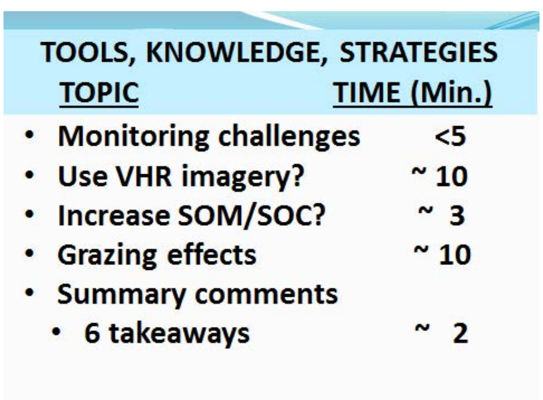
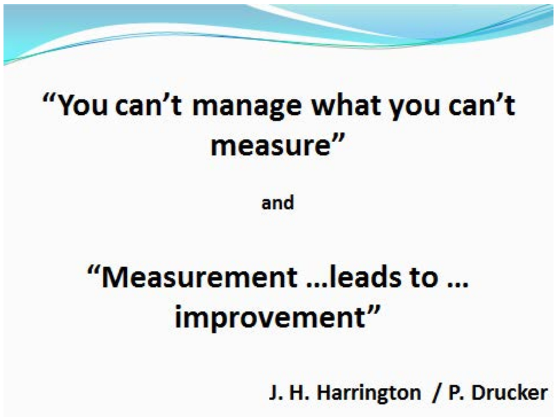
LeRoy Poff: Thank you very much, Stafford. That was very interesting. We all learned a lot from California's experience, hopefully you won't be experiencing it again any time soon.

Our next speaker is Dr. Terry Booth. Terry is a retired rangeland scientist from the USDA ARS and affiliate faculty at the University of Wyoming. So I guess Terry will bring us more of a riparian, terrestrial perspective on monitoring and management of head water streams to restore and maintain ecological services. So, Terry . . .

Dr. Terry Booth: Thank you, LeRoy. I'd like to recognize my co-authors, Sam Cox, who is with the State Office, Bureau of Land Management, Cheyenne, Wyoming; John Lichens is retired, Rangeland Management Specialist in Lander, Wyoming; and Jay Norton is Soils Extension Specialist, University of Wyoming.



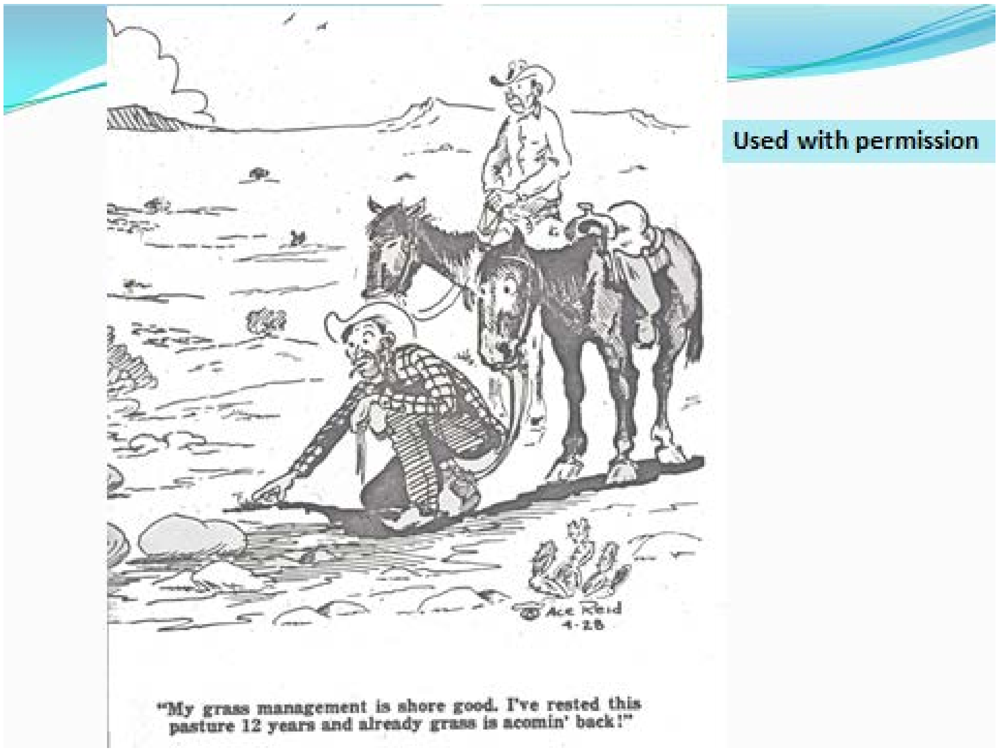
I'll be talking about tools, knowledge, and strategies. We'll start with less than five minutes on the challenges that we face in monitoring natural resources; about 10 minutes on how very high resolution imagery can help address those problems; three minutes reviewing the importance of soil organic matter to water storage; about 10 minutes on some exclosure studies that we used to measure grazing effects to wetland; and in summary comments I will review six things I hope you take away from the presentation.



We are all familiar with the above quotes,

but when faced with a vast resource such as shown in the above Landsat image (notice the narrow IR-red of the riparian areas), how do you get across that landscape to make meaningful measurements that give you dependable conclusions?

In the past, resource managers have used ocular estimates, including "windshielding". Ace Reed has commented on that with his character Slim (below) who you see doing an ocular estimate. But you also see that the other characters in the cartoon don't seem to agree with Slim's estimate. That's why we need measurements.



If you want dependable, change-detecting resource monitoring, it has to be practical. It has to be repeatable. It has to be affordable. And it definitely has to be measurements (Dan and Daniel talked about this in the workshop on Tuesday). And, we usually need measurements over time.

Effective Measurements :

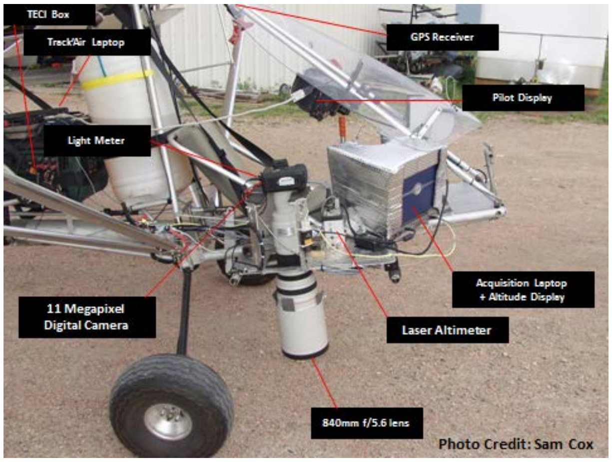
- Allow application of Statistical Science
- Have high sample numbers consistent with natural variation to reduce risk of false +s
- Sample distribution that is a true representation of area of interest

We want to use statistical science. One of the shortcomings that we often have in natural resource monitoring is that we don't get the sample numbers that we need to truly measure the natural variation in the system. That puts us at risk of a type two error, also called false positive.

The other problem in natural resource monitoring is our sample distribution. We need to get a true representation of the area of interest. That's why wind-shield monitoring doesn't work; it's biased by road locations and other accessibility challenges.

Dragonfly sport airplane with Rotax 4-stroke 115-hp turbo engine (Joe Nance, pilot). Photo Credit: Sam Cox

One way to address these natural-resource monitoring challenges is to use very high resolution (VHR) imagery. We used a light sport airplane to acquire images. Because the plane is light, it can fly slower, which reduces image motion blur.

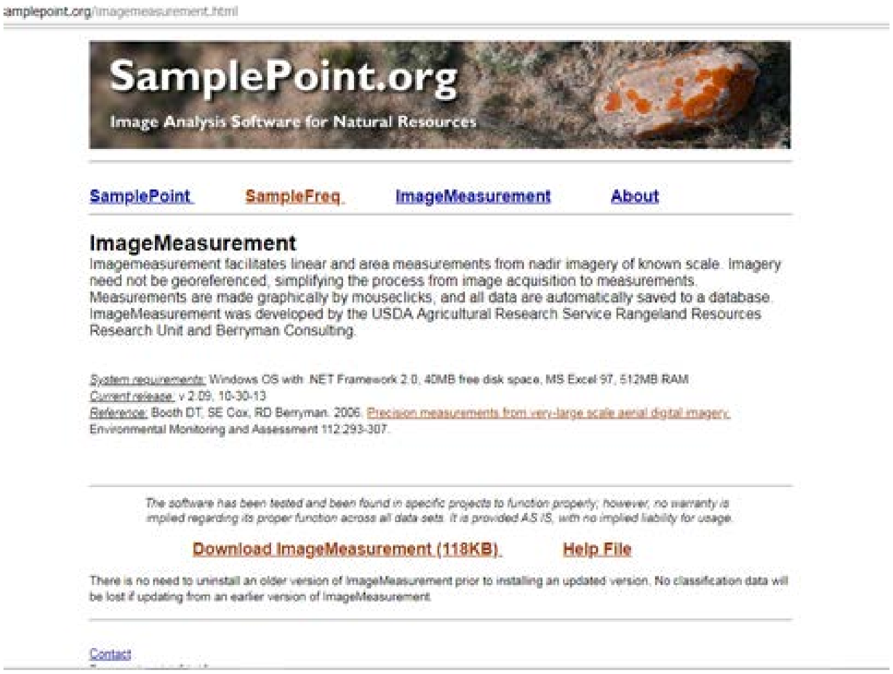


The photo above shows a close up of our very high resolution aerial photography equipment.

