ROUGHLY EDITED TRANSCRIPT

SOIL CRUSTS SCIENCE FORUM
AUGUST 6, 2014
0900 MDT

Captioning Provided by:
Closed Caption Productions
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>> KATHIE LIBBY: Good morning, everyone.
Hi.
Welcome.
I'll introduce myself in a few minutes, but just I want to say bright and early this morning as a visitor to Kanab, Utah, I cannot tell you how envious I am.
That you live in this beautiful land.
So, but first, I would like to turn the microphone -- we actually have on telephone Cindy Staszak, who is the new Monument Manager here at the grand Escalante, and, Cindy, are you there?
>> CINDY STASZAK: Yes, I am.
Are you going to be able to hear me okay?
>> KATHIE LIBBY: Good.
All right.
>> CINDY STASZAK: Good morning, everyone, and welcome, welcome to this forum that we're hosting here.
My name is, as Kathie mentioned, Cindy Staszak, and I'm the incoming Grand Staircase-Escalante Monument Manager.
I'm calling in from Sacramento where I am working.
I report for duty in Kanab in about three weeks but I'm excited to be able to participate for part of the forum via the phone, and I'm excited that you all are there and those of you that are participating online as well.
I'm able to watch the LiveStream as I speak, not quite the same as being there, but definitely it helps.
I welcome all of you to the forum.
As many of you already know, Grand Staircase, and our cooperators, are in the process of

developing a monument management plan amendment and an EIS to address livestock grazing decisions on the lands administered by Grand Staircase-Escalante National Monument.
And the goal for that EIS and plan amendment is to find decisions that will enable sustained use of the land through improved land health and science-based grazing management.
And many of you probably have read the monument proclamation and you know it recognizes a long and dignified human history in a place where nature shapes human endeavors and ranching and livestock management remain at the core of the traditional uses of the region's public lands.
Many of you probably participated in the scoping process for the plan amendment and the EIS and you know that we heard often that biological soil crust is a concern and an issue that needs to be addressed in the EIS.
Biological soil crust is one of the objects specifically called out in the monument proclamation.
For some of us, including myself, one of the first questions that we asked was: what is biological soil crust?
Why is it important to southern Utah rangelands?
And more important, I think, why does the management and protection of -- how does the management and protection of biological soil crust play into the management of grazing on the monument?
I know for myself that I had only very basic scientific knowledge of what soil crust is from high school and college biology classes, and as far as management, how do you manage soil crust, my basic knowledge of that was from my backpacking and mountain biking days in southern Utah where it was "don't step on the soil crust" and "don't ride your bike on the soil crust."
So definitely realize we have a lot to learn about soil crust and management of soil crust.
So realizing that that knowledge is power and that as we work through this EIS we want to have as much science-based knowledge and information at our hands so we can make the best possible decisions in our EIS.
And with that in mind, monument managers and staff and the cooperators conceived of the idea to host this biological soil crust forum, and we have a couple of objectives we want to achieve with the forum: gain a better understanding of biological soil crusts and their role in the area ecosystems.
We want to share scientific information about biological soil crust on the monument.
We want to address specific questions about soil crusts and managing ecosystems in which soil crusts play a critical part.
And we want to gain information that will support management alternatives in the livestock grazing plan amendment and EIS.
And with that, I would like to thank everyone that's been instrumental in putting this soil crust forum together, and that includes our cooperators in the EIS process, Garfield and King Counties, state of Utah, National Park Service.
I would like to thank our panel members who took up their time and energy to share their knowledge and expertise on soil crusts with us, our BLM managers and staff that worked to pull this together, and it was quite the team effort.
We have folks from the Washington Office, State Office, our training center to help with the technology.
And, finally, I want to thank all of you that are participating today.

You're key to this process as we go through you'll see there will be times for questions and your questions and your interest will help get the answers we need to move forward.
So I'd like to thank you as well for being a part of this.
And with that, I would like to turn this back over to Kathie Libby, our facilitator, to talk us through introductions and the process for the day.
>> KATHIE LIBBY: Thank you very much, Cindy.
Thank you and welcome again.
I am Kathie Libby.
I am a member of the BLM community.
I am out of the Washington Office.
I wouldn't know by logic soil crust if I saw it, so I have no particular perspective on this issue.
But I think it's an interesting day, because as I've read some of the history, this has been a very long conversation, not just on the soil crust, but the whole conversation about what is allowable on the monument grounds.
Obviously very, very strong, committed feelings on the issue on many, many sides, and we respect all of those.
Unfortunately, the BLM is often in a position where it needs to make some determinations in the midst of conflicting perspective, conflicting understanding.
And what I find so interesting about today is today really is about information.
I often field things about things, but I don't really -- that I really don't know much about.
Are you losing me?
No.
And what's really interesting is the incredible interest in people who have differing opinions to actually come and hear some facts, and we often don't do that.
So we really, really welcome your interest, whether you are here with us in the room, whether you are live watching us LiveStreamed or on a webcam.
We just really, really appreciate the fact that we're here to gather some information.
And in that regard we have some folks with some information.
I'm going to read these names so I don't get them all botched up.
So starting on your right, this is Janis Boettinger, and she is professor of soils science at Utah State University.
She's a liaison at the national and Utah cooperative soils survey program, which includes the soils survey of the Grand Staircase-Escalante National Monument.
So very specific experience on these grounds.
Matt Bowker.
Sorry I have to move some paper out of the way.
Is an assistant professor at Northern Arizona university school of forestry.
And Dr. Janis Boettinger notice a B thing going on a professor at the college of agriculture and applied sciences.
And -- I have to get these people in the right order.
Dr. Tim Anderson is a forest ecologist.
[inaudible] and Dr. Fee Busby who is a professor at Utah State University at Quinney college of natural resources.
And I skipped Jayne, and you're right there on the list.

But there's something about Jayne.
She's first, last and always.
So you'll get to see that today.
Dr. Jayne Belnap is a research ecologist at the United States geologic survey at Canyonlands research station.
I'm going to invite each of you as you first get into your comments today to say a little bit more about yourself that applies to some of the information you're bringing.
Thank you all very much for being here.
So what we're going to do today, I believe everybody has an agenda.
There were agendas available.
Is that true?
Were there agendas available at the table?
There were not?
Okay.
I'm going to bore you with a little information.
Cindy went over our objectives, which are about sharing information and directing specific questions and really gaining information for the BLM and for the community of interested parties so that we know how to move forward in managing alternatives in the livestock grazing plan amendment EIS.
So we did a welcome.
What we're going to do is we have two major panel sessions today.
The first one is on: what do we know about biological soil crusts in our planning area?
And actually I think some of the ranching permittee guys were helpful in helping us talk not just scientifically about soil crusts, but soil crusts on the monument.
What are our issues?
What do we need to fix if anything?
What do we need to leave alone if anything?
So what are the issues here?
The panelists will discuss that and what we did, meaning BLM, is had a number of conversations with cooperating agencies, with the public, ranchers, with various interested parties and developed a set of questions under that general topic.
So in a lot of ways your interest, your focus, is already present in the way the questions are going to be addressed.
However, in this panel and in this second panel, as you listen, if you have additional very focused questions that you don't hear being addressed, we've invited you to take one of those cards that are in the back of the room, and we'll kind of maybe walk up and down the rows and offer them to you again, but take one of those cards and put the more specific piece you're not hearing and what we'll do is we'll theme those, meaning we'll take a look, if we get 12, there may be three different issues among those 12 questions, and we'll address those -- we'll have the panel address those issues specifically.
So that's the first one.
What do we know about biological soil crust in our planning area.
That will run from when I stop talking until noon.
At which point we will take a half-hour break.

So that's a quick lunch break.
And we will take a little bit of a break about 10:00, whenever it's natural, so that we can get up and move around a little bit.
At 12:30 we'll do the second panel.
It will run pretty much the same way.
There are questions that have been developed and you will be asked in addition to add your questions, and, by the way, if you're LiveStreaming or webcamming, there is an email address to which you can send your questions and we will treat those in the same way, we will theme those with those from the audience.
The second panel is: what are our options for management action?
So first we learn what is the situation of biological soil crust on the monument.
And then we talk about what are the options we have.
The panelists are going to share ideas on what could be done, not necessarily will be done, but what could be done, to preserve and restore biological soil crusts.
So are there things once disturbed we can do to fix something?
Or are there things that we can do that will reduce the disturbance?
And they have some basic facts, again, about that.
Again, we themed questions based on your input but we'll accept additional questions.
The last panel session, which we think will start about 2:30, is kind of: what else do we know?
What haven't we asked specifically in this session that we still have gaps in our understanding that we may to do some additional research on?
What doesn't show on the agenda but will be available is about 3:15 we will open up the mic for anybody in the room to address an issue, ask a specific question.
Okay?
So at that time the microphone will be available to you.
Up until that time your input will be pretty much filtered through others so that we -- we just think that's probably a more efficient way to handle the day.
And then about 4:00 we'll adjourn.
And we hope you're with us most of the day.
We know that that may not be possible for all of you.
Greatly appreciate your being here and we look forward to a productive session with you all.
So, shall we get started?
Let's do it.
The panel discussion one is: what do we know about biologic soil crusts in this planning area, and some of the subquestions are: where is biologic soil crust found?
And how much of the monument is involved.
So even before we get into lots of definitional stuff, what are we talking about.
I think, Matt, are you going to kick us off?
>> DR. BOWKER: Sure.
Can you hear me?
First, thank you for inviting me and all of us here.
It's really an exciting opportunity to come talk to you all today.
So where are biological soil crusts found?
A real quick version of an answer is almost everywhere on the monument.

You can find at least a little bit of crust.
There's really two big things that control where crusts are at the current time.
One is the disturbance history and the other one is habitat characteristics.
By habitat characteristics, I'm talking about properties of the soil and also the climate.
So on the disturbance thing, the most -- grazing may not be the most impactful of all the disturbances out there, but it is the disturbance affecting the most real estate, basically.
So the compressional forces of cow hooves are damaging the crust.
So in order to see crusts at their full potential, you need to go where the cows don't go, and these might be areas that currently aren't utilized for grazing or they may be places distant from water sources or just not used that much for various reasons.
With regards to the habitat quality, it's easier to talk about where crusts are not than where they are.
There are just a few soil types that crusts just seem to sort of take.
One is clay Badlands that are made out of clays that really swell up when they get wet and shrink down when they get dry.
There is another type of badland formed.
Crusts just don't really seem to grow there at all.
I have a map if you wouldn't mind.
It's the first slide.
There.
Nope.
Next one.
>> Can you turn down the lights?
I would like to add this is Matt's dissertation work.
He mapped the soil --
>> DR. BOWKER: I forgot I was supposed to talk about who I am a little bit.
Maybe we can pick that up later.
There it is.
So it's easiest to talk about where crusts aren't.
There's a couple soil types where you don't find a lot of crusts, and I'm going to try to talk loud --
>> Participant: [inaudible]
>> DR. BOWKER: Okay.
Let's try it this way.
You see all these yellow areas here?
First of all, we're looking at the potential cover of three different types of crust, and this is from some work done about 10 years ago, and we did to the best of our ability estimate how much crust could be on the landscape if you subtracted disturbance out of the equation.
And the yellow areas, these are areas with pretty low crust potential, and you'll see big patches here.
That's soils derived from [inaudible] see some pretty dry areas down here and you also see substantial areas down here.
These are those clay shales and there's a little bit more clay over here.
So there's some soils that just don't have crust.

