisingly the native plant community can be resistant. What can we do as managers? Well, certainly we cannot pull down one of those large dust plumes that are occurring after a fire; however, pre-fire site management is clearly important.

I show that for example we know that cheatgrass for example affects fires, fuel breaks can be put in place to minimize the occurrence of large fires, the presence of sagebrush is lined to grazing, and furthermore a lot of times we drive vehicles out in to burned sites. Sometimes we drill seed or till soil or disk them. These sorts of activities are important.

0:30:26 For example, Mark Miller showed for the 360,000-acre Milford Flats Fire in Utah that there's a lot of connectivity between upwind site management and downwind erosion. Here's a Google Earth image where you can clearly see the streaking that's occurred over many miles. This burn site located within here is actually a patchwork at state BLM and other land management jurisdictions and all of this area apparently was heavily treated by discing or repeated drill seeding in hopes of preempting the weeds and increasing the desirable vegetation to stabilize the site.

The punch line from Mark Miller's work was that your ability to prick wind erosion space here requires that you know what's going on upwind of you. Also, the impact of these sorts of post fire activities on a given site also should take into account that they

impact the downwind conditions.

So there you have some causes, consequences and management implications and we ask that you hold off for questions until afterwards. So now I'm going to turn it over to Jason Williams.

0:31:45 **Eugénie MontBlanc:** Thank you Matt. Jason Williams is a hydrologist and support scientist with the USDA Agricultural Research Service, Northwest Watershed Research Center in Boise, Idaho. His work with Dr. Fred Pierson at NWRC investigates rangelands, hydrologic processes and hydrologic impacts of rangeland restoration practices and

0:32:10 **Jason Williams:** What I'll talk about today really is how fire impacts hydrologic processes in rangelands and I'll show some tangible examples of that from some fires on the Boise front near Boise, Idaho and then talk about some of the implications for altered fire regimes in the Great Basin.

I wanted to start first by just talking about some of the things that control hydrologic response on rangelands, those mainly being soil characteristics and the topography of the landscape and the vegetation. We know that soil texture, bulk density and the structure of the soil affects infiltration usually with course-textured soils and low-bulk densities and good soil structure promoting infiltration, and likewise for soil organic matter. But also soil organic matter aids in developing aggregate stability, strengthening the protection of the soil surface.

0:33:05 Surface rock is kind of an interesting variable to look at and once it can armor the surface and protect it and also when we see rocks laying on the surface we tend to see an increase in infiltration. However, rocks embedded in the soil matrix but still at the surface can promote runoff generation and actually increase runoff and erosion relative to just having them laying on the surface itself.

Then of course soil water repellency is a big driver of runoff generation on rangelands and we're seeing that it's wildly occurring on rangeland landscapes. Anywhere you have these organic litter mats forming underneath shrubs or underneath piñon or juniper trees, we'll see strong soil water repellency. It's not necessarily induced by fire and rangeland systems; it's commonly reported that way for forest systems but we do see it naturally occurring and persisting post fire. I'll talk more about it as we move forward.

0:34:06 Of course topography can influence runoff generation, particularly in the post fire environment; the steeper slopes and convergent terrain really producing more runoff in erosion than we would see from, say, toe slopes with gentle terrain.

Canopy and ground cover really are more dominant controls I would say than soil characteristics, in part because they control how much water is available for runoff generation but also they do influence soil properties that dictate infiltration. Interception and storage behind plant clumps delays runoff generation and actually

traps water and allows more time for infiltration but also acts to dissipate the energy of water moving across the surface and also of the raindrops as they move through the canopy.

Vegetation promotes low-bulk densities and formation of micropores and selectivity in the soil profile that increases infiltration.

0:35:04 Ironically, it's the organic material from the plants themselves that facilitate the development of soil water repellency so in the one sense, they're creating repellency that you think would increase runoff but by trapping the water and delaying runoff it allows water to move slowly through the water repellent layers, either for it to move through cracks or break through the water repellent layers at the surface.

So that's just a quick run through of what controls runoff generation on rangelands but now what I want to talk about is really how far it changes those things and then we'll move on to discussing some tangible examples. Primarily, what a fire is doing is removing the vegetation and changing the storage capacity of the system making more water available for runoff generation. I have here that it's exacerbating soil water repellency effects. Again, it's not necessarily that it's creating water repellency. In fact in most cases we see it to be the same or reduced by fire in shrub steppe systems. It's that you're basically removing the mitigating cover component and allowing the effects of water repellency to be brought forward.