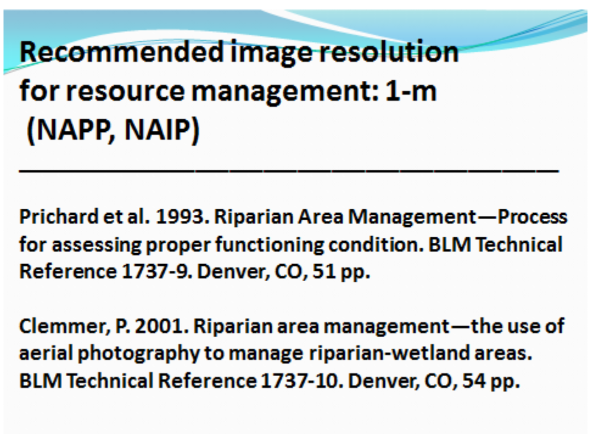
1 mm per pixel image resolution

How good is the system? It's good. The above one millimeter per pixel image captured a Mormon cricket sunning itself on a rock in Nevada. That's the kind of detail we can get.

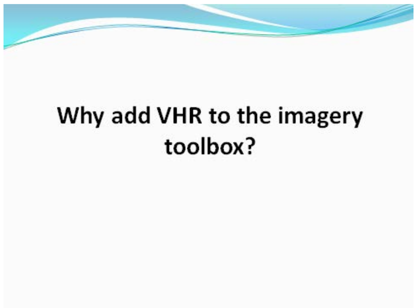
A problem with this imagery is that “off-the- shelf” software to evaluate images couldn't handle the high detail in high-resolution images. We worked with programmer Bob Berryman developing SamplePoint, ImageMeasurement, and SampleFreq (below) which are software programs for analyzing high-resolution images. ImageMeasurement is the program that we've used most in our riparian work and I will be showing application examples.



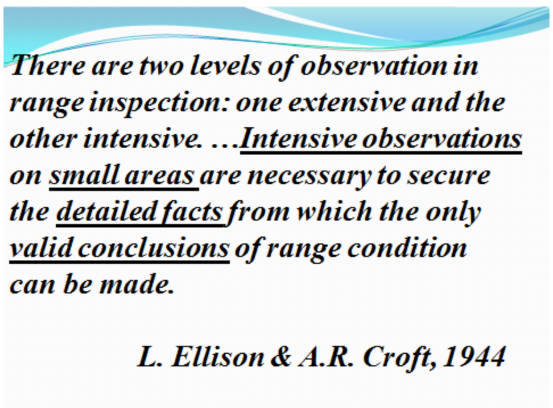
These programs are free online (above), courtesy of the U.S. taxpayers. To download, go to samplepoint.org, or google SamplePoint; this site is usually the first site up.



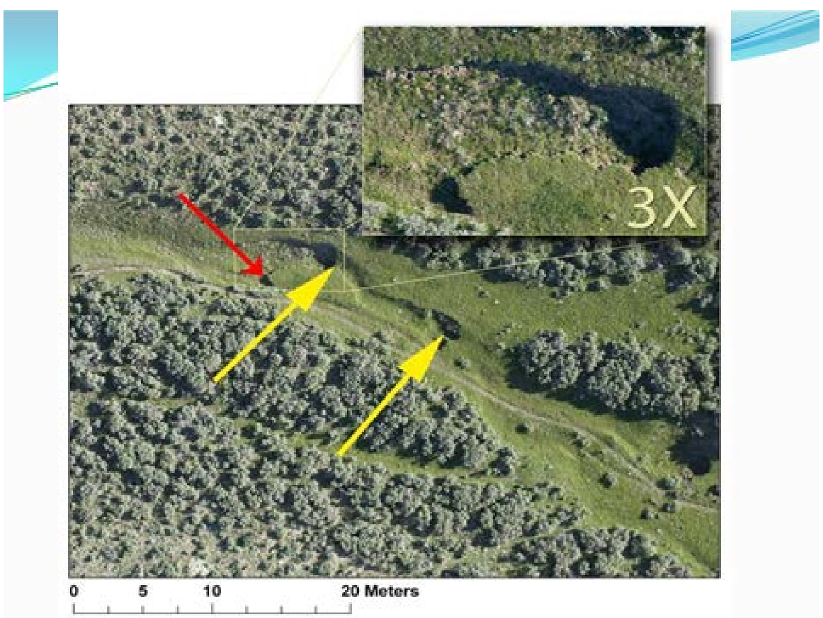
Above I cite two publications recommending 1-m imagery (1,000 millimeters) for riparian / wetland monitoring and management. We maintain that the 1-m imagery does not give enough detail and must be used with VHR imagery for effective monitoring.



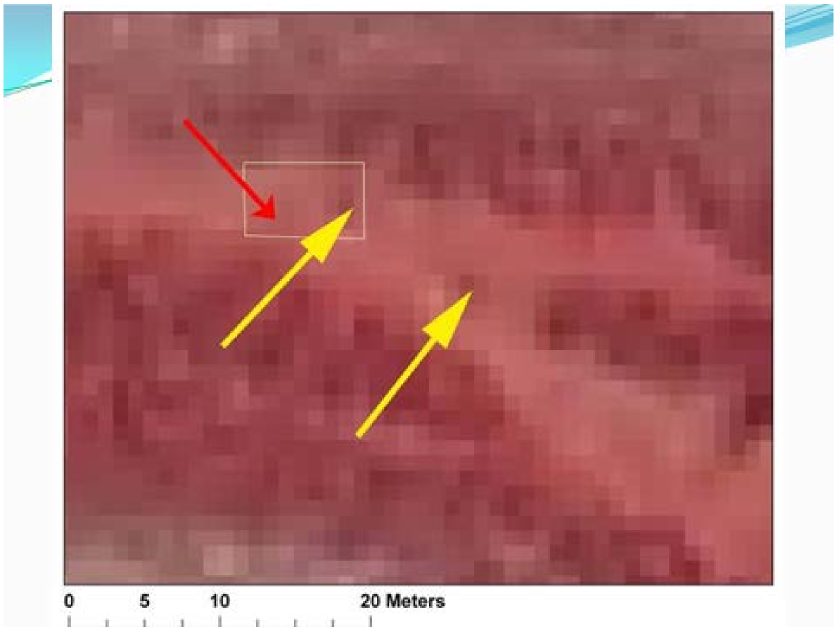
Why add the very high resolution to your toolbox? Here's some reasons.



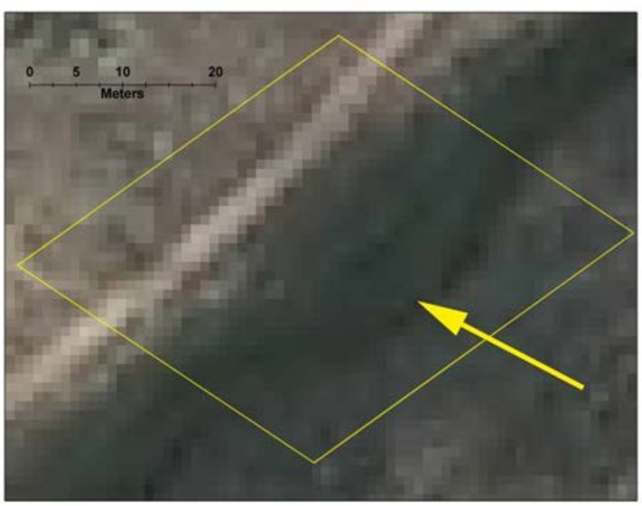
Back in 1944, two of the founding fathers of resource inventory emphasized (above) the importance of intensive observations to obtain "detailed facts" to support "valid conclusions".



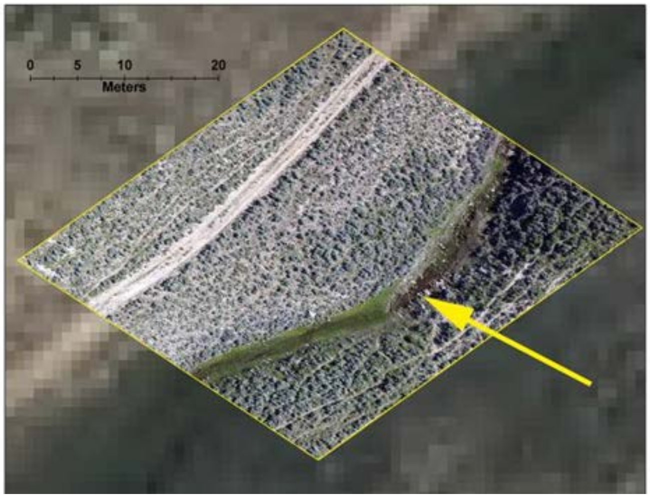
Here are examples of what they were talking about. Above is a VHR image between 10 and 20 millimeters per pixel. You can see an old cow trail and the red arrow points to a head cut following the old trail. You can also see a new trail on higher ground. And, you see the other head cuts.