As for where is the really, really high crust cover, the best possible habitat is on gypsum soils, and those aren't very widespread.
They are just little pockets here and there.
You see it especially in this map.
See that purple area?
Those are some gypsum soils.
And also limestone derived soils.
A pretty good crust habitat.
And you see that popping out here, buckskin mountain area and the monument.
Now, sort of in between, moderate habitat quality, are most of the soils, most of the sandy soils.
They do have some sort of medium level.
If you could advance just one more, please.
Here's one more map.
This just integrates those three before.
It's really just adding them together.
I was showing you three different kinds of crust, and this is a map of all three kinds, sort of at the same time.
And we consider these sort of the later successional, most functional elements of the crust, [inaudible] so -- once again the color is similar.
Yell colors are low cover, purple colors are high cover.
This is trying to estimate potential, what there could be.
>> KATHIE LIBBY: As we mentioned yesterday, if you want to chime in as somebody finishes theirs, that's fine.
How healthy is the crust cover that we're looking at?
And do we have any information on how its health compares to the last 50 or 100 years?
So how healthy is it now and how healthy has it been over time?
And maybe Matt can --
>> DR. BOWKER: I volunteer for some of the early questions.
That's why you're going to hear from me a lot.
First let me go back to introducing myself a little bit.
So I've been working on researching biological crusts for nearly 20 years now, going back to some research I did as an undergraduate at UNLV in Las Vegas.
I worked on desert moss back then.
And I had a stint working for Jayne for a while in the USGS and then I went to Northern Arizona university where I went to grad school and a sizable chunk of my dissertation work was conducted here at Grand Staircase.
So over those 20 years I've mostly been focusing on crusts.
I have other interests, too, but it's really crusts that I keep coming back to that's an endless well of fascination for me.
So regarding how healthy is the crust now and how does it compare to the last 50 or a hundred years?
I think it's really important up front to say that that's a hard question to answer, and it's virtually impossible to make the comparison back to 50 or 100 years ago because there is no

available data resource that tells us what crusts were like 50 or 100 years ago.
Okay?
So it would be possible for us to go out and see what crusts are like at this moment, we could go do that tomorrow if we wanted to, but then we couldn't compare to the past because there isn't that data.
Just not around.
Nobody has been watching crusts for that long.
We could do some guesswork.
100 years ago -- actually in the 1860s we know a lot of cattle were here, and that was back in the days before the Taylor Grazing Act and the cattle were really unregulated and most people believed that there was just a lot more cattle than there is now.
So we can guess the crust cover a hundred years ago was local and probably higher now.
50 years, I don't know if we have any basis to say.
In terms of how healthy they are, I think the comparisons you can make is not to the past but what is possible is to -- is comparing what is on the ground now to what could be there.
So what's the potential.
Okay?
So I showed you these series of maps that, like I said, was our best estimate of the potential that we could muster 10 years ago.
So we have that.
And if we were to have a data set from now across the monument or any other recent times we could make that comparison and see how sites are doing compared to their potential.
What this comparison doesn't tell you is how much crust is needed on the landscape in different ecosystems.
This comparison would only tell you how much is missing.
So I have one more slide on this, and I think I put them out of order, so if you would advance like three, please.
One more.
Okay.
So there is one pretty good data resource.
During the early to mid-2000s here in Grand Staircase Mark Miller led the collection of a rangeland health data set.
So they visited hundreds of plots around the monument, and they measured all kinds of indicators of rangeland health, and one of the things they did was collected some data on how abundant crusts were.
So there's a data -- a set of data with hundreds of points that estimate crust cover.
So some folks are working on this right now to compare this to those crust potential maps that I showed you, and that comparison is not complete.
So I can't really talk about it in detail, but I just had a quick look the other day, and I pulled out that crust cover data, and average across the whole monument and all these points, the crust cover that they saw averaged about 19%, and then if I go back to my maps, my maps of the potential crust cover, those come out to about 30% on average.
So you could think of that as across the whole landscape just a rough average, quick and dirty comparison, maybe one-third of the crust that could be on the landscape seems to be not

there, which may or may not be bad.
We don't have enough information to say that.
And another thing I noticed was that in this 2000 data set about one-third of the plots had no crust at all.
So it seems like there are a lot of places where the crusts have been highly degraded, but then again, there's enough places where the crusts aren't degraded that it pulls the average up reasonably close to potential so that it's almost one-third less.
So that's really all the data that I think is available to base this on.
Other than that, it's just going off of my personal experience and walking around other areas, and I find that this landscape is very heterogeneous in terms of its condition.
Lots of places have really great crusts and not a lot of erosion, and then I see other sort of hot spots that there's a problem and there needs to be a little more crust on the landscape.
>> KATHIE LIBBY: Okay.
I think Kim would like to get in and then Fee.
>> DR. ANDERSON: Just to follow up with what Matt had to say, I pretty much agree.
I think the crusts are getting a lot better.
You've got the variety of the [inaudible] bacteria, which is defined in the circle cliffs area.
You've got the pinnacled crusts.
Kitchen corral is a good example where you can find some of that.
So we have the whole range of crusts here.
I think everything -- it all looks healthy.
We've got everything, all the components that we need.
As Matt mentioned, the Taylor Grazing Act, that's kind of changed how management has occurred throughout the West and even here on the monument.
So I think even in the past 50 years with the change in grazing management I think that has helped to invigorate the soils here on the monument.
>> I just wanted to ask Matt a question.
Could you explain how you went from what you saw to how you estimated potential?
>> DR. BOWKER: Yes.
The way you do this, because most of the landscape is grazed fairly recently, so you would he can spec the crust cover to be a -- you would expect the crust cover to be a little compromised and not at potential.
So what you have to do is go to places that are in the least disturbed state that you can find.
And these might include isolated Mesa tops.
They might include areas really distant from water sources where cattle just aren't going.
They may include retired allotments.
And sometimes you have to get creative.
For example, highway 89 in between -- a little bit past Johnson Canyon up to close to the Cox Cone there is actually a 100-yard-wide road easement by the highway that's been fenced off since about 1960ish.
So it's long term released from grazing pressure and it's a really useful resource and it crosses a lot of natural gradients and soil types.
So what you have to do is go to a lot of places like this, measure how much crust is on the ground, and at the same time you've got to record key properties that you think are important

for crust habitat.
For example, what's soil type like?
What's the climate, et cetera.
Then you can use those predictors in a statistical model to sort of get the equation or what's the equation for good crust habitat.
Once you have that equation you can then map it over a landscape.
As long as you have maps of those predictors.
>> KATHIE LIBBY: Okay.
Before we move onto the next question, which Matt is also going to take the lead on, let me just remind you that, of course, again, that if you started to generate questions on your little note paper you can do one of these and someone will come and collect them.
Here's one over here.
And thank you.
The next question, Matt: what role do biological soil crusts play in the local area ecosystems?
Role they play in the local area ecosystem.
>> DR. BOWKER: Okay.
So I promise I'll be quiet for a while after this.
Crusts are -- they perform a lot of functions in local and Colorado plateau ecosystems and dry ecosystems around the world.
Probably the number one thing that most people talk about is their ability to stabilize soil against erosion, protect soil from erosion.
I'm not going to go too deep because I know Jayne is going to talk about this in a little bit, but a defining characteristic of crust is that they're a collection of organisms that live right on the top of the soil surface and they aggregate, hold together, that soil in a continuous horizontal layer, kind of like a skin on top of the earth, like a living skin, and because they hold that together, its protected against erosion.
Could you back up two slides, I think?
There.
There we go.
So here's an image of what I'm talking about.
Now, this isn't a very late successional crust.
This is very cryptic.
It's the same color as the soil underneath.
What's happened here is the people that took this photo, they've used a petri dish to kind of cookie cutter out of crust, and you can see this crust layer all holds together, and you see all these little strings here?
Those are actually cyanobacteria filaments.
Those are the crust elements.
They network together so it he holds its shape.
This is sort of the protective shield against erosion.
You can see what is under there in this case, just a pile of loose sand.
So the implications for erosion are pretty big.
Another thing that crusts are particularly good at is creating and maintaining soil fertility.
Most of the main crust organisms are photosynthetic, and that means that just like plants they

are drawing CO2 out of the atmosphere, building it into their bodies and then when they die there is organic matter going into the soil -- actually when they're alive, too.
[inaudible] it's a technical term.
So these organic residues have a long-term impact on soil fertility because they're charged and they hang on to charged nutrients.
Another mechanism is called nitrogen fixation, and this -- the best way to explain this is think of miracle grow, the number one ingredient in miracle grow is nitrogen, because nitrogen is the most limiting element for plants in most places in the world.
The problem on planet earth is that almost all the nitrogen is in the atmosphere.
We're breathing a 75% nitrogen atmosphere.
But that nitrogen is no good to plants.
It's the wrong form.
What they want is a different form, ammonium or nitrate, and it's a rare subset of biota that can grab that into and then through some magic turn it into a useful form.
Some of these organisms in habit crust.
Some of our cyanobacteria in crusts.
Also regarding fertility, they attract dust.
Dust is important because dust comes in with a lot of nutrients clinging to it.
So anything that holds that dust in place is going to be adding fertility.
Last one I'm going to talk about is hydrology.
Crusts influence where water goes on the landscape.
So when rain is falling and that rain hits the soil surface, there's two basic states.
Either it's going to soak in or it's not going to soak in and it's going to start to run off the surface.
And crust influence this.
They do different things in different places.
But generally most of the studies conducted on the Colorado plateau suggest that crusts help capture that water in ecosystems like these where you have very pinnacle, very bumpy crusts.
I really want to show you a video just so you can see the effect of certain organisms is.
So I think the next slide -- sorry.
This one.
So crusts have mosses growing in them, and if she clicks that "play" button you're going to see what happens when water starts falling on dry moss.
They just soak that up.
This is real time.
They spring into action.
They're soaking up probably 10 times their dry weight in water, and that happens in a matter of seconds.
So certain types of crusts are really good at grabbing the water.
And the last major role is the influence that crusts -- interactions crusts have with [indiscernible] but that's linked to the next question.
So I'm just going to punt on that one.
>> KATHIE LIBBY: Kim, did you --
>> DR. ANDERSON: I have a question.