0:36:17 So we have more water running off. It's typically moving down slope at a faster rate of speed or higher velocity due to decreased roughness and lack of flow dissipation, loss of a lot of the roughness elements, the water is moving faster and it has greater erosive energy and transport capacity and we start to see these formations of concentrated flow. You can see in this picture here these little micro channels that form. They're conduits for the water where they actually can entrain sediment and then transport sediment that splash into the flow past themselves. Then, all of these effects of course are amplified by higher rainfall intensities.

0:37:00 So in just contrasting the unburned system versus a burned system, we generally see decreasing runoff and erosion with increasing land area for the unburned condition and that's largely because runoff and erosion are dictated in this system by the rain splash process. Although the little patches of bare ground you might see between the shrubs or in the interspace areas there can be a lot of sediment generated there for rain splash. It generally just goes a short distance down slope and then it's deposited. It's just the rain splash is not a good transport mechanism for taking sediment long distances down slope.

Once the site is burned then you have an increase in the continuity of bare soil. We see a shift from rain splash to concentrated flow dominated processes and see concentrated flow passing the picture here to the right. Then what we see with this type of condition is runoff and erosion generally increased with increasing land area so the exact opposite of what we have with the well-vegetated site.

0:38:03 So in terms of looking at a tangible example of this, we can look at the 8th Street Fire that burned the Boise foothills in 1996. It burned about 6,000 hectares there in late August, basically removed almost all of the ground cover and reduced live canopy biomass and vegetation biomass by about 80%. With these uniformed conditions, we had a decrease surface roughness and exposure of strongly water repellent soils.

It was around this time that Fred Pierson here at ARS and Peter Robichaud at the Rocky Mountain Research Station began doing some rainfall simulations on burned rangelands and they went out and conducted some simulations in the unburned hill slopes and burned hill slopes from the 8th Street Fire.

What they saw was that runoff generation began in about two to four minutes and peaked within about 10 minutes from artificial rainfall simulation. Then we saw that infiltration rates were about 40% less in the burned area than for unburned hill slopes and erosion was really increased by burning; it increased two to 14-fold.

0:39:14 Shortly after the rainfall simulation worked, a natural storm came over the burned area and it rained about 67 millimeters per hour for approximately nine minutes and caused flooding to Northeast Boise in the residential areas there. When they went back and looked at the burned hill slopes there, it was really the south-facing hill slopes that were extensively burned but we saw formation of these concentrated flow paths or real networks and most of the flooding and erosion was attributed to the intensity of the storm, the reduced storage in surface protection, water repellent soils and of course the concentrated flow paths themselves.

0:39:52 So this was not something new for the foothills of Boise. There's a movie that chronicles the fire in the '50s. The movie is called The Pot Boiled Over. I think you could probably find it on the web, but basically the area burned and then there was a series of intent storms that came over the burned areas and produced similar events to what I just described for 1996. These pictures are clips from the movie so they're pretty blurry but basically the high intensity storm created these concentrated flow paths, these linear features you see here and they generated intense flooding and mud flows for residents of Boise. This has been a reoccurring thing for the Boise area.

So that's a lot to cover pretty quick and then we can kind of conceptualize it here in this model. On the Y axis of the model, we look at the runoff and erosion response and we can think of that as being your hydrologic vulnerability. It's really a function of the conditions on the site, the site's susceptibility, those things that we talked about that are the controls on hydrologic processes. So how much bare ground is there, what's the degree of surface roughness, the strength of water repellency all dictate how susceptible a site is, but the overall response of vulnerability is not only a function of that but also of the magnitude of the storm that supply it.

0:41:16 So you can actually have a pretty high site susceptibility but for a low-intensity storm, say, this blue here which might be the five-year event, hydrologic vulnerability is actually quite low. But for that same susceptibility, you're highly vulnerable to flooding and erosion from, say, something like to 50 to 100-year event. So it's just a

conceptual model or way to think about how we need to consider site susceptibility but also the magnitude of a particular storm event and then what might be at risk, be it just soil loss or some sort of resource damage versus property damage or potential loss of human life.