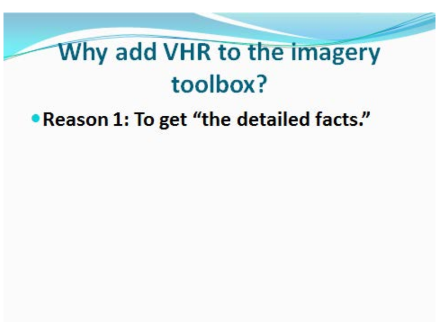
Above, is the same view at the standard 1-m resolution image. You can't see cow trails. You can't see head cuts. You can't see the detail that you need to make valid conclusions about the resource condition.



Another example; above is a scene from the standard 1-m resolution imagery and below is the scene at VHR (10 to 20 mm per pixel) image. At the higher resolution you see a headcut chewing up a stringer meadow and spitting out the organic matter and the water storage capacity of the system.



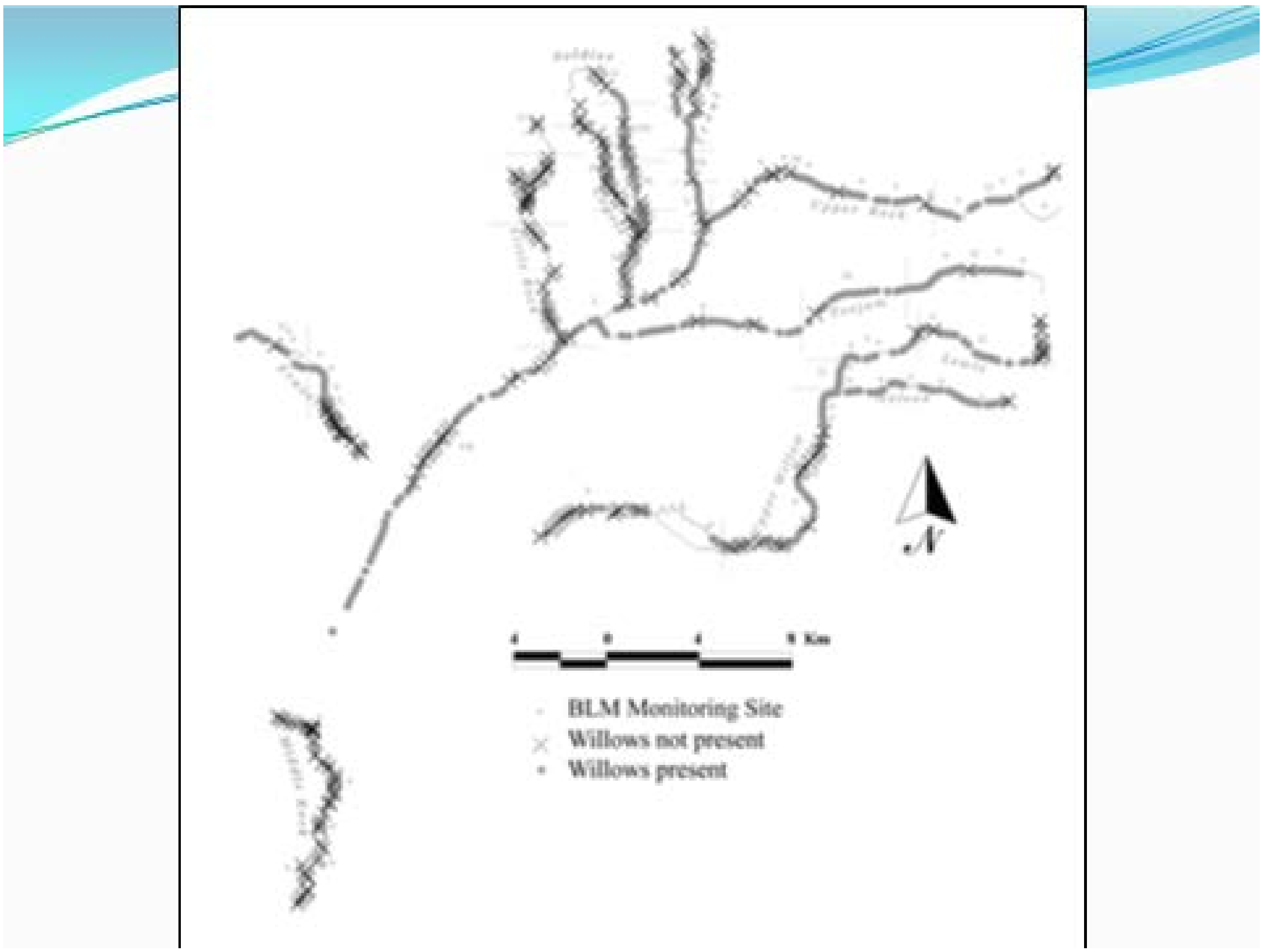
We have to be able to see these problems if we're going to keep our organic matter and our water storage capacity. We have to be able to see the head cuts. We have to be able to see the cow trails.

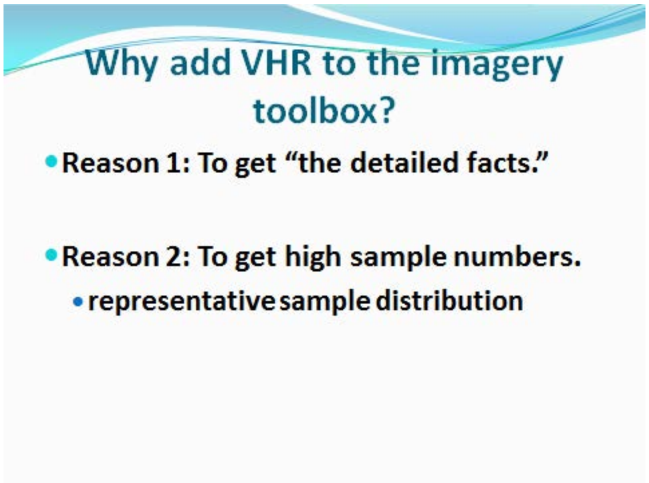


So, the first reason to add VHR imagery to your tool box is to get the "the detailed facts from which the only valid conclusions of [resource] condition can be made."

The question in one of our riparian projects was whether a conservation grazing system was allowing willow recovery? The graphic below illustrates image acquisition for the project. Every X on the graphic means no willows detected and every dot means willows were visible in the image. But this graphic also illustrates the very large number of samples (images) that we obtained within this riparian system.

When using VHR imagery we do not acquire continuous coverage. It's not “wall to wall”; it's samples, at regular intervals, and as you can see we collected hundreds of samples of this watershed.





The second reason to use VHR imagery is to get high sample numbers, reduce the type-two error risk, and get a sample distribution that represents your resource and area of interest.

The image above is of a stream in Nevada where the BLM was doing proper-functioning-condition assessment. They asked us to work with them by doing an aerial proper-functioning-condition assessment.

Riparian Aerial Survey 2004 Costs

Item	Rate ($)/hr	Time (hr)	Cost ($)
Flight costs			
air time	125	6.5	813
pilot grd time	40	13	520
Ground time (flight plan / support)			
	25	65	1,625
Travel costs (2 salaries)			
	25/40	47	3,055
		Total	6,013

We flew the project in 2004 at a cost of $6,000 and collected images for 770 sites in the riparian system. We used ImageMeasurement to get stream width, and other measurements from the images. Below is an ImageMeasurement screen shot illustrating use of the software for stream-width measurements.

Riparian Aerial Survey Image analysis Costs

Item	Rate ($)/hr	Time (hr)	Cost ($)
Image analysis			
measurements (ImageMeasurement)			
	25	30	750
data entry/organization in GIS			
	25	40	1,000
PFC from aerial photos (8 streams)			
	170	8	1,364
		Total analysis	3,114
Total All Aerial Costs (770 Sites)			9,127

The cost to do the image analyses was $3,114 for a total project cost of around $9,000.

Actual salary costs for BLM stream assessments and measurements

- Rate = $43/hr
- Time = 530 hr
- Cost $= $22,586 (60 sites)
  - Salary cost information is courtesy of C. Evans, Fisheries Biologist, BLM Elko, Nevada Field Office (personal communication, 18 November 2005).

The BLM ground evaluation required 530 hours to look at 60 sites (versus 770) at a cost of $22,500.

Why add VHR to the imagery toolbox?

- Reason 1: To get "the detailed facts."
- Reason 2: To get high sample numbers.
  - representative sample distribution
- Reason 3: To reduce monitoring costs.

The third reason to use VHR imagery is that it saves money by avoiding most of the cost (time) of ground travel.

Bad news: Few service providers

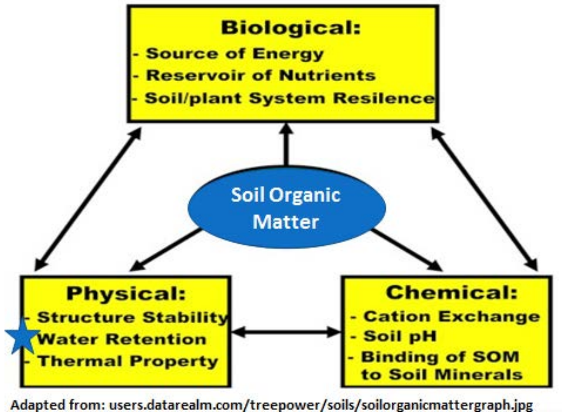
Now the bad news; there are not many aerial-photography companies that will supply VHR imagery. Some helicopter companies will do it but using helicopter usually bumps the cost up.