Would you bring up Slide 4?
While you're doing that, my educational background, I have a Ph.D. in lichenology.
So a lot of things I'll talk to deal with lichen.
I've collected lichens in soil crusts in Arizona, Colorado, Utah, New Mexico, Baja, California.
So I've been able to -- especially Baja.
Real interesting.
Some real interesting things down there.
On nitrogen fixing, I always struggled with that, tried to understand that.
Based on the lichen collections that you made in 2001, 2002, I came up with eight species that fix nitrogen.
Could you go to slide 5?
This is the plant list put together when collecting the [indiscernible] on the monument.
They collected, I counted, about 45 vascular plants that fix nitrogen.
Is there any difference -- you know, vascular plants, you've got a number of the legumes.
They die during the wintertime, drop their leaves.
That adds nitrogen to the soil.
Cliff Rose, things -- they'll do that.
Even as the whole plant dies you have the root system.
Is there any difference in the Nitrogren those plants fix and the nitrogen the lichens with cyanobacteria fix?
>> DR. BOWKER: So the -- there is no difference between the nitrogen.
But I would point out that you're giving the impression there's very little lichen nitrogen fixation because there's only a few species but actually these are really common species in undisturbed landscapes and also there's cyanobacteria.
All the dark crust you see have a covering of nitrogen fixing bacteria.
So when they attain their true cover they have the potential to fix quite a bit of nitrogen.
But there's no difference in the nitrogen itself.
The nitrogen -- they turn it into NH4 or NO3.
Jayne?
>> DR. BELNAP: I just wanted to add there is no difference in the nitrogen form, but to me the difference is when the crust is at its higher potential, basically you have a continuous carpet of nitrogen of fixation because of the cyanobacteria.
Not that lichen is anywhere near as much as the [indiscernible] free living in the soil and that's the dominant cyanobacteria.
So instead of having a patch -- the plants are occurring as the units here and one over here and one over here.
Instead what you've got is this continuous carpet going across the landscape.
That to me is the big difference, that it's -- and so it really depends on that plant distribution when you asked the quantity, I can't tell you because it's going to depend on the distribution of those plants.
>> DR. ANDERSON: And [inaudible] in areas overgrazed where you've disturbed the soil you've still got these other plants, but because they're dying --
>> DR. BELNAP: And -- and definitely should not discount them.
My only process that I think about that I really would love someone to do their dissertation on

is to look at the spatial distribution of the nitrogen input and what does that mean?
You know, is it just right here?
Does that get to Joe plant over here or does it just stay right here?
We don't know that.
So I would love someone to follow up on that.
[inaudible] absolutely.
>> DR. BUSBY: We've talked a little about the distribution of the lichens.
You have to look at the distribution of these vascular plants, the forbs and shrubs that are listed here, and as you look at a list like this, you basically start seeing that the likely occurrence of more and more of those plants are going to be at the higher precipitation zones and the higher elevations because that's what drives precipitation.
As you get into the arid salt desert shrub or more arid semi desert sagebrush, it's not a rich nitrogen-fixing flora and so the system is tilted towards higher precipitation, more nitrogen from these plants, as well as possibly the biological crust.
Those semidesert sites in particular, low sagebrush, sagebrush areas are not covered well in this area.
I don't know what the rest of the 45 looks like.
My experience has been that the presence of nitrogen fixers in the semiarid country is lower, which is a problem.
>> KATHIE LIBBY: So I would like to get the room in here.
>> Participant: [inaudible]
>> I'm trying to put together things Matt started out with and this last conversation where climate is important here.
The higher amount of atmosphere precipitation you have with rain, snow or some combination, the greater potential for spatial cover by higher plants like we have here.
The drier the environment, the more space potentially there is going to be between the plants.
If you have plants that are capable of fixing carbon, all are, and some of those which are capable of fixing biologically available nitrogen, and you have them in fewer places on the landscape, what is going to feed the ecosystem in between.
It's that biological soil crust that is bringing in that primary carbon as organic carbon into the soil and the nitrogen.
So it's kind of a trade-off if you think about wetter environment, greater cover on the surface of higher plants, greater potential of carbon and nitrogen.
As the climate gets drier, the potential from the higher plants becomes less in terms of nutrient input into the soil and we rely more on that soil cover of those cyanobacteria, the dark cyanobacteria that can fix nitrogen as well as carbon and then the lichens and moss fixing carbon and nitrogen.
>> KATHIE LIBBY: Thank you.
That was very helpful.
I would like to get some questions from the room.
And also I think it helps the panel understand what people are looking for and thinking about.
Here's a couple, most for Matt, but not all.
And real good expressions of the fact people are listening: when you indicate crust with about 19%, do you mean on average 19% of the ground was covered by crust or do you mean about

19% of the points there with some crust?
>> DR. BOWKER: That's a great question.
I mean that averaged across all those points 19% of the ground was crust.
About 70% of the points had more than zero crust and about 30% of the points had zero crust.
>> KATHIE LIBBY: And I'm going to go onto Kim.
Kim, you indicated crusts are getting a lot better.
What quantitative data indicates it's getting better and from what point in time?
>> DR. ANDERSON: Just looking at the mix that we have across the monument.
I do have one study where I measured the soil crust, and I -- like 36% soil crust on that site in an area that has had some historic grazing in there.
Most of it is just based on observation as I wandered around.
I've seen areas that just aren't covered with the [indiscernible] soil, and like I said, just -- in fact we'll probably get into this this afternoon.
I have some other slides that we can look at and I can explain some of that.
>> KATHIE LIBBY: Good.
Some of these will float into the afternoon.
But thank you for that.
Back to Matt.
Matt, you said about a third of rangeland sites are missing crusts.
Are they particularly vulnerable veg types where this is occurring?
>> DR. BOWKER: That's another great question and I don't know the answer yet.
I haven't really gotten my teeth into that data set yet.
>> KATHIE LIBBY: Okay.
So more to come and maybe that will be part of session 3, what else do we need to know.
Historic data, last one for this session, be more specific about the number of cattle that occupied the -- this National Monument in the past compared to today.
My understanding is that historical livestock grazing use was more sheep than cattle.
Does that make a difference in impact to crusts?
Anyone else who wants to answer.
>> I think someone else might be better qualified.
>> First thing is we don't know because nobody was here counting.
We just know these landscapes around 1858, into the '80s, actually into 1890s, when there was a huge die-off, had tremendous numbers but nobody knew.
That's just this word tremendous.
So you can take it or leave it.
And there was a lot more sheep on at that point in the state of Utah but as far as down here in the corner of Utah, I don't know that either because sheep traditionally have been certainly and heavily utilized in the higher country, so I don't know about down here in the lower country.
And I don't know that anybody knows.
As far as the dropping back there was that huge die-off at the end of the century that the numbers really never came back that from.
Secondly was the Taylor Grazing Act, which then started to establish BLM and other people to get out there and really look at these landscapes and start to manage them.

So the answer is nobody really knows.
>> KATHIE LIBBY: Fee?
>> DR. BUSBY: Wow, wake me up!
I don't know the numbers, but it's my understanding, and some of you in here -- Bill Hopkins was here in the 1890s -- sheep are typically herded in large flocks, and that basically means that you're moving a large number of hooves across wherever they are at one time, and all of those hooves then are trampling and turning up the crust.
So I can imagine a very large sheep herd moving through some of this country as being pretty tough on the crust, and we've all talked about the way they were managed with one herd following another, and you can count the herds on the mountain with the number of dust clouds, flocks on the mountain with the number of clouds.
I imagine that was tough times on biological soil crusts.
We know it was hard times on the shrubs and forbs.
We know the result was floods coming offer the mountains.
That's what created the Forest Service, basically, to get some control on the high mountain ranges.
Cattle, on the other hand, don't tend to herd, unless you're moving them from one pasture to another.
Cattle tend to spread out.
And certainly where they go, everywhere there is a hoof there is probably going to be [indiscernible] but I don't think it's as uniform as a band of 3,000 sheep moving across the landscape.
Again, I don't know the numbers, but I know they were larger than they are today.
Total animal unit harvested off range is quite a bit larger than it was now when you put the sheep and cattle together that were here and across the rest of the state.
But think about the management of the two kinds of animal.
They're very different.
Herding versus open grazing, and that's a very different impact on the land.
>> DR. ANDERSON: [inaudible]
What effect did that have on how things are today just beyond the livestock?
But a historic [inaudible] culture here.
>> [inaudible]
>> KATHIE LIBBY: I think we're going to move onto the next question.
If you did not hear your question asked and you had already submitted it, it's because we made a judgment that it would work better in the next panel.
So we're not ignoring you.
And thank you.
Those were very good questions, as the panel has said.
We will probably take a break about 10:20, 10:30, depending on Jayne.
I didn't ask exactly what this session would take.
In that just know if you're going to speak for two hours, just know somewhere in between there's a break.
And with that, Jayne has been doing some emerging studies in China and it's going to help us with the question: what's the relationship between biological soil crust cover and healthy grass

and forb cover.
>> DR. BELNAP: And I am actually going to merge that in the next question because very much are the same question.
I've been studying soil crust since I was born, I think.
It sure seems that long.
And every aspect of it has been of interest to me at one point or another in my career.
I did my Ph.D. add Brigham young universe because it was the [indiscernible] and Larry Sinclair.
And other people -- I mean, it really was the place to go.
So that's why I went there, is it was the Mecca for soil crusts.
Anyway, the relationship between plants and soil crust is always a topic that is of interest and concern, and I've spent -- I did a large review on this topic not many years ago because it's something that always people are asking about.
For us here in this ecosystem of the Colorado plateau, we have no experimental evidence of soil crust having any negative influence on the germination or establishment of any species that has been tested.
Now, notice that I qualified that statement with "any species that have been tested."
We have seen some real advantage in terms of nutrient content of the plants growing in the crust.
So once a plant gets established, then the crust fixes nitrogen and they have a lot of carbon and so almost across the board have almost higher nitrogen content in their leaves, which makes perfect sense.
That said, there's a whole bunch of species that have not been tested, and so it's something that people go back and forth about, but we have done a lot of the forage grasses and there has not been any effect on any of the forage grasses that have been detected.
There's not been any -- what has been very negatively impacted is cheatgrass, and we see that over and over again.
There's been multiple studies on this, and every single one comes out with the same answer, that they inhabit germination and establishment of cheatgrass.
The problem, though, is if you then break them up, don't forget, you now have a nitrogen-rich soil because of the -- so if you break them up and the cheatgrass gets germinated, then it takes off.
It's even happier.
So it's kind of a double-edged sword when it comes to cheatgrass.
So when the question comes up what is that relationship between healthy plants and the crust, we know that once the plant is established that there is both higher nitrogen content, so it's more nutritious for the wildlife and the cattle, or sheep if there are sheep there, normally not, and that they -- there is no evidence that it's competing with the forage, but that instead they fill in the interspace between the plants rather than the plants somehow struggling to get in there.
And the one thing that I would invite you to do is go out and get on your hands and knees and look, and basically what you'll find is the soil crust is not this continuous mat of mosses or lichens or whatever.
What it is is it's the surface that's got cracks everywhere it.
So all it takes is a little bit of wind or water to wash seeds into those cracks, which makes

perfect sense about why it's not inhibiting the vascular plants that have been tested because, indeed, what you will see, if you experimentally put seeds out, they are being washed or blown into these cracks and they're germinating down in these cracks and you'll see this line of plants being established, little seedlings coming up out of these cracks, and the cracks -- I'm talking on a scale of inches.
So it's not across the large landscape that you have to look for a single crack.
And so we really don't have evidence of anything negative.
The only study I ever ran across was somebody took a moss clump and put the seeds under it and put the moss back on top and they didn't germinate.
I'm like, okay, I don't think that's quite fair.
And so that's the answer I have.
What I don't want to say if that it never inhibits germination of vascular plants because there's plenty of species we haven't tried, but for the ones we've tried and we've tried all the major forage grasses, I can say the answer is, no, it doesn't.
But we do have -- and I should add the thing about cheatgrass.
We found the same thing in Australia, Israel and the Mojave.
So this has been tested -- and in the Colorado plateau and up in Boise.
So what this one is pretty solid.
What we're thinking is the cheatgrass seed is so big, and it needs so much watt in order to germinate, it has a hard time getting down into the cracks sufficiently that it maintains enough water to germinate.
So that's the answer to the next two questions I have.
>> DR. ANDERSON: I have a question.
Bring up slide number 7, please.
This is a site, there's a lot of annual species -- if you could go to the next slide, please.
There's also a lot of annuals -- in both slides the annuals included cheatgrass.
Notice this one all that cactus coming in here -- so you've got a lot of cactus coming into these sites.
Like I said, there's -- on the previous slide there's a lot of annuals, including cheatgrass.
This site has never been grazed.
This is on top of no man's Mesa.
Help me understand this --
>> DR. BELNAP: Sure.
Well, one, is we have another site that's never been grazed in Canyonlands National Park and it's full of cactus.
So this idea that cactus only increases the -- [inaudible]
>> DR. ANDERSON: I don't either.
>> DR. BELNAP: And I'm not saying cheatgrass cannot get in ever, because we also had [inaudible] invasion is luckily contained to a certain soil type that it can actually get into, and it's interesting because this has been 20 years now, and there's not a blade outside of this one soil type.
But what happened for us was that we had a year in which we had rain happening every single week for like six weeks in a row.
So the cheatgrass didn't need to be down in the soil.