As we look at the model, there are other things that are incorporated here. For low-site susceptibility, this would be like a well-vegetated rangeland site. Typically, those are dominated by rain splash processes and then as you shift more to the right of the site susceptibility curve, we're moving more towards this concentrated flow of real erosion effects.

0:42:16 Just like that at a prescribed fire and its impacts on runoff and erosion, we can look at it in that same framework. This is a prescribed fire that was done in the Reynolds Creek Experimental Watershed. We went out and measured runoff and erosion from artificial rainfall simulations for the unburned hill slopes there and then also for the burned hill slopes immediately after fire one year and two years post fire.

Basically, you can see here that for uniformed conditions after the fire about 80% bare ground, we also had strongly water repellent soils on the site so we really were in this portion of the graph where we have really high site susceptibility and we applied a high intensity storm which would be equivalent to, say, a high hydrologic vulnerability. What we saw on our plots is they're really dominated by this concentrated flow process and resulted in about a thousand grams per square meter erosion.

0:43:13 So again, this 80% bare ground is plotting this high-site susceptibility, high hydrologic vulnerability portion of the curve dominated by concentrated flow processes.

We came back one year post fire and we can see that we've accumulated about 40% of ground cover and there was a shift from the dominant process from being essentially concentrated flow to being a combination of concentrated flow and rain splash and sheet flow processes and it was a significant reduction in the amount of erosion.

Two years post-fire, we had about 60% bare ground. This is a rain splash dominated type of system and erosion was pretty much back to pre-fire conditions.

We're commonly asked about hydrologic recovery and how long it takes for a site to recover and what does recovery entail. What we generally see is that fire effects are greater for erosion than runoff and they're more persistent for erosion than runoff. We can look at these two graphs here from one of our research sites.

0:44:15 The one on the left is a hydrograph showing runoff versus time. The black line is for runoff immediately post fire. The blue line is one year post fire. The green line is unburned conditions then of course this darker green line here is for two years post fire. But you can see there's a pretty big difference in the magnitude of runoff that we see from unburned versus burned conditions but it's an even greater difference if you look at sediment yield. Fire effects from sediment yield persisted beyond this immediate post fire period; there is still much greater erosion one year post fire than

from the unburned condition. We've seen this commonly across a number of our sites.

This lag in the sediment yield returning to pre-fire conditions really is because even though runoff is almost back to the pre-burned condition there are still some concentrated flow paths out there. We still saw them on our plots; they're just much fewer.

0:45:18 We commonly see that for our sites in the Great Basin or shrub sites once we get about 40% ground cover, we see a significant decrease in erosion. You can see from this graph here, this is just one site, bare ground was greater than 60%, there was an exponential increase in erosion. So it seems that in terms of hydrologic recovery where we're trying to achieve at least 40% ground cover on a site but I would suggest that that's just a relative recovery measure. Certainly 40% ground cover on the site one or two years after a fire is not the same as 40% ground cover on a site 15 to 20 years after fire. The depth of litter and soil structure might be different but it's at least a relative measure to look at in terms of trying to get a site back to, say, pre-fire conditions.

0:46:10 Then, I wanted to put in I guess a statement about cautioning assessing hydrologic vulnerability or fire effects from static measurements in time. Oftentimes what we've seen in a number of our sites is the annual variability is greater than fire effects.

If we focus for a minute just on the lines that you see here, these are infiltration curves versus time for a prescribed fire site in Reynolds Creek Experimental Watershed. These solid blue lines are infiltration for the burned site and then the dashed lines are for the unburned site. There is a fire effect here but if we look one year post fire you can see that there's really not much of a fire effect there but this difference in the infiltration from one year to the next is much greater than the fire effects. This particular case was associated with soil water repellency.

0:47:03 These blue bars are water drop penetration times which are indicators of the strength of soil water repellency and we see that for the first year of the study in burned and unburned conditions, the soils were strongly water repellent One year later, soil water repellency was greatly decreased and those effects are much greater than those of the fire.

So just briefly wanted to shift gears here and talk about some of the impacts of the altered fire regimes relative to hydrology. Matt even talked about this that fires are occurring more frequently in certain places in the Great Basin especially where we have cheatgrass invasion in the shrub steppe. Those systems would burn, say, every 10 to 100 plus years depending upon the site and the productivity of the site and now we're seeing return and it was on the order of, say, three to 10, maybe 15 years. Basically what's happening is that we're exposing sites, larger areas of the landscape are becoming highly susceptible and we're staying in that susceptible condition much more frequently than we were historically.