Good news: You can now get your own aerial system

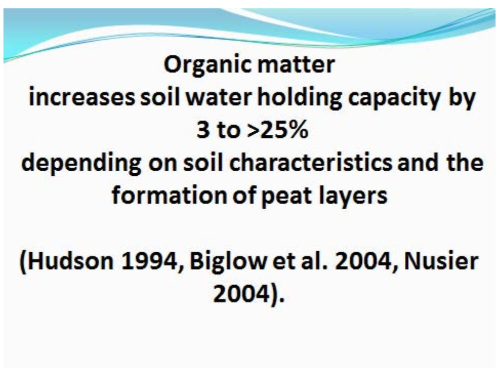
The good news is, you can get your own aerial system. The above photos show Sam Cox operating a BLM drone.

1 mm per pixel image resolution

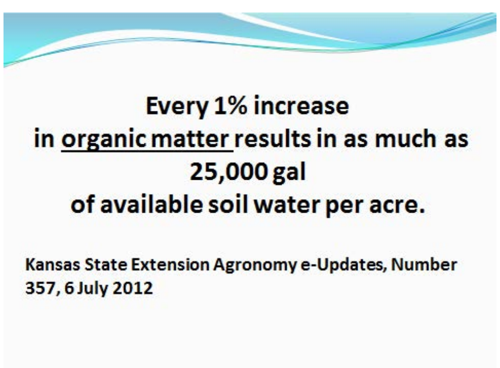
Sam has been able to get one millimeter per pixel resolution. That's putting the drone pretty close to the ground but he's learning how to do it.

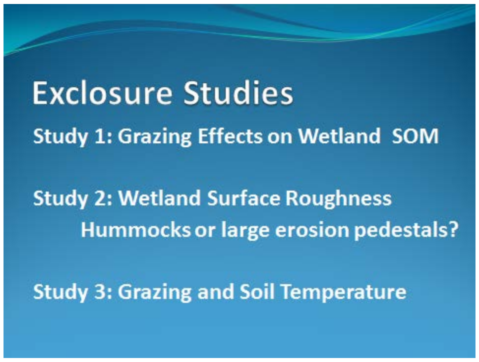


Now let's go to soil organic matter (SOM). SOM has three main function areas, biological, physical, and chemical. For now let's focus on water retention (physical).

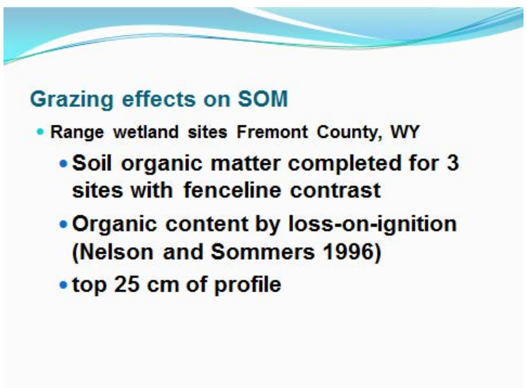


Above I cite three papers reporting the effect of increasing SOM on soil water-holding capacity. Add to that the Kansas State Extension report cited below, describing the SOM-water-storage relationship on a per acre basis. Land management that is increasing SOM is management for increasing instream flow.

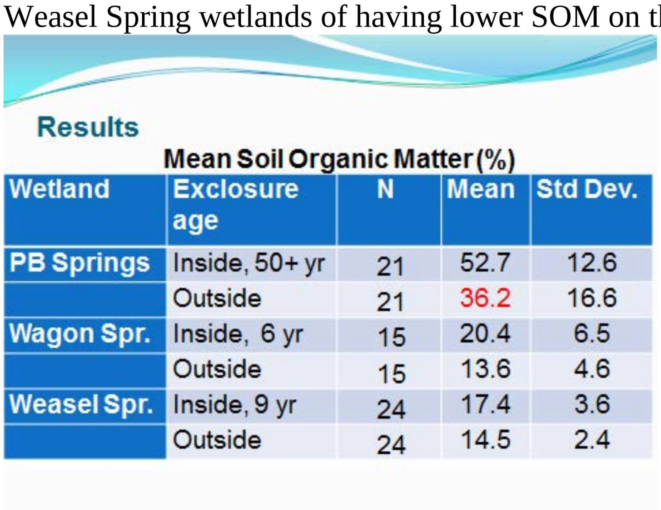




Next, let's consider grazing effects as measured by fenceline contrasts.

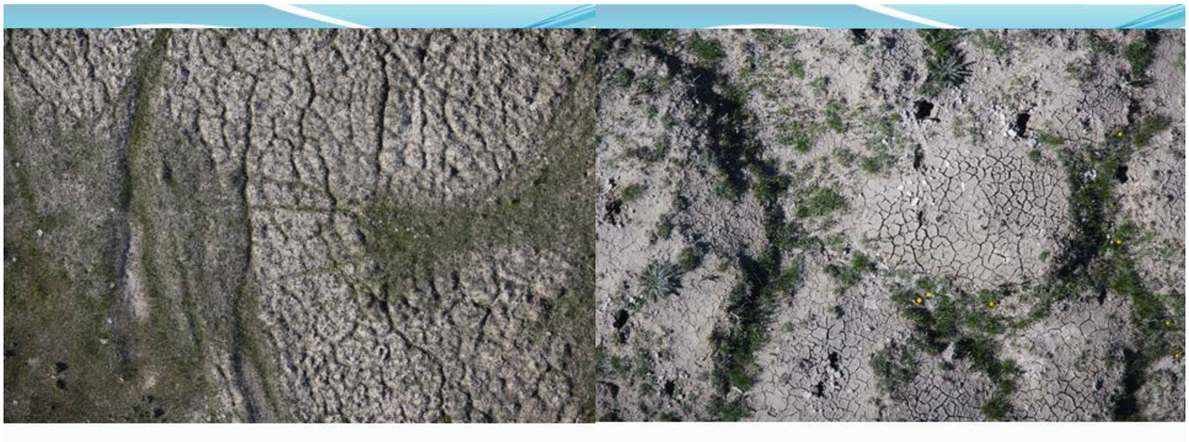


We used fenceline contrasts provided by two public-land grazing exclosures, and a private pasture, to compare SOM inside/outside using the loss-on-ignition method for the top 25 centimeters of the soil profile. The results are tabulated below. The PB Spring private pasture had been conservatively grazed for 50+ years and SOM = 53%; outside it was 36%. The 36% is in red because I believe that number is biased by having the transect too close to the fence so that upstream SOM moving downstream resulted it a measurement that was not representative of the heavily grazed wetland. Nevertheless, it is consistent with the trend from the Wagon Spring and Weasel Spring wetlands of having lower SOM on the more heavily grazed areas.


Results

Mean Soil Organic Matter (%)

Wetland	Exclosure age	N	Mean	Std Dev.
PB Springs	Inside, 50+ yr	21	52.7	12.6
	Outside	21	36.2	16.6
Wagon Spr.	Inside, 6 yr	15	20.4	6.5
	Outside	15	13.6	4.6
Weasel Spr.	Inside, 9 yr	24	17.4	3.6
	Outside	24	14.5	2.4



Above are images of a remnant wetland; the findings of the next two studies help us understand the processes that leads from a proper-functioning-condition wetland to land like that show above (the second image is a close-up of the first).

The second study was of wetland surface roughness as illustrated below by an over-grazed horse pasture in Iceland. Similar wetland conditions been reported by Kafke (2008) from Transcaucasia Georgia (second image below), a country Rebecca also talked about yesterday in her noon presentation. The third and fourth images below are examples from Colorado and Wyoming, US. Wetland surface roughness is present in Iceland, in Georgia, in the US, and in other places around the world where wetlands are grazed.

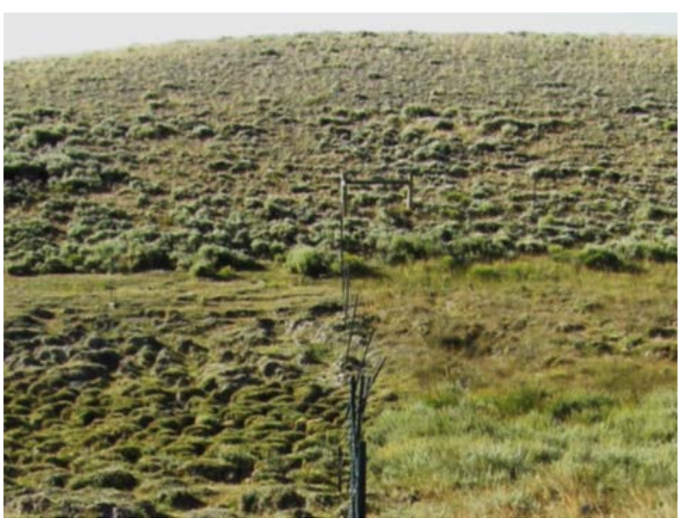
There are a number of papers that conclude grazing is a cause for a rough wetland surface—often referred to as hummocks, sometimes and more accurately, as large erosion pedestals. However, no paper we found had sufficient data to support that conclusion. Therefore we retested the question.