It was wet the whole time.
And so it didn't matter.
Then it gives up.
Because once that thing germinates you have nitrogen fixing everything and it's a very happy plant.
There are plenty of places, though, where I think what it is is just a mechanical barrier.
I don't think there's anything magic about the crust or [indiscernible] or anything like that.
They just keep those seeds from getting in and germinating.
But that doesn't mean climate can't overcome that.
It doesn't mean there's not a special place where it's cracked an then it can get in.
So by no means am I saying it's the magic bullet.
There are no magic bullets.
I discovered that in my life.
They don't exist.
>> DR. ANDERSON: There was a study done by [indiscernible] and I may touch on that later that indicates that cheatgrass will actually take advantage of the nitrogen.
So --
>> DR. BELNAP: Absolutely.
That's what I'm saying.
That's what I'm saying.
If you just -- you have some sort of climate thing, you have a nitrogen-rich soil.
So absolutely.
It's going to then be happier.
But that's going to be true anywhere.
So that's one of the reasons that you find more cheatgrass underneath shrubs, because shrubs have higher nitrogen on the ground because all the leaves drop.
That's the reason it's there.
It's an annual plant.
Annual plants like -- well, if you think about an annual plant, they have to do their whole life cycle in one year.
They can't mess around.
They can't be like a perennial.
They can't hunker down and wait for a good year.
They have to have a year in which they get sufficient water, sufficient nutrients to go.
So they're always going to be after slightly more fertile sites.
Which is why in our grassland that got invaded it's only in one site that has more fertility and water holding capacity.
And it can't get out because [indiscernible].
>> DR. ANDERSON: Could you hit one more slide for me, please?
Number 9.
Go back one.
All right.
I don't understand when we get to sites like this and there's nothing in there.
We have some shrubs.

We don't have any forbs or grasses.
>> DR. BELNAP: So I did a big experiment on exactly this setting because I had the same question.
I'm like, what in the world is going on?
So I went into Canyonlands National Park, and for some incredible reason they let me trample the place in a nicely blocked design where we went in and -- and said if I get rid of those soil [indiscernible] will I get anything else?
We did this in three separate places.
And the answer was no.
I think what's happening here, these soils -- plants can, especially perennial plants, can only grow where there is sufficient nutrients.
We have areas where it's not.
It's not that these guys are necessarily keeping stuff out but they are coming in because there's nothing there.
Those experiments are 15 years old now.
We haven't got a single thing coming in except for some cheatgrass.
One thing I should add is that never grazed grassland I'm talking about got invaded in 1996, but the surrounding landscapes had been invaded for almost 50, 60, 70 years and I mean heavily invaded.
So that area had actually kept out cheatgrass for a long time before that kind of [inaudible] climate came along.
>> This picture illustrates why we changed [indiscernible] the issue to me and several others that have been on lots of these kind of places is the competition of the root system of those perennial plants underneath that blanket, that utilize the resources, every one of us that's done a lot of range work has been out a pinyon juniper site where there was actually nothing underneath.
Maybe a few sagebrush like you have here.
But you also see a dead one on the left-hand side of that.
Oftentimes the sagebrush are weak.
These are sites we chained because we couldn't figure out how to get any forage under those juniper.
So I think Janis -- I think Jayne is correct that the juniper and other perennial, woody plants in this system are usurping the [indiscernible] nutrient from the depth that perennial grasses would have used but not from the shallow soil that the biotic crust used.
So you basically come in there.
And if you had water in the soil, you kill trees around that and you provided a seed source, and they could -- the -- the plants would grow.
>> This is a site where I would not recommend chaining.
The soils are very, very shallow.
Now, look at the rock outcrop right there and there.
>> DR. BUSBY: I didn't say we should chain them.
I said this is the kind of site we did chain because we wanted forbs.
>> And this is the kind of site where we come back in we see the pinyon and juniper comes back in because the soil is so shallow to begin with.

So this is an area where in between those higher plants, and those plants are likely rooted -- the pinyon juniper in this case, some of the sagebrush, and other shrubs, are probably rooted in cracks in the underlying bedrock, but the area in between is so shallow, what it supports well is a biological soil crust cover and not perennial grasses or other forage.
>> DR. BELNAP: And I would add those plants can't put their roots down in the cracks.
Grasses have fibrous roots.
They can only pump water for so far and they can't go down through cracks.
So they have to have sufficient volume on the surface where they can utilize -- get enough water and nutrients.
That's something that shallow there aren't enough water and nutrients for them to make a living.
You have to be something that can send your roots down through cracks.
>> DR. ANDERSON: With the shrubs, I guess the lichens -- why do you have so many dead shrubs?
And the next slide --
>> They're not holding all that water.
They're just keeping it from running off and it infiltrates down.
>> DR. ANDERSON: [inaudible]
>> But they're down, too.
They can go through fractured bedrock.
So those guys can make a living and mainly nobody else can because there's not enough -- I don't know how deep that soil is but we see that all the time in pothole gardens.
There's nothing in there because the soils are only that deep or there might be a few shrubs on the outside and going down through cracks in the bottom. So there's just not enough there.
>> DR. BUSBY: [inaudible] that soil is probably only like 20, 30 centimeters deep judging from that exposed bedrock.
I would ask would there not be soil without that crust?
I wonder if we would see a lot more connectivity.
>> DR. ANDERSON: Go one more.
>> DR. BELNAP: You're answering my next question.
I won't have to do it.
>> DR. ANDERSON: Now you have a bunch of dead sagebrush in here.
I know in this -- the soils every deeper in this site.
This is up around five Mile, the substation area up there.
We have nothing.
>> DR. BELNAP: Well --
>> DR. ANDERSON: Half that site is dead sagebrush.
>> DR. BELNAP: I have a lot of answers for this because I can't believe the soil crust is doing anything to speak of in terms of sagebrush dying or nothing coming back in.
I have so many [inaudible] outside of Canyonlands I think I have been to every two years for the last 35 years on tours trying to figure out why the sagebrush is dying in deep basin.
Everyone stands around and kicks it, and it's everything from plant pathogens to soil drainage.
It's just unbelievable.
I giggle yet every time there is another field trip to deep basin.

There is a million reasons that this could be, and Janis, you've been at deep basin, too, and all these discussions of all the reasons sage may be dying or not, but it's -- you know, it can be a soil thing.
My personal opinion about, since I have never been here, about deep basin, is that these sagebrush were established in the wet period, it's been dry and they're dying off [inaudible] and so everybody is just kind of hanging out.
So I can't tell you, but I -- it's a complex question on the sagebrush.
It's like very complex.
>> KATHIE LIBBY: Before we get any more complex, we have a couple of questions.
Help me, are we moving now into the question on disturbance or do we still have the question -- I heard Jayne at one point say that covered the next two questions.
>> DR. BELNAP: No, no, not the next two.
I touched on [inaudible]
>> KATHIE LIBBY: I guess my question is, have we covered the area of biological soil crust competing with wildlife forage?
>> DR. BELNAP: Yes.
>> KATHIE LIBBY: We actually are receiving questions both from the room and on the Internet on disturbance.
I think they are more disturbance related.
So we would like to move into that conversation.
However, I would also like to invite you to take a 10-minute break if you think that would be useful.
>> Would that be useful?
>> KATHIE LIBBY: Okay.
I'm more concerned about my panelists.
You guys can get up and take a comfort break.
Let's go ahead.
Literally, though, 10 minutes.
Okay?
And we're back on it.
Thank you.
[10 minute recess]
>> KATHIE LIBBY: Okay, everybody.
That was 10 going on 12.
We are going to reconvene.
Okay, everybody.
Welcome back.
We cull back and thank you.
So we have -- we have about an hour and a half before lunch, and I will say the library has indicated that we all have taken up all of their parking spaces, and if someone wants to come take a book they don't have a place to park.
So we will ask you at lunch if you would consider moving your car either -- actually if you swing around there's a section of parking over here across the street.
At the hospital?

I don't know.
But on the street, maybe.
If you could help the library with that a little bit, that would be lovely.
Go to the hospital.
Fee, I know you want to say something, and I'm going to let you do that.
A couple quick things, though, when you speak, would you please make sure you really are speaking into the microphone.
We're having a little time catching you, Kim -- you're all fine in the room but not necessarily online.
So let's be conscious of that.
Before I let you speak I'm going to throw out two questions that are related to the last conversation.
You don't have to you a dress them directly but we should.
One is, do I understand correctly the biological soil crusts are a shield to cheatgrass establishment but do not impair other grasses from establishing?
So that's one.
That's a "yes" or "no."
You can feel free.
>> DR. BELNAP: It's yes and no.
As I said yes until the crust gets broken up or yes until you have a series of climatic events because it's just a mechanical barrier.
So if the cheatgrass can overcome that through some way by staying moist because it rains all the time, you know -- but, again, it's got to be on the right soil type.
It can't be just anywhere.
So it's really a yes and a no.
[inaudible]
>> -- versus the size much a lot of our other grass -- they're much smaller.
>> And a lot of our seeds have self-drilling mechanisms or they're cached by rodents.
>> KATHIE LIBBY: Is the prominent value of biological soil crusts a successional phase to allow the system to move toward a perennial plant community?
>> DR. BUSBY: I'll start and then I'll let somebody that actually knows something speak.
I came to Utah in 1970 from west Texas, and I did my Ph.D. work at maverick point near -- south of blanding on chained pinyon juniper sites and I never encountered biological soil crust before, and I saw these pinyon juniper stands that had not been chained, but I saw these pinyon juniper stands that were covered in crust very similar to the picture that Kim had earlier, and I basically came to the conclusion that that was, in fact -- because I grew up in the [indiscernible] era where succession goes and you have these -- you have these beautiful mixed species of communities and retrogression is where you go to a single few species communities and maybe they'll go back and forth and maybe they won't, and my experience was with mesquite, which didn't.
So here I am in pinyon juniper stand and basically two species, every now and then a sagebrush plant and maybe a [indiscernible] squirrel tail or [indiscernible] scattered here and there.
And all this crust.