0:48:10 We can think about that in terms of this model that I presented a few moments ago. Historically we would have moved around in this site susceptibility axis here, staying

mostly in the hydrologic and stable portion of the curve where runoff and erosion is quite low and occasionally we would shift far to the right with fires maybe on the order of every 30, 50 or say 100 years. Well, now, we're spending much more time in this portion of the curve so we're losing soil from even these low-intensity storms but they're occurring very frequently and we're in this portion of the curve much more often than we historically have been so we can think about the soil loss being reoccurring at a greater rate than historically it ever did.

We're also highly exposed to flooding and events like we saw from the city of Boise much more frequently. In that case, we're looking at things at risk being property and human life.

0:49:10 So these are really concerning for places like Boise or cities in the intermountain west that are on the wildland urban interface where some of these plant transitions are occurring. It's not just really in the Great Basin. There are places in the desert southwest like Tucson or Phoenix that are down slope from areas that rarely burn and now have a whole different fuel structure that favors fire and these systems they're monsoonal storm driven hydrologic processes so these cities are very concerned about changes of this nature.

Then, back in the Great Basin we have changes like this going on with woodland encroachment where we're having the increase in fuel densities on the site and so rural communities adjacent to these woodlands are at risk.

0:49:58 Okay, so just to summarize really in terms of fire effects, what we're seeing with the removal of vegetation is the shift in the dominant hydrologic process from splash and sheet to concentrated flow, and these post-fire responses are generally dictated of course by the amount of cover that's there. But we've seen across a number of sites now, really the target is about 40% ground cover to try to gain some stability back to the site, at least from a low or moderate intensity storm and perhaps the lower end of high-intensity storms. These responses to fire are greater for erosion and take relatively three years for erosion or runoff to return to pre-fire levels but of course that's a bit determined by climate and what kind of productivity you have on the site after fire.

Again, I wanted to point out the annual variability oftentimes is greater than the effects of fire so when we go out to assess hydrologic recovery for a particular site we need to focus on that, just isolate it in time measurements but looking at repeated measurements.

0:51:03 I mentioned soil water repellency several times. This is something we know has a major effect on runoff generation even in the unburned condition for rangelands. It's highly variable in space and time. For one particular site, it may exist there one summer under very dry conditions even without fire so that an unburned site you could come back to that same site the next year under the same soil moisture conditions and soil water repellency may not be there at all. So it's a variable really we're trying to get

our arms around but we know has a strong influence on hydrologic processes.

Then, finally, this hydrologic evaluation we should really start to look at things in a probabilistic framework like the model that I talked about where we're looking at not just what are our conditions but what is the likelihood that these different types of storm intensities occurring? That will give us a better idea of what's at risk so we can start to make decisions on how to mitigate against those things.

With that, I'll take any questions that you have.

0:52:00 **Eugénie MontBlanc:** Okay, thank you Jason. Now we'll open the floor for questions and discussion. All of our presenters' mics are open so you can either type in a question or I thought maybe since there are 60 of you, I see your name, if you want to ask a person you can just put in person and I'll try to open your mic.

The first question is Dennis Donacaster. I hope I said your name right. It says is there any data comparing the erosion resistance between sites reclaimed. Well, I guess just answer those.

0:52:41 **Jason Williams:** Okay. Well, I guess I'll talk about the water first. I think there are some data sets like that but it's certainly something to think about. I know a lot of times we want to treat cheatgrass for instance or some other noxious weed on a site but really, in one sense, some cover is better than none in terms of protecting against water erosion so having some type of cover even if it's cheatgrass. If you're just strictly concerned about water erosion that would be better than having nothing on the site at all. Of course there's a risk of fire after that so there are some other ecological reasons why you might want to favor one particular plant community or another.

I realize the question isn't focused specifically on cheatgrass but my main point is having some cover there is certainly better than having nothing. I think we're just starting to learn about how different plant communities how they affect infiltration. We certainly know a lot about sagebrush and different grasslands but comparing them is something we're starting to get more into.

0:53:43 **Matt Germino:** Besides that, we've looked at for wind erosion and the upper Snake River Plain appear to be fairly well stabilized where there's little as 10% cover and it doesn't seem to matter much if that cover is cheatgrass, crested wheatgrass which is I think the most common nonnative that's used in restoration, or whether the vegetation is the native next that you might expect in a diverse sagebrush steppe community.