Iceland (Magnusson et al. 1998)

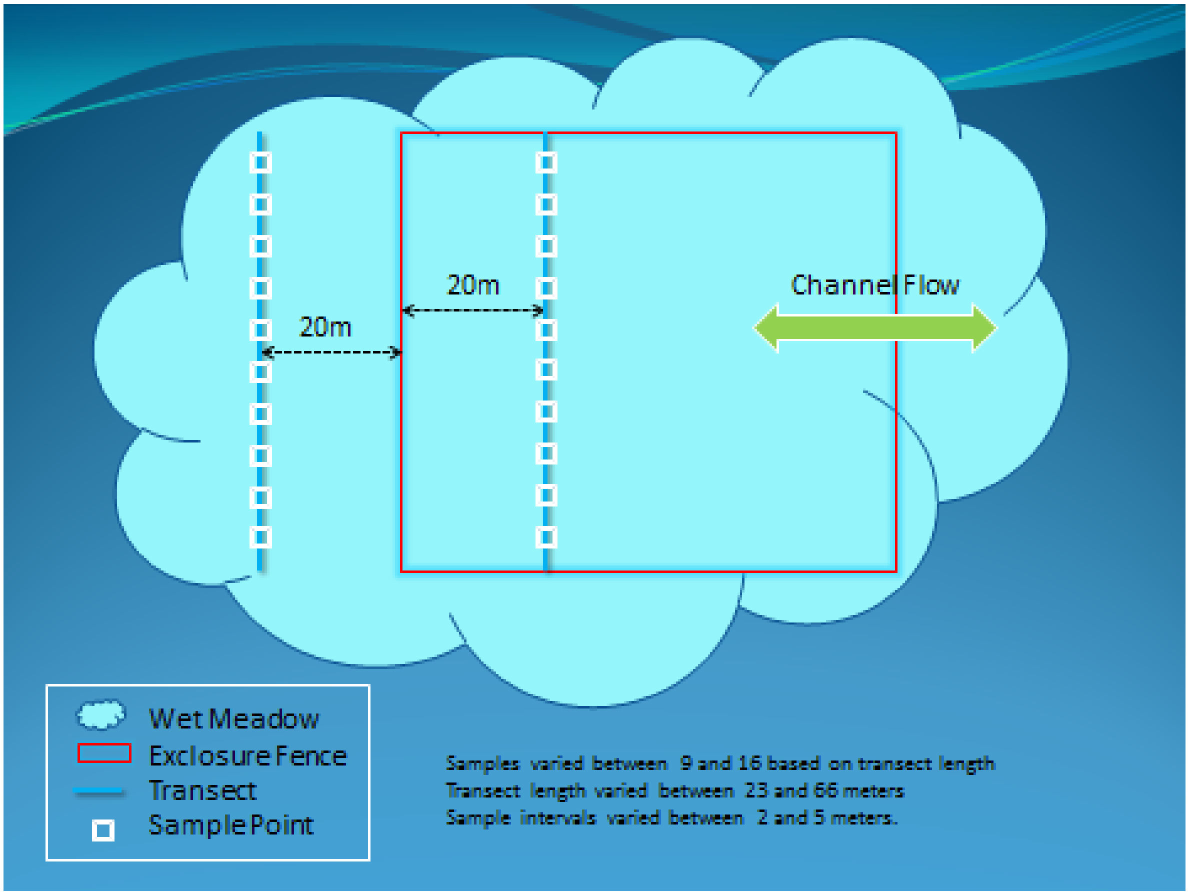
“…peat compaction by cow trampling …leads to increased surface water run-off , larger water level fluctuations, and …to a disturbance of peat accumulation.”

A. Kaffke (2008) Phytocoenologia 38:161-176

Colorado, US (Johnson and Cary 2004)



Above is a fenceline contrast at one of six exclosures we used in our second study of grazing effects. We tested the question of grazing as a cause of wetland surface roughness using the design show below.



We collected data from an erosion bridge (also called a pin meter), by photographing pin height as shown above. We used ImageMeasurement to measure pin height above the leveled bar from the photographs. We calculated the pin-height standard deviation which we used as a surface roughness index (SRI).

Mean Surface Roughness Index (SRI) by Site and Exclosure

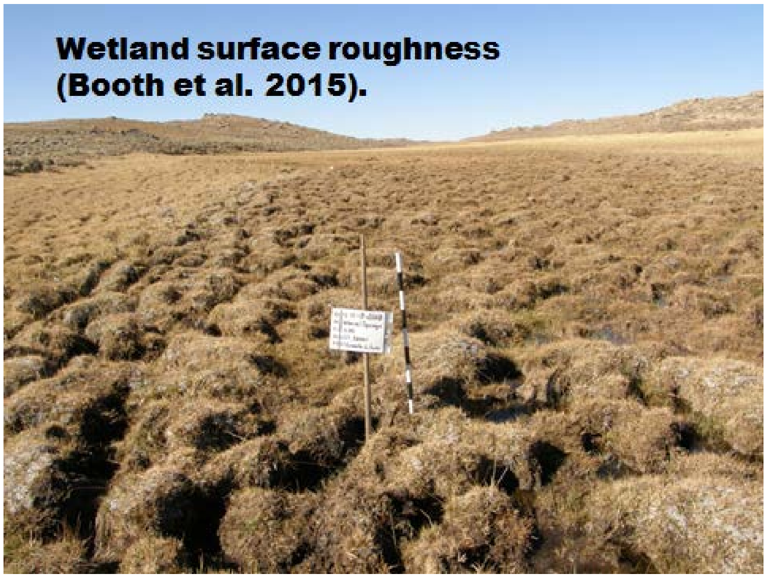
Site	Inside	Outside
PB Spring	20.6	107.7
Atlantic East	67.3	66.7
Atlantic West	59.5	116.6
Gilespie North	35.5	58.3
Gilespie South	33.9	53.1
Long Creek	35.1	87.4
MEAN	**42.0**	**81.6**

ANOVA

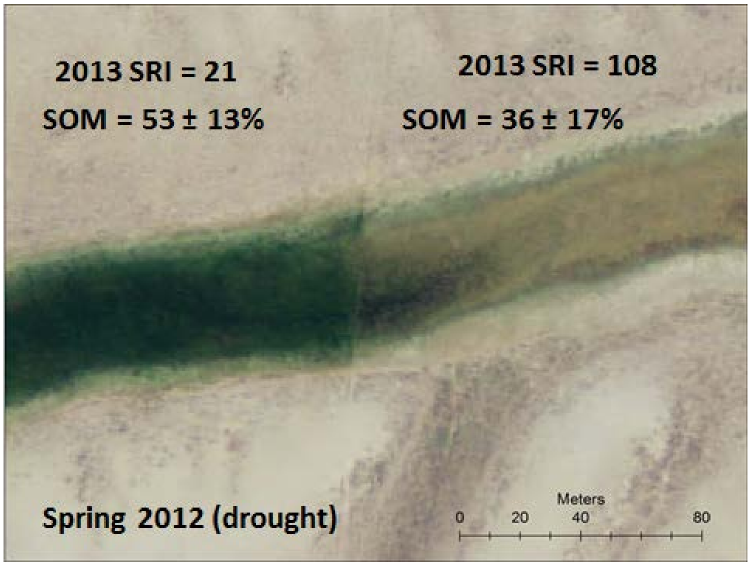
Source	DF	Type III SS	Mean Square	F Value	Pr > F
site	5	30329.94990	6065.98998	2.64	0.0264
exclosure	1	48522.51957	48522.51957	21.10	**<.0001**

PB Spring pasture (50+ years light grazing) had a SRI of 20 compared to outside the pasture fence where the SRI was 108. As you can see the inside/outside trend was the same at all sites and the difference was highly significant, indicating that surface roughness is due to grazing by livestock. This <u>is</u> a cause and effect relationship and supports earlier papers making that claim.

The above image shows the PB pasture inside the fence (SRI=20) as it looked October 2009.



Compare the PB pasture with the above unfenced wetland (October 2008 photo) that is an example of a high SRI wetland.

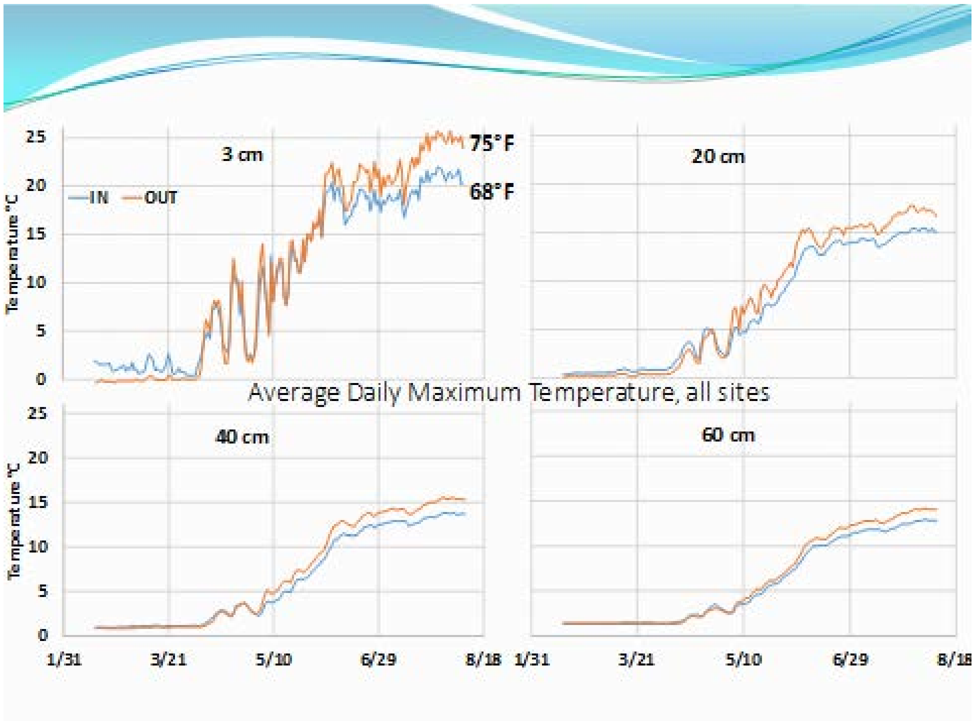


If you looked at the meeting posters, you know that in 2012, Colorado and Wyoming experienced a serious drought. This is what the PB wetland looked like during that drought. Inside the fence (left) where the SRI is low and the SOM is high, there's water supporting green vegetation. You can see some water leaking downstream but for most of this wetland below the fence (grazed), there's no water. The wetland vegetation is brown. It's dormant.