And so I say to myself, early succession.
This is the early successional species and these trees die, reach their age and die, and this process will work its way out and these will be replaced by these wonderful other plants, and over time I came to realize on both sides, with 800-year-old trees, that was the end of succession, was the juniper pinyon [indiscernible] and that the crust were not early successional.
The crust went along with the late successional of trees.
That was my own discovery of how this stuff works.
After that I learned a little bit more, but that's how I came [inaudible] this is just part of the system.
>> [inaudible] because the crusts are going along their successional phase.
They're going from really low biomass to cyanobacteria and they accumulate more and more and stabilize so the likens and mosses can come in.
They're doing this thing over here and the plants are doing their thing.
I'm not sure they're totally linked but they're certainly interacting all the time.
So I'm not quite sure how to grasp that in my mind and say that, first you have this crust come along and then you have the plants come in.
No.
There is certainly interaction, but they're also kind of doing why their own thing at the same time that I have observed.
>> DR. ANDERSON: That's kind of my observation, is that -- like this photo here, there's a lot of lichens mixed among that soil, and I would say this soil here is late successional.
So you start off with the light cyano.
They get things stabilized.
And you can build up from there.
So within the crust --
>> DR. BELNAP: But I do think it's that initial stabilization is important for everybody, because if the soils are moving, then the seeds are going to be washing away, you're going to have scouring of plant tissue when the sand is blowing.
So there is that sort of initial stabilization that can definitely help the rest of the community go.
>> KATHIE LIBBY: We want to move into our disturbance questions, but, Fee and Jayne, did you have something else you wanted to say?
>> DR. BUSBY: Sara came up and said that one of the questions the ranchers asked before was you have these pinyon juniper stands, as Kim had a slide of them a moment ago, and you have just a solid cover of lichen underneath them, and nothing else, for all practical purposes, and we got into this discussion about that shallow soil from the picture, and juniper and pinyon trees do put down roots in the cracks, but if any of you have ever gone to an area that had a slight bit -- had erosion so that you're beginning to have gully cutting between trees coming down the hill slopes, you basically see those roots crossing from this tree through the gully to the other side.
You see the roots from this tree crossing the gully to the other side.
If any of you have done any digging out there, you know you almost a network of pinyon juniper six to eight inches, six to 12 inches underneath that soil and they are competing with anything else that might grow there to basically making it a more arid [indiscernible] as a result

of the trees using water for [indiscernible] so with that loss of water in that interspace between the trees there is no deepwater support for the perennial grasses or forbs or shrubs.
That's why on lots of sites you'll see sagebrush slowly, slowly -- last thing to go will be a sagebrush plant.
You'll see them slowly, slowly weaken until you have just a handful of old scrubby sagebrush scattered here and there and virtually not much else.
It's that competition underneath the soil, six to 12 inches deep that from juniper pinyon root system.
>> DR. BELNAP: So my comment was based on a break conversation in which I was asked a critical question and I just don't -- it's supposed to be in this afternoon but I don't want to miss the opportunity.
The question was: are you suggesting we manage for soil crops?
My answer is no.
What we're trying to manage for are the systems that it provides -- I mean, the services that it provides.
It provides that stabilization.
If we lose those soils we lose everything.
It preserves the fertility.
If we lose that fertility we lose everything.
So this whole thing is about preserving those services, and they are in lots of situations the only game in town.
When you have plants that are this far apart and there's nothing else in between to keep those soils stable and to keep those soils in place and fertile, that's our answer, and that's point of all this, is to use them for the services they provide, and I can't emphasize that enough, and I wanted to make sure that that came out really explicitly that that is the point of the --
>> DR. ANDERSON: [inaudible]
>> KATHIE LIBBY: Thank you.
That's very helpful.
And thanks to asked that question.
That's why we're here and listening.
Sometimes you know better than us -- or how to express the direct question.
We do thank you.
Now we're going to talk about disturbance.
And we have several questions from the audience already on this but I'm going to frame the first one and ask Kim to take the lead, and I think Janis is going to pipe in.
What are the major kinds of disturbance in the planting area?
Where and how are they impacting biological soil crusts?
So major kinds of disturbance in the planning area and how are they -- what is it doing to the biologic soil crust.
>> DR. ANDERSON: In trying to think over this question, looking at the -- how the monument was designated and things, there's not a lot of -- I couldn't think of a lot of disturbance that goes on.
People are directed to stay on the roads.
There's a few trails people can use.

There's no mining activities.
There's no real big disturbance.
So if you could hit -- find slide 14 for me, please.
Now, there are those individuals that are going -- previous to this one.
There you go.
Yeah, people wander off the trail a little bit and disturb some things that way, but just all the time that I -- my opportunity to wander around on the monument, I came across little things like this.
This is deer.
Some deer come across here.
I don't know what they're looking for.
Doing that, of course, they've disrupted the soil here.
Close to a water flow pattern.
Don't know what will happen with it, if it will actually end up filling in there and cause a gully.
So there is this little disturbance going on.
Previous slide.
The other thing that I realized is that probably the major disturbance that is going on the monument right now is management of rangelands.
This is out east of town, the Five Mile area.
You can see that we've got -- there's one off the other side.
They're actually doing some chaining out here.
Prior to this in 2007 we looked at the -- the monument look at some different methods for removing -- treating the rangeland.
They looked at -- it was suggested to use a Dixie Harrell.
The configuration is a pipe with fins to drag that through and remove some of the sagebrush.
They found out it turned into a big scraper and took everything off the soil service, including the cryptogamic soils.
In doing the chaining they used an Elie chain in which every other link a section of raid road tie is welded to the link, and the chain will royal along and take up sagebrush as needed.
In doing that, I went out and followed behind these dozers as they were doing it, and you can see right here you've got a moss that missed being run over, and that's what happens with the -- using the Elie chain, and these are deeper soils, Wyoming sagebrush type community.
The chain will take up some of the sagebrush, leave some of the sagebrush.
Not quite a 50-50, but it's pretty close.
In doing that, it did leave that -- there were other places -- you know, when it leaves the sagebrush, it usually leaves the lichens and mosses underneath it.
So this was the major disturbance that I could see across the monument, and it wasn't the chaining itself, using the Elie chain, was nearly as destructive as was using the Dixie.
Like I said, still maintain some of the soil crust.
It's there.
You've got -- with having the moss here, lichens under some of the sagebrush.
Lichens through their propagation methods can release spores into the site and you can maintain those communities or help -- help reestablish those communities in the site.
>> KATHIE LIBBY: Janis, did you want to speak to this issue?

To follow up with what Kim just said, we have to carefully consider the characteristics of a site before we prescribe the management for the site.
So getting at the question I talked about before, or the site I talked about before with the very shallow soils, which I interpreted because I saw the rock outcrop, that would be a site in contrast to this that you definitely would not want to take a chain out to.
There are other sites that have greater potential for a positive response to disk methods.
-- different methods.
I know we need to treat often a lot of acres, but we have to be very careful with what kind of treatment method we use.
There could be more expensive, more labor-intensive methods that if the sites are well chosen could result in a more positive response than if we don't take the site consideration into consideration.
Another thing that I wanted to mention is I know Kim mentioned humans.
As this monument is going to be further developed and more people are going to want to visit here -- let's face it, it's a phenomenal landscape.
It's just a world-class site for people to visit.
There's going to be more human impacts.
Yes, they may be more concentrated, but the human animal is going to be something that I think is going to become more of a management issue in the future.
>> KATHIE LIBBY: So we have a number of questions --
>> Wait a minute, we're not done yet.
We're not done.
>> DR. BUSBY: I wanted to --
>> DR. ANDERSON: I wanted to mention a couple things.
We didn't mention grazing in you will a of that, and that is -- and Miss the most widespread form of disturbance and it's a mechanical disturbance.
It's animals stepping on crusts and crusts don't have much resistance to these kind of compressional forces.
So that's the -- that's sort of the sledgehammer across the landscape.
There is a lot of these treatment areas, a lot of acreage, and -- while I do agree with Kim that the chaining was probably less impactful, I did see this area by the transfer station before and after treatment, and I would say that although you can find patches like that, like that moss there, a large amount of the preexisting crust cover was compromised, and it's not there anymore.
>> DR. ANDERSON: That's because [inaudible] that's where it's scraped off the soil.
So, yes.
Oh, yeah it -- the problem with the harrow, the way the pipes are positioned on the tractor and the fence and everything, they just catch the sagebrush, and with -- that just made like I said a big scraper, and that took everything off -- that's where it was, the substation.
>> DR. BOWKER: Is this telegraph flat?
>> DR. ANDERSON: That was further either on the Five Mile east of the substation.
>> I would like to address the grazing a little more specifically.
We know that there are areas that are overutilized.
There are areas that are probably underutilized.

And there's lots of areas in the middle, and so it's -- all comes down to how much is too much, how much is okay, how much is this and this.
We're going to talk about this later, but I want to put the idea in your head that there is no set answer.
It's going to depend on how much it rains in that area, what are the soils, what's the timing and intensity of use.
It's really -- what I don't want you to think is that there is no answer.
It's just that it really depends on the site, and that's where a whole grazing management plan is supposed to get at, and that's a point of what we're here to help inform is that, yeah, you need to think about the soil crust, but it's in the context of all these other things.
Because, again it's the Service they provide.
If you're at a higher elevation and have plant cover, you're not going to care.
It's as you get down low that they become more critical.
So in terms of disturbance, it really comes down to this, yeah, it can be graze -- grazing can be hugely impactful in some places.
In some places it can be a lot less.
In other places -- there's lots of things in the middle.
>> KATHIE LIBBY: This may help with some very specifics.
I think you covered a little bit of it, but I would like to go through some questions specifically.
So from the Internet, what native animal species historically impacted the soil?
And what are their numbers like today?
>> DR. BOETTINGER: I want to answer this.
Walter Cottham in 1931 wrote a monograph entitled Utah Sahara bound and traveled around the state and looked at all these different landscapes and asked the question of what's the impact of cattle grazing been and native animal numbers, and in that he had some pretty stunning numbers, that the estimate of mule deer, which would be the thing we would most think of, because mule deer utilize lower elevations but during times of year -- not all the times because think desert, not much surface water available, so you will never have large numbers at lower elevations, his estimate around 1900 was about 10,000 to 15,000 deer in the state.
So that's not a lot of animals.
That's tiny.
The DWR's goal right now is 450,000.
They're at 430-ish I think.
So there's a lot more animals out there than there ever was in terms of wildlife that go down to the lower elevations to utilize it.
But, again, we really have to keep in mind there was very limited surface water for these animals to utilize.
They were going to come down in the winter when the soils were frozen or -- and plants are more dormant.
So they're going to have a very different kind of impact than when you have lots of water sources.
Because we told everyone to get water sources out there so that the cattle and animals -- livestock would be dispersed.
So now there's water sources almost every mile or so, and so suddenly there's all this surface

water available.
So you can imagine how the native animals can now utilize the landscape in that same -- I should say in a very different kind of intensity with a very different timing.
So it's now a very different situation.
>> KATHIE LIBBY: And this follow-on question from this individual is kind of in line with what you were suggesting.
It is: do livestock affect it, the soil, differently than these native species?
>> DR. BELNAP: Not really, I don't think.
I guess deer hooves are smaller.
No, not really.
>> DR. ANDERSON: More the number probably.
>> DR. BELNAP: Goats, yes, because they rip the plants out [inaudible]
>> DR. ANDERSON: And horses as well.
Horses are a very different critter in terms of the hoof action as well as the way they can bite vegetation.
>> KATHIE LIBBY: So horses would affect it differently.
>> DR. BUSBY: You have different size hooves.
If you take a sheep hoof, cow hoof, the amount of pressure is about the same per square inch.
>> KATHIE LIBBY: Thank you.
Different question, directed at Matt, but not necessarily.
Anybody could answer it maybe.
What are the disturbances other than cows that significantly affect crusts?
>> DR. BOWKER: Four-wheel drive vehicles.
Off-road vehicles.
>> DR. BUSBY: And you take a critter about half the size of a horse and you make it 95 horsepower, wow!
It can spin its tires.
[inaudible]
>> DR. BOWKER: Wildland fire.
It can actually consume crust material if there's some fuel nearby.
But often what happens is the heat from the fire can actually sterilize the soil surface to some degree.
This is a worse impact in places with woody vegetation rather than herbs because the fire gets hotter.
>> KATHIE LIBBY: That was one of the questions.
Would you comment on the role of fire [inaudible]
>> DR. ANDERSON: We saw that on buckskin fire in 2006.
Pinyon juniper woodland.
And it just went through, and it did, it sterilized the soil and took care of everything that was there.
>> KATHIE LIBBY: Again, if you would maybe kind of summarize and get back to something you already mentioned, absent grazing and human activity, what are the natural events or processes that degrade or erode biological soil crusts?
>> DR. BOWKER: Maybe extreme weather events.

