Hummocks Report - 2014

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Quantitative Site Surveys Completed (22)

- Water Canyon, Dixie (6/18)
- Birch Creek, Dixie (6/19)
- Hog Ranch Spring, Dixie (6/20)
- Racetrack Reservoir, Manti-La Sal (6/23)
- Round Mountain, Manti-La Sal (6/24)
- Webb Hollow, Manti-La Sal (7/02)
- Wilcox Flat, Manti-La Sal (7/02)
- Old Fence Pole Spring, Manti-La Sal (7/03)
- Stink Flat, Fishlake (7/05)
- Beef Meadows, Fishlake (7/06)
- Beef Meadows Exclosure, Fishlake (7/06)
- Blue Lake, Fishlake (7/07)
- Griffin Spring, Fishlake (7/08)
- King's Pasture, Private (7/18)
- Garkane Power Plant, Private (7/19)
- Bowns Lake, Dixie (7/19)
- Friskey Creek, Dixie (7/20)
- Chriss Lake, Dixie (7/21)
- Lake Creek, Fishlake (7/24)
- Danish Meadows, Fishlake (7/25)
- Pond near Nizhoni CG, Manti-La Sal (8/02)
- Ute Cabin Spring , Manti-La Sal (8/05)

Additional Qualitative Assessments

- Wilcox Flat North, Manti-La Sal (6/06)
- Gold Basin, Manti-La Sal (6/07)
- Boren Mesa, Manti-La Sal (6/07)
- Duck Lake, MLSNF (6/12)
- Monticello Lake, Manti-La Sal (6/12)
- Robertson's Pasture, MLSNF (6/12)
- North Notch Spring , MLSNF (6/25)
- The Nature Conservancy Preserve, Sevier Valley (6/27)
- Big John Meadow, Fishlake (6/28)
- Mud Lake, Fishlake (6/29)
- Griffin Spring exclosure, Fishlake (7/08)
- Dry Lake, Dixie (7/20)

- Black Lake, Dixie (7/20)
- Sevenmile exclosure, Fishlake (7/27)
- Danish Meadows Exclosure, Fishlake (8/10)

Contacts Made

- David Cooper- Professor of Ecology, Colorado State University
- Paul Meiman- Professor, Colorado State University- "vastly interested in hummocks"
- Dave Weixelman, Range Ecologist, USFS
- Linda Whitam- Central Canyonlands Program Manager, TNC
- Jonathan Ratner, Western Watersheds
- Jennifer Lewinsohn- Utah Botanist, US Fish and Wildlife
- Brooke Shakespeare, Hydrologist, Dixie NF
- Bob Davidson, Wetland Specialist, Manti-La Sal
- Kurt Robins, District Ranger, Fremont River RD, Fishlake NF
- Lisa Bryant, Moab District, BLM
- Bob Beschta, Professor, Oregon State University

Introduction

I spent this summer evaluating hummocked and non-hummocked wet meadows and riparian areas on the Dixie, Fishlake and Manti-La Sal National Forests. The goal of this survey was to explore the variability in location, morphology, and vegetation communities in hummocked areas in order to better understand the mechanisms of formation at play. A better understanding of hummock formation, exacerbation and decay could better direct how the Grand Canyon Trust's Utah Forests Program and federal land managers approach wetland protection and mitigation. Very little research has been conducted on the role of ungulates in the development of hummocks. The lack of suitable ungrazed reference areas compounds the difficulty of determining ungulate impact. This report outlines a few types of hummocks observed on the forests this summer and indicators that a hummocked area is ungulate formed or exacerbated.

Methods

For the purposes of this study, a hummock was defined as a knob-like protrusion from the ground at least 3" tall with relief on all sides. This allowed for a wide variety of hummock types to be surveyed. For each quantitative site survey, measurements were taken for elevation, slope and aspect in addition to length and width. A qualitative assessment was made of each site type, either spring, basinal, riverine. A point transect was conducted to determine dominant vegetation canopy cover, ground cover and hummock cover. Four 6'x6' plots were conducted along the transect to measure hummock density, height, length and width. Soil samples were taken at five points within each site and combined to create an aggregate sample. See the Standard Operating Procedure for more detailed information.