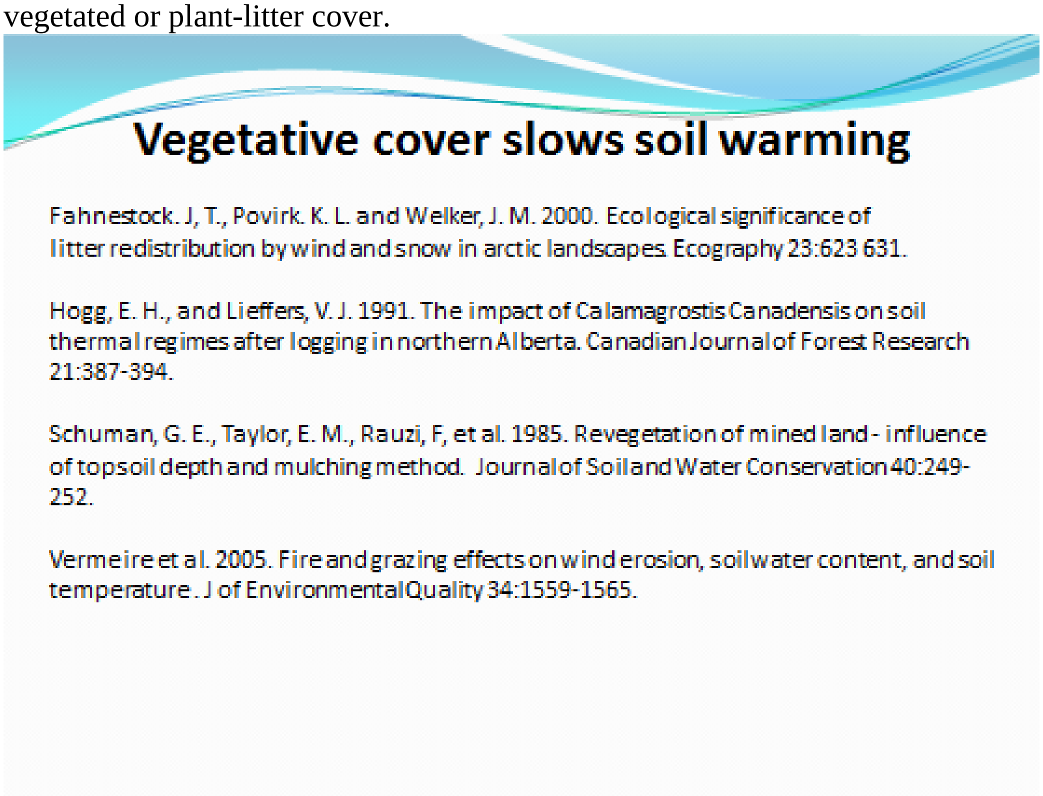
Consider the low SRI part of the PB wetland. If we had that kind of wetland all the way down to the Sweetwater River, how much water would be added for maintaining instream flow during drought?

Our last study was an investigation of soil-temperatures as influenced by grazing. We used iButton temperature loggers--Dan and Daniel also talked about these miniature temperature sensors / loggers. We looked at wetland soil temperatures at 3, 20, 40, and 60 cm depths.

The sensors where enclosed in PVC housings as shown above, and the housings inserted into the soil profile to the desired depth as shown below.

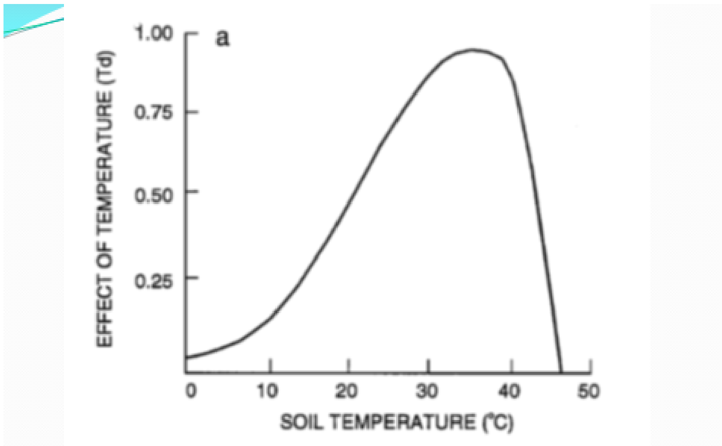


The image above shows average daily maximum temperatures across all six study sites (exclosures), for the four depths. (This is the first year of the two years for which we have data). Notice that at every depth the soil is cooler under ungrazed vegetation (blue line). Even down to 60 centimeters it's cooler under the vegetation. Our data are not fully analyzed, so you may wish to consider the four publications, shown below, that support the finding of cooler soils under a vegetated or plant-litter cover.



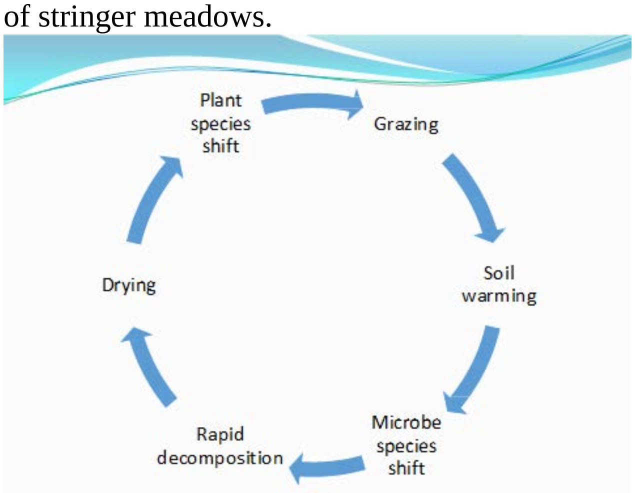
Why is it important to keep wetland soils cool? Besides the obvious reduction in evaporation and transpiration, there is also an effect on SOM.