For example, I've seen crusts flattened by hail and heavy, crazy rain, sort of 50-year kind of stuff.
Crusts are susceptible to drought.
In fact, I have some data from here in Grand Staircase where I looked at the chlorophyl in the soil, and my samples from 2001, which were a dry year, had more chlorophyl, quite a bit more, than samples from 2002, which was an incredibly dry year.
So the crusts do respond to droughts like that, and they are responding to increasing prevalence of drought.
>> DR. ANDERSON: Would you mind kind of addressing this?
Slide number 2.
One more.
No, back one.
Okay.
This is interesting.
What other side of human or livestock disturbances.
This is a site on no man's Mesa.
In anybody knows about no man's Mesa, I think I mentioned it before, it's been excluded.
There's never been a cow there.
In 1927, '28 for a few months they put some goats up there, but as I remember they -- reading the history on it they brought them off because there wasn't any water.
The herder had to haul up water in barrels and got tired of doing that so abandoned the site.
Aside from a few goats, there's not been any livestock up there.
This picture was taken in 1975.
If you will go to the next picture, please.
Nope.
Forward.
There you go.
Same area in 2010.
In the 1975 picture it shows -- it seemed to be a very stable, functioning crust system and now it's kind of blown out.
We've lost half that site, and it may be from one of these heavy rainstorm events that Matt talked about.
But, anyway, no man's Mesa is a very interesting area to go see.
A lot of things get blamed on livestock and humans and stuff occur on no man's Mesa, and it's just amazing you can see that in an area that's basically been untouched.
>> DR. BOWKER: Those two photos, are they the same location?
>> DR. ANDERSON: Yeah, the tree in the background.
I got off a little bit because I wanted to capture how much was going on, but that juniper in the background there is the same tree.
Just slightly different angle.
>> Can you go back one?
[inaudible] is that what blows out?
>> DR. ANDERSON: No, it's the section on the left.
I tried to angle it because I thought, wow, that is --

>> I'm just wondering, we do get a lot of water flow underneath the pinyons and junipers.
They're actually hydrophobic.
So you can get a nice little watershed coming off of there.
I was wondering if it was just flowing off that tree right there.
But, yeah, especially if there's some channelized water it's going to come through them.
>> DR. ANDERSON: That really wasn't channelized but -- as far as a gully but it's like, wow.
>> I was thinking the tree.
Because that --
>> DR. ANDERSON: Anyway.
>> Anyway.
>> KATHIE LIBBY: The question for those of you not in the room: is it not a question of scale?
[inaudible]
>> DR. ANDERSON: I'm not sure I understand your question.
Scale?
>> Participant: [inaudible]
>> DR. ANDERSON: There are a number of spots like that.
That just seemed to be the most dramatic to me.
>> DR. BUSBY: [inaudible] 5 locations in no man's Mesa and the crust cover goes up to 5%.
It's heterogenous.
I wouldn't say it looks like the surrounding area, or actually a better comparison would be another cliff top that's not isolated on the same soil at the same climate, and if you make that comparison, and some people have -- Guenther did that a few years ago and found you can tell the difference.
No man's Mesa has more crust.
I'm not denying that crust never erode in extreme events or anything like that, but this idea that there's no difference between no man's and other places is not correct, in my opinion.
>> DR. ANDERSON: As far -- I'm thinking as far as the disturbance that occurs.
Those there's areas on no man's Mesa where there is no crust.
There's sand dunes up there that there's no -- so, looking at it compared to the other -- you know, surrounding areas, I see it just kind of the same.
You have areas where there's crust, areas where there's not crust.
You have different soil types.
Kind of that way.
Yeah, maybe there are -- you indicated 45% crust.
A lot of pinyon juniper and shrubs.
Old brush is coming in heavy there now.
The cactus are moving in.
I don't know, last time I was up there was 2011.
So a lot of change going on up there.
>> KATHIE LIBBY: Again, this may be repeating somewhat: do soil crusts exist in areas that have been reseeded, in areas that have been chained, in areas that have been burned?
>> DR. BELNAP: It depends.
I mean, chaining doesn't necessarily hit the ground the whole way, and they come back after some time.

The same with seeding.
If you [indiscernible] seeded you probably left areas in between.
Fires don't burn uniformly across the landscape.
So all of those answers depends on what the treatment actually was and what -- or I should say what actually happened at that place.
Because the impact doesn't directly hit them, they're going to be fine.
>> DR. ANDERSON: Yeah, example I gave for buckskin fire, pinyon juniper, yeah, it took out all the soil crust.
We had another fire about the same time, Davis Flat, I think it was, the northern part of the monument.
It was in a sagebrush site.
Different time of year.
Burned in the spring.
So it wasn't as hot of a fire.
There's still cryptogamic soil up there.
So, yeah, it depends.
>> KATHIE LIBBY: I have a question for you, too.
I will tell you that and you can speak to both.
You indicated we have to treat a lot of acres.
What needs are we meeting when we treat large areas with -- especially with mechanical treatment?
>> DR. BOETTINGER: That's probably not the question for me.
I was just speaking to that there are a lot of treatments that seem to be going on all over BLM-managed lands in the Southwest and that if a treatment is deemed necessary, then the site consideration really need to be taken into account before the treatment is prescribed.
So one of the things I would like to bring up is drought.
So we could have the perfect storm.
We could have a series of events.
For example, we could have drought cycles.
We think about wet years, dry years, wet years, dry years, and then we can think about those kind of things actually operating on a much larger time scale.
And we could be at a time where we're at very low precipitation in a cycle that's part of a larger very intense drought cycle, and water is needed by higher plants.
It's needed by the organisms that populate biological soil crusts and if we get other types of disturbances on top of those drought cycles such as wildfires or some very intense rains when the plant cover is low, the biological soil crusts are stressed because of the drought, we could have the perfect storm,nd it could be that there was no enhanced or human influence/disturbance.
And we could have a catastrophe on our hands.
We could basically have huge amounts of soil erosion and really degrade the potential of a particular site.
On top of that, there may also be disturbances such as grazing.
So we have to think about what is the big picture?
What is the site?

Where are we in those drought cycles?
And what are the disturbances as well as maybe extreme natural events that are happening at that time so that we then can think about, okay, we're not going to blame it on one thing.
We have a number of different factors that are influencing the outcome of perhaps, then, an extreme event.
Let's face it, we're going to face more drought.
It's going to be warmer temperatures.
We're going to have -- the potential for mow evapotranspiration of water back into the atmosphere.
We're going to be facing prolonged droughts.
So everything I think we do in the future we need to keep in mind the cycle of drought, and that the droughts are going to get worse.
>> KATHIE LIBBY: Thank you.
Another comment -- question.
[inaudible]
>> Specifically asked about treatments.
So I think -- I mean, to address that, one of the things that hopefully everybody in this room recognizes, sometimes it's painful to recognize it, but we need to recognize that we've shifted our grazing, our domestic livestock grazing almost exclusively to cattle, and cattle are a grazer which means they eat grass and don't each very much shrub brush.
And so we have selectively grazed plants because of the preference of the cow.
As a result of that, grasses that are grazed then have to -- are weakened in their competitive ability.
They may be well able to recover in a grassland where everything was grazed a little or a lot, but when you have a grass that's been graze and weakened in a sagebrush stand, the sagebrush gains the competitive advantage.
And so I don't think there is any surprise that over millions of acres in the west here on the monument we have areas that will very low biodiversity.
In our ecosystems now because we have mostly sagebrush and a few species that are hiding under the sagebrush and a smaller number of species that grow out in the interspaces.
So one of the issues, then, is what can you do with biodiversity to increase the diversity of the community, including microbiotic crusts?
Well, here's the cruncher.
Plants that you want to put back in the system to improve biodiversity has been to be forage plants because that's the ones the cows ate and removed.
That and the sagebrush competition.
So one of the things we're going to be doing in terms of treatments is we ought to be thinking about restoring that mix of shrubs, grasses and forbs as well as crusts back into the system.
And then the question then to the monument is, if you get into that to improve the issue of biodiversity and take care of the land, this is a true land health question, then how do you manage the grazing in a way that perpetuates that degree of improvement?
That's really the challenge that I think that you're facing.
I don't think you're going to eliminate livestock grazing.
I don't think you're going to maximize livestock grazing.

In fact, you've got a newsletter that says that.
So you're going to have -- but you need to work on that.
You need to work on that better balance of the mix of plant species across the landscape, which we call biodiversity.
You need to think about its distribution, not of all the herbaceous plants hiding under a sagebrush plant, but some of them growing out in the interspaces, semidesert, upland sites, upland sites in particular, and then you need to manage it to perpetuate it.
That includes crops.
I think I've summarized what you guys are facing, but that's one.
Where you've got the 800-year-old junipers, you haven't had a fire in a long, long time.
I'm not sure how much 800-year-old juniper you have on the monument.
Some of you range cons here from the monument can answer that question better than I can.
But where you don't have 800-year-old juniper and pinyon but you have rather recently invaded juniper the last 100-plus years, then you need to be treating juniper partly for the same reason that we just talked about, biodiversity, but you also need to be treating juniper to reduce the fire threat.
Because if you burn it, Kim has already talked about what happens to the system where you take a thick stand of juniper and it burns.
It sterilizes the system.
So you need to be thinking about -- to me those are the two kinds of questions to be thinking about as you talk about doing treatments, fire management, reduce the fuel load, thin the juniper, don't remove it, thin the juniper so that you can't have crown fires, and figure out how to increase the diversity of your plants with primarily native species.
That to me is the -- kind of the piece of the puzzle in terms of treatments.
>> KATHIE LIBBY: One more challenge, and that's the -- --
>> One more challenge and that's the shrubification that's going on locally.
So woody plants are increasing globally.
There's a few exceptions but there's not a ton of exceptions.
Despite changes in livestock management, changes in fire regimes, changes in putting out fires, lighting fires, lots and lots and lots of rangelands are seeing woody plants coming in, and it can be natives.
It can be growing bigger.
It can be nonnatives coming in.
But that's another real challenge for land management, as you're thinking about trying to make that balance between grasses and shrubs, is that you're probably fighting the rising CO2 that's favoring the shrubs, and so that's something that really needs to be kept in mind when these treatments happen.
It could just be the way it's going to be.
>> I do think both of those issues you both just raised probably very much related to this afternoon's conversation on management actions, what kind of options we have and how to think about those.
Got a couple more questions from the audience and a couple more questions on our agenda.
One comment is: biological [inaudible] and there must be some level of disturbance that is accustomed or adapted to.