Figure 1: Hummock plot at Round Mountain

Thoughts on methods

The sampling procedure used three randomly selected locations along the long-axis transect. In retrospect, this method, while giving every point in the site an equal chance to be surveyed, likely did not provide the most representative look at the site. I think in the future, a better sampling method would be to divide the long axis length into three equal intervals, pick a random point within the first interval for a perpendicular transect and then use the interval to set the next two perpendicular transects at equal spacing. More perpendicular transects would also create a more representative sample but this would add time to the survey.

Larger plot size would also create more representative values for density. Smith et. al. uses a 2m x 5m plot. More plots could also help reduce variability but would add time to the survey.

It was difficult to take soil samples in many of the sites surveyed. The soil often was very wet in the interspace. When soil is very wet (e.g. Racetrack reservoir), soil samplers do not hold the soil very well. Thick mats of vegetation or litter also make it difficult to penetrate to the soil. Some areas even had litter up to 6" from the surface (e.g. Bown's lake). For these reasons, I first suggest using a soil sampler with teeth which cuts roots more easily. For wet, unconsolidated soils, it's helpful to use a spade to take a soil sample, but this introduces variability in the depth and width of the sample.

In the future, I would characterize sites differently. Instead of including any hummock within 15 yds as part of the same site, I would only include hummocks within 5 yards or so. Using the 15 yd metric often extended the site further than is practical for analysis. The definition also allowed the edge of the site to leapfrog out and caused the transect to be placed in areas of relatively few hummocks. This was most notably the case at Round Mountain where only one perpendicular transect lay in the area of dense hummocks

Initial Findings

Hummocks vs Pedestals

There is wide variety in what different people characterize as "hummocks." The Wikipedia definition is "Hummock is a general geological term referring to a small knoll or mound above ground. They are typically less than 15 meters in height and tend to appear in groups or fields." It is important to be clear on what constitutes a hummock when discussing management. I found that some ecologists (e.g. Bob Beschta) think of hummocks only as depositional features. These features can be created through the buildup of organic material (like sphagnum moss) or the entrapment of aeolian or fluvial sediment by vegetation. Many geologists think of hummocks in terms of cryogenic (freeze-thaw) processes. Hummocks were not typically considered in

Figure 2: Pedestal Hummocking, Ute Cabin Spring

erosional terms in the literature I reviewed. If erosion was mentioned, it was secondary to formation processes.

The term 'pedestal' is associated with an erosive process of formation. Pedestals are formed by sheet erosion and are usually thought of in drier, upland areas. The preponderance of bare ground at some hummock sites suggests that erosive processes are at work there as well. A more accurate term for these types of features might be "pedestal hummocks". While upland pedestaling rarely appears over 5-6 inches, pedestal hummocks can reach heights in excess of a foot.

Bob Beschta mentioned that the fact that we could even be speaking of erosive processes in wetlands means that something is very wrong. These environments should be primarily depositional. Ute Cabin Spring is clearly erosional because the height of the hummocks is the same as the height on the banks. It is not uncommon to find areas with tiered hummocking, with a lower section of hummocks with wet interspace and a higher tier on the banks. To me, this looks like multiple generations of hummock formation. The hummocks on the bank formed first and then a head cut and/or drop in the water table caused a new period of downcutting and erosion.


Figure 3: Tiered hummocks at Wilcox Flat

It's likely that vegetation or root masses are holding these hummocks together as the area around them erodes. Most of the hummocks I've cut into have been full of root material. These pedestal hummocks usually exhibit signs of shearing on the edges and have bare interspace. Areas with pedestal hummocking are the easiest to show that ungulates are having an impact. Indicators of pedestal hummocking like high percentage bare ground, bank shearing and headcuts are things the Forest Service is already looking out for in terms of riparian overgrazing. The areas I found that exhibited pedestal-type hummocking were Beef Meadows, Stink Flat, Hog Ranch Spring, Round Mountain, Racetrack Resevoir, Wilcox Flat, Danish Meadows, Water Canyon, Nizhoni Pond, Webb Hollow and Ute Cabin Spring. Pedestal hummocks appeared to be present at all of these locations but they were not necessarily the only type of hummocking present.

Rounded hummocks

Many areas surveyed had smaller, rounded hummocks that were well vegetated. Rounded hummocks never seem to get more than 9 inches or so tall. Often sites could have both this type of hummocking and pedestal hummocking. I am still uncertain whether these hummocks are formed by the same process though it seems likely due to their proximity to obvious pedestal hummocking.