I know that there are several efforts right now to measure what we call backward ground wind erosion in sites that have not been disturbed. It's fairly difficult to get good data under those situations because there is so little wind erosion and so we run into issues with detection and it takes a lot of time to allow your sensors to see some wind erosion. To my knowledge, there are not many papers that address that question for wind erosion.

0:54:57 **Eugénie MontBlanc:** Okay, thank you. Are there any other questions? That was the only question written to us. Anyone have anything else? I'm not sure how long to wait. Mike, do you have any? Wait, I see another question. It's so weird this box is so little. Karen, okay, thank you. Karen Prentice asked how are you each measuring cover? Sorry about this.

0:55:42 **Matt Germino:** For the wind erosion projects, we tend to use a point intercept type of approach. We've done two different things. One is looking at points along the line or picking random locations along a transect to put a 36-point frame on the ground so we're actually looking at fully recover.

We've also used line intercept diffraction that canopy occupies along a line transect and that's for wind erosion for relatively low-lying grasses. So we focused on fully recover but basal cover is also very important for assessing vegetation impacts on erosion. So I wonder, Jason, if your group tends to look more at basal cover.

0:56:38 **Jason Williams:** Yes. We measure both usually through some sort of line transect method. We measure gaps as well. I think one of the things we've seen with gap measurement is it's also not only just important to know the gaps between plants but what's on the ground in the gap. For instance, you can have a big gap between plants but there could be litter there and so at least from a water erosion standpoint, it's a pretty protected gap. Yes, we typically use a line transect method and we measure basal cover as well as canopy cover there with pinpoints.

Matt Germino: For us, there's a real limitation to focusing on ground-based measurements of vegetation because the process of wind erosion is affected by huge ground areas. So actually, some of our biggest insights so far actually come from the remotely sensed type of data, for example, the LiDAR renditions of vegetation cover. Just like Jason stated, it's really the configuration of cover as much as the amount of cover that is most directly affecting erosion.

0:57:59 **Eugénie MontBlanc:** Okay, the next question is from Mary Colbert and it is how large are fires that are most likely affected by wind erosion?

Matt Germino: Well, it's funny. The first few sites that we instrumented were fires that were on the order of like a thousand or two acres, and we didn't see much erosion on those sites at all. The next largest fires that we observed were 10,000 acres or larger and those exhibit plenty of wind erosion.

0:58:37 Unfortunately, we have not either had the right kind of burn patterns or have not seized the opportunity to actually find the threshold of burn size but it's somewhere in between about a thousand and 10,000 acres. Certainly, this is going to vary based on the landscape surrounding the fire. If you are at a site, for example, between Burley and Massacre Rocks, Idaho on that high windy plain, a relatively smaller burn area might generate more dust than for example the same size area that's nestled in the Wood River Valley near Sun Valley or something. But in general, we know for sure that there is some sort of identifiable threshold burn size and that size is larger than

about a thousand acres we think.

0:59:41 **Eugénie MontBlanc:** Thanks. Next question from Dennis Doncaster, what about fire return interval with regards to erosion, are more erosive sites more likely to burn? I'm thinking that weeds might be more disturbance based and less more vulnerable to re-burn.

Matt Germino: For water or for wind or both?

Eugénie MontBlanc: I guess both.

Matt Germino: Well, for wind erosion there's not good empirical evidence to allow me to give a sure answer to that question so I'm just going to speculate a little bit. If a site loses a lot of organic matter as well as some nitrogen and so that in itself should begin to diminish the likelihood of shrub islands being present, maybe not so much after one fire but certainly after repeated fires.

1:00:54 I showed data that indicated that rangelands in relatively good shape that didn't have much cheatgrass and only burned one steppe, the interspace shrub island heterogeneity is persistent. That's an important pattern because those interspaces appear to be one of the microsites where the exotics particularly cheatgrass can take hold.

So one way to think about this is what would it take for a fire return interval and cheatgrass invasion to make more of the landscape having soils that are typical of interspaces. Certainly, I think a high frequency fire like burning four times in 20 years should certainly begin to have the effect of increasing the microsites that are more suited to cheatgrass than they are to the native vegetation. Therein, you could expect to see a positive feedback where the site continues to become more favorable for cheatgrass and you see more fires and so on.