What is the right amount of BSE for the land?
>> I was actually going to bring that up at the end of the day.
That's a research question we need to answer here at the monument, how much is needed to avoid weed problems and erosion.
>> KATHIE LIBBY: Why don't we treat it that way.
That's perfect.
I'll set it aside and you remember it.
What is the trade-off between doing vegetation treatments to improve vegetation versus loss of biocrust and ecosystem processes due to surface disturbance inherent in these projects?
And I can repeat that if you'd like.
[inaudible]
>> It depends.
But it does.
It depends on the soil type.
It depends on the vegetation.
It depends on -- I mean, I've seen treatments done in droughts when no plants came back and there was massive erosion as a result.
I've seen treatments done where there was a great wet year and everything came back and there was very little.
So you know, I don't think there is a stock answer for that at all.
>> I think it's a management decision, what do you want to manage for?
What's going to give you the best productivity for a site.
>> It depends.
>> I think you have poo weigh costs and benefits.
Productivity is a benefit but you have to think about possible costs.
Are weeds getting in?
Is erosion happening?
>> That's why I think it's so site dependent.
A question like that is not very answerable because it's so site dependent.
>> KATHIE LIBBY: Good.
Kim, I'm going to give you what I think is an easy one.
Then we're going to talk about weed control.
Kim, have any quantitative studies been done of no man's Mesa in relation of soil potential of crust and observed crust on no man's Mesa?
>> DR. ANDERSON: No.
There's only been one study done up there.
It was established in 1975.
They were looking at just the overall landscape.
They did have a three-by-three foot plot that they look at the change that was going on, but as far as -- and I tried to follow up on that one.
But as far as crust specifically, no, it's just been observational, photographic documentation.
>> There was a study by [indiscernible] in 2001 and she did measure crust.
Like I said, I have some measurements up there.
I didn't write a paper just about no man's, but they went into my data set that I built while -- so

I had some observations on the ground.
>> KATHIE LIBBY: Okay.
And one particular reference.
So, Jayne, apparently at some point today you used the term underutilized area of grazing.
What did you mean by that?
>> DR. BELNAP: I [inaudible] I am working on the assumption that the monument and the BLM lands have grazing on them, and they're going to have grazing on them for a really long time, and so I do think that there are areas that are pretty -- I like to use the word hardened.
It's not a very good word because it's not a parking lot.
But areas that are much better able to handle use, but they're either really far away or there's no water or there's all these reasons that animals aren't using them that they for those reasons are being underutilized relative to the level of use that they could handle.
So I kind of summed it up in one word that was probably not a great way to do it, but it's that.
Things -- grazing can happen there.
It's just not because of physical access or just something that keeps it from happening.
>> DR. ANDERSON: [inaudible] would be a good example of that.
So they don't -- livestock don't really want to cross all that stuff.
There is nothing for them to even draw them into those areas, but I know there's one little sagebrush flat out there that is covered with crypt organic soil.
So [indiscernible] is a pretty good example.
>> KATHIE LIBBY: Were you getting closer to the microphone because you wanted to say something?
>> DR. BUSBY: No.
>> KATHIE LIBBY: Last few formal questions.
Cross crust help with weed management?
That's part one.
Does that crust help with weed management?
And does crust help with erosion control?
So we did number one.
So I'm going to move to two.
>> DR. BELNAP: We have tons of studies on this and I'm happy to report that globally there are probably 60 studies looking at the effect of crust on wind and water erosion and every single one of them are unanimous in saying that they reduce it or eliminate it completely.
So this is an easy question.
There's other questions that are harder, but this one is not.
Now, there is one little caveat in here that's really interesting, and that's as a crust develops, when it's at a pretty low biomass, it's actually pretty susceptible to erosion because there -- there's enough biomass to hold it together, but there's not enough to resist being undercut if you get large raindrops impacting or you get a really stiff wind just hitting it a certain way, and you can actually dig underneath it and flip a whole piece off.
So in that sense there's actually a pretty vulnerable stage along that successional development when they, in a sense, enhance erosion, but I want to emphasize, this is a tiny spatial scale and a tiny temporal scale, and so in the big scheme of things it's probably not that important, but it is important if we're impacting large areas and pushing them all the way back to kind of a bare

soil, and then as they rougher, there is going to be this little point at which they're extra vulnerable.
When people ask how much soil crust is enough, I don't want to push them back past that point because at that point they're going to have a hard time maintaining enough stability to stay put, and so that's one of the questions that we're going to get to about how much is enough, is not getting back to where they're so thin they can barely hold on.
>> DR. ANDERSON: Would you mind pulling up slide 8?
Okay.
Keep going.
Whoop, whoop, back one.
There you go.
This kind of, I think, illustrates a little bit what Jayne was saying.
This area has -- there, the light cyanobacteria in this site but it's not enough to hold the soil.
So you can see we're starting to get a little headcut here from the water running off, and so in a situation like that, no, there's not enough soil crust to hold the soil.
If you'll go back one slide, please.
Here's another area.
You can see you've got a lot of -- underneath the sagebrush you do have a lot of cryptogamic soil.
That seems to be holding the soil together.
I had a discussion with another individual on this a few years ago.
That individual felt like this whole thing should be covered with cryptogamic soil but you have water coming in and it's got to go somewhere and so it's created its little path.
Again you have the light cyanobacteria in here but it's not going to hold it.
>> KATHIE LIBBY: Anyone else?
>> DR. BOWKER: May I say something about the soil?
Correct me if I'm wrong, but I'm seeing lots of circular depressions right there, right there, right there.
They look just like hoof prints, old hoof prints.
>> DR. ANDERSON: I think that's probably why there's such a stark contrast here.
Animals don't walk straight through shrubs.
They walk in between them.
So you can have kind of these blow-out areas where the crusts have been compromised.
And you can see erosion has definitely happened here because everything that can move is moved and notice all these rocks here.
The rocks aren't being moved.
They're what's left behind.
>> KATHIE LIBBY: Great.
Before we get to our final formal question, and I don't know if they've showed up yet, but we did arrange to have some copies of the agenda, which has the specific questions on it, made available -- not for the whole room because we were only getting a few questions.
There are a few on the table.
Thank you, Matt.
This is from the audience.

And this particular one is for Dr. Fee.
Since most grazing here occurs during the winter, is reduction of perennial grasses a major concern?
>> DR. BUSBY: It's not the question on my sheet.
[laughter]
He.
>> KATHIE LIBBY: You can pass it along.
>> DR. BUSBY: Grasses go dormant in the fall because of the cold weather, and when they're dormant, the growth points for next year's growth is in the root crowns, which is just below the surface of the soil.
So grazing the dry dormant material in the winter is not detrimental to the grass from a grazing management standpoint.
But the purpose of the grass is the dead stems is not just potentially valuable for forage, because it provides cover, and so you're warmer down here, so you probably get more rain events than we do in [indiscernible] in the winter, and so those grass stems intercept those raindrops Jayne was talking about just a moment ago and break their energy and at that point of breaking the energy it begins the process of managing erosion.
So to think that you can go out on an area in the winter and just slick it off and you're not going to have any effect on the plants is marginally true but to think that you're not going to have any effect on the ecosystem is totally wrong because you're removing that protective cover.
>> DR. BELNAP: I did an interesting experiment once, and I didn't intend this, I wanted to see how fast grass leaves decompose.
I went out to grasses and clipped all the dead material away so I could know how old the leaves were when they dropped down.
Literally that night every green blade of the probably 60, 70 plants I did this to was mowed down by the mice.
So it also acts to protect the green leaves from getting mowed.
I was just devastated.
It took us like -- it took like 20 of us all day for days to do this.
It was horrible.
But, anyway, I learned something about that dormant material, that there really is a value to it.
>> KATHIE LIBBY: Good.
So one final -- actually we've got two online questions on this.
I want to fit it before we go to our last question.
Do chemical treatments affect crusts?
Chemical treatments.
>> DR. BELNAP: I know the answer because we're fighting a new volume of the crust book right now and someone has done a chapter about this.
That's the only reason I know it.
Yes and no.
It depends on the chemical.
Roundup gets coil crust, the mosses, because it is a plant, and so it really depends, of course, on what chemicals you're using and what organisms in the crust you are worried about.

The cyanobacteria are pretty bountiful.
There are a few chemicals that will affect them.
I think actually Plateau does the cyano bacteria but the likens and mosses are fine.
Again, you will have to ask your question what are you worrying about and what chemicals do you want to use on and to what degree.
Mostly the cyanobacteria are pretty bomb proof and mosses seem to be the most vulnerable.
>> KATHIE LIBBY: Final question on the agenda: there are areas that are not currently being grazed, yet we aren't seeing either healthy crusts or healthy grass there.
Any thoughts on why that may be true?
Matt, Kim, everybody?
>> DR. BOWKER: If you have removed the -- removed the disturbance agent and recovery is still not happening, I can see a variety of reasons why that might happen.
Maybe there's low potential for crust at that site.
Okay.
That would be the first one to cross off the list.
But if you have seen other sites like that and you see they have crust, then that's not the answer.
So maybe when the site was disturbed the disturbance was so great that it created a new ecosystem state and it's kind of like putting the ecosystem off on a different train track and it can't recover passively on its own, and that's a situation where people might have to intervene in a restoration context.
So let's say the first two aren't true.
Maybe the disturbance wasn't that heavy and you're still not seeing recovery of crust.
The last possibilities would be crust recovery is happening.
It's just perhaps slow.
And maybe the crusts that are there are the more cryptic, early successional forms and maybe if you took a closer look in the soil you would be seeing those cyanobacteria still in there.
And related to that I would point out that in recent years, the 2000s, have been marked by a lot of drought years and some very extreme drought years.
So it has not been a hospitable time for crusts in recent years.
So I don't know what specific areas are being referred to, but those are some possibilities.
>> DR. BELNAP: And all that applies to grasses as well, because this question asked about both.
I just -- because the question asked about grasses.
>> DR. BUSBY: Am I talking in close enough?
One of the things --
[laughter]
>> You are trouble.
>> DR. BUSBY: I'm crusty.
One of the things that you have on the monument that you need to celebrate is with the creation of the monument this monument had a soil survey.
BLM contracted, as I remember, with natural resources conservation service to do a full soil survey across this entire monument.
That's very rare on BLM lands.
Once you have a soil survey, you correlate the soils so that maybe multiple soils that all

correlate together because they have the same potential, you correlate them at ecological sites.
So on this monument you know what all the ecological sites are on the -- on this landscape.
Now, those may be a few tens of acres, 10 acres or tens of acres or hundreds every acres of an ecological site because of such a uniform soil and climate.
Every ecological site describes the unique kind and amount of vegetation that is expected to grow on that soil.
Unfortunately, because we're still learning, I'm not sure that those ecological sites have map data in them to describe the potential of biotic crust.
But you ought to be able to use the soil survey at ecological sites to answer this question, and that is you've got this area, figure out what the ecological site is from the soil, and it tells you that the productivity is 150 to 250 pounds per year.
Shallow soil, salty soil, rocky soil, whatever the reason is, but you should be able to answer that question site after site after site on this monument and explain where you have low productivity, whether it's grazed or not grazed.
And with Matt's information, there ought to be a way to begin the process of adding the potential biotic crust component into those ecological sites so that you could answer that question site by site by site as well.
But you guys need to celebrate the fact that you have that kind of a data layer on this monument to inform you of a lot of those kinds of questions.
>> You soil scientist you.
>> DR. ANDERSON: They're asking specific sites -- or areas, and I can think of -- as I mentioned earlier, the Pria Breaks area, Big Bounds Bench.
What was the other?
I thought of another one.
But as Fee was discussing, yes, the reason most of those sites, they're kind of degraded, but they're not being grazed, it is the soil component.
You know, the Pria Breaks has the Chinle formation.
You're not going to get any productivity vegetatively out there.
You're not going to have livestock grazing anyway.
>> I would like to go back to something that Matt said was I think it's so important and that's this idea we can push systems into a new state and they're not going to come back unless we do something, and so lots of people say, oh, we'll just take whatever, we'll stop the fire, we'll stop the whatever, but if the soils have already started to erode and they're just eroding and eroding and that surface horizon is lost, that changes everything, and so, you know, you may not be able to get back to where you were, or you may be able to, but regardless, it's going to take management action.
You can't just be passive about it by taking off that disturbance.
I think that's -- you're past the threshold.
He referred to the ecological sites and the goal of NRCS is to come up with a diagram of all the different possible states that that ecosystem can be in with arrows to show you how to get back to where you want to go with what kinds of actions.
And so that's exactly what this is based on, is that there are thresholds out there, and if you pass them, you're not going to be able to just remove that disturbance, and so that was my

first reaction to this question, was you're probably over a threshold and you need to look very carefully at what you've lost and, therefore, what you need to put back.
Could be simple.
Could be simple just like seeds, and it could be really hard like, uh-oh, I lost a foot of soil.
I liked that question.
>> DR. BUSBY: Again, your soil survey will give you a little bit of information on that, although you have to dig a hole to verify what you're doing, but if the soil scientists mapped the soil that said that the upper profile should be about eight inches in depth, and you're out there that area, you dig that hole, you find that that upper profile is only half of that, then you've got a little information to point to what Jayne just said that you've already lost a huge amount of soil.
You also have to verify that by looking at -- by looking at that soil and verifying, in fact, that you've lost it.
You can basically see the break in the horizon and you may have to do some texture analysis to figure it out.
But the soil survey is a gold mine of information.
>> Can we get another amen?
>> Amen!
>> KATHIE LIBBY: I'm going to provide a few more minutes for you folks to close out on this in any way you want.
But before we do that, we actually have reasonably completed in -- half an hour early.
Because we are live streamed and webcast and all of that, we are going to keep to our regular schedule and have the afternoon session start at 12:30.
So we're not going to start earlier, because other people have long known that they are -- what the schedule is going to be.
So we're going to do that.
Let me take a minute because agendas were not available to give you more description of some of the questions that will be covered in the afternoon.
So the afternoon is largely dedicated to what are our management options, and some of the questions are what kind of management actions can support biological crust recovery, and how long does it take for crust to recover?
Are there areas with biological soil crusts can be preserved, restored or conserved.
And where does it need to be conserved or restored to maintain ecosystem health.
What is the potential of a biological soil crust restoration.
And would this area respond favorably to a planned rotation/holistic management approach?
And what management practice can we adopt to help BLM respond to year-to-year changes in conditions, long-term climate change for drought?
So those are the general questions we will, as we did this morning, respond to your individual questions throughout the afternoon.
During lunch two things to note.
One is, if you would please consider, if you move your car, parking it someplace else so the library can have more spots.
There is a gentleman in the room who may be looking for interviews with some of you.
So don't be surprised.