Figure 4: Rounded hummocks at Round Mountain

There are a few plausible explanations for these hummocks. The first is freeze-thaw. There are several proposed mechanisms for how freeze-thaw processes can create hummocks including cryoexpulsion, cellular circulation and differential frost heave (Grab, 2005). The most widely accepted of these theories is differential frost heave. The mechanism functions because the well vegetated tops of the hummocks insulates better than the less vegetated interspace. In the winter, the interspace freezes first,

Figure 5: Rounded hummocks at Blue Lake

expanding and compressing sediment up into the hummocks. This process may be induced by pre-existing variation in ground condition from vegetation, soil type, soild moisture or microtopography. It's conceivable to me that trampling by ungulates might create the variation in soil conditions necessary to induce hummock formation. Trampling, especially in wet areas, creates a rugose ground surface that collects water in small puddles. It also introduces variation in vegetation cover.

Large Hummocks

Beef Meadows and Stink Flat both had wide, flat hummock features that may be forming from a different process. These features were found near the edges of large hummock fields and could be over 6 feet long . The height of the hummocks was not very different from the smaller hummocks closer to the center of the site. I found that there were sometimes large pockets of exposed rocks within these large hummocks.

Figure 6: Large hummocks at Stink Flat

I'm still uncertain of what produces these collections of exposed rock. It could be that the ground surface was higher and has eroded away, leaving the larger clasts that could not be carried away by wind or water. It may be possible that frost push and pull has exposed these clasts by cryoexpulsion. If this is the case, rocks that have been pulled near the surface but have not yet been exposed to the surface may form

Figure 6: Exposed rock at site margin, Stink Flat

these larger hummocks. I didn't cross-section any of these larger hummocks, so I can't say if they contained large clasts. These large hummocks were found near other types so a similar process might be controlling both.

Vegetation "hummocks"

These are hummock-type features that are very well vegetated. They are often difficult to spot because of the height of the canopy cover. Sometimes, these features are called "tussocks" and are formed by the buildup of plant material. I'm not certain that any of the features here in Utah are true tussocks. Often, stepping on these features completely crushes them because they do not contain any soil or supporting structure. I don't think these features should be of high concern to the Trust or range managers. It's just important to categorize them to differentiate them from problem hummocks.

Figure 7: Vegetation "hummock" at Mud Lake, Tushars

Management Recommendations

Identifying problem hummocks

There are a variety of hummock-type features on the forests, possibly created and developed by multiple mechanisms. In order to find out which of these features are a problem, it's necessary to address the impacts these hummocks might be having. Dave Weixelman told me that hummocks can negatively impact surface flows by channelizing water, creating "preferential flow patterns". The hummocks stay dry, while the proximity to groundwater of the interspace keeps them wet. This results in a bifurcation of species in the area between wet and dry. Eventually the hummock tops might become too dry to support riparian vegetation while the interspace becomes too wet and trampled to support any vegetation at all.

You can see this easily at the Round Mountain site. There, grasses rather than a mix of riparian grass and grass-like species dominate the tops of the hummocks. Where the hummocks are tallest, the interspace is most bare.


Figure 8: Tall hummocks with bare interspace, Round Mountain

Percent bare ground is a staple indicator of range health. Talking to Kurt Robins, the District Ranger for the Fremont River ranger district, it seems that hummocking, by itself, is not used as an indicator. However, there are indicators that often coincide with hummocking or are exacerbated by the hummocks. Bare ground is one instance, another is slope shearing. The microtopography created by hummocking creates many opportunities to observe shearing in riparian areas. Hummocks may also increase utilization because the vegetation on top of the hummocks is easier to reach than the vegetation in the interspace. Basically, hummocks bring the ground closer to the ungulate's mouths allowing a higher level of utilization to be reached earlier in the season.


Figure 9: High utilization on hummock, Blue Lake

The coincidence of these indicators with hummocking has led to the interpretation by Kurt that hummocking is being exacerbated by ungulates but he stops short of saying that ungulates can cause these features in the first place. This opinion seems common among both scientists and range management professionals.

Figure 10: Color alteration on a rock, King's Pasture

One important indicator brought up by Brooke Shakespeare, hydrologist with the Dixie National Forest is cosmogenic alteration of rock color. Rocks exposed to the surface are altered by radiation from the sun. This alteration causes the exposed surface to change color however the process takes a significant amount of time. A relatively rapid drop in the land surface surrounding the rock exposes new surface area that has yet to be altered by the sun. This may be an indicator that the ground around a hummock has dropped rather than the hummock being pushed up.