Effect of soil temperature on decomposition rate

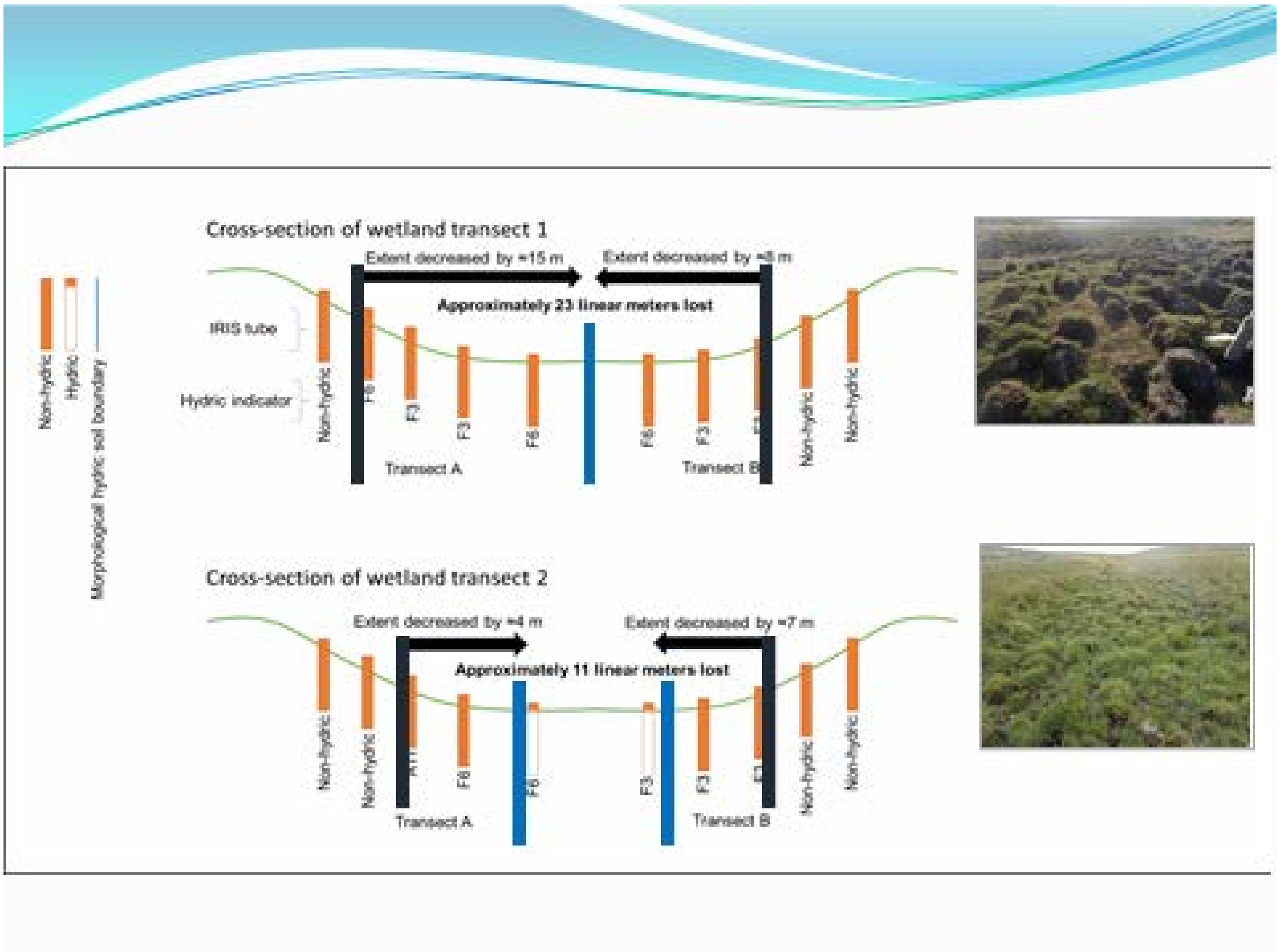


Parton, W. J., et al. 1993. Observations and modeling of biomass and soil organic matter dynamics for the grassland biome worldwide, Global Biogeochem. Cycles 7:785–809

Parton et al. (1993) found that as the temperature increases, the decomposition of the water-storing SOM increases. Decomposition of SOM, whether in grasslands or wetlands, has been described (Conant 2011) as more complicated than is implied by Parton's graph; however, the graph conveys the basic information that helps explain part of the reason we are losing the edges of stringer meadows.



Above, we illustrate what we think is happening. When a wetland is grazed the soil warms triggering rapid SOM decomposition. Over time that creates a drier site. As the sequence is repeated, the wetland conditions begin a downward spiral as evidenced below.

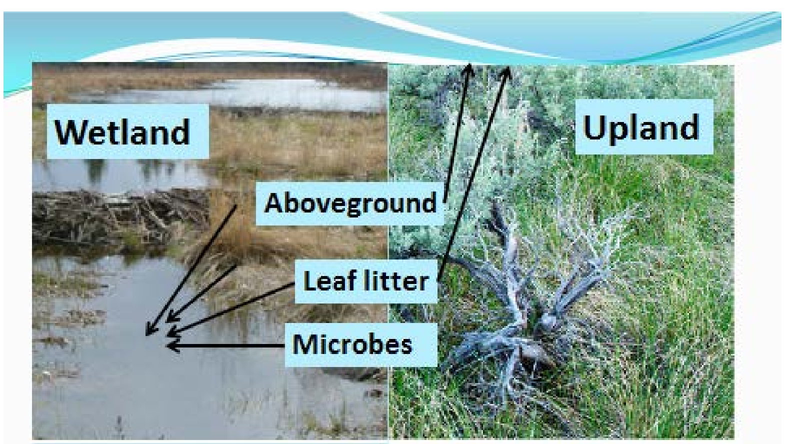


Dr. Norton and his graduate student used cross-sectional transects to test for wetland losses in headwater stringer meadows. They employed IRIS (Indicator of Reduction In Soils) tubes (above) as hydric indicators. In both transects they found the wetland shrinking in width with losses of 23 and 11 linear meters of wet meadow cross-section.

The aerial photo below shows an example of losing the edge of stringer meadows. The upper right appears to be low SOM remnant wetland. Diagonally through the middle from upper left to lower right appears to be drying wetland—wetland that is being lost due to high SRI and decreasing SOM. The lower left is still wetland but has a high SRI.

The above image shows the PB wetland above and below the fence in color IR, one-meter resolution. Note how the wetland below the fence is shrinking towards the middle of the stream.

From these studies, I conclude that our wetland vegetation is too valuable to be used for cow feed. We need the vegetation in place for the SOM. We need it in place for spring runoff—particularly that unusual year like the upper Rio Grande in 2017 where they had 780% of average snow pack (www.wcc.nrcs.usda.gov/ftpref/data/water/wcs/basinsweplots). We need it to slow run off; spread it out; and increase infiltration and ground-water recharge.



In wetlands most plant C is sequestered (adapted from http://loer.tamug.edu/research.htm)

Finally, we know that most all wetland vegetation is sequestered. It goes into the ground. It becomes organic matter. It stores water. That contrasts with uplands where you should graze because you're not going to save that above-ground carbon anyway.

I recommend that we work toward getting the cows off of our wetlands / riparian areas and that we put them under efficient irrigation systems on low-water-use forages that produce more cow feed with a fraction of the water that, for example, Nebraska sedge or willows will produce.

We need the cows. We also need the water. Moving cows onto water-efficient pasture systems is a way to manage for livestock and for water conservation.

I am excited that many people are now recognizing the importance of beaver for repairing damaged streams and for increasing water storage on the landscape. Increased water storage is not just from pond formation. The organic matter that beaver put in the water is an important factor increasing the capacity of wetlands to be an “organic sponge”. Beaver also increase infiltration to the groundwater (Apple 1985, Collins 1993, Westbrook et al. 2006) likely contributing to aquifer replenishment.

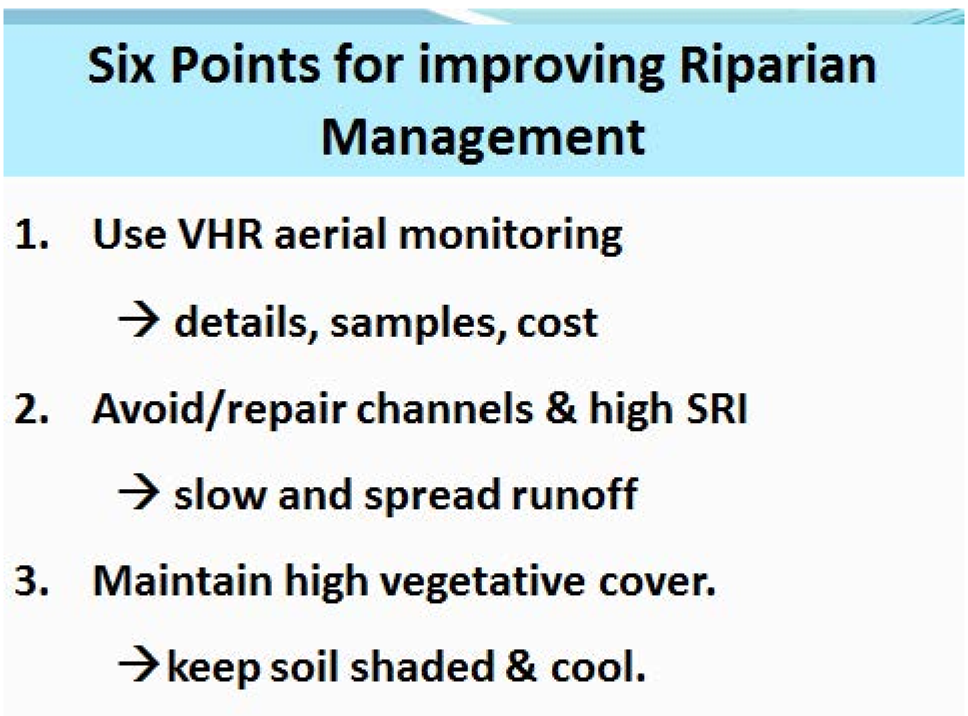
To maintain beaver populations on grazed uplands it is often helpful and sometimes required that the beaver colony be protected from competition with livestock. Consider the example below from the Laramie Range west of Cheyenne, Wyoming. The five images from Google Earth (2014) show four remaining riparian exclosures of six that were constructed fall 1984 (Henszet et al. 1991). The existing exclosures are outlined in yellow. Red lines in the 4th and 5th images indicate detectable fencelines of a removed exclosure. The images are arranged by elevation (note overlap in 3rd and 4th images).