1:02:06 **Eugénie MontBlanc:** Did you want to address that as well, Jason?

Jason Williams: Yes. I have pretty much the same thing that Matt is saying. I think as far as something like cheatgrass invasion and conversion of shrub steppe sites with cheatgrass, we really don’t know how that in and of itself changes infiltration, say, a site that used to be shrub steppe and now has been cheatgrass for 15 or 20 years and it's been burning more frequently. I think that's a question we'd really like to address in research. We don't know how that affects infiltration, erosion and things of that nature yet, at least not from a research perspective.

1:02:44 **Eugénie MontBlanc:** Great, thank you. Next question is from Todd Ellsworth. How do you look at debris mudflow mechanisms in the Great Basin systems? Do debris mudflows fit within your hydrologic vulnerability model?

Jason Williams: That's an interesting question. It's certainly not an area of research that I'm involved in or Fred that I work for here. So that model that I talked about is really more about hill slope processes but I think that you could use the same kind of

conceptual model if you knew how to populate those site susceptibility components that represent the X axis. So I don't know if that gives you a solid answer for your question but I'm certainly no expert on debris flows, at least to answer a lot of questions about those types of things.

1:03:41 **Eugénie MontBlanc:** Okay, thank you. Next question is for me from Todd again. Are you going to post the PowerPoints on your website? Yes. In this webinar, you can hit this recording button which I did and it should record the PowerPoints as well as our voices and that will be available on our website. However, I noticed when I first clicked it at the very beginning of this, it said they're having some problems so indeed if we have problems with the sound, the audio, then at least the PowerPoint presentations will be posted and they'll be up on the website hopefully before Thanksgiving.

Okay, next question from John McCann. Is there any evidence that temporary wind breaks could be installed in burned areas to prevent wind erosion while vegetation reestablishes? Would it be economically feasible over several thousand acres?

1:04:42 **Matt Germino:** I don’t think it would be economically feasible and furthermore, the impacts of putting the windbreaks up, the disturbance itself would be something to be concerned of. My general feeling is that once a site has burned, there's probably not a lot we can do in those precious few months, late summer and fall when the site is devoid of any vegetation and highly vulnerable to wind erosion. Probably just staying off the site is about all we can do; keeping vehicles off, etc.

1:05:25 I've contemplated the different things that could go on but really, the management of this problem requires a much longer term perspective. For example, when we're managing a site regularly like prescribing different grazing regimes or treatments of vegetation abundance or whatever, I think what we can do is think about how our treatments might render a site more or less vulnerable to massive soil loss following an erosion.

We can think about how each management unit is related to the landscape in terms of its erodibility like if we look up wind, do we see things that indicate we're more likely to get a fire and following that fire we're more likely to see a cascade of saltated particles come on to our site. That's where I think the management can make a difference.

1:06:24 **Eugénie MontBlanc:** Okay, thank you. Next question is from Mary Colbert. I'm not sure how to pronounce your last name. Having too much shrubs can increase the wind erosion which is something cows can impact based on land management.

Matt Germino: So what we found was that the supply rate of erodible sediment is not uniform across the landscapes after a fire. So if you're looking at charred environment there are microsite hotspots where we're more likely to see a lot more sediment be supplied to the wind to basically create a dust plume. Those microsites happen to be

from under shrubs.

So I was speculating that a site which has developed a high abundance of sagebrush like you see sometimes in areas that are lightly to moderately grazed over many decades to a century or so and then therefore they have a high abundance of sagebrush compared to herbs. Those sites might be ones where we could predict to see a greater loss of sediment compared to a site that has a lower abundance of shrubs. Does that answer the question though?

1:07:57 **Eugénie MontBlanc:** He will write back if it doesn't answer it. All the questions are in a queue, you can't respond to your own question so that makes it a little bit difficult. I'll move on to the next one for now from Cameron Boyce. Is chemical soil stabilization practical or warranted?

Matt Germino: Well, if Mike Pellant is still on the phone, we can ask him what the BLM thinks that's bringing things on to soils after wildfires. I'm partly jesting because we know that what you spray on to a site like for instance herbicide, if that site is vulnerable to wind erosion you might see that those chemicals are transported downwind and the impacts can be significant.