And -- and don't be bashful.
>> I have one other question to add to the list.
How much do we [inaudible] I know this is a burning question.
How much soil crust do we need?
>> KATHIE LIBBY: That was a question we had this morning that we -- excuse me?
>> [inaudible].
>> KATHIE LIBBY: We are fixing to break and have some lunch unless you would like to say a few more things.
>> [inaudible] we didn't give anybody a chance in the audience to say you missed the point.
>> KATHIE LIBBY: Right, we are --
>> DR. BUSBY: I wondered will you take some time to just open it up to the audience.
>> KATHIE LIBBY: We could take maybe 15 minutes?
>> DR. BELNAP: Yeah, did we miss the point?
>> KATHIE LIBBY: But you're going to use my microphone.
So you have to raise your hand.
So not the stuff we're going to do this afternoon but some reactions to what you heard?
>> Participant: On a macrolevel beyond specific factors such as erosion and fertility factors, what impact does healthy soil crust have on the landscape at large?
What would I be able to actually see if I was comparing similar soil and landscapes with soil crust and where soil crust has been destroyed?
>> DR. BUSBY: That's a great question and I pondered that question, and it goes back to those first two that you mentioned, and that is the stabilizing the soil and soil nutrients.
And I ponder the life and productivity of a crusted wheat grass [indiscernible] as an example with a healthy soil crust that was, in fact, providing the nitrogen that that crested wheat grass needs.
I know one of the issues in rangeland health assessment down here was some real concerns about the deterioration, loss of productivity of the crested wheat grass sites, and I just kept questioning, you know, is -- are we seeing a decline?
Do you chain it?
You plow it.
You do whatever.
You've had all those soil crusts on it prior.
So you have all that built-up nitrogen, and over a period of time the crested wheatgrass utilizes the nitrogen.
Some is harvested by the cows and moved off.
If the nitrogen depletion curve occurring on this land that's been seriously impacting its productivity?
I do not know the answer to that question.
So I'm rephrasing your question to say there's so many -- that's a great question, and I just have to believe that that may be the issue, is that loss of the nitrogen fixing on these arid and semiarid systems is really beginning to show in terms of a loss of overall production.
>> DR. BELNAP: And I have another one.
One is spiritual and silly, and the other one is serious.
They're cute.

What can I say?
I mean, they're really, really wonderful to look at.
And so to me, you know, when I think of that and I think of the plant community, I'm asking the same community.
What value are plants?
You know, yeah, animals can eat them.
But we have an aesthetic attachment to them, too.
And so, to me, there they're gorgeous and they are part of the system, and I would hate to lose that.
To go to the more science-y kind of aspect, one thing we didn't talk about is plant nutrients are more available under well-developed soil crusts because they have more abundant and a higher diversity of soil to break down the plant materials to make all nutrients available to plants.
So there is also nutrient cycling that they enhance.
And the third thing that Fee sort of touched on is biodiversity.
If you want to look at the die EEO diversity in these systems, don't look at the plant community.
Look at the biocrust, because they have an extraordinary number of species in them.
And I mean just that top centimeter.
It's extraordinary.
And so that is actually got a lot more organisms in it than the plants do.
So we need to think about the whole system.
And if we talk about services they provide, they are providing nutrients at a level that are not available otherwise.
The other thing that Matt talked about nitrogen but another big one is phosphorous.
The phosphorous gets bound up.
It's not available to the plants.
But the soil crusts secrete an enzyme can that break that bond and make the phosphorous more available to vascular plants.
So they play all these roles that we don't know a lot about.
We sort of can speculate about.
But I do think that there is that just overall aesthetics.
I mean, when I go to a place where the crusts have been stomped out, my heartbreaks because it doesn't look as wonderful, it doesn't have all those colors, the Reds and the greens and the yellows and all those things are gone, and it's just not -- and it's not bumpy.
It's flat.
And it just doesn't look to me like a landscape that is flourishing like it should.
So my 2 cents.
>> DR. BOETTINGER: To expand on that, so, the soil below that living crust is a precious resource that has taken thousands and thousands of years in most cases to form, and as you're seeing the plants depend on that soil, the animals depend on the plants that depend on the soil, the nutrient cycling that keeps the plants going enhancing that biodiversity on the surface, it depends on that cover of soil below the crust.
If we lose that cover, especially if we're already beginning with a very shallow soil, we're down

to bare rock, and, really, to bring that site back we're looking at thousands and thousands of years for that soil to form again.
So we need to think about things on a larger landscape scale, I think, a larger time scale, that with increasing temperatures we're going to be facing more drought, more extreme events.
We're going to be facing the perfect storm more in the future.
So what can we do to enhance biodiversity of the plants and the soils and to keep that soil cover, to keep the plants and the animals healthy, as well as keeping that landscape intact for future generations?
>> KATHIE LIBBY: Okay.
We have another question or comment.
>> Participant: This is a quick thing.
I don't know if we addressed this one yet.
What do the grazer propagate?
You know, they're grazing.
They're pooping, you know.
What kind of nutrients or plants, or what are they propagating when they do this?
>> DR. BELNAP: I can do the nutrient part.
So it's actually really interesting because if you think about the grazers, munch, munch, munch here but they don't necessarily poop their or pee there.
They're moving.
So the nutrients that are more -- they're sort of even across the landscape, yet concentrated in this Pooh or this place where they decide to pee, because -- especially with cows because they might only poo once a day.
So you get these concentrations and you're taking all the nutrients off the landscape and moving them into a spot.
The other thing to think about is you're also generally exporting that animal to market, and so you're also removing the nutrients that way.
Phosphorous is a very stable nutrient, and so it will kind of stay in that pile and not go very far in terms of soil depth or anything.
It's very stable.
Nitrogen is not.
Nitrogen gets lost as a gas very easily and so you have a tremendous loss of nitrogen when you move from munch, munch, munch to that pile.
One, you lose a lot, because pee is hot and it turns nitrogen into a gas and nitrogen is very easily leached down through the soil, and so you lose a bunch down past the plant root level.
And then the other thing is that that animal is generally exported, and the biggest thing an animal eats plants for is nitrogen, not for vitamins and minerals.
There's a lot of nitrogen.
Tissue.
So the estimate is you lose about 90% of the nitrogen for every level you do.
So when you have a cow or any herbivore eating the grass you lose about 90% of the nitrogen from the system into that animal.
So there is a real big impact on nitrogen cycling.
Which is good why heavy nitrogen input that on to systems is so important.

I should add most ecosystems depend on lightning and rain for nitrogen inputs.
The reason deserts are so low is we don't have much rain and so the lightning fixes the nitrogen in the air and the rain washes it out.
Well, we can have the lightning fix it up there but then we don't have much rain so it doesn't wash it out.
So that's why we get the -- that conundrum.
But in terms of plants --
>> [inaudible]
>> DR. BOWKER: I was wondering if they're propagating plants and what kind of plants.
Briefly, there are some grazing tolerant grasses, like people often point at the native grass blue gram as a grasp stands up to grazing, and if it's competitors aren't standing up to grazing, the blue Graham will proliferate.
People mentioned cows that make possible vectors of some weeds like cheatgrass as well.
I think Fee should take this one.
>> DR. BUSBY: I mentioned before in the winter they're dormant and the buds are in the root crown.
Ones in the spring begin to put up leaves and begin the chute.
Some grasses, blue bunch wheat grass elevates its growth point above that root crown quickly.
If a cow comes along and eats that, then that stem, the leaves below will remain green, but that stem will grow no more.
That then triggers the plant having to take energy and create another what's called a tiller or another stem and to try to grow back.
And so there are plants that are not very tolerant of grazing, and blue bunch wheat grass is one of those.
Compare that to crested.
One of the reasons that the crested was chosen, a variety of reasons, one, it was an agronomic crop for all practical purposes to be seeded, but it elevates a stem, but the main growth point stays very low on that stem until very late in the season.
So you can come along and graze the crested wheat grass early in the spring and the growth point is still low and is very unlikely to be grazed, and that stem will then tine grow, including go to seed.
So there's a whole variety of different tolerances of grazing of different plants, and the -- when you graze, basically there's a choice.
You know, they'll pick the ones they like the best, and sometimes they'll pick the one that is most available, put up the most growth, instead of little bitty short plants.
So those are the ones that are selected.
And any plant community that's multiple species, the one that is grazed then is put at a competitive disadvantage because it has to -- it has to take energy to regrow while the ones around it that weren't grazed and don't have to take that energy to regrow win.
And so you see that competitive advantage begin to shift your species composition.
So grazing -- grazers choose, and as they choose, they begin the process of shifting what's out there.
>> Participant: I guess what you're saying as they graze and digest the foot, they aren't necessarily letting seeds on the ground and growing more species of plants?

Be they invasive or not.
>> DR. BUSBY: Seeds will be consumed and in a ruminant digestive system, they're pretty much -- unless they're a hard seed like a mesquite bean, they're pretty much digested.
And so you won't oftentimes see a big bunch of grass begin to grow from a cow pie.
You will see a mesquite grow from a cow pie because that bean survived the digestive system.
We don't have that plant here.
So no need to worry.
And so the -- that won't necessarily help with that.
Now, if you graze late in the season when the seeds have already matured, then the cows will, in fact, knock some of the seed off if the seed has not already fallen to the ground.
[indiscernible] and actually had a treatment in his grazing plan that said if you go in after seed sets, cows will actually make sure that the seeds are in direct contact with the soil.
Result of being in better contact with the soil rather than just laying there on the surface, there's a likelihood the cows will help plant those mature seeds that have reached the ground.
And so that's -- and that works with some species better than it does with others, but it does work.
So cows can, in fact, do that if they're grazed -- if the plant is grazed [indiscernible]
>> KATHIE LIBBY: I just want to check more broadly.
Is there anything else someone like to give feedback to the morning or ask an additional question?
Yours if you want it.
Okay.
I think it's lunchtime!
Thank you all very much.
We will begin again at 12:30.
Keep those questions coming.
Thank you.