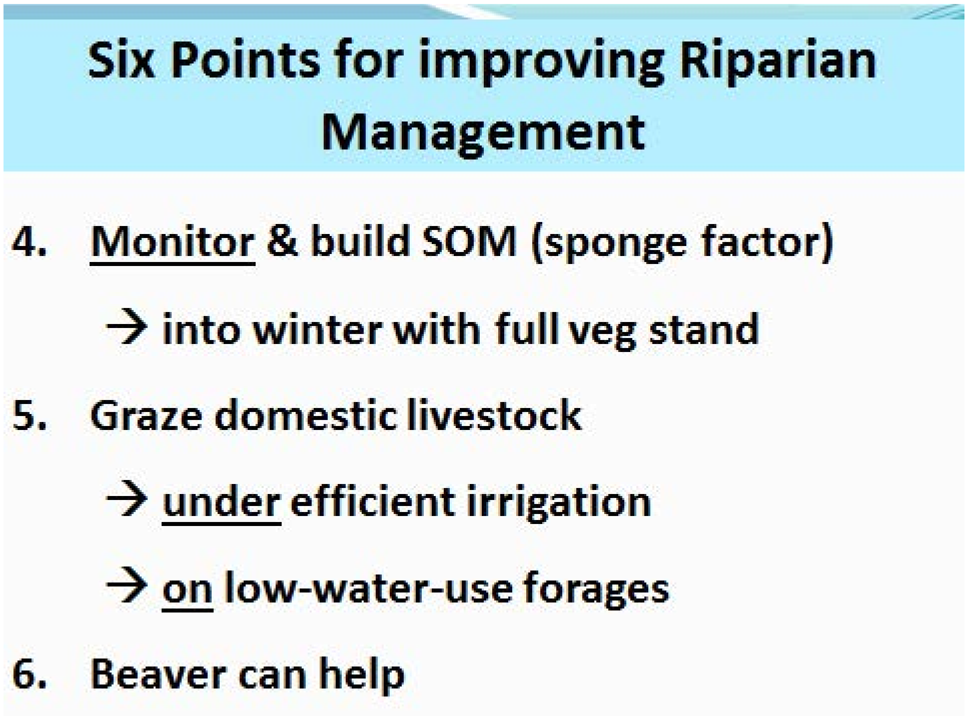
Note that in all four exclosures the density of beaver dams and amount of surface water behind beaver dams, exceeds or greatly exceeds, that on adjacent land not protected from grazing. The evidence suggests that to increase water storage in riparian systems with a sequence like that shown below may require that beaver not have to compete with livestock.

Photo credit: http://www.ecology.info/beaver-ecology.htm

There are alternatives to beaver-dam systems for stream repair and for increasing ground-water recharge. Some alternative systems / methods are illustrated above; however, I question the relative cost-benefit ratio of such systems wherever habitat restoration might support beaver.

Summary:





The six points main points we have discussed are:

1. Very high resolution imagery will help you get the details necessary for valid conclusions about resource conditions; it will help you get the high sample numbers and representative sample distributions; it will reduce your monitoring costs.

2. Headwater wetlands / riparian systems need to be managed to avoid channels and high surface roughness index so as to slow water flow and spread water out, thereby increasing infiltration and storage.

3. Maintaining a vegetative cover will help keep soils cool thereby reducing the decomposition rate of the water-storing wetland SOM and slowing evaporation and transpiration.

4. Monitor wetland SOM. Know if land management practices are increasing or decreasing the “organic sponge”; go into the winter with a full stand of vegetation in all riparian systems.

5. Graze domestic livestock off the wetland, under efficient irrigation, on low-water-use forages.

6. Beaver can help restore damaged streams, increase riparian SOM, slow and spread water, and increase infiltration and ground-water recharge.

References

Apple, L.L. 1985. Riparian habitat restoration and beavers. Paper presented at the Riparian Ecosystem Management Conference. www.fs.fed.us/rm/pubs_rm/rm_gtr120_489_490.pdf.

Bigelow, C.A., D.C. Bowman, and D.K. Cassel. 2004. Physical properties of three sand size classes amended with inorganic materials or sphagnum peat moss for putting green root zones. Crop Science 44:433-435.

Booth, D.T., S.E. Cox, and R.D. Berryman. 2006. Precision measurements from very large scale aerial digital imagery. Environmental Monitoring and Assessment 112:293-307.

Booth, D.T., S.E. Cox and R.D. Berryman. 2006. Point Sampling Digital Imagery with 'SamplePoint'. Environmental Monitoring and Assessment 123:97-108.

Booth, D.T., S.E. Cox and G.E. Simonds. 2006. Riparian monitoring using 2-cm GSD aerial photography. Journal of Ecological Indicators 7:636-648.

Booth, D.T. and S.E. Cox. 2008. Image-based monitoring to measure ecological change. Frontiers in Ecology and the Environment 6:185-190.

Booth, D.T., and S.E. Cox. 2011. Art to science: Tools for greater objectivity in resource monitoring. Rangelands 33:27-34.

Booth, D.T., S.E. Cox, G. Simonds and E. Sant. 2012. Willow cover as a recovery indicator under a conservation grazing plan. Ecological Indicators 18:512-519.

Booth, D. T., and S.E. Cox. 2015. Resource Management in Rangeland. In: T.G. Mueller, G. F. Sassenrath, and S.A. Shearer (editors), GIS Applications in Agriculture – Conservation Planning. CRC Press. Boca Raton, Florida.

Booth, D.T., S.E. Cox, J.C. Likins 2015. Fenceline contrasts: Grazing increases wetland surface roughness. Wetland Ecology and Management 15:183-194.

Booth, D.T., P.J. Meiman, and J. C. Likins. Unpublished report: Fenceline contrasts in high-elevation wetlands of a sagebrush ecosystem: soil organic matter. On file with D.T. Booth.

Clemmer, P. 2001. Riparian area management—the use of aerial photography to manage riparian-wetland areas. BLM Technical Reference 1737-10. Denver, CO, 54 pp.

Collins, T. 1993. The role of beaver in riparian habitat management. Wyoming Game and Fish Department, Habitat Extension Bulletin 38.

Conant, R.T., M.G. Ryan, G.I. Agren, et al. 2011. Temperature and soil organic matter decomposition rates– synthesis of current knowledge and a way forward. Global Change Biology 17:3392–3404, doi: 10.1111/j.1365-2486.2011.02496.x

Cox, S.E., D.T. Booth, and J.C. Likins. 2016. Headcut erosion in Wyoming's Sweetwater subbasin. Environmental Management 57:450–462.

Fahnestock, J.T., K.L. Povirk, and J.M. Welker, 2000. Ecological significance of litter redistribution by wind and snow in arctic landscapes. Ecography 23:623 631.

Gibson, P.P. and J.D. Olden. 2014. Ecology, management, and conservation implications of North American beaver (*Castor canadensis*) in dryland streams. Aquatic Conservation: Marine and Freshwater Ecosystems 24:391-409.

Gurnell, A.M. 1998. The hydrogeomorphological effects of beaver dam-building activity. Progress in Physical Geography 22:167-189

Hafen, K. 2017. To what extent might beaver dam building buffer water storage losses associated with declining snowpack. All Graduate Theses and Dissertations 6503. http://digitalcommons.usu.edu/etd. Accessed 6 June 2018.

Henszey, R.J., Q.D. Skinner, and T.S. Wesche. 1991. Response of montane meadow vegetation after two years of streamflow augmentation. Regulated Rivers: Research & Management 6:29-38.

Hogg, E.H., and V.J. Lieffers. 1991. The impact of *Calamagrostis Canadensis* on soil thermal regimes after logging in northern Alberta. Canadian Journal of Forest Research 21:387-394.

Hudson, B.D. 1994. Soil organic matter and available water capacity. Journal of Soil and Water Conservation 49:189-194.

Johnson B, and T. Carey. 2004. Cows and ditches make fen delineation a unique challenge or lessons learned in delineating an impacted, subalpine fen. Aquatic Resources News 3 (4):9-12

Kaffke, A. 2008. Vegetation and site conditions of a Sphagnum percolation bog in the Kolkheti Lowlands (Georgia, Transcaucasia). Phytocoenologia 38:161-176

Kansas State Extension. 2012. The value of soil organic matter. Agronomy e-Updates Number 357, 6 July (www.agronomy.k-state.edu/documents/eupdates/eupdate070612.pdf). Accessed 4 June 2018.

Magnusson, B, A. Elmarsdottir, B.H. Barkarson.1998. Horse ranges – a method to assess range condition. Agricultural Research Institute, Keldnaholt, 112 Reykjavik, Iceland. http://www.rala.is/umhvd/hhagar/edefault.htm. Accessed 20 Dec 2013.

Nelson, D.W. and L.E. Sommers. 1996. Total carbon, organic carbon, and organic matter. Chapter 34 in *Methods of Soil Analysis. Part 3. Chemical Methods.* Soil Science Society of America Book Series no. 5 SSSA, Segoe Rd., Madison, WI 53711, USA.

Nusier, O.K. 2004. Influence of peat moss on hydraulic properties and strength of compacted soils. Canadian Journal of Soil Science 84:115-123.

Parton, W. J., J.M.O. Scurlock, et al. 1993. Observations and modeling of biomass and soil organic matter dynamics for the grassland biome worldwide, Global Biogeochemical Cycles 7:785–809.

Prichard, D., et al. 1993. Riparian Area Management—Process for assessing proper functioning condition. BLM Technical Reference 1737-9. Denver, CO, 51 pp.

Schuman, G. E., E.M. Taylor, F. Rauzi, et al. 1985. Revegetation of mined land - influence of topsoil depth and mulching method. Journal of Soil and Water Conservation 40:249-252.

Vermeire, L.T., D.B. Wester, R.B. Mitchell, and S.D. Fuhlendorf. 2005. Fire and grazing effects on wind erosion, soil water content, and soil temperature. Journal of Environmental Quality 34:1559-1565.

Westbrook, C.J., D.J. Cooper, and B.W. Baker. 2006. Beaver dams and overbank floods influence groundwater-surface water interactions of a Rocky Mountain riparian area. Water Resources Research 42, Wo6404, doi:10.1029/2005WR004560.