1:08:47 I don't know, I think there's some sort of chromate sorts of things that have been used to stabilize soils probably on relatively small areas. But what would you do over a 100,000 or 500,000-acre area? It might be practical to predict where the initial saltation events might occur. It might be practical to try to do some sort of airplane-based stabilization of those erosion starting zones and that might confer some nice benefits for stabilizing the downwind parts of the fire.

Again, I'm only speculating because I don't know if anybody has ever tested an experiment like this. Hopefully, we'll at least have good models in the next decade or so where we could simulate the potential benefit of that approach. I also don't know about the costs or the collateral impacts of the chemicals that could be used. Those are all important questions.

1:09:52 **Mike Pellant:** Matt, this is Mike Pellant. There have been some small-scale tests and I'm not sure exactly what type of chemicals that would kind of bind the soil surface and reduce erosion. I think the finding is that the results are mixed and they're done on very small plots which as you so aptly demonstrated in your presentation, the wind erosion is a bigger problem just from the larger landscape involved. So I don’t think a lot of work has been done other than some small plot work and those results were generally pretty variable.

Eugénie MontBlanc: Is that an area for further research?

Mike Pellant: Yes. My big concern would be just from a cost basis, cost benefit, would it prove out? I think we need to look at it more in-depth to justify not only if it works but what does it cost and can we afford to use it given the cost? So it definitely would be worth looking at but if we had the Murphy Complex Fire again, I think worth

well over half a million acres burned that would probably be not feasible.

1:11:15 **Eugénie MontBlanc:** Were you going to say something else, Matt?

Matt Germino: Mike, what kind of chemicals do they use, do you know?

Mike Pellant: I don't remember. This was some research that was done 10 or 15 years ago in Utah and I think it was done by ARS out of Logan, some work, but I'll dig back through. I have some old progress reports; I might be able to find that. If I can't find anything on that, we'll post it on our website.

Eugénie MontBlanc: Okay, thanks. Next question from Dennis Doncaster: how do you measure raindrop infiltration rates?

1:11:55 **Jason Williams:** Well, in general, what we do on our plots is we're applying artificial rainfall and we're measuring runoff from the plots. So it's basically assuming that everything else is either captured as an infiltration component. Obviously when there's vegetation there, there's a part of it that's intercepted but we know how much we apply and we know how much runs off and then everything else should be to interception and infiltration, but we really haven't done a good job of separating out the intersection component quite yet.

Eugénie MontBlanc: Okay, thanks. Next question from Lynn Danley. If I understood one of the grass correctly, soils were more water repellent in certain areas even without fire influence. Why would this be?

Jason Williams: Well, as I mentioned, we see that water repellency is commonly occurring on unburned soils as well as burned soils so it forms from the leaching of organic material into the soil and forms coating on the soil particles and it's, like I said, widely occurring even under unburned conditions.

1:13:07 **Eugénie MontBlanc:** So the difference would just be due to like the different plant matter that's in specific sites. Is that what you're saying?

Jason Williams: Yes. One site might be different from another just by the amount of organic material that's there. That could be a reason why one site is different from another. It's also highly variable in space for similar reasons. It's also dictated to some degree by the soil moisture content which can also vary in space in between sites.

Eugénie MontBlanc: Okay, great, thank you. Next question from Jason Spence. Are these research findings being incorporated into AGWA? I don't actually know what that is. Do you guys know what AGWA is?

Matt Germino: I don't.

Jason Williams: No, I don't either unless you're talking about AGWA perhaps.

Eugénie MontBlanc: Yes. What's that?

1:14:03 **Jason Williams:** So there's some modeling being done with ARS and some other folks that uses AGWA and I don’t personally know a lot about that model but I know that some of the results from hydrologic work will eventually be part of some components of AGWA but I don't know a lot of specific details about that.

Eugénie MontBlanc: Okay. All right, well, that looks like that's it for our questions. Mike, do you have any final thoughts or shall we sign off?

Mike Pellant: Well, just a quick thanks to Matt and Jason for coming in on this first webinar and again, just encourage those of you that are still on it to provide feedback both on the webinar and on future topics or future presenters and we'll try to keep up the one-a-month routine and do that as long as it's beneficial to everyone so thank you to everyone.

Eugénie MontBlanc: Great. Thank you. Yes, thank you everyone for joining and I will post these on our website this week. All right, thank you.