Figure 11: Hummock with truncated A horizon

Another method for determining if hummocks are forming from an erosive or compaction process is to look at a cross-section of a hummock. By digging a trench across a hummock, you can reveal the shape of the A horizon of soil. A truncated A horizon on the edges of the hummock indicates that hoof action has sheared and compressed the area between hummocks, instead of hummocks being pushed upwards.

Hummock shape may also be an important indicator of the mechanism of formation. Some sites have almost all rounded hummocks. In other areas hummocks look elongated or even serpentine. Most cryogenic hummocks have a round shape. Grab (2005) mentions one area of "beaded hummocks" in a permafrost environment but I think that is not what I've observed on the forests here in Utah. In riverine systems, Hummocks are often elongated parallel to the bank.

Exclosures

Figure 12: Exclosure fenceline at Beef Meadows

The primary response to hummocking has generally been the same as the response to degraded riparian areas throughout the forest, exclosures. There is evidence that this response can be effective. Exclosures have been put in place at Beef Meadows (~1986), Danish Flat (2003) and Bown's Lake (date uncertain). Hummocking is significantly less apparent to the eye within these exclosures however it's less certain whether the exclosures are reducing the size or density of the hummocks. All exclosures exhibit significantly more litter cover because the vegetation is not being grazed. This litter cover tends to fill in interspace, creating the impression that the hummocks are becoming smaller. It also introduces difficulty in measuring the hummocks. In order to measure height, width and length its necessary to remove a significant amount of litter from on and around the hummock.

Anecdotal evidence at the Danish Meadows exclosure suggests that exclosing a hummocked area does indeed decrease size of the hummocks. After 2 years of exclosing the area, range specialist Dave Grider remarked in a photo-comparison report that the hummocks were "progressively 'melting' into this productive wet meadow". The litter in the exclosure was up to 3-4 inches deep in places.

Changing grazing pressure

Figure 13: Fenceline, King's Pasture on left, Garkane on right

The sites at King's Pasture and Garkane Power Plant provide an important look into how different grazing management can alter the degree of hummocking. King's Pasture has been grazed only by trespass cows for the last ten to fifteen years. Garkane Power Plant grazes at a higher intensity than the Forest Service would typically allow. Hummock density on the Garkane side was much higher than at King's Pasture (10,464 hummocks/hectare vs 4484 hummocks/ hectare). Hummocks at King's Pasture were slightly under an inch shorter on average. Unlike the exclosures mentioned before, this area has continued to have some grazing pressure so litter cover is not nearly as thick. This allows an easier comparison of the shape, height and density of hummocking at these locations. The comparison between these two adjacent sites shows that grazing can have a control on hummock morphology and density. This site should continue to be monitored, especially now that recently-built fences have totally removed grazing pressure from cows on the King's Pasture side.

Plans

Analysis

I plan to analyze all of the soil samples taken from both hummocked and non-hummocked areas for texture. This will produce a % clay, silt and clay content for soil at the site. This should give a better indication of whether frost-heave processes are possible in the hummocks sites. I also plan to find climate data for the sites surveyed to find whether conditions are right for cryogenic hummock formation.

I will be running statistical analysis comparing the different factors measured between sites to find if any of the factors are predictors of higher hummock density, taller hummocks, etc. I have a sample of a rock from King's Pasture that I suspect shows signs of cosmogenic alteration. I would like to confirm that with my professors back at Whitman and explore whether it is an good indicator for erosional hummock formation.

My goal is to create an simple and accurate categorization of the hummock types observed on the forests here in Utah. With this categorization, it should be easier to disentangle what types of hummocking should receive the most focus for restoration.

Presentation

I will be giving a preliminary presentation on my research at the Grand Canyon Trust homestead on August 15. I will be presenting a poster on my research and findings for the "Restoring the West" conference in Logan, UT in October. I may also present to Alan Rowley, forest supervisor for the Fishlake and Manti-La Sal National Forest in the Fall. My research will also be presented at the Whitman Undergraduate Conference in the spring of 2015.

Research

I plan to spend more time researching the indicators of ungulate-exacerbated or induced hummock formation mentioned earlier in the report. I am especially interest in length/width ratio as a simple indicator that freeze-thaw processes are not mechanism of formation. I also plan to look at the grazing history of many of the sites surveyed by looking at their AOI's.

Thanks Mary for another great